FARU PROCEEDINGS – 2019

Re-evaluating Space

Across Disciplines

The peer reviewed and accepted research papers of the conference are included in this volume

About FARU

FARU is the research unit of the Faculty of Architecture, University of Moratuwa, Sri Lanka. FARU which consists of four academic departments: Architecture, Town and Country Planning, Building Economics and Integrated Design) organizes international research conferences for the past eleven years. It attracts academics, students and practicing professionals.

FARU 2019 is held at The Institute of Technology University of Moratuwa, Diyagama, Homagama for the 12th year consecutive year and, is co-sponsored by University of Moratuwa, United Nations, Sri Lanka. The FARU Organizing Committee acknowledges the support extend by the University of Moratuwa and all sponsors.

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Editor
Dr. Sumanthri Samarawickrama

Technical and Administrative Assistance
AMS Attanayake

Formatting
GPD Thalis

Conference Logo design
Dinidu Senevirathne

Tele/Fax: +94 11 2650216, Email: faru@uom.lk
Web: https://www.mrt.ac.lk/web/foa/faru

Editor's note

Faculty of Architecture Research Unit (FARU) of University of Moratuwa, Sri Lanka has organized the 12th FARU International Research Conference under the main theme of 'Re-evaluating Space across disciplines'. The conference provides as a forum for researchers, academics, practitioners and students in the areas of architecture, built environment, planning, building economics and integrated design.

Theme of FARU 2019 discusses research on 'space' and to 'lookback' at the conscious decisions taken within the disciplines of build environment, town and country planning, building economics and design to translate space. 'Space' can be interpreted as an element of design in architecture, design and the build environment, or as agglomeration of urban elements, open spaces in town and country planning. It is defined as the professional space within the construction industry and the contribution towards building economics and quantity surveying. Be it a physical or a virtual space the discipline of design also revolves around it.

FARU 2019 opens up the platform to discourse theoretical or empirical case studies through discussions, debate across disciplines under the following:
The main theme:

- Re-evaluating Space

Sub-themes:

- Usage of space and human interaction
- Professional space and economic impact
- Experiencing space and perception
- Spaces in history and new learnings
- Physical and virtual space as concepts

I wish to congratulate all the authors for their contribution, sharing their insights that will provide ample opportunity for discussion, debate and exchange of ideas, information among the conference participant.

Looking forward for a successful conference.

Dr. Sumanthri Samarawickrama
Director, Faculty of Architecture Research Unit
Faculty of Architecture, University of Moratuwa, Sri Lanka

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31. Dr. Naduni Wickramarachchi
    Senior Lecturer, Department of Town and Country Planning, University of Moratuwa, Sri Lanka

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Keynote Address

RE-EVALUATING CLIMATE RESPONSIVE ARCHITECTURE

PROFESSOR JÜRGEN REICHARDT
Professor at the Münster University of Applied Sciences
MSA- Münster School of Architecture, Department of Building Construction, Industrial Construction

I would like to begin this talk with a small story.

I was in Ankara, Turkey back in 2000 curating an exhibition of German Architecture at the Goethe Institute. "*Volume, envelope and climate*" was the focus for presentations by a group of then contemporary German and Turkish Architects. An enthusiastic young Turkish Architect proudly presented an office project located somewhere near the Turkish Riviera, where it is very hot and sunny. The project appeared to be quite like the widely published Cartier building at Paris designed by Architect Jean Nouvel. I finally mustered a bit of courage and asked if such a glass palace project would be appropriate considering the extreme climatic conditions of the Turkish site. The said architect initially acted naïve but on being questioned further become hostile as doubts were being raised on his seemingly unquestionable artistic expression.

Now after almost 20 years difference, looking back it appears that not much has changed across the world with reference to 'our' collective conscience towards climate responsive architecture.

What are the forces which drive climatic architecture and where can we find suggestions? From my point of view, historical examples of 'volume', 'envelope' and 'climate' might still show us the way forward. I would then like to explain a simple methodology with which we work in our office and would become the basis for student seminars and projects at the MSA Muenster. Finally, I have the pleasure to propose aims and a broad roadmap for the two-year German Government funded DAAD ISAP cooperation project with Faculty of Architecture of Moratuwa University, Colombo.

The first architect we want to look for in our pursuit for "volume" is *Albert Kahn*, an immigrant from a small village of Hunsrück in Germany. His father was a Jewish wandering preacher who immigrated with the eight-member family to Detroit, U.S. in 1880. With no formal academic background, poor but talented Albert was lucky to be recognized by Packard Automotive Company and Henry Ford. From 1905 onwards, Albert Kahn was commissioned for the construction of huge factories which went on to become definitive role models for the Bauhaus Movement in Germany. In his lifetime he built more than 2,000 industrial buildings, including more than 500 factories in the Russia. The Packard Forge, a 1910 building for welding of automobile parts, looks like a Gothic Cathedral in iron. The basilica type floor plan with a suspended gantry crane and a step-shaped fully glazed sections were chosen to permit maximum natural light as possible into the workplaces. Moreover the hot swaths could thermally drift upwards during welding. From our point of view one of the very first brilliant examples for *"form follows performance"* approach in architecture. Another stunning building of his is the Ford Glass Plant in River Rouge 1922. Henry Ford was producing Model T car in millions of units at that time, making everything himself in his works, including 2 million square meters of glass for windshields. This glass was melted under the "ears" at the front of the building, hot exhausts were sucked out through smart profiling of the section of the huge building, similar to the Forge Shop.

We are delighted to have recently chronicled his brilliant designs in a book titled “Albert Kahn, Form Follows Performance”, Excerpts of the said book is currently on display in an exhibition at Faculty of Architecture of Moratuwa University.

The second position applies to aspects of building envelope and aerodynamics with Buckminster Fuller. Professionally a naval officer, Fuller designed and built the “Dymaxion Car” in the early 1930s, the drop-shaped device for 8 people ran at a top speed of 180km/ h in its time, a three wheeler with an awesome CW value of 0.27, similar to a futuristic airplane with a metal sheeted shell. At a time when the subject of wind was not even on the screen of the developers, Fuller had a clear understanding of aerodynamics, leading in 1946 to the Dymaxion House project, a saucer like shell following manufacturing ideas of aircraft industry. The house was raised high off the ground, thereby introducing relatively cold air through the floor. This air flowed through the house as spring air and escaped again through an upper “fin”. It was indeed a very smart way to passively ventilate a house by means of aerodynamics and meteorology, without stuffing it with mechanical A.C.

The third example clearly deals with the topical climate. The building is not very well known in the Western world. It is located in Pondicherry, near Chennai (formerly Madras), India. The *Golconde House* was planned and built around 1935, as a guest house nearby the ashram of Indian philosopher Sri Aurobindo. There was a contact to Tokyo based Architects Anthonin Raymond and George Nakashima, former employees of F.L. Wright for 1922 Imperial Hotel Tokyo. The envelope of this highly remarkable structure is made of movable louvers, deliberately orientated towards the sea breeze, away from the extremely harsh eastern and western sun. Also interesting are the aspects of sustainability, where the complete house was built with locally sourced materials by the disciples of the “ashram workshop”. Incidentally, it was the first exposed concrete construction site in India, that Architect Charles Correa says, *‘was the beginning of Indian modernism…’*. The building is still functional today, even after 80 years, probably one of the coolest places in Pondicherry.

In the second part we ask ourselves, how can we re-evaluate these examples for the present, and especially for our future amid dramatic global climate change? We strongly believe that architecture must work holistically and intrinsically with the regional parameters of volume, envelope and climate. In analogy to the DNA of living entities, one could understand the design parameters as the genetic code of the building’s specific performance requirements, hence its *“Building DNA.”* In a nutshell, architecture must provide comprehensive "performance" against measurable parameters.

We have therefore subdivided this performance approach into sub-projects, which we try to optimize from programming till the finished project, all together these sub-projects cling together in a network to synergies of a holistic “Form Follows Performance “project.

First sub-project topic deals with analyzing specific *Geographic* situation. As you are aware, it makes a huge difference in building in the arctic circle, where it is consistently cold throughout the year, requiring only insulation when compared to designing and detailing in the temperate zone, where we live in Central Europe. This is quite challenging, because in the winter one might experience temperatures upto minus 10 degrees Celsius and in the summer upto 40 degrees nowadays, making a difference of 50 degrees. It is complicated to detail and specify building systems, technologies and materials; a cozy insulated building in winter would trap internal heat gained in summer making it unlivable. Similarly, dry, dry hot and humid warm environments need to be treated very differently. One can cool a building in the dry hot zone at night, because it is pleasantly cold in the desert climate at night, open the windows and the building cools down. This strategy cannot be used in the subtropics, where the nights are warm as well as extremely humid. So, one must deliberately analyze in which climate zone the building is being designed and built. It would be appropriate to follow the local building tradition of the zones under discussion. In the subtropics, for example, large thermal storages would be counterproductive. The building components would attract fungal growth due to the existence of hot and humid conditions.

The aspect of *Topography* is another sub-project. Location, windward versus leeward side, azimuth as well as altitude, temperature, air pressure, rainfall, precipitation and humidity, others all add up towards a comprehensive understanding of the site topography.

The raised houses of Indonesia were a result of understanding and use of thermal drafts, which pulls the hot air through the tops of the roof, and thereby generate a natural passive cooling. In Turkish Cappadocia and southern France cave dwellings were advantageous for a hot climate, because stone walls proved to be pleasantly cool. As is Mesaverde in U.S., the flat warm winter sun is caught to warm up the pueblos, but not the high, hot summer sun. For the building it is a truism that we must build compactly in Central Europe, e.g. in Envelope / Volume ratio, Lots of Volume, little envelope surface avoids the loss of heat in winter season. That would be favorable in Central Europe, but this strategy is not transferable to other climates and may look quite different even in Europe when the climate changes. Emperor Penguins of the Antarctic Circle are well suited to their environment, their large volumes lose less heat.

Zoning is a next aspect. In the simple example of the Black Forest farmhouse, where the cow in the center of the volume warms up the inhabitants in winter, and the cut straw around is the insulation. In the summer cattle and straw are in the fields, resulting free air spaces cool the house. It is therefore about understanding which zones of use require which temperature and how are these then arranged in plan and section. Another example of energy optimization, for the climate of Central Europe, is the passive house. We have analyzed the same in projects of passive house research. Different structures, which have a relatively similar footprint, have relatively similar volume. Due to the rotation of the building in the virtual climatic space it is obvious, for example, how the sun travels over a specific location and the consequent energy patterns across the year. Lounge to the south, with use of the flat winter sun, adjoining rooms to the north.

This strategy would not be very clever in India, problems would certainly arise. Incidentally the essence of VASTU and FENGSHUI dating back five thousand years is still relevant in India and in China respectively. Rooms were carefully zoned, e.g. never put a kitchen and storerooms to west, because bread and rice will be spoiled.

The *Envelope* would be the next aspect to be examined, certainly a very difficult one, also from the dynamic development of building materials technology. We need sunscreens, we must balance energy, we also must be versatile, optimize cleaning and maintenance, then consider the various aspects of aesthetics. It's really a huge topic, and I think that perhaps not everything industry promises us should be believed.

For example, a combination of naive architects and hungry glass industry led in Central Europe to the propaganda for double façades, which were marketed as highly sustainable. After 20 years and manifold experiences we are now much more critical towards twice amount of façade construction material and summer heat accumulation within the glass layers.

Sustainability comes as the next parameter, a comprehensive life cycle assessment is very complex, because the lobbies of any building materials claim that their materials are extremely environment friendly and favorable for recycling. Of course, this is interwoven by aspects of Lifecycle, so to say total expenditures over the useful life of a project. From our point of view, perhaps the visualization of “Construction Kits" brings us a bit further here. Visualizations show examples of explosive sets of construction systems, conveying a better awareness of production, logistics and (re) assembling steps, BIM approach here might attach multiple text data to 3D objects as: Totality of energies involved? Consistency of Materials? Weight of Materials? Transport Ways? Ability of parts to be recycled or rebuilt? As a result CO_2 pollution footprint services should be minimized.

We would prefer to build sailboats in architecture and not motorboats. Contrary to needs for mechanical techniques, passive *Natural Ventilation* should be aimed at.

Good examples for sailing strategies in traditional architecture might be looked at Rudowskys book "Architecture without Architects". Essentially it is about understanding how thermals work, or more scientifically, about balancing of negative pressures and overpressures. Rudowsky includes the wind towers of Hyderabad. In a dry, hot climate, with cold nights, winds are captured with special, wind-facing surfaces, steer them into the house and water bodies, hence cooling spaces passively.

At the end of the day probably the most important aspect is *Ecology*, networking our projects with the flora and fauna of nature. It is for an example not understandable as to why we continue to build black cardboard roofs, whilst extensive roof greening just in the city could help to reduce Urban Heat Island Effect. It would be good for the microclimate and for all living beings. Thus, being able to and open for networking with nature is major task in future. Unfortunately, an architect`s beautiful concept sketches are often too optimistic with intuitively created darts for "air in and out"; in reality air and thermal flows rarely behave accordingly. Of course, engineering's now may be done better then purely sketched by hand (as with Kahn and Packard Forge Shop) based upon state- of-the-art 3D simulations of thermals and flow from the 3D models, on basis of weather data of specific site. I believe that we are part of a development that goes further and further towards BIM (Building Information Modeling) that we as architects are capable of a comprehensive engineering, analyzing formal decisions for an example in daylight capacities and energy balancing as general qualities of architecture. It is possible that this regionally influenced sensitiveness was lost through the uniformity of the International Style.

Now I introduce shortly three RMA office projects and three MSA Muenster student projects. First is my own *Studio in Essen*, Germany. The design uses the north backbone slope as a thermal mass to support the house in winter and summer. In the light weight hybrid steel house climate-buffering storage masses are provided by concrete slabs and a central brick core. the "construction kit" illustrates a complex hybrid system of different building materials. The mixture of concrete walls and slabs, steel construction, inner cement block core, shell in redwood sidings and glass. Solar thermal and water storage for gray water are also part of the project. We also learned that nature does not always behave as we assumed. In our thermal simulation, the tree they see in front of the picture was planned. He was part of the simulation an existing huge tree was responsible for shading the large glass surfaces on the Westside. He was sick at some point over the years and then had to be cut down. As natural sunscreen was thus no longer available, shadow structure had to be retrofitted, tailored from old sails of fishing catamarans cruising at Negombo coastal line.

The second RMA project is Peter Solar Bakery in Essen, Germany. The building materials and technical systems used were selected from the perspective of holistic material cycles and holistically optimized in the 3D BIM model. The total of 2200 m² large roof areas of phase 1 and 2 will be completely equipped with photovoltaic collectors in the final construction. On the approx. 1100 m² large roof area of Phase 2, 123.000 kWh of solar energy will be used directly in the baking process of the rolls as well as in the refueling of the emission-free delivery van fleet for the sales branches introduces. With the delivery of the sales branches in the city area, approx. 36,000 liters of diesel fuel, equivalent to approx. 100 tons CO2 / year, are saved with a total mileage of approx. 300.000 km / year. The integral planning for layout and logistics, building and building services was monitored over the entire project period by a certification according to DGNB (German Sustainable Building Council). Within the framework of the competition "Energy-Efficient Building " of the Federal Ministry of Economics and Technology BMWI, the submitted projects were analyzed and evaluated according to their energy consumption in KWh / m²a. The project was awarded the City of Essen Environmental Prize, German Government BMWI award as well as international attention

The third project RMA is a *High Bay Chocolate Storage in Aachen*, Germany, amidst an existing complex industrial plant. Client asked for a 100 x 40 x 40 m automatic warehouse, as shelved space continuum, with a 36 x 36 m three story multifunctional volume for mainly shipping the goods. Special requirements were fire protection and thermal comfort of warehouse. As chocolate goods are very temperature as well as humidity sensitive, task was to engineer most economically strictly limited temperature span between 18 and 23 degrees Celsius in the warehouse structure. Logistics, architectural design and engineering of utilities were based on complete 3D BIM approach with Revit construction, with thermal and CFD simulations of interior of warehouse structure. Thermal modeling had to comprehend a multitude of different weather as well as logistical situations, e.g. temperature of stored goods out of producing plant, degree of loading, climatically winter and summer embedding. The fairly complex simulation calculation modeling finally comprised 8 million nods. In accordance of simulation results all utility equipment was detail planned and built. The future real life of temperature inside the warehouse will be monitored.

Then on basis of a series of student seminars I show shortly *three student projects at MSA Muenster* exploring CFD simulations out of BIM design and construction modeling's.

First project is an inner-city proposal for an urban apartment building refill in Medlin, Columbia. MSA student Sandra Aguirre explored thermal comforts in a three side closed dense building block on basis of specific weather conditions and different floor and section zoning as well as a variety of atrium strategies. Out of four options finally aroused the optimized design.

Another project dealt with a workshop for Bamboo constructions in Byanas, Philipinnes. Whilst visiting MSA in spring this year, Nethmi Jayaratne nicely fed in her Moratuwa ecology expertise into an international student design group. The shown project proposes the idea of an "upside down" wooden ship for volume of the workshop production area, thermal comfort of working environment was proven by means of CFD simulation. The third project is MSA student Anna Okon proposal for a new low cost new rural village in Mexico, with a system of simple building techniques, constructed by the inhabitants themselves. Out of modularity of an atrium twin house cell and infrastructure system layout was developed a communicative urban scheme, with ability for dynamic growth. CFD simulation was used to analyze the indoor and outdoor natural ventilation thermal comforts of the twin house cell. Finally in the third and last part of my contribution to FARU 2019 it is indeed my pleasure to broadly sketch the academic roadmap for German government funded two year DAAD ISAP cooperation project *"Climate Responsive Architecture"* between Moratuwa University, Department of Architecture, and MSA Muenster School of Architecture, Germany. Following *DAAD 2005 to 2008 Triloka* cooperation project, MSA Muenster was glad to initiate and invite a series of privately funded academic projects for selected students of Moratuwa for 2-month periods between 2016 – 2018.

Based on knowledge gathered so far, one noticed further possibilities in "Form Follows Performance" 3D BIM architectural engineering and simulation techniques, embedding in Muenster and Colombo parameters; it was broadly agreed that this academic basis should be thoroughly investigated and transferred to respective Universities for a WIN – WIN scenario for ALL.

It is needless to mention that MSA Muenster has extensive theoretical knowledge as well as practical experience in 3D BIM construction, e.g. prefabrication techniques in concrete, steel, wood, sustainability scorings of dynamic 3D simulation, passive housing, natural and artificial lighting, energy, ventilation. We are delighted to note that the University of Moratuwa is equally adept both in theory as well as practice, having a clear focus on South Asian Tropical Building Parameters e.g. ecology, nature and research in low energy systems and technologies.

We strongly believe that intense collaborative research will help synergizing the individual strengths aiming at a “finite” roadmap, improving existing digital tools, definition of requirements and fulfillment routings of “project milestones.

Further, it is believed that academic possibilities will arise due to now decided PhD classes in Muenster, allowing for even deeper involvement and outstanding expertise in integral planning techniques for Muenster MA/ PHD students as well as Moratuwa future Master students.

Special focus of the current two-year DAAD PPP student academic project is research on architectural support on ways out of global warming issue. Thus, on basis of state of the art and fast forward integral planning BIM techniques, as well as dynamic simulations of energy, daylight and ventilation, architectural engineering “quality assuring milestones” will be developed in close cooperation with tropical climate expertise in these fields at University of Moratuwa, Colombo.

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IMPACT OF COLOUR ON WORKER PRODUCTIVITY AND SATISFACTION IN THE GARMENT INDUSTRY
A case study implemented in Awissawella, Sri Lanka

GUNATHILAKA D.M.L.R.[1] & HETTIARACHCHI A.A.[2]
[1,2]Department of Architecture, University Moratuwa, Sri Lanka
[1]*lankarasadi@gmail.com,* [2]*anishkah@uom.lk*

Abstract
Attracting workforce to Sri Lanka's current apparel industry has become quite a challenge. Absenteeism and labour turn over have been recognized as critical factors on productivity of workers and consistent quality of the products. Accordingly, identifying strategies to enhance job satisfaction, performance and productivity of workforce is vital for the sustenance of the industry.

In view of this, the current investigation investigates the potential of colour, being an established psychophysiological agent to enhance worker satisfaction and productivity. A sample of female machine operators (n = 30, age – 25 - 60) of a garment factory in Awissawella, Sri Lanka was tested during a period of four weeks via a mixed method. Colour of the internal walls of the factory space was changed on a weekly basis to record the level of satisfaction and productivity induced by each colour. Existing wall colour (pink) was replaced initially by blue (a cool colour) and secondly red (a warm colour) followed by white (a neutral colour) using coloured fabric. Employees rated their level of satisfaction and productivity via a questionnaire survey while the records of their productivity were obtained from the administration.

The study substantiated the impact of colour to manipulate worker satisfaction and productivity. Most employees (77%) were satisfied to work in the blue interior while 73% of employees were dissatisfied in the red interior. 50% of workers were satisfied with white interior while 24% employees were dissatisfied. However, Red interior was found to maintain an average worker productivity of 70% compared to the existing productivity level of 63% with the pink interior. Average productivity induced by blue and white interiors were 65.4% and 56% respectively. Accordingly, red was found to improve productivity over blue and white though many employees were dissatisfied regarding the presence of red in the interior. It is recommended to extend this study seeking the favourable quantity, proportion or the percentage of colour red that needs to be incorporated in an interior to increase productivity of employees while being satisfied. Testing the combined impacts of red (warm) and blue (cool) hues and their corresponding proportions for an environment where employees are equally productive and satisfied can be another aspect to investigate.

Keywords: *Garment Industry; Interior Colour; Labour Turn Over; Productivity; Satisfaction.*

1. Introduction

Designing an environment incorporating diverse attributes such as temperature, sound, light, odour and colour with a specific layout can stimulate perceptual and emotional responses in users, affecting their behaviour. Being fundamental design elements, light and colour play a vital role in manipulating human emotions and behaviour. The diverse research carried out have proven that the colours which surround the humans in their day-to-day routine have a profound impact on their moods and behaviour (Babin, Hardesty, & Suter, 2003; Kwallek, Lewis, & Robbins, 1988; Kwallek, Woodson, Lewis, & Sales, 1997).

According to research findings of Kwallek et al (1997,2005), colours of the interior designs affect the level of satisfaction, performance and productivity of employees in work environments. Yet, colours are found to be used mainly for aesthetic and visual purposes in design interventions which can be identified as negative in terms of user perception and behaviour. This research mainly focuses on analysing the impact of colours on worker's productivity and satisfaction in industrial environments.

1.1 BACKGROUND OF THE STUDY

Garment industry plays a vital role in the Sri Lankan economy and it has become Sri Lanka's largest export industry since 1986. Due to the competition, their major focus is on maximizing their profits through a higher level of employee performance and an overall equipment effectiveness rather than proving a better working environment (Kelegama and Epaarachchi, 2003). As established by literature, there are assessable environmental and human parameters favourable for conducive work environment design. The lighting level, temperature level, ventilation, humidity sound level, the size and volume of

the building and availability of sensory stimuli (colour, lighting, texture, materials etc.) have been considered as vital environmental factors while job satisfaction, belief and trust, performance, motivation, job involvement, job satisfaction and organizational commitment are defined as human factors. It is apparent that job satisfaction has a strong impact on employee performance (Warnasooriya & Jayawardena, 2011). The current investigation recognises colour as a significant parameter leading to the level of satisfaction and productivity of factory workers.

1.2 NEED FOR THE STUDY

It is believed that the Sri Lankan garment industry specifically, the industrialized garment for the local market began in 1960's. The exportation of readymade garments began a decade later, which expanded speedily. After liberalization of Sri Lankan economy during 1977, it kept on expanding throughout 1980's representing 27% of all exports (Kelegama, 2005). Since 1986, Garment industry has been the Sri Lanka's largest gross export earner and accounted for more than 52% of the total export earnings of the country (Dheerashighe, 2009). Garment industry earned nearly 400 million US dollars in 1992 (Kelegama, 2005).

Employee satisfaction is an important factor in the success of the field of garment industry which entails with the working environment built through conducive factory design. However, most of the working spaces of the garment factories are designed having least concern on the employees' satisfaction. It is an obvious fact that employees working with dissatisfaction directly affect their level of daily productivity. As a result, the level of absenteeism and labour turn-over may also increase creating a major issue in the apparel industry. Improving productivity through reducing absenteeism and labour turn-over is essential to survive in this highly competitive apparel industry under quota free situation (Razzaue & Eusuf, 2007).

This research aims at assessing the impact of 'colour' on worker satisfaction and productivity and how it in turn influences reducing absenteeism and labour turn-over within the case study organization. The findings of the study can be helpful for Architects, Designers and Interior Designers in incorporating appropriate colours to create effective and conducive working environments in future industrial building design interventions.

1.3 RESEARCH GAP

Many research scholars have revealed the impact of colour on manipulating thoughts, emotions and behaviour of human beings. Colours are established to manipulate the perceived dimensions and qualities of space namely; perceived temperature, lighting level, volume, visual size, visual weight and even smell within built spaces (Mahnke,1996). There are several experiments done on the impact of colours on user satisfaction and performance which are mostly focused on office employees, academics etc. (Kwallek and Lewis 1990, Kwallek 2005). According to established literature, colours associated with worker satisfaction are quite different from the colours that improve productivity. For instance, Kwallek and Lewis's (1990) experiment revealed that the subjects who were working in a red office made the fewest errors, while the subjects in the white office made the most errors. Even if the workers were found to be more productive reporting less errors in the red office, they found the colour of their office more distracting than subjects who worked in the white office. The subjects in the white office reported that they would like to work in this environment and considered this colour as most appropriate for an office. However, Kwallek and Lewis (1990) speculate that a sterile, white environment may not be as conducive to work as is believed. Another study by Kwallek et al. (2005) conducted with office employees re-affirmed that the workers most satisfying colour is white while the office colour with highest perceived performance was red.

However, less attention has been paid on the impact of colour on worker satisfaction and productivity with reference to industrial buildings, which this research aims to cover with reference to the employees of a garment factory buildings in the local context.

1.4 THEORETICAL FRAMEWORK

Enhancing job satisfaction and productivity of workers are key factors to be considered in factory design. Satisfaction is identified in literature as a productivity indicator. For instance, Ostroff (1992) found that organisations with more satisfied employees tend to be more effective and productive than organisations with dissatisfied employees. As clarified by Myskova (2011), satisfaction lowers fluctuation of employees, positively influences productivity indicators and thus overall company output. A working environment should be comfortable and pleasant in terms of the sensory stimuli provided for the employees to be satisfied physically as well as psychologically enhancing their effective performance. As highlighted by Heerwagen and Wise (1998), absence of distractions and discomforts, presence of tools and environmental features that support thinking, offloading of cognition to the environment, support habitability and thereby foster positively toned moods and well-being and ability to control and adapt conditions to individual preferences are identified as conducive parameters of a working environment which lead to high level worker performance. Accordingly, providing appropriate levels of light, ventilation, temperature, acoustics and maintain healthy levels of indoor air quality (Locke and Lathan 1976) are identified as key factors of conducive factory design leading to high performance and productivity.

According to theory of colour, red is identified as a warm colour which stimulates, excites and activates people while blue is recognised as a cool colour having a pacifying, relaxing and calming effect (Mahnhke,1996). Further, white is acknowledged as a neutral colour which neither stimulates nor pacifies a user (Mahnhke,1996). Aligning with above established psychophysiological effects, red, blue and white colours were chosen as appropriate to explore the impacts on the satisfaction and productivity of garment factory workers.

1.5 SCOPE AND LIMITATIONS

The study was limited to test the impact of a warm colour (red), a cool colour (blue) and a neutral colour (colour). Considering practical and ethical aspects, coloured fabric of the said colours was incorporated instead of painting the walls. The research subjects were limited to machine operators and the gender was limited to only females since there were no male machine operators. Investigation time period per colour was reduced to one week in order to respect their schedules. The study was limited to measure worker satisfaction and worker performance/productivity among a range of human factors associated with factory design with reference to 30 nos of participants.

2. Research Design

Initially, seven garment factories located in Maharagama, Ratmalana, Horana, Kurunegala, Dehiwala, Diyathalawa and Awissawella were considered via direct observations and interviews with the management to assess their suitability to conduct the final study. Being an export industry, which is accessible and having fixed parameters in terms of the design being produced, the calibre of workers, lighting level, temperature, number of participants and working hours, a garment factory in Awissawella was selected for the case study considering the criteria mentioned below. Ever since, the quota abolishment took place in 2005, the selected company has been facing tough challenges with shrinking margins. As stated by the management, they are in a continuous struggle to increase employee satisfaction using different means.

2.1 METHODOLOGY – FIELD WORK

The colour of the internal walls of the factory space was changed to observe the reactions of the machine operators. The existing pink colour was initially replaced by red (a warm colour) followed by blue (a cool colour) and finally with white (a neutral colour) using colour fabric. Taffeta, an opaque fabric which was used for interior decorations selected as the best option to cover the wall.

Figure 1: Blue, red and white fabrics introduced to the factory interior

While the daily productivity of employees was calculated with the assistance of the administration, their perceived productivity and level of satisfaction were recorded through a questionnaire survey. Once the current status was observed for a period of one-week, blue (a cool colour) colour was introduced to the interior walls using blue fabric. After the first colour change the employees carried out their normal routine for a week and interviews were carried out with the supervisors/top management and questionnaire was given to the employees. Several variables were measured including gender, age group, type of work, sicknesses of the participants etc. The subjective variables measured included occupant job satisfaction, satisfaction with the colour scheme and self-reported productivity.

A questionnaire survey with a 5-point Likert scale was adopted to collect qualitative data namely, worker satisfaction, self-reported productivity and response to the introduced colours. The conditions of the working environment and interior space were observed and recorded. Interviews were conducted with factory employees and the management to obtain information/statistics on employee turnover and absenteeism of the machine operators. Random interviews were also conducted with employees to obtain information about their feelings and satisfaction levels after introducing each colour scheme. The Jenkins Achievement Striving Scale, an instrument with a 5-point Likert scale which assess the presence of achievement-related behaviour and attitudes in employees from much less too much more than others was adopted to measure the level of satisfaction. The Eysenck Personality Inventory (EPI), an item which has a dichotomous response (Yes or No) (Kwallek et al, 1997) was adopted as well. However, there were some issues when measuring satisfaction due to the lack of understanding of the Likert scale by some of the employees.

Information related in measuring productivity were taken from the management. Measured productivity is the ratio of a measurement of overall outputs to a measure of inputs used in the production of garments (Kapuria, Rahman and Haldar 2017). Accordingly, the equation below was adopted to measure productivity in the whole factory.

$$\text{Efficiency} = \frac{Total\ output\ per\ day\ per\ line \times SMV \times 100}{Total\ man\ power\ per\ line \times Total\ operating\ minute}$$

3. Findings and analysis

3.1 PRODUCTIVITY

As per the findings, the highest average productivity (70%) of machine operators was observed under the exposure to red interior while the lowest average productivity (56%) was reported in the white interior. This finding is in parallel with the work of Kwallek and Lewis's (1990) and Kwallek et al. (2005). Though productivity under exposure to blue colour was observed as lower compared to red (65%), it was observed as higher compared to their normal overall productivity when exposed to the existing pink interior (60%) and the white interior (56%). Aligning with the existing literature red colour was identified as the best colour to boost productivity in factory workers.

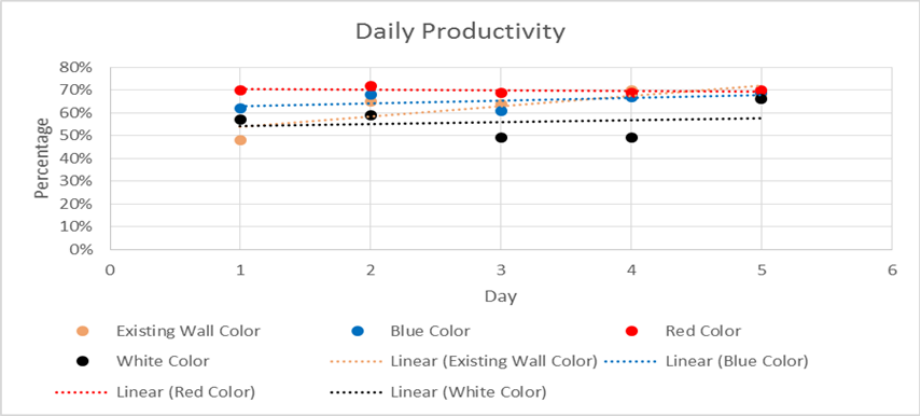

Figure 2: Daily Productivity vs Colour exposure

3.2 OVERALL SATISFACTION

•Level of satisfaction on the existing working environment: While 57% of the workers were unsatisfied, 20% of them remained neutral. Only 23% of employees were found to be satisfied with their existing working environment.

•Stress Level related to the existing working environment: 44% of the workers' responses were neutral regarding their stress level at the existing factory setup while 30% were found as not stressed and another 26% mentioned that they are stressed with the company.

•Level of satisfaction regarding the job: Only 27% subjects were found to be satisfied about their job. While 30% of the workers responded as unsatisfied, 43% remained neutral.

3.3 PERCEIVED PRODUCTIVITY:

The workers reported their perceived productivity under the three-colour schemes per day of the 3 weeks. Quite significantly they have reported a higher level of perceived productivity on Wednesday out of which red exposure dominates (73%) as the highest followed by blue (56%) and white (43%).

3.4 CONDUCIVE COLOURS FOR FACTORY INTERIOR BASED ON WORKERS RESPONSES:

According to the workers' responses; a majority of employees have reported to be satisfied with the blue interior (77%) while only 10% of them are unsatisfied. Conversely, a majority is unsatisfied with the interior with colour red (73%) whereas only 7% are satisfied. However, demonstrating a diversity in the level of satisfaction to white 50% of the employees were satisfied, 17% were not satisfied and 27% indicated a neutral response. This was also evident in the responses given by the workers in the qualitative study. For instance, participant no 12 highlighted that, "blue is a simple colour and it is pleasant to see during the time of work. On the other hand, as stated by participant no - 13, "red background was uncomfortable to the eyes and it was difficult to look at the wall. But white is a very calm colour which is a pleasant sight". Further elaborating the same notion participant no – 18 stated that, "white background can increase the productivity because it is pleasant to see and therefore red is not suitable for the working environment.

Quite opposingly there were workers who were satisfied about working in a red interior. For instance, according to participant no-22, "red colour is a very attractive colour and the white colour interior is not attractive as it is boring to work. Participant no.24 was found to be satisfied with the red colour because it attracts his eyes. However, most employees were found to be happy and relaxed under the exposure of blue working environment. On the other hand, the highest number of distressed (sad, stressed, and bored) employees were reported with reference to the red interior.

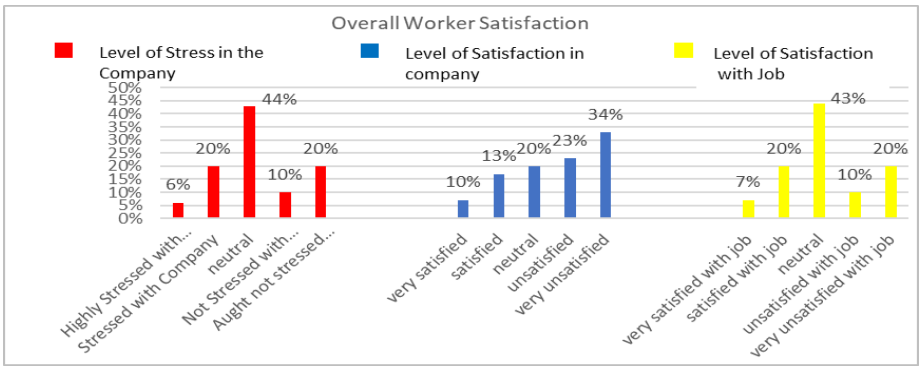

Figure 3: Overall worker satisfaction

3.5 CONDUCIVE COLOURS FOR FACTORY INTERIOR BASED ON WORKERS RESPONSES

44% of the employees preferred blue as the best interior colour for their factory interior. Red was seen as the least suitable colour for the interior as per the workers' preference. Only 6% of employees were identified to be satisfied with the red interior. On the other hand, 37% of employees selected white as the best interior colour. 13% of employees responded that any other colour can be suitable for the factory interior.

3.6 SELF-REPORTED PRODUCTIVITY IN DIFFERENT COLOUR EXPOSURE

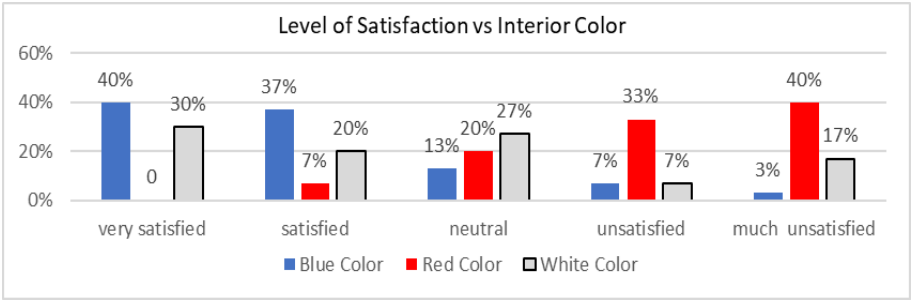

Figure 4: Level of satisfaction – Interior colours

As per employee's response towards the self-reported productivity, most of the employees (94%) responded that they were productive within the red working environment (very productive - 67%, productive – 27%). This is parallel with their actual productivity (average -70%) demonstrated during exposure to the red colour. Accordingly, the study validates the findings of Kwallek et al (1997 and 2005) obtained from studies implemented in the western context to a study sample of an eastern context.

84% of the employees have perceived themselves as being productive in the blue colour working environment as well (very productive - 47%, productive – 37%). This finding too corresponds with the workers actual productivity which is reported in the statistics (Overall- 65%).

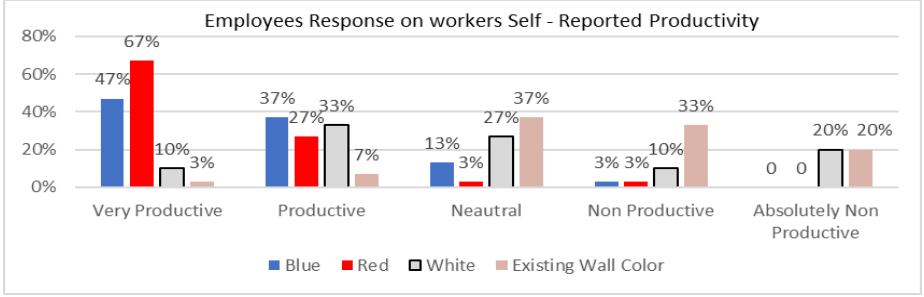

Figure 5: Self-reported productivity in different colour exposure

Self-reported productivity during the exposure to white colour demonstrated quite a variation. For instance, 33% felt that they were productive in white environment and opposingly 30% perceived that they were not productive. Another 27% workers were neutral in their response. However, in the actual scenario lowest productivity was reported in the white interior (56%). On the other hand, most of the workers (53%) believed that they are non-productive in the existing pink setup in which they are conditioned for a long time. Further elaborating the same, only 10% of workers believed that they were productive in the pink setup while 37% were neutral. Nevertheless, the actual average productivity in the existing pink setup was 63%.

4. Conclusion and Recommendations

Regardless of the deviation between the impact of colour on worker productivity vs. satisfaction the study obtained positive results proving the possibility of colour beyond its aesthetic and visual purposes to manipulate worker satisfaction and productivity in the factory buildings.

Accordingly, Red was found to increase productivity compared to all the colours tested yet the employees were very much dissatisfied with the use of red in the factory interior. On the other hand, the workers were satisfied in the blue interior, but blue colour did not help in increasing overall productivity in comparison with the red interior. White colour did not have a significant impact on productivity compared to red, blue or the existing pink colour.

It is recommended to extend this study seeking the favourable quantity, proportion or the percentage of colour red that needs to be incorporated in an interior to increase productivity of employees while being satisfied. Testing the combined impacts of red (warm) and blue (cool) hues and their corresponding proportions for an environment where employees are equally productive and satisfied can be another aspect worth investigating.

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UNDERSTANDING THE CHALLENGE OF DIGITALLY TWINNING THE GEOMETRY OF EXISTING RAIL INFRASTRUCTURE

ARIYACHANDRA M.R.M.F.[1] & BRILAKIS I.[2]
[1, 2]University of Cambridge, Cambridge, United Kingdom
[1]*mfa47@cam.ac.uk*, [2]*ib340@cam.ac.uk*

Abstract
The exploitation of the concept of Digital Twins, i.e. virtual copies of physical assets, for existing rail infrastructure has the potential to revolutionise asset management in this sector. However, such exploitation is only possible if methods exist can cost effectively generate the Digital Twins of rail assets. The first step in this "twinning" process is the capture of the asset's raw geometry and its conversion to high level geometry suitable for further enrichment with design, construction, operation and maintenance data. This paper investigates the state of the art in the first twinning step, i.e. generating geometrically accurate models of existing rail infrastructure, focusing on the track assets. The paper starts off by defining the digital twin, then explaining the benefits of real-virtual synchronisation and challenges to exploit the digital twin in its full potential. The subsequent sections provide a longitudinal literature indicate that current studies are sensitive to varying railway geometries, neighbourhood structures, scanning geometry and intensity of input data. These factors render methods designed for digital twinning ineffective for any track structure which contains varying horizontal and vertical elevations. Such variance is quite common; hence, we conclude that the problem of automatically generating geometric digital twins of track structure is yet to be solved.

Keywords: *Geometric Digital Twin (GDT); Point Cloud (PCD); Rail Infrastructure.*

1. Introduction

Digital Twin (DT) is the digital representation which links the physical and virtual model. It was initially defined by the National Aeronautics and Space Administration (NASA) as "an integrated multi-physics, multi-scale, probabilistic simulation of a vehicle or system that uses the best available physical models, sensor updates, fleet history, etc., to mirror the life of its flying twin" (Shafto *et al.*, 2010). The Geometric Digital Twin (GDT) contains the core dataset of a DT; which is the geometry; on top of which all other structured data can be linked. The GDT is static throughout the infrastructure life cycle. Its first iteration is as-designed model (AD-GDT) during the design phase; as-built iteration (AB-GDT) during the construction phase; and as-is iteration (AI-GDT) during the operation phase (Koch et al., 2014). However, few assets today have a usable digital twin, because the perceived cost of creating and maintaining the DT counteracts the perceived benefits of the twin. This happens in part due to the labour cost required to manually build/maintain the digital model, which is roughly 10 times greater than laser scanning it (Fumarola and Poelman, 2011). This explains the need to automate the process of creating digital twins of rail infrastructure.

In this article, we provide a longitudinal view of current practice and the state of research of the geometric modelling process. We discuss the current state of digital twin in Section 2 and 3, and then outline the current practice of digital twin generation in Section 4. We identify the knowledge gaps in the DT generation of rail infrastructure in section 6 by thoroughly reviewing in two parts the past studies on the state-of-the-art DT technologies given on section 5. Finally, we elaborate potential research directions in section 7. The contributions made by this paper to knowledge highlight the knowledge gaps derived by the review.

2. Benefits of real-virtual synchronisation

Over the last five years, an estimated £770 billion worth of global investment has been expended to maintain and upgrade railway networks (Leenen and Wolf, 2018). The top industry challenges are capacity, operational efficiency and reliability, structural and component issues, safety and security (Love *et al.*, 2017). Among those, cost overspend, delays and shortcomings in scope and quality are

endemic features of rail projects. 48% of the rail projects failed to achieve the required baseline time, cost and quality objectives (Love, Ahiaga-Dagbui and Irani, 2016) while the Edinburgh Tram System being the latest to experience a cost overrun of over 100% (Love *et al.*, 2017). Hence, the need to maintain better documentation of the existing and under construction railways has been established.
UK is undertaking the biggest rail system modernisation programme for the 21st century with £48 billion for maintaining and improving the network (Crossrail, 2017). The majority of these railways were built before the advent of Computer-Aided Design (CAD) in 1977 and dates to 1830 therefore, working models are not available to assist any regenerating operations (NAO, 2014). Hence, these recent developments have resulted in an increased demand for digitised railway environments since it provides an opportunity to visualise, explore and plan railway scenes indoors (Bower, 2014; Love *et al.*, 2017; Bensalah and Elouadi, 2018). Research evidence highlighted that the DT can deliver 80% reduction in time, 10% saving through clash detection, 40% elimination of unbudgeted change (Eastman *et al.*, 2008; Furneaux and Kivvits., 2008), especially to address current hurdles in rail projects.

3. Challenges to exploit the digital twin

The creation of GDT is a complex process, starting with the acquisition of the Point Clouds (PCD)s, followed by the accurate creation of surfaces and the inclusion of information regarding the objects, such as materials and costs. While other applications of DT use automated sensor technology for this process, the construction industry still relies on manual processes. For instance, a recent laser scanning process was only 4 hours, whereas Three-dimensional (3D) semi-automated modelling of scanned 2,602 objects took 15 days (Fumarola and Poelman, 2011). Thus, despite its potential; its time, cost and knowledge-intensive nature, make GDT a laborious manual task. The total cost of DT generation can be broken down to fixed and variable costs. Fixed costs refer to fees for DT modelling software licenses, hardware required for the software, and training for inexperienced modellers. Variable costs spent on each individual modelling project, which are usually represented by the total modelling hours of and the corresponding hourly labour cost. Assuming the fixed costs and the hourly labour cost are constant, the total cost GDT generation is then determined by the total modelling hours. This means cost savings will be achieved if we can reduce the total modelling time by automated solutions. Hence, geometric modelling remains the “bottleneck” during the creation of DT of any rail element given how costly and time consuming it is.

4. Current Practice of Digital Twin Generation

The current practice of digital twin generation known as “Scan-to-BIM process” (Tang *et al.*, 2010) consists of 4 main steps (1) raw image and/or PCD capture; (2) data preparation; (3) geometric modelling; and (4) semantic enrichment of the model with additional information, such as topological relationships and material specifications. The final DT can be continuously updated using data collected from the sensors. As 3D data become popular nowadays, the advantage that PCDs can avoid problems such as illumination and background confusion, which are common issues in images and videos, has been realised. Airborne Laser Scanning (ALS) and Mobile Laser Scanning (MLS) are two LiDAR systems for acquiring accurate PCDs over large areas. According to the comparison given on Amos et al. (2018), ALS is the most robust method to scan over large areas, hence the ideal scanning technology for rail infrastructure.

Major software vendors such as Autodesk, Bentley, Trimble, AVEVA and ClearEdge3D, etc. provide the most advanced PCD-to-DT modelling solutions. Agapaki and Brilakis (2018) provided the pros and cons of current DT modelling commercial software. These software packages can automate to a large extent the DT generation process; however, they are still far from being fully automatic. For example, existing software packages can automatically extract the maximum number of planar features, up to 90% pipes in a plant PCD, and specific standard shapes like valves and flanges from industry catalogues (ClearEdge3D, 2017) followed by fitting built-in models to them, though a few clicks and manual adjustment. However, ClearEdge3D is tailored for building and industrial environments. In the following

table 1, we elaborate the entire workflow of the DT generation of a typical double track railway from its PCD using CloudCompare 2.8.1 (2018) and Autodesk Revit 2018. According to the table 1 modellers must first manually segment a PCD into subparts, and then manually fit 3D shapes to the subparts. This demands a significant amount of attention when extracting the target objects and the fitting accurate 3D shapes to the segmented sub-point-clusters is quite challenging.

Table 1: Workflow of the manual rail infrastructure GDT generation from PCDs

Step 1: After registering the raw scans, the registered raw PCD of a railway is imported into CloudCompare.
Step 2: The PCD is sub-sampled using the Cloud Sub Sampling functionality in CloudCompare and then the sub-sampled result is saved. The reason for down-sampling the original PCD is that current modelling software such as Revit is an in-memory system which slows down significantly or even collapses when working with large PCD.
Step 3: The sub-sampled data is cropped, which aims to remove irrelevant points such as trees, vegetation, etc. Modeller needs to repeatedly select regions of interest to delete by creating polygons through CloudCompare's clipping functionality.
Step 4: The clipping functionality is again repeatedly used in order to segment the cropped PCD into individual sub-point-clusters, such as masts, rails, sleepers, and cables etc. which correspond to the components making up a railway. Each segmented sub-point-cluster is saved into an .e57 file.
Step 5: A Revit project is opened and a point cluster in .e57 file is imported by clicking the Insert Point Cloud tab. The .e57 file needs to be first converted into an .rcp file by an indexing process, and then positioned by shared coordinates. This procedure is repeated until all .e57 files are indexed and a set of .rcs and .rcp files are created.
Step 6: The sub-point-clusters are modelled one by one. Based on the geometric nature of the current point cluster, a modeller uses his or her engineering knowledge and modelling experience to decide the object's type and to fit the point cluster with (1) a generic shape from the built-in shape library, or (2) a manually created customized shape using Revit Family editor. For complicated point cluster like the cantilever, a modeller needs to fit it using multiple customized shapes by manually generating Family objects so that its overall topology can be approximated.
Step 7: Finally, the Revit modelling project can be exported into an .ifc file after a manual semantic enrichment process. To do so, a modeller can label each component with its real-world taxonomy and then choose a specific IFC setup (IFC2x3 or IFC4) to create an .ifc file. The final IFC file can be visualized in Solibri Model Viewer or any other IFC viewer

Next, modellers need to enrich other explicit and implicit information such as the component's taxonomy, the connectivity and aggregation and the defects. Finally, all detected shapes need to be exported in a common format such as Industry Foundation Class (IFC) format (table 1).

As explained, a modeller can only manually produce a railway GDT with components' labels using current software. However, this GDT modelling process is laborious, containing many repetitive processes. Step 6 is the most time-consuming step, with 95% of the total modelling time spent on customizing shapes and fitting them to the sub-point-clusters especially for rail infrastructure which generally lengths over kilometers. The results of this process summarize the "bottlenecks" of current software packages in modelling an actual railway DT. Firstly, existing software packages cannot automatically extract non-canonical shapes, which are frequently present in railways. Manual shape customisation is laborious. Secondly, the presence of occlusions and sparse data add hours of adjustments. Thirdly, the generated 3D models from existing software packages do not carry any implicit information. This information is necessary to produce a "meaningful" DT, which can be used to support the condition rating, including but not limited to the semantic meaning of elements, element materials, relationship, defects, schedule, cost, and maintenance history. Finally, there is no single software that can offer a one-stop DT generation solution. Modellers have to shuttle intermediate results in different formats back and forth between different software packages during the modelling process, giving rise to the possibility of information loss.

5. State of Research of Digital Twin Generation

The use of existing software packages in the DT modelling process is still human dependent to a great extent. Hence, much research effort has been devoted to automating the modelling process using PCDs and/or images.

5.1 METHODS EMPLOYING A BOTTOM-UP STRATEGY FOR RAIL ASSET TYPES

In bottom-up strategy, the individual base elements of the whole system are initially defined in fine detail, and arranging those elements together to provide a more complex system at the end (Borenstein and Ullman, 2008).

Arastounia (2015) proposed a sequential algorithm in which the recognition of objects is carried out separately and highly dependent on each other. First, track bed is extracted identifying points with uniform-height neighbourhood. However, this method recognises rail track points as track bed points hence needed a further segmentation process. Thus, considering their three primary properties such as height variation on the track bed; continuity; and smooth curvature gradient, tracks were separated from track bed points. Overhead cable structure points were then identified based on the track bed points by first considering the 3D vector connecting each non-track bed point to its closest point on the track bed. Cable points were then filtered using their linearity and the rest of the points considered as mast and cantilever points. The sequential identification implies that a failure in recognition of an object leads to failure in detection of the remaining objects which was a major limitation of the study. Also, the performance of the algorithm deteriorates for poorly sampled data includes more diverse features such as humans, cars, and buildings in a much denser configuration. This issue emerges due to its low sampling rate and complicated configuration. Furthermore, the neighbourhood analysis imposes a significant computational load (taking roughly 3 hours). Addressing limitations of this method, another algorithm has later improved the computational efficiency of the rail track extraction by coarsely classifying all of the data based on height of points into three clusters from which the rail tracks, contact, and catenary cables are identified (Arastounia and Elberink, 2016). The rough classification assumes that the vertical spatial offsets among the railroad assets are constant throughout the entire dataset. This assumption holds for most parts of the urban rail corridors, but it may not be the case in rural rail corridors such as mountainous areas whose track bed may experience a large slope.

Yang and Fang (2014) used the geometry and intensity data to detect objects belong to the track structure. Initially, the track bed was identified using spatial patterns of the scanning lines. Rail points were then located using shape features such as height and slope and intensity data such as incidence angle, and the material features of the surface. However, this method only focused on the extraction of rail tracks and other objects are not recognised and highly depend on the scanning geometry. Also, the method is less accurate in extracting forking junctions. This is due to the complexity of track geometry, the existence of side tracks, and constructive measure.

Jwa, Sohn and Kim (2009) used Voxel-based Piece-wise Line Detector (VPLD) to automatically reconstruct 3D powerline models using PCDs. The method uses voxels to detect powerline candidate points from the unclassified raw laser scanning data; line compass filtering to determine powerline orientation; outlier testing and segmentation to extract powerline primitives and finally VPLD for 3D powerline reconstruction. This method assumes that the transmission line is continuous within one span and the direction of the powerline is not changing abruptly within a span. Furthermore, partial detected powerlines occur in case that powerline passes through vegetation and powerline points are sparsely distributed at the lower height. In case of un-detected part, as powerline points with low point density can be grouped as other object, the powerline cannot be extracted in the VPLD process. Hence, the assumptions decrease the performance of the method, and the accuracy of the results obtained was limited due to its' under and over segmentations. To avoid under- and over-segmentations, later they improved the method with a multi-level span analysis (Sohn, Jwa and Kim, 2012). They proposed a

piecewise catenary curve model-growing algorithm to identify the points, which achieved clustering by iterative catenary curve fitting and cubic growing. Power cables in Jwa, Sohn and Kim, (2009) and Sohn, Jwa and Kim (2012) were recognised using polynomial functions to fit models to catenaries. The piecewise model growing (Sohn, Jwa and Kim, 2012) precisely modelled power-line spans with catenary curve models in 3D, once the pylon localization is accomplished. Yet, these methods assumed that the powerlines were parallel. In practical applications, cables are not always parallel.

A similar approach has been used in Cheng *et al.* (2014), where a voxel-based hierarchical method is developed for extracting power line points from PCDs. For the power line point's extraction, two hierarchical layers were used namely; single voxel filtering and neighbouring voxel filtering. This method only considered the point distance, and it ignored breakage points, which may have detrimental effects. Finally, a polynomial function is used to fit the power line points to obtain the 3D power lines. The Hough Transform and Euclidean Distance clustering were used to extract power-line points in the identified non-road points in Guan *et al.* (2014). However, previously mentioned algorithms cannot fit to a complex railway point data very well as there are a lot of lines in railway traffic circumstances, yet only part of them is power lines. Those methods cannot distinguish a power line from a vertical suspension wire and a horizontal suspension wire in the wire net and cannot find the joint region of the power line either.

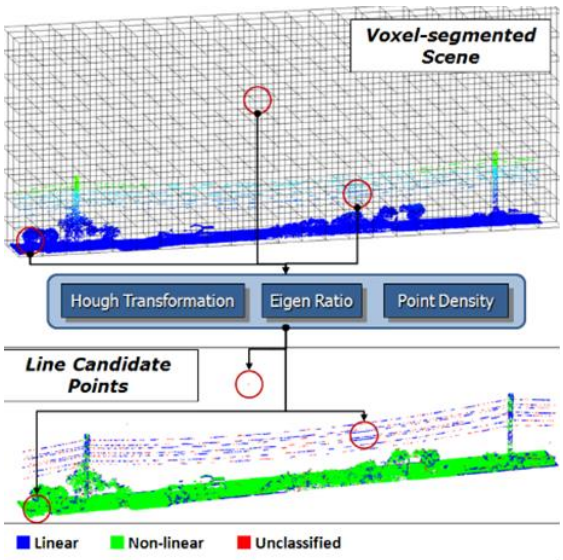

Figure 1: Voxel-based Piece-wise Line Detector (Jwa, Sohn and Kim, 2009)

RANdom Sample Consensus (RANSAC) line detection was used in Guo *et al.* (2016) to detect powerline points. Prior to the reconstruction of power lines, they classified points into five categories (power line, vegetation, building, ground and pylon). Due to the detection rate of power-line points and data gaps, there are still several defaults of the performance of their reconstruction method. Furthermore, they have circumvented the sag of power-line span; which changes with the time according to the ambient conditions such as the temperature and the ageing of span.

5.2 METHODS EMPLOYING A TOP-DOWN STRATEGY FOR RAIL ASSET TYPES

The top-down strategy begins with a broad-picture view, breaks it down for gaining an insight into a few major compositional sub-systems followed by individual solutions for each sub-system (Kokkinos and Yuille, 2006).

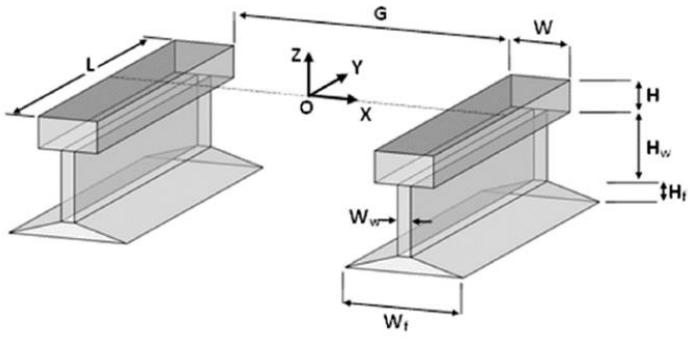

Figure 2: Parametric model of a pair of two rail pieces (Elberink and Khoshelham, 2015)

The method proposed in Elberink and Khoshelham (2015) used top down strategy to detect the rail track centrelines using piecewise model fitting. Firstly, they coarsely extract the rail tracks by using local properties of rails such as height and parallelism; using grid wise height histogram analyses. The fine extraction of the rail track was done using a 3D rail model, which was generated by fitting parametric pieces to point segments along the rail followed by interpolating a smooth and continuous rail model between the pieces. This method was computationally intense due to; (a) the least squares adjustment applied to every piece of rail track; (b) the employed mathematical model has too many unknown parameters; (c) the utilised least squares adjustment is a non-linear model, which needs to be linearised and run in many iterations in order to deliver acceptable results; and (d) the Fourier series is applied (after modelling) to enforce the smoothness in the rail tracks' shape, which imposes even more computational load. Addressing the limitations of this method, Arastounia and Elberink (2016) proposed a method which identified points belonging to rail tracks by fitting a Two-Dimensional (2D) grid to the track bed and investigating the height variation within each grid cell. This method significantly decreases the computational load. Local neighbourhood distribution of PCDs in 3D space (including the height information) was analysed for the initial classification of rail tracks. This is followed by a customised template matching algorithm for the elimination of rail track false positives by considering the topological relationship among rail tracks and cables. The template matching used a simple equation which obviously is computationally very much less intense than previous methods (Elberink and Khoshelham, 2015) presented.

6. Gaps in knowledge

The existing methods in bottom-up strategies are computationally less intensive than top-down strategies however, the latter is likely to produce better results when the dataset point sampling is poor. Furthermore, 'top-down' methods are very useful in recognising parameterised-shape objects that are composed of geometric primitives such as planes and cylinders. The dominant approach used by the researchers is bottom-up process, since the physical shape of the railroad elements are more complicated than those of geometric primitives. The current practice and the state of research summarises the following research gaps, which remain as challenges in digitally twinning the geometry of existing rail infrastructure.

The existing methods for rail track detection cannot be applied for sloped rail tracks, as well as short radius track curvatures. In practice, these remain as major limitations for digital twin generation, as tracks contain varying horizontal and vertical elevations as they are (a) not always flat-sloped and (b) along the track, short radius curvatures are a frequent occurrence. Current methods have provided promising results for overhead cable system, yet most of these methods lack precision and accuracy. For instance, their assumption that the contact and catenary cables are parallel and straight is debatable for railroad environments (Jwa, Sohn and Kim, 2009; Sohn, Jwa and Kim, 2012; Guo *et al.*, 2016). In addition, many methods have dependencies over scanning geometry and neighbourhood structures

(Arastounia, 2015). Furthermore, no attempt was made to automatically detect sleepers and droppers in both state of research and the state of practice to our best knowledge, despite the substantial cost incurred for manually modelling them.

7. Summary and discussions

The use of DTs for existing rail infrastructure is limited as the perceived benefits outweigh the cost of and the effort required for DT modelling. The average time required to manually create an infrastructure GDT from a PCD using cutting edge modelling software (e.g. Autodesk Revit 2016) is about 10 times more than the time required to obtain the PCD, as the current software packages are not fully automatic. This stresses the need for automating the PCDs-to-GDT process.

The knowledge gaps in the DT generation of rail infrastructure were identified by thoroughly reviewing in two parts the past studies on the state-of-the-art DT technologies. The approaches presently available cannot effectively tackle the detection of sloped rail tracks, as well as short radius track curvatures. In addition, none of them can address the challenges of complex geometry and topology of overhead cable system where the sag and the unparalleled structures are frequent. Moreover, the existing methods cannot automatically detect and reconstruct sleepers and droppers despite of the cost and time incurred to manually model those assets. The contributions made by this paper to knowledge highlight the knowledge gaps mentioned in Section 6. These gaps lead to potential research directions such as;

(a) Investigating a method to automatically detect rail infrastructure assets in PCDs – These assets include rails, sleepers, track bed, cables, masts and cantilevers. The approach will differ with the non-idealised shape of the particular asset type. In addition, this approach can combine the strengths of the data-driven strategy scenarios with very high point densities and model-based strategy in scenarios with very low point densities. For instance, on a railway track PCD the vast majority of points are concentrated on the elements sitting on the ground, with a lot fewer points on the overhanging cable structure. This leads us to safely hypothesize that the number of points per asset type on the wire-like assets is substantially less than the rest, and likely inadequate for traditional 'data-driven methods searching for local features. On the other hand, no such restriction applies to the rest of the assets.
(b) Investigating a method to automatically fit 3D solid models to the detected point clusters – To tackle the need of the common format, the output 3D model shall compatible with many software available, such as Industry Foundation Class (IFC) format.

(c) Leveraging a reasonable 3D model assessment metrics to assess the generated GDTs of rail infrastructure – This is necessary as the problem of evaluating the quality and degree of automation of a generated GDT compared to its PCD has yet to be studied in depth. This assessment must compatible with the end user requirements and the level of the detail expected from the resulting model.

8. Acknowledgements

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IMPACT OF NATURAL SPACES ON MENTAL HEALTH AND SATISFACTION IN WORK ENVIRONMENTS

Referenced to The Service Providers in Selected Health Care Institutions of Sri Lanka

BANDARA. D.U.[1] & HETTIARACHCHI A.A.[2]
[1,2]University of Moratuwa, Moratuwa, Sri Lanka
[1]duminduudara@gmail.com, [2]anishka_h@yahoo.com

Abstract
Productivity of a facility is defined by the efficiency of the workforce and outcome of the facility. The natural spaces and the Landscape establishment maintenance has not been prioritized in Health care institutions and the importance of those factors have not yet been identified. According to reports government constantly supports the development of health care services and technical facilities by providing a considerable amount annually. Even though the overcrowding and delays in the health care institutions cannot mitigate, functional way of increasing the facility productivity is improving the efficiency of the workforce. The hypothesis is that the healing environment based on natural element has effects on the workforce efficiency because of its impact on Mental Stability and Satisfaction.

This study intends to identify workforce response to work experience through the evaluation of mental comfort and satisfaction levels of the service providers in the healing sector. Both Open ended and multiple choices, questionnaires were used as the assessment method. Lanka Hospitals, Nawala is selected as the case study due to the well-designed landscape spaces in the premises. The literature suggests that the nursing staff spend most of the time in the movement due to their duties; therefore, nursing staff was selected for gather data. Findings suggest that there is no significant impact from the natural elements in the interior spaces. Furthermore, the natural outside view from the break room and the floor lobby areas have been selected as the most favoured feature of the workplace.

It is concluded that the outside view from the health care institutions has been impacted more with compared to the other natural elements like interior landscape elements. It is concluded that natural spaces and visual accessibility to the outside view is making a significant positive impact on the Mental health and Satisfaction in health care work environments.

Keywords: *Natural spaces, Work environment, Mental health, Service providers, Hospital environment*

1. Introduction

When developing health service coverage of the system the outcome depends on the availability, accessibility and capacity of the health workers to deliver quality service for the people centered care. Situating primary health care is the beginning of achieving Universal Health Coverage in the context. According to the World Health Organization (WHO) investing in the health care work force is the most cost-effective way to ensuring of health care will improve.

To achieve the sustainable development of the UHC by the 2030 the health workforce requirement is additional 18 million health workers but the gap between supply and demand of the health workers in the field is low. Because of that the newly adding workload added to the existing low health work force. (World Health Organization. 2019) WHO defined that for deliver the good quality service in this low workforce they must be well funded, managed and delivered. A fundamental shift in delivery is needed such that services are focus and integrated communities and people. This includes reorienting health services to ensure that care is provided in most ensure setting.

2. Research Need of Study

In a theory called Attention restoration theory in that theory it concludes that concentration of human mind enhances when interact with nature. Interacting with the nature improve the emotion restoration is efficient and because of that the attention restoration is became efficient. In a stress full environment, we can recognize that nature can be make a major part for restore the efficiency and minimize the mental and physical fatigue. (Kaplan. 1995)

The research question is stated as:
Does healing environments those are based on natural environment have effects on the workforce efficiency because of its impact on Mental Stability and Satisfaction.?

Government and the investors always identified the quality service outcome depend on the technical equipment and facilities of the institution, so the resources are used only on technical facilities. Because of that the Natural Environment & Landscape influence on Efficiency must be studied to identify the impact on that context. Aim of this study is to provide proved evidence to design and develop evidence base healing environment with natural environment to deliver quality services with maximum outcome.

2.1. LIMITATIONS OF THE STUDY
When doing this study there are few limitations that occurred in the process. First the number of hospitals that developed through using the natural environment is limited in Sri Lanka. Currently most of the hospitals are developed while only focusing on the facility development. So, for the case study there are only few hospitals have been taken as case study.

Then the participants demographic information like age, gender, shift details and responsible duties however the questioner was concluded focusing on the workforce satisfaction and comfort toward the workplace environment. Because of that the overall study may be not representing the whole health care system in Sri Lanka. For validate this study more data must be collected to confirm the study, but this may be helping to identify the connection between workforce of health sector and the natural environment around them.

3. Theoretical background and theoretical framework

Just as Medicine are developed with the time the hospital development also moved to the “Evidence Base Design”. A research project that completed by research team from Texas A&M University and Georgia Tech combined found that hospital design makes an impact on clinical outcome and staff outcome on the hospital. From the research the team have found out that better ventilation, better ergonomic design, supportive workplace and improved layout that can help to reduce errors, reduce stress and improve the outcome. (Ulrich, Quan, Zimring, Joseph, Choudhary. 2004).

Positive distractions are that group of factors that aid for reduce stress effectively. As examples music, pets, HUMOUR and specially nature can be taken. (Ulrich, Simons, Losito, Firito, Miles, Zelson. 1991). From a study done by showing COLOURS either everyday nature scenes or unlighted city views lacking nature such as greenery to the subjects. In this study findings suggested that natural scenery create an effective positive impact on recovery and reduction of stress. (Ulrich. 1981.)

In a working environment attention is a very critical factor to completing and solving the problems. Direct attention is a key ingredient in human effectiveness. In a stressful environment it creates a fatigue emotion which ultimately leads to the ineffectiveness and human error. (Kaplan, 1995). Fatigue is that extreme tiredness or exhaust of mental or physical body. When specially looking for the mental fatigue prolonged mental effort leads to mental fatigue. There are many progressive illnesses that related to build up with fatigue and 76 – 99% of the populations face for this problem. (Curt. 2000)

Direct attention, which is required effort, concentration keep focus and ignoring thoughts. This can be experienced when working without a break for a long time. This kind of attention leads to direct attention fatigue. There is significant impact on human thought and human mind when a subject face to direct attention fatigue for a longer time. Following areas are the mainly effected by direct attention fatigue. Capacity to problem salving & selection, Inhibition, Fragility, Perception, Thought, Action and Feelings are the main areas that significantly damage by the direct attention fatigue. (Cohen, 1980).

3.1. ATTENTION RESTORATION THEORY

Attention Restoration Theory (ART) was developed and studied by American environmental psychologist (Kaplan 1995; 2001). He named that there are two types of attentions. One is direct attention, which is required effort, concentration keep focus and ignoring thoughts. This can be experienced when working without a break for a long time. This kind of attention leads to direct attention fatigue. Second type of the attention is involuntary attention, in this method the tasks are done and focus on with fascination, curiosity and exploration. It is effortless and restore mental functioning of human mind. (Donbavand, Kirshbaum. 2013)

The effective restoration is the recovery from direct attention fatigue. Sleep is one approach to the recovery of fatigue. Kaplan and Kaplan formulated a theory that the exposing to nature can have restorative effect on the brain's ability to focus. Direct attention in long term create mental fatigue as previously mentioned and involuntary attention is effortless. Previous studies suggested that environment with fascination will create an environment with involuntary attention which is effort less and helps to focus easily. (Kaplan, 1995) In those studies they have identified three more additional components that environments make restorative. Those can be identified as,

i. Being away
ii. Fascination
iii. Extent
iv. Compatibility

3.2. STRESS REDUCTION THEORY

Ulrich suggested that landscape with natural elements such as view of water vegetation help to moderate and diminish state of negative thoughts within minutes. Capacity to recover from stressful event is enhanced by the exposure to the green spaces.

Variety of studies have demonstrated that managed green landscape is associated with reduced blood pressure, lower levels of stress hormone cortisol, a decrease in self-reported stress, and increased in positive mood. Using this factor, identifying how importance of the greenery in the workplace to the workforce. It can be used to get the data how the greenery effects on the workforce to reduce workplace stress

4. Methodology

This study consisting the workforce mental satisfaction of a well-designed greenery spaces containing hospital. For gather correct data it needs to be done under those circumstances. Data collection and analysing process used to collect correct and proper data using suitable methods. Data collection consist of two fields.

i. Literature study
ii. Case study

The questionnaire was developed based on the previously prepared research related to the patient comfort and satisfaction in the built hospital environment (Ulrich, 2008; Heerwagen, 2000; Lee et al., 2008; Paul, 2008; Veitech et al., 1998). Structure of the questionnaire was developed focusing on the health care workforce perception on the designed natural spaces within the work environment. Questions were designed using the main 4 component of the natural attention restoration theory and the stress reduction theory. Questionnaire structure has thirteen which focusing each component from component from the theoretical framework

Table 1, Structure of the Questionnaire (Source: Bandara D U)

Selection	Item	Method
Characteristics	Number of Working Days of Month Shift Duration	Categorical
Built Natural Environment and Comfort	Space planning Walking experience of the space	Uncomfortable (1) Less uncomfortable (2) Neutral (3) Less Comfortable (4) Comfortable (5)
	Extend of natural environment in the hospital	
	Natural fresh air and ventilation Indore landscaping	
	Pleasant Spaces characters	
	Safety and wellbeing	
	Exterior view	
	Interior fascination	
Workforce Satisfaction	Design factors were questioned for get the idea about satisfaction levels.	Uncomfortable (1) Less uncomfortable (2) Neutral (3) Less Comfortable (4) Comfortable (5)
		Que card method

5. Method of Case Study Selection

Most ideal case study location was needed to select for get the better data. In this study it focusses on the how workforce is affected by the designed natural environment in the workplace. For this the case study location needed to be well designed with proper natural environment. Second selection criteria are that the selecting of the ideal workforce from the health care institution for achieve best data for the study. Nursing staff uses as the workforce that studied in the hospital because of they spend their 29% of working time on movement. So, they have much more interaction with the hospital environment more than any other service providers in the health care institution.

6. Lanka Hospitals, Nawala As The Study Context

Lanka Hospitals, Nawala former branch of Apollo Hospitals. In 2009, it was renamed Lanka Hospitals after it ended a licensing and support services agreement with Apollo Hospitals. This hospital developed and maintain the landscape when considering the other health care institution in Sri Lankan Health care sector.

Comparing to other healthcare institutions Lanka Hospital has developed and maintained the surrounding landscape with care.

Figure 1, Satellite Image of Lanka Hospitals (*Source: https://yandex.com/maps/ Edited by Bandara D U)*

6.1. CASE STUDY - WORKPLACE NATURAL ENVIRONMENT SATISFACTION

To the question of are there enough natural environment in the workplace? The common respond is that 33.3% of them were somewhat disagree as somewhat disagree. This respond can be identified as the most of the major landscape developments are done for the outside of the hospital. Nursing staff is interacting with the limited time of the day. When they were in the shift theses natural elements are not noticeable due to the responsibilities of the duty. (*Refer – Figure 2*)

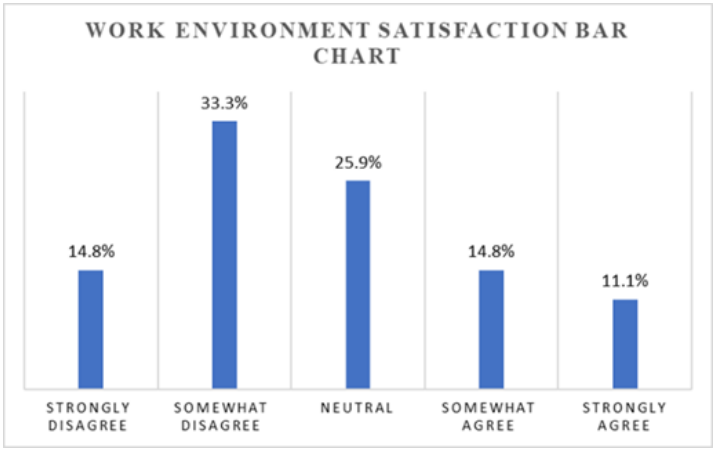

Figure 2, Work Environment Satisfaction Bar chart (*Source: Bandara D U)*

6.1.1 Interaction Feeling with the Natural Spaces

37.03% of the responded nursing staff got refresh feeling of the natural spaces when moving through the court yards. They commented outside the questioner that they are so busy in the shift and most of the time they were not noticing the surrounding environment. When the natural environment factors such as rain wind where going through the area they notice it specially. Those kinds of factors have more influence on their refreshing feelings. Even though 3.7% strongly disagree with the idea that they have refreshing feeling when moving through them provided environment. In attention restoration theory Fascination component is influence by the soft natural element such as elements. When the natural spaces providing the raining like views direct accessibility to the workforce that environment is providing the capability of effortless attention to the workforce. (Refer – Figure 3)

In this case study break room outside view is relevant because extend of the environment is represented by the outside view. In an urban area like Nawala land extent can't achieved due to land occupation. In this situation using outside view is the practical way of use the Extend of the land. In this healing environment there were break rooms were supplied averagely two rooms for a one floor. Some of these

rooms have the outside view accessibility and some break rooms are not have the outside view accessibility. In this service providing staff 59% were responded that they have outside view from the break rooms and 41% of the staff using the break room without the outside view. (Refer – Figure 4)

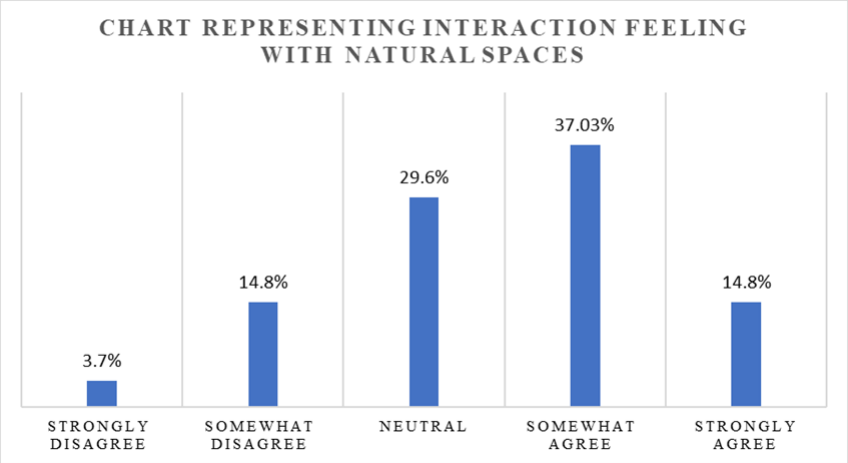

Figure 3, Chart representing Interaction feeling with natural spaces (*Source: Bandara D U)*

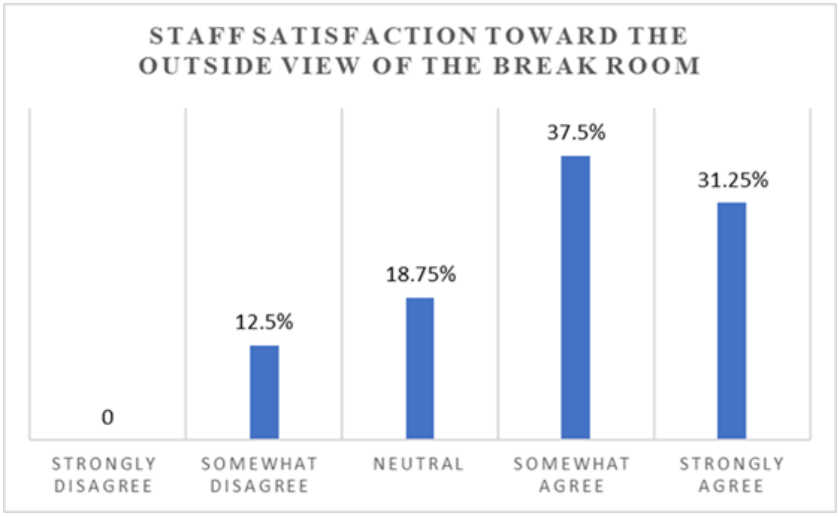

Figure 4, Staff satisfaction toward the outside view of the break room (*Source: Bandara D U)*

One of the Attention restoration theory component is the extent of the space. In the theory Afterall when they were questioned about how the natural environment have effects on the work force. Extended environment feeling can achieve from the physical extending of the land and the design elements can also manipulate the extend. In a healing environment it was designed with limited accessibility due to maintain the quality of the air and the content the area from the outside. Hence staff is working in a enclosed environment with limited accessibility to the outside, this environment create a work environment with less curiosity, exploration and fascination. Lack of these factors ultimately resulting the direct attention fatigue. Providing of outside view create the extended feeling of the environment and theses accessibility providing the fascination and exploration to the work environment which create environment which have the capability with attention restoration

6.1.2. Natural environment influence on relax busy mind

As a final respond to the natural environment staff respond is that they have an influence on the busy environment from the natural environment. According to the stress reduction theory natural elements have influence to mitigate stressful event within minutes and this respond prove that 81.4% of them think that they have influence from the natural environment. 48.1% of the staff responded that is somewhat agree on the idea that natural view is important in the healing environment. In the given

comments according to them the natural environment is helping to the patient's recovery. Response to that they have the idea that healing environment must be developed with the natural environment. (*Refer – Figure 5*)

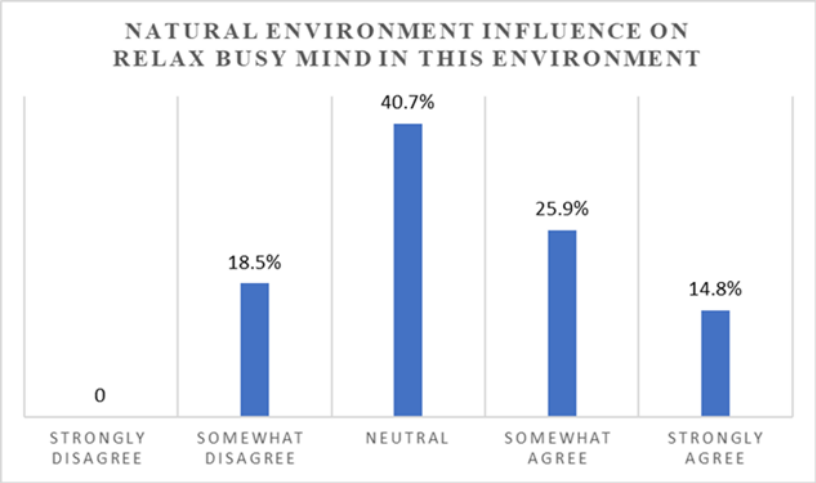

Figure 5, Natural environment influence on relax busy mind in this environment (*Source: Bandara D U)*

Staff do not have a direct idea that how the provided natural environment have built a stress reduction environment. But that environment is appreciated by them as previous experience of other healing institutions. (*Refer – Figure 6*)

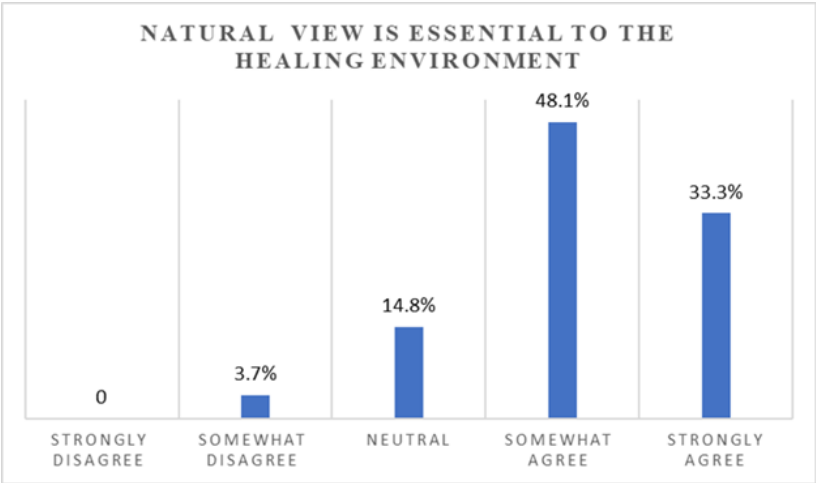

Figure 6, Natural view is essential to the healing environment
(*Source: Bandara D U)*

8. Conclusion

Health care sector work responsibilities are deferent from other work responsibilities. In this sector human life is handled and life and death were the limitation in the field. Theses major responsibilities make the service providers in health care institution not noticing the designed spaces directly. Most of them can not identified a direct influence on their mind from the provided natural spaces. Even though as a work environment service provider are FAVOURED for this institution due to the organized and developed environment. Those responds were given considering the previous experience from the other health care institutions. This respond can identify as that they have subconsciously recognized the current working environment have the mental satisfaction more than other institutions. So, developing natural spaces and environment in a healing environment is important in the healing environment for the workforce.

8.1 RECOMMENDATIONS

Identification of the study was that service providers are much likely to notice the outside view of the hospital, which giving a vast extending view from the work environment. This view is mentioned in many responses in the data collection. As found in some literature studies, the extending view from a work environment providing relief to the work force. Close environment creates a cluster phobic feeling to the long-term working shift which ultimately create stressful work environment.

As conclusion developing work environment spaces with the extending outside view is ideal for a stressful work environment. This view does not need to be High-rise or large land area, designing of the surrounding natural space of the work environment with the extended feeling by the design elements is possible. This study is applicable to create a work environment with providing mental satisfaction and comfort to the service providers' which is lead to effortless attention restoration in a work environment with higher efficacy containing work force.

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THE IMPACT OF LEARNING SPACES ON CREATIVITY: A USER PERSPECTIVE ANALYSIS WITH REFERENCE TO STUDIO SPACE DESIGN

PRAMOD S.[1], PATHIRAJA M.[2]
[1]University of Moratuwa, Moratuwa, Sri Lanka
[2]University of Moratuwa, Moratuwa, Sri Lanka, Swiss Federal Institute of Technology, Lausanne, Switzerland
[1]142133M@uom.lk, [2]m_pathiraja@yahoo.com.au

Abstract
The learning process and learning environments have an unbreakable, embodied relationship. In almost all instances, learning environments have a negative or positive influence on the learning process of students. In the first part of this paper, the concept of creativity has been defined using a variety of theories and interpretations, and a comprehensive framework for assessing creativity has been established. The second part analyses literature on creative learning spaces and develops a theory to be used as a guideline in evaluating the quality of such spaces. A detailed description of the methodology in which the research is carried out and how the two frameworks derived in the previous parts connects to this methodology is illustrated by the third part. The study concludes with a user perspective analysis where the perception of the students on studio spaces is used to investigate the relationship between spatial characteristics of space types in studios and intrinsic characteristics of creativity. The results indicate that there is a clear relationship between studio spaces and the intrinsic characteristics of creativity. Therefore, design studios should be specifically designed with careful consideration of prioritized spatial characteristics relating to each space type.

Keywords: *Creativity; Architectural design studios; Socio-psychology of creativity; Space types & characteristics; Intrinsic aspects of creativity*

1. Introduction

In architectural education, creativity plays a major role. There are numerous definitions for the term creativity, out of which one influential definition is: "Creativity as an outcome should be novel (in terms of being original, unique, and surprising), meaningful, and useful at the same time" (Amabile, 1996). Even though there are numerous definitions to creativity, giving a precise definition to its nature is still a difficult task. This is because, creativity by nature is a subjective condition which is sensorial and forms within the mind of a person. Given that architecture is predominantly a creative process, there is inevitably a strong relationship between the function of architecture and the notion of creativity, although the very nature of that relationship is still difficult to fathom. With respect to architectural education, however, facilitating creative thinking is crucial to the production of future design intellectuals.

This study focused on the dual dependencies identified with respect to the juxta-positioning of architecture and creativity within a learning environment. Even though the main objective of this research was to find out the impact of the design-production spaces on the function creativity, a direct investigation was not possible due to the intangible nature of creativity. The assessment of student creativity can generally be done by using evaluation methods such as creativity tests, portfolio marks, exam marks etc. (both qualitative and quantitative measures). This study does not follow such evaluation methods, simply because of their unreliability and irrelevance to the end objectives. Instead, the study developed an indirect and qualitative analysis method to endorse and verify its findings.

The study thus aimed at defining a methodological framework to evaluate the relationship between the 'function creativity' and a physical space supporting that act of creativity. Secondly, from a specific technical standpoint, the research sought to investigate the relationship between learning environments and the creativity aspect of an architectural design process. The research methodology for achieving these objectives were primarily consisted of qualitative data collection and analysis methods. This particular methodology was identified and formulated to investigate the dependency relationship between spatial characteristics (of learning environments) and the creative process. The research identifies spatial characteristics as the 'extrinsic aspects of creativity' and the subsequent creativity process as the 'intrinsic aspects of creativity'.

There are several extrinsic factors which can create a strong impact on the creativity levels of people. Out of those 'several' factors, this research will only focus on the spatial characteristics of design studio spaces. Furthermore, creativity of the people wise, the research only focuses on the impact of psychological process of creativity, particularly concentrating on how students perceive space with respect to creativity potential. At no point the research evaluates students' direct creative outcomes. In other words, this research has neither focused on any creativity tests to assess the students' creativity outcomes, nor has it evaluated learning outcomes of students in order to measure the subsequent impact of spatial characteristics on creativity. By relying on a user-perspective study alone, the research has limited its assessment to a psychological evaluation on the creativity process. This however is a choice made at the initial definition of the study, where it was deemed as adequate to rely on a user-perspective study to achieve the expected research outcomes.

2. Creativity

2.1 DEFINITIONS OF CREATIVITY

In human psychology, creativity plays a major and significant role. Yet, regardless of its strong association to human psychology, precisely defining and interpreting the term "creativity" is still a huge task for researchers who are involved with studies related to creativity. Such ambiguity in meaning and characterization has led the researchers to build various new definitions and interpretations for creativity in different fields.

Amabile (1996) stated,

> Creativity researchers are often accused of not knowing what they are talking about. The definition and assessment of creativity have long been a subject of disagreement and dissatisfaction among psychologists, creating a criterion problem that researchers have tried to solve in a variety of ways. (p.19)

At the heart of this study's research objectives however is to explore how the social and environmental behavior of and around humans influence on the act of creativity, and how such observation is critical in developing a theoretical base to evaluate the impact of learning environments in the process of creative thinking.

2.2 CREATIVITY_IN_ARCHITECTURAL_EDUCATION_AND_THE_PROCESS_OF_ARCHITECTURAL DESIGN

In architectural education, creativity holds a very powerful position because architecture involves with conceptualizing new ideas. According to Danaci (2015), creativity and design course can be considered as the backbone of architectural education. Further she states that architectural education should facilitate the cognitive thinking which can productively use in the creative process. (Danaci, 2015). According to Nervi & Ricken (1990), "creativity" is an indispensable factor when considered architecture as a work of art. Agreeing with Nervi & Ricken, Willem (1990) stated that the function of designing in architectural education is fundamentally a creative problem-solving process. For, Torrance (1990), on the other hand, creativity can be lifted up to an advanced position through the training in architectural education. All these statements elevate creativity as an essential feature of an architectural educational process.

Understanding the architectural design process is therefore essential when investigating the connection between creativity aspects and the design outcomes of each creative individuals. Mozaffar and Khakzand (as cited in Darmei & Safari, 2017) explained that the design process contains two main characteristics: the first is the essential creative effort, and the second is the close association with drawings. According to Christopher Alexander, on the other hand, there are two main phases of design process, which can be named as analysis and synthesis. Alternatively, RIBA (1973) proposed a three stage design process, namely analysis, synthesis and evaluation.

After understanding that creativity is central to an architectural design process, the definition of a study-specific position for intrinsic aspects of creativity was seen as necessary to move ahead with the research.

To this end, four main creativity related theories leading to the derivation of 'Developed Theory - 01' was studied. Those being:

- Theory 1- Four steps of creativity solving process
- Theory 2- Creativity relevant skills
- Theory 3-Concept of divergent and convergent thinking
- Theory 4-Concept of flexibility and fluency

As such, the 'Developed Theory - 01' was established by evaluating the aforementioned four theories, in order to delineate "**intrinsic aspects of creativity"**, which are the essential inner psychological attributes representing one's creativity function. The process in which the 'Developed Theory – 01' was formulated while considering the commonalties of the above 04 theories is illustrated below.

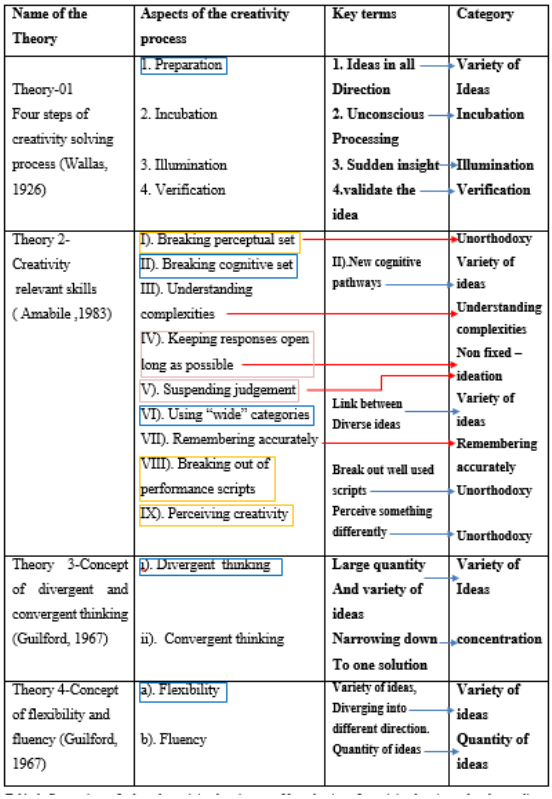


Figure 1, Analyzing similarity between selected four (04) theories (Source: Author)

Accordingly, the 'Developed Theory -01' consists of eight intrinsic aspects of creativity, which can be identified as follows:

1. Novel initiation
2. Incubation
3. Illumination
4. Verification
5. Non -fixed ideation
6. Accurate memory
7. Understanding complexities
8. Concentration

3. Learning Spaces

3.1 DEFINITIONSOFLEARNINGSPACESANDTHEIR CONNECTIONTOARCHITETURALEDUCATION

Giving a precise answer to the particular question of "what is a learning space" is quite a difficult task. Because, the answer can spread across a large area of spatial and cultural commodities. As an example, a learning space can be a classroom, an auditorium, a studio, or a conference room; but it can even be a few benches under a tree. In that case, learning spaces can generally be divided into two categories:

formal learning spaces and informal learning spaces. According to Oblinger (2006), a physical and virtual space, which creates an impact on learning process, can be defined as a learning space. Further, she describes that the learning space is a place that generates human interaction while simultaneously satisfying the explorations and collaborations of a learning outcome (Oblinger 2006). This definition has attempted to break the conventional conception of a learning space, which often focuses on the physical aspects of it.

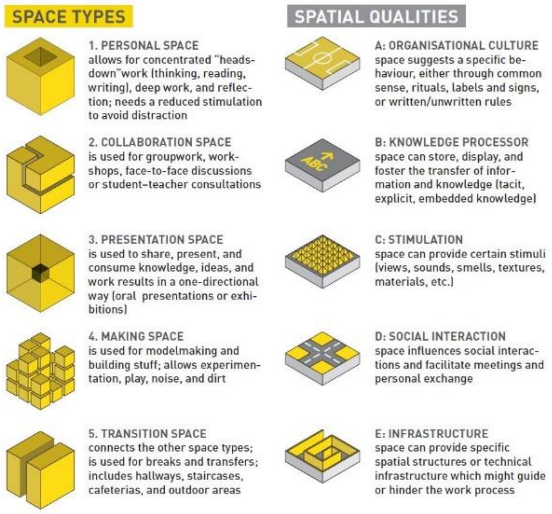
Learning spaces in Architectural education has clear distinction when compared to other subject fields. The main reason for that is the unique nature of architectural learning process. Mainly, the architectural learning process contains of design teaching on the one hand, and studying theory subjects on the other hand. In such case, the learning spaces will have to be different when they cater to one function as opposed to the other. Generally, design studio spaces are used for design teaching and the subsequent exploration of architectural design, and classrooms are used as the learning spaces of relevant subjects.

According to conducted research, there are sixteen (16) spatial characteristics of a learning space, which can create an impact on the student's creativity (Thoring et al., 2017). These sixteen (16) spatial characteristics are:

1. Atmosphere
2. Climate
3. Colours
4. Flexibility
5. Furniture
6. Health issues
7. Light
8. Location
9. Materials
10. Objects
11. Plants and flowers
12. Room Layout
13. Smells
14. Sound
15. Technology
16. View

3.2 LEARNING_SPACES_SUPPORTING_CREATIVITY

Many researches have proposed that learning spaces should support the student's creativity and the traditional classrooms should change accordingly. Thoring et al. (2017) introduced a theory called 'typology of creative learning spaces' to describe the connection between learning spaces and creativity. This consists of five 'space types' and five 'spatial qualities'. The second theory selected to emphasize the study-specific position on creativity-supporting learning spaces consists of twelve propositions about the impacts of space on the function of creativity. (Thoring et al. 2017)

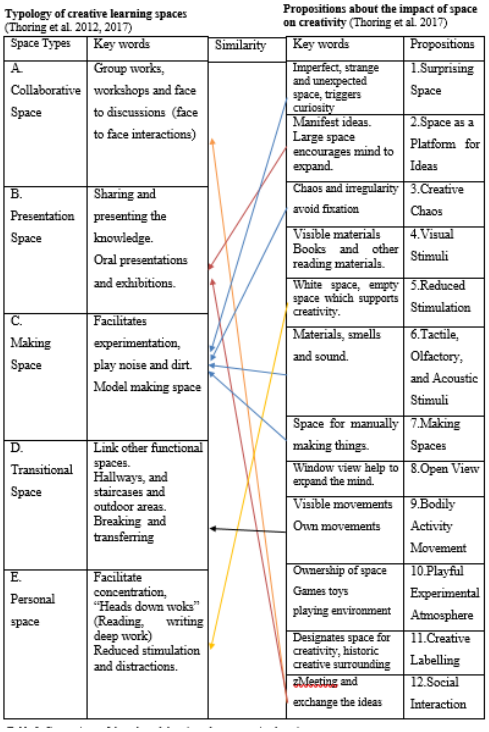


P#	Proposition	Explanation	Creativity Theory
P1	*Surprising Space*	strange, unexpected, imperfect space triggers curiosity and hence creativity, forces people to interpret and generate their own ideas	Illumination Flexibility Serendipity
P2	*Space as a Platform for Ideas*	space to manifest ideas; large space lets the mind expand and allows building and testing more and larger sized models	Fluency Verification
P3	*Creative Chaos*	triggers creativity as it prompts associations; if space is filled with old projects might lead to fixation	Flexibility Serendipity Fixation
P4	*Visual Stimuli*	visible materials, books, and other information can inspire new ideas and increase creativity	Preparation Flexibility Fluency Fixation
P5	*Reduced Stimulation*	white space, empty space fosters creativity, invites people to project their own ideas into it	Incubation Illumination Avoid fixation
P6	*Tactile, Olfactory, and Acoustic Stimuli*	materials, smells, cooking, and sound inspire creativity	Incubation
P7	*Making Spaces*	Space that allows to make things manually fosters creativity	Verification
P8	*Open View*	Window view, inspires creativity, lets the mind expand	Incubation
P9	*Bodily Activity Movement*	visible movement or own movement (e.g. walking, sports) facilitates creativity	Incubation
P10	*Playful Experimental Atmosphere*	Games, toys invite to experiment, risk-taking, and allow failure; Ownership of space	Incubation Flexibility Verification
P11	*Creative Labelling*	designating a space for creative work, or historic creative surroundings can set a mood or mindset receptive for creativity	Preparation Priming
P12	*Social Interaction*	creative people are more important than space, so space should facilitate meeting and exchange	Flexibility Incubation Serendipity

Figure 2, Space types (Source: Thoring et al)

Through the incorporation of related theories, an attempt was made to establish a relationship between creative learning spaces and intrinsic aspects of creativity. Subsequently, the 'Developed Theory – 02' was established to investigate **"the relationship between creative learning spaces (space types) and the intrinsic aspects of creativity** (identified by Developed Theory – 01 earlier)**."**

The process in which the 'Developed Theory – 02' was formulated after finding the similarities of Thoring et el's two (2) theories and their collaboration with the 'Developed Theory – 01' is given below.



Typology of creative learning spaces (Thoring et al. 2012, 2017)

Space Types	Key words
A. Collaborative Space	Group works, workshops and face to discussions (face to face interactions)
B. Presentation Space	Sharing and presenting the knowledge. Oral presentations and exhibitions.
C. Making Space	Facilitates experimentation, play noise and dirt. Model making space
D. Transitional Space	Link other functional spaces. Hallways, and staircases and outdoor areas. Breaking and transferring
E. Personal space	Facilitate concentration, "Heads down woks" (Reading, writing deep work) Reduced stimulation and distractions.

Similarity

Propositions about the impact of space on creativity (Thoring et al. 2017)

Key words	Propositions
Imperfect, strange and unexpected space, triggers curiosity	1.Surprising Space
Manifest ideas. Large space encourages mind to expand.	2.Space as a Platform for Ideas
Chaos and irregularity avoid fixation	3.Creative Chaos
Visible materials Books and other reading materials.	4.Visual Stimuli
White space, empty space which supports creativity.	5.Reduced Stimulation
Materials, smells and sound.	6.Tactile, Olfactory, and Acoustic Stimuli
Space for manually making things.	7.Making Spaces
Window view help to expand the mind.	8.Open View
Visible movements Own movements	9.Bodily Activity Movement
Ownership of space Games toys playing environment	10.Playful Experimental Atmosphere
Designates space for creativity, historic creative surrounding	11.Creative Labelling
zMeeting and exchange the ideas	12.Social Interaction

Figure 3, Analyzing the similarities between two (2) selected theories of Thoring et al (Source: Author)

Intrinsic aspects of creativity	contributing creative space types
1. Novel initiation	A/B/C/D/E
2. Incubation	A/B/C/D/E
3. Illumination	A/D/E
4. Verification	B/C
5. Non -fixed ideation	A/B/C
6. Accurate memory	E
7. Understanding complexities	A/E
8. Concentration	E

In here:

A= Collaborative Space
B= Presentation Space
C= Making space
D= Transition Space
E= Personal space

4. Methodology

4.1 COLLECTION_OF_DATA

This research weaves around two (02) main data collection rounds. In the Preliminary data collection round (general observations and open-ended questionnaire) a number of fifty (50) architecture students from the level 5, B.Arch. degree program at University of Moratuwa formed the population sample undertaken for the user perspective analysis. The main objective of this data collection round was to collect more original, genuine and non-specific comments on the character of the design studio spaces. That step helped understanding and defining the methodological directions the research followed in its eventual unfolding.

In the secondary data collection round, a close-ended questionnaire was given to a 25 number of focus group, which has been selected by evaluating the findings of the preliminary data set. The objective of

this data collection round was to find out more specific details about the spatial characteristics of design studio spaces and their impact on the function of creativity.

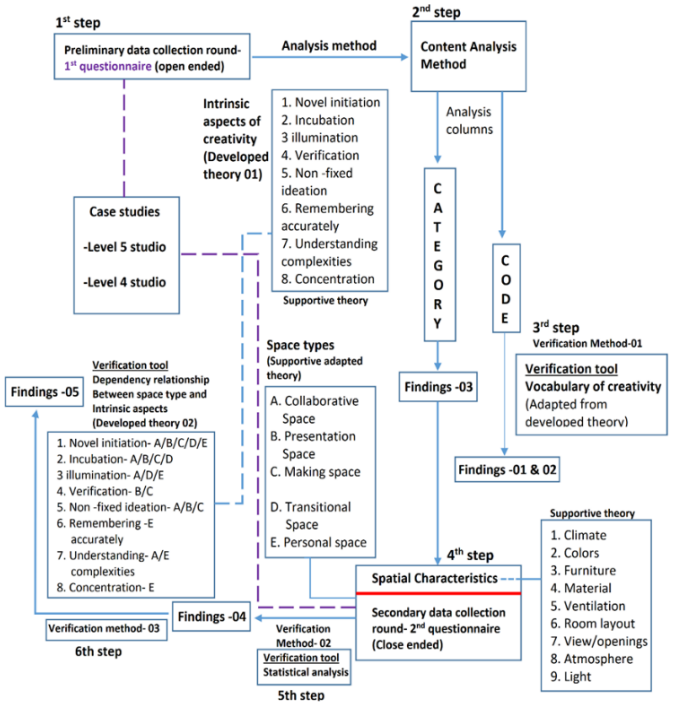


Figure 4, Detailed research program (Source: Author)

4.2 VERIFICATION_AND_ANALYSIS_OF_DATA

In the verification of the research findings, the study followed the 'content analysis method'. In the first step of this analysis, preliminary data collected from 50 undergraduate architecture students were evaluated using the afore-mentioned 'content analysis' method. This contained two main steps as follows:

1. Deriving codes
2. Categorizing the codes

The subsequent analysis of the research has followed three main verification methods and tools.

1. Verification method 1- use the "vocabulary of creativity" (adapted from Developed Theory-01) as the verification tool
2. Verification method 2 - use the statistical analysis methods as the verification tool
3. Verification method 3 - use the 'Developed Theory - 02' – i.e., Dependency relationship between space type and intrinsic aspects - as the verification tool.

The following diagram illustrates the usage of adapted and developed_theories in data collection rounds and_verification process, and the subsequent research program of the overall study.

5. Case_Study_Analysis

The case study investigation pursued for this research was predominantly a user perspective analysis, where the preliminary and secondary data collected from the two selected case studies were analyzed to obtain research findings. The two selected case studies were Level 5 architecture design studio and Level 4 architecture design studio located at the University of Moratuwa. As mentioned earlier, the preliminary data (user perspective data) derived from each case study was evaluated under the content analysis method. Following this - as the second step of the analysis - the results of content analysis were verified under the Developed Theories 01 & 02. The third step of the case study analysis was to evaluate

the statistical content of the secondary data. Afterwards, the results of the statistical analysis were verified under the Developed Theory -02 to establish the final conclusions of the research.

5.1 CASE STUDY 1: LEVEL 05 ARCHITECTURE STUDIO

Level 5 architecture design studio is located in the ground floor of the "Sumanadasa" building at University of Moratuwa. It usually accommodates over 50 architecture students. The user perspective analysis of this design studio consisted of two methods of analysis.

1. Content analysis of preliminary data
2. Statistical and theoretical analysis of secondary data

50 samples were selected for the content analysis, which resulted in the identification of 26 codes. The identified codes from the above analysis were then divided into the code types. As the third step of the content analysis, the identified codes were classified into categories. According to that, ten (10) categories were founded as outlined below.

1. Functionality of the space
2. Physical impact of the space
3. Psychological impact of the space
4. Color
5. Views
6. Outcomes
7. Climate
8. Atmosphere
9. Furniture and layout
10. Concentration

Selected codes from the 10 categories were then used to evaluate and verify the connection between the learning space (as a whole) and intrinsic aspects of creativity.

For the statistical and theoretical analysis, the data from the questionnaires were used to find out the specific relationship between intrinsic aspects of creativity and spatial characteristics of the design studios. The first part of this secondary data analysis was conducted through a statistical analysis. The second part includes a theoretical analysis which has been carried out by referring to the 'Developed Theory – 02'.

5.2 CASE STUDY 2: LEVEL 04 ARCHITECTURE STUDIO

Level 4 architecture design studio is located in the fourth floor of the "Sumanadasa" building at University of Moratuwa. It also generally accommodates over 5 architecture students. As with the level 05 studio, the user perspective analysis of the level 04 studio followed two analytical methods:

1. Content analysis of preliminary data
2. Statistical and theoretical analysis of secondary data

50 samples were selected for the content analysis, which yielded in the detection of 24 codes. The identified codes from the analysis were then divided into the code types. As the third step of the content analysis, the identified codes were classified into categories, which were the same as the analysis on the level 05 studio. As with the level 05 studio, the steps were repeated for the statistical and theoretical analysis using the data obtained from questionnaires.

5.3 SUMMARY OF THE STATISTICAL AND THEORITICAL ANALYSIS OF THE TWO CASE STUDIES

The ideal conditions of spatial characteristics for space types were founded to be different from one space type to another. When considering the two case studies, similar ideal situations were found in some spatial characteristics, while others were different in terms of their impact on the function of creativity.

When considering the both case studies, the most important and prioritized spatial characteristics that contribute to the formulation of each specific space type were identified separately.

6. Conclusions

The findings of this particular research have addressed different resolution levels. The findings of content analysis, which were particularly related to the user perspective analysis of level 4 and level 5 studios, have established resolution levels of low and medium conclusions. According to those particular results, it was found that the overall studio spaces have created a clear and direct impact on the several intrinsic aspects of creativity. The confirmation of the hypothesis that the function of creativity is indeed impacted by the character of learning spaces (studios) can be considered as a low-resolution conclusion, while the identification of directly impacted aspects within the creativity component - such as non- fixed ideation, concentration, incubation, novel initiation, illuminance and accurate memory, etc. - can be identified as a medium-resolution conclusion. Furthermore, the user perspective analysis has clearly shown evidence supporting the fact that the overall creativity is directly and indirectly affected by the conditions of the studio spaces. The established 26 code types and 10 categories, while directing to a broader understanding of the creativity component, have proven the aforementioned connection between creativity and space.

After establishing low- and medium-ranked conclusions, the secondary data analysis was used to generate high-resolution conclusions, which were instrumental in proving that the specific space types catering to the intrinsic aspects of creativity should be meticulously designed by incorporating the relevant spatial characteristics. Furthermore, the developed theoretical frameworks introduced in this research are expected to be used in the advancement of the fields of architecture and psychology. Indeed, such research should be introduced as tools for designing student-friendly studio spaces, which would foster the creativity of students and make their learning experience stress free, effortless and productive.

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THE ETHEREAL PARTITION
DEMOCRATIC STREETSCAPE POTENTIALS OF JASHORE ROAD TOWARDS EQUITABLE BENAPOLE

J.F. SONIA[1], S.M.M. ABEDIN[2] & S.N. ANJUM[3]
[1] Nippon KOEI BD Limited, Dhaka, Bangladesh
[2]Khulna University, Dhaka, Bangladesh
[3]Khulna University, Faridpur, Bangladesh
[1]jannatulferdous110106@gmail.com, [2]mailtominhaz@gmail.com, [3]anjumnabil.1@gmail.com

Abstract
Benapole, the most vibrant land-port city of Bangladesh is divided by a bold line at its geographical level, the historical 'Jashore Road' running almost in-between the city bifurcating the community of Benapole. The northern part of Benapole is pulsating with mixed use development, vendors and people's engagement but the southern part is comparatively less vibrant because of traffic congestion and the adjacent lands being 'Port' and other ancillary government facilities with over heighted solid boundary wall. Meanwhile, the railway running parallel with the 'Jashore road', itself is creating a barrier within the city causing social segregation between the communities. This segregation and street adjacent activity pattern lead to social inequities in terms of community engagement and area development. But developing the Jashore road as a democratic street space instead of just a highway can reduce these social inequalities by providing street that has meaning for people and space for vehicular circulation. This paper aims to identify the social form of inequities burgeoned in Benapole due to Jashore road and explore this street's potentiality as a democratic street in integrating the communities of both parts. The data used in this investigation are collected from questioner survey, observation, FGD and KPI. Photograph and spatial mapping analysis indicate the lack of social equity among communities and the impact of Jashore road in various scale on adjacent space and the user group. The outcome of this paper will describe the role of a street in cultivating social equity and advocate community engagement of cities.

Keywords: *Democratic Streetscape, Jashore road, inequity*

1. Introduction

A Street is a public thoroughfare in a built environment adjoining buildings in an urban context which belongs to everyone in the city. People rely on the street for most of the daily activities and eventually the street accommodates the city life. According to Mark Francis (2016), much social life and learning occurs along streets. Streets are the main public spaces of a city which serves all the city dwellers in traveling, shopping, social interactions, gatherings and trading etc.

But in the context of Beanpole which is the largest port city of Bangladesh, the main street (Jashore Road) of the city itself is raising some social-spatial issues. Jashore road almost divides the city into two parts and doing so emerges issues of inequity in both social and spatial terms. This paper identified the reasons behind this inequity in Benapole. Insensitive infrastructural development with predominant economic focus along Jashore road has bifurcated the communities, while unequal distributions of infrastructural facilities and urban amenities have historically promoted inequity between communities. Also, the concept of 'zoning' of urban facilities has also contributed to inequity through a sense of spatial injustice within Benapole city.

This paper aims to identify the socio-spatial incompatibilities prevailing in Beanpole interpreted in terms of specific spatial problems related to Jashore road and also explores the idea of a 'Democratic street' as solution to those problems. This paper contributes to knowledge as mentioning streets role in cultivating community engagement and abolishing inequity amongst the dwellers in such a small city like Beanpole in Bangladesh as well as to other similar transitioning cities of the world.

2. Methodology

This study is based on the contextual problem documentation of Beanpole city using fundamentally a qualitative approach. As secondary data the Development Plan for Jashore Benapole Highway Corridor Final Report, and Final Report on Transport for the aforesaid Corridor Project by Urban Development Directorate (UDD) of Benapole were reviewed. These sources helped understanding the larger planning

context for Benapole city and from primary data collected via physical survey, KPI including the mayor of Benapole Pourasava, the administrative head of Benapole port, FGDs with local people and observation. Photograph analysis, activity mapping analysis and manual content analysis from questioner survey helped to construct a summary of problems. And this summary indicates the spatial and physical environment of Beanpole agonises from the problem of socio-spatial equity because of Jashore road and any development intervention to recompense this, would require the former review of theoretical materials.

The study involved the review of global theories, planning and design approaches related to the concept of equitable and democratic street space, and followed by a review of case studies relevant for Bangladesh. Through the synthesis of problems and theoretical materials, a theoretical stand point has been constructed for Jessore road, while specific ingredients of street democracy are discussed in respect of equitable beanpole.

The following sections of this paper will describe the social and spatial issues of Beanpole occurring due to Jashore road. Hence will discuss the democratic street concept and review the theoretical perspective. The next section will provide a schematic idea of socially and spatially equitable Beanpole in respect of having Jashore road as a democratic street space. And to conclude, the paper will discuss the inevitability of recognising streets potentialities and their impacts on dwellers in small city development like Beanpole.

3. Socio-spatial Inequity in Benapole

Benapole, the largest land port of Bangladesh is a type 'A' municipality which includes 09 administrative wards with total area of 8.6 sq.km. The historical Jashore Road (Jashore-Benapole Highway) cuts through Benapole in almost a symmetrical manner, with a railway running parallel to this arterial highway. This vibrant land port has a significant impact on the country's economy.

Presently, Jashore Road (Jashore-Benapole highway), the railway (Khulna-Jashore-Benapole-Kolkata) and the highway-adjacent land-use like port and government services and facilities have become the strategic contributors to its major social problems of segregation and inequality as they cut across them spatially and segregate the city.

With the growth of economic development, the pressure of migrant population in cities increasing day by day and Benapole is not different. In Khulna division overall 18% of people migrated from rural to urban areas between 1991-2010 (Marshall, Rahman 2013). Moreover, being a port city Beanpole is always crowded by various mobile people throughout the year. With this increased flow of people also increase economic activities, transports, traffic congestion, land development. With this hasty growth, city's social cohesion, social balance and control are also critically affected, as a group of people migrates from rural to urban area and they become outsiders for the host community. New infrastructural development for growing population is creating spatial segregation, hence raising the question of social inequity responsible for social injustice. As Benapole is now the most important land port of Bangladesh that handles more than 90% of total cross-border trade between India and Bangladesh, it draws both national and international interests. Therefore, balancing the cohesion and integration between communities in terms of social and spatial equity are essential.

3.1. THE "JASHORE ROAD"

The Jashore Road earned its name for being a crucial communication link between the eastern and western parts of Bengal. But it reappeared with a new significance in September 1971 when millions used it as a highway to life, defying natural calamities, to evade Pakistani atrocities.

Primarily the positioning and locations of Jashore Road, the railway track and the port service area stand as the key barriers between communities of either side of the road (Figure 1), thus these developments spatially segregate the community.

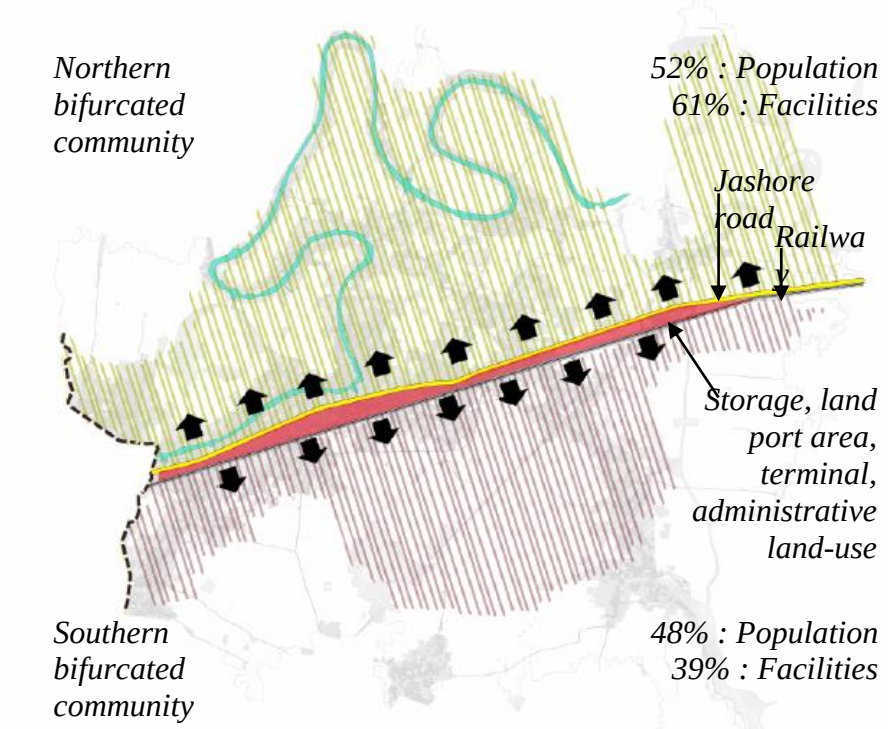

Figure 1, Jashore road, port's service block and railway segregate Benapole into two parts (*Source: Author*)

On the other hand, [Figurer 2(b)] shows that the southern part with the city bus terminal which is bounded by a full height (almost 9 feet) boundary wall that stands like a barrier between the southern community and northern community affecting the visibility, accessibility and permeability of the neighbouring areas.

Jashore Road, the railway and port service blocks also hamper the equitable distribution of facilities and disrupt the equilibrium of overall development process of Benapole. In interviews, shopkeepers, students express their fear of crossing this high-way on daily basis. Some believes in southern part the accommodation is affordable but facilities are not so available. Eventually this barrier of infrastructure can be held guilty of creating spatial as well as social segregation.

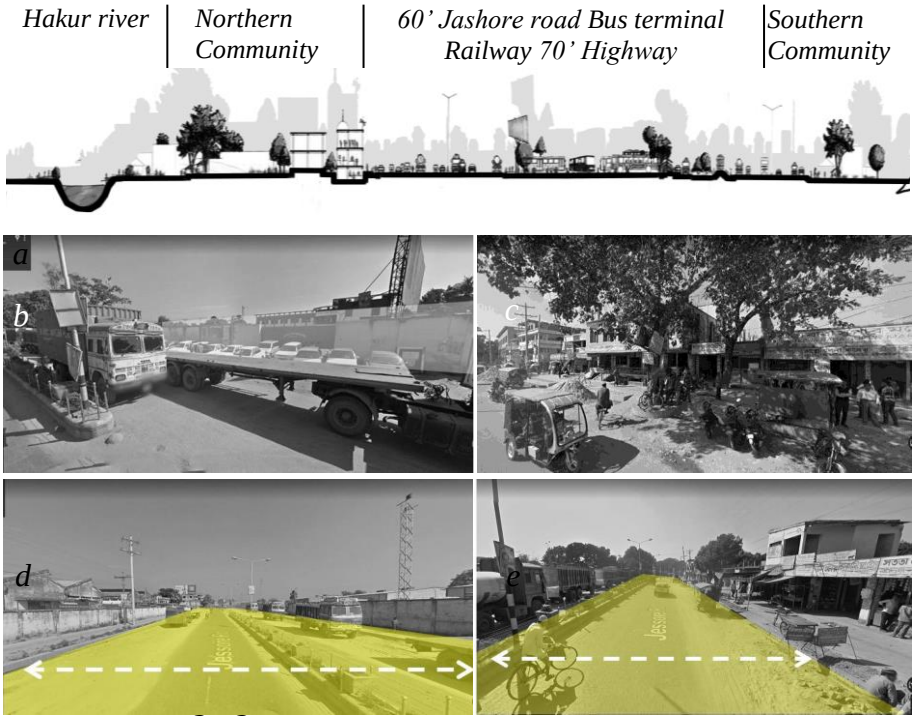

Figure 2, (a) Jashore road, port's service block and railway segregate Benapole into two parts and bifurcate

community, (b Bus terminal with over heighted boundary at southern part, (c) Market, mosque, vendors & vibrant pedestrian at northern part, (d) Port storage service area segregates the city and bifurcates community, (e) Traffic congestion and city segregation in-front of land port bus terminal area (*Source: Author*)

3.2. LAND USES ALONGSIDE JASHORE ROAD

Most of the land use along Jashore road is commercial. Almost 40% road adjacent land is under Government ownership-used as a service area for port activities like warehouse, customs and lorry/truck terminals, while the rest 40% area is used for commercial and mixed-use purposes, 10% for residential use and the rest 10% for playgrounds, educational institutes and religious purposes.

This land use and zoning pattern of government land (and used by Customs, port office) are also accountable for inflicting social inequity. A longitudinal section along the Jashore road is used which shows blocked (surrounded by high boundary walls) by the government office and port authority, segregates the northern and southern community.

- Jashore Road, itself contributes to the production of irregular pedestrian accessibility for the roads (not all roads have pedestrian footpaths).
- Uneven distribution of public, private and commercial functions as shown in (Figures 3) in the northern part with facilities like mosque, Bazar (market) and vendors make up the vibrant image on that side, while the southern part with bus terminal that bounded by heighted (almost 9') boundary wall that stands like a barrier between the southern community and northern community leading up to the making of a less-public front.
- Too many community road intersections with the arterial Jashore Road – 63 in total at different points interjecting the Jashore–Benapole Highway traffic.
- Insufficient space for heavy vehicle parking (Cargo Lorries and Buses are commonly parked on the side of Jashore Road).

3.3. 'ZONING' PATTERN ALONGSIDE JASHORE ROAD

In Benapole, lack of social interaction, social segregation and lessened accessibility to public facilities for people are somehow promoted by the zoning of the city at a certain level. In terms of specific zoning, around 40% of total land alongside Jashore Road is used for government service area, while the first layer or sometimes the second layer adjacent Jashore road are used for commercial and mixed-use purposes, as they are almost non-existent on the roadside creating a non-public front of the road. The railway track with rail station also creates a different layer of land use, further distancing the two communities of northern and southern parts. If summarized, three main zones can be located in Benapole.

- Railway and the adjacent development zone
- Northern part of the city which holds larger share of public amenities and facilities
- Southern part of the city where amenities and facilities are comparatively lower than the northern part. (Figure 3)

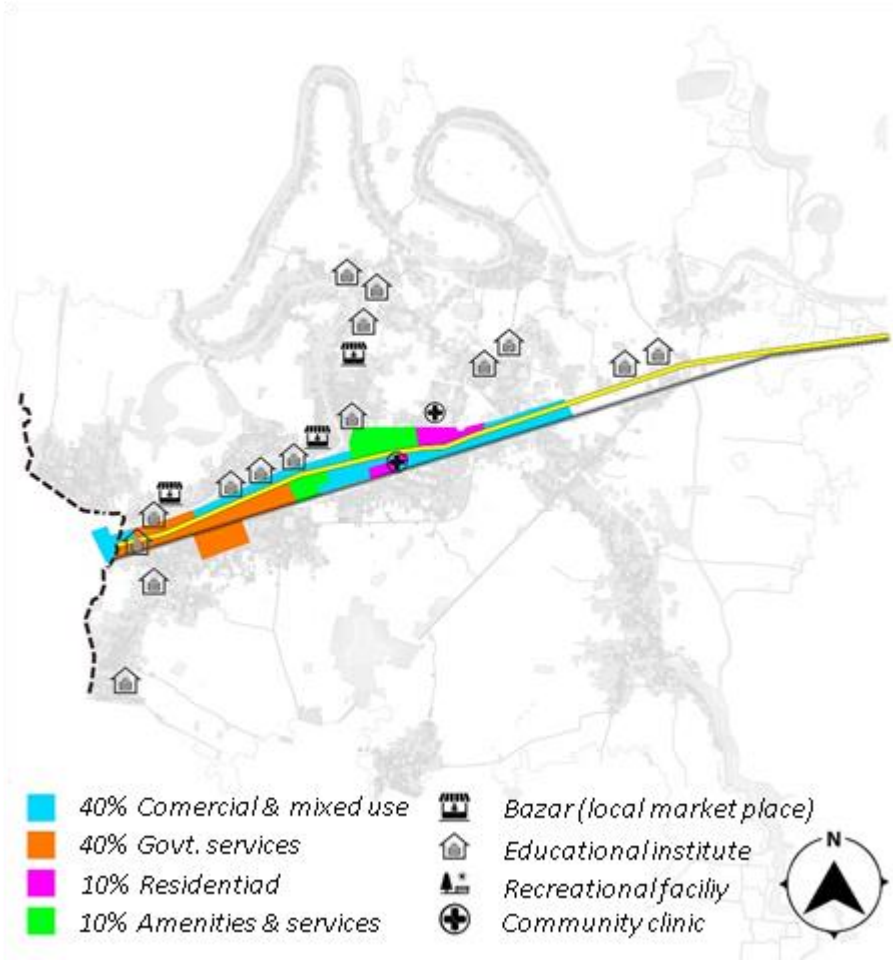

Figure 3, Jashore road adjacent land uses and locational distribution of local market place, educational institute, recreational facilities, community clinic (*Source: Author*)

This zoning pattern has been further aggravated by an inequitable distribution of whatever facilities are available in Beanpole city. As the total area is separated into two distinct parts, the facility distribution also becomes separated and not equitable here. Apparently, the percentage of total population of northern part is 52% but it mainly consists of 62% of facilities (Figure 1) like educational, Bazar (market), health and recreational facilities.

As for educational facility the northern part of beanpole contains 12 educational institutes within 400 m radius, on the other hand southern part only consists 4. In terms of recreation, northern part of Beanpole consists an open filed and a community centre, where southern part has no such facility. In both cases the facility distribution creates inequity amongst the community. Moreover, more than 33% of inhabitants of Benapole think they don't have adequate recreational facility. In the health sector only 2 community clinics exit and both are located in northern part (Figure 3). For diurnal livelihoods, Bazar (market) is the most essential facility and location and accessibility of Bazaar (market) is important for the urban inhabitants. In Benapole Bazaars (market) are located in the northern part (Figure 3), leaving the southern community neglected as usual.

Clearly both social and spatial issues are correlated with each other. Social spectacles do not work in vacuum; a spatial form also coincides. In the context of Beanpole, as the Jashore road divides the land in two parts, so does form a communal segregation. But isn't community means that a group of people living together having certain attitudes and interest in common? These distinct communities not only got separated but also got deprived of facilities in terms of distribution and allocation. Here spatial injustice turns out to be the reason behind social segregation and a segregated community. In communal

development practice, an important question arises that how can a street space integrate the communities instead of segregation and balance the socio-spatial equity through spatial development?

4. Jashore Road as a Democratic Street Space

This section aims to assume a theoretical standpoint with reference to global practices. Following this, the socio-spatial issues that prevail in Benapole are synthesized using the indicators of the theoretical premise of 'Democratic Street'. Finally, the concept of Equity through a democratic Jashore Road is outlined as the key ingredient of a socially and spatially Equitable Benapole.

According to A. & P. Smithson, 1970, "It is the idea of the street, not the reality that is important". Streets are playing larger social, economic and ecological role in towns and cities. The past decades have seen increased interest in the role of public space and streets can play in shaping culture (Francis 2016). Streets are the main public-privet intersection where most of the public activities occur. Both historically and culturally urban streets were seeking attention and growing concerns as potential public domain. Therefor urban thinker and researcher discussed theories and applications including "pedestrianization", "liveable Streets", "private indoor streets" and "democratic Street".

4.1. WHAT IS A DEMOCRATIC STREET?

'Democratic' street is the alternative holistic concept of Good Street. "A democratic street is one that reflects the history as well as the social and economic diversity of the larger neighbourhood and city" (Francis 2016). This street offers friendly pedestrian and liveable street space. A democratic street reflects social justice, ecological vitality and economic health which doesn't exclude the automobiles but create a more equitable balance with street users. "Yet the democratic street also emphasizes the access and needs of many different kinds of people, provides opportunities for discovery and challenge, and actively encourages user manipulation, appropriation, and transformation" (Francis 2016).

4.2. SPECIFIC INGREDIENTS TO BUILD A DEMOCRATIC STREET

Based on the work of Jacobs, Lynch, Appleyard, and others, we can further define democratic streets as ones that are well used and that invite direct participation, provide opportunities for discovery and adventure, and that are locally controlled and broadly accessible (Francis 2016). So basically, street democracy grows out of the idea of 'Publicness'- that recognizes habitant's right to free and boundless access to the public places. According to Jane Jacobs "eye on the street" is important to create secured neighbourhoods. All along a democratic street is secured public place with equitable, unlimited accessibility of its habitants. Mark Francis (2016) discussed the ingredients or the indicators of democratic street for evaluating existing street or for designing new ones. The ingredients are,
i. Use and user diversity; ii. Accessibility; iii. Participation iv. Real and symbolic control; v. Traffic management; vi. Safety/Security; vii. Ground floor street relationship; viii. Comfort; ix. Ecological equity; x. Economic health.

A balanced mix of different uses and user group is needed for a lively and successful street. When diverse people can come together to perform diversified activities in a place, the place become democratic and to welcome diverse group of population, unconditional accessibility to its habitants is a must. According to Appleyard, "safe and easy access to nearby street spaces continues to be a major factor in residential satisfaction" (Appleyard 1981). Streets also need to be modified by their users to fit the changing activities and needs of the community (Francis 2016). Varity in use and belongingness to the street space encourage its habitants in direct participation. Recent research has documented that users who develop vacant lots into community gardens and plant flowers and vegetables on sidewalks often encourage other people to participate in the improvement and care of the rest of the street (Francis, Cashdan, Paxson 1984). Streets work democratically when people feel a sense of control over them. Conversely, streets fail when people perceive them as belonging to the "city" or when they seem to be controlled by no one (Francis 1987). Democratic Street space allows its users to own the street and maintaine the space

having a symbolic control. Hence traffic management and safety security are two important ingredients for street democracy. Appleyard and Lintel (1977) described that resident satisfaction with neighborhood streets in San Francisco depended in large part on traffic volume and speed. 'They also found greater social contact among residents on streets with less traffic' (Appleyard, Lintel 1977). That makes sense as a street under ongoing traffic management is more democratic as it allows people participation, accessibility and user diversity. In terms of ground floor-street relationship, "in democratic streets social connection links ground floor building uses to be adjacent street space" (Francis 2016). Other indicators like Comfort, Ecological quality, Economic health are as important as others. A democratic street needs to be comfortable where businesses and land values prosper and where abandonment, vacant lots, and disinvestment are discouraged. Besides an ecologically healthy street contribute to clear air, buffer noise and add visual relief.

"Democratic streets are places where we learn to deal more competently with our everyday environment (Ward 1978); they communicate much about the economy and social structure of urban life" (Francis 2016).

4.3. POTENTIALITY OF JASHORE ROAD AS A DEMOCRATIC STREET

Section 3 outlines the social and spatial problems of Benapole. Segregated community, socio-spatial inequity within community due to uneven distribution of facilities, unequal access to facilities have been identified as main obstacle to achieve an equitable Beanpole. By nature, Jashore road itself with the adjacent land and insensitive land development is one of the main contributors to this inequitable situation. Nevertheless, the presence of a street like 'Jashore road' can integrate the whole community to fightback this 'inequity' of Benapole. A democratic Jashore road with its historical value and century old rain tree can create a street scape where the street users and vehicle get equitable balance, where habitants get unlimited access to public facilities, where street are always safe and vibrant with diversified users. And finally, street democracy will achieve when habitants will own the street as a social space, not as social barrier.

4.4. DEMOCRATIC JASHORE ROAD FOR SOCIO-SPATIALLY EQUITABLE BENAPOLE

Finestine believes equity, diversity and democracy these are the main three components for a socially spatial just city (Fainstein 2014). Although these components stand as individual but are co-related. An equitable city will ensure by democracy and diversity. To warrant a socio-spatially equitable Beanpole a democratic Jashore road with diversified use and users from all over the city, remains prerequisite. To develop Jashore Road as a democratic street scape,

Firstly, there should be an equitable balance for traffic and street users, to ensure user safety and reduce traffic congestion.

Secondly, the adjacent land development of Jashore road needs more sensitivity considering accessibility of all stages of users, diversified functions, and street ground-floor relation.

Thirdly, equitable distribution of basic facilities should be provided ensuring adequate facilities and infrastructure to access those facilities. For example, If Jashore road become safe enough to cross often both road side facilities will be equally accessible for all.

Fourthly over heighted boundary wall, port ancillary facilities should be relocated from Jashore road adjacent land or for future development the existing railway can be overhead rail way to minimize this spatial buffer between communities.

Lastly street safety, traffic management, diversified function to enhance street ground floor relation, balance in facility distribution all these indicators promote access and need of different kind of habitants for which a democratic street stand for.

5. Conclusion

“Streets are not the dividing lines within the city. They are to be communal rooms and passages” (Duany 1994). But in the context of Benapole Jashore road is certainly dividing the community along the city. According to Talen, "Streets are designed to encourage street life, since any increase in pedestrian activity bonds and promote sense of place” (Talen 1999). Jashore road hold that ability to produce a public place for the inclusion of bifurcated communities in Beanpole. Preservation of the century old rain trees can maintain ecological equity. ‘Buildings and landscape shape urban streets into “outdoor living rooms” (Speck 2013). The historical Jashore road as a democratic street scape can have a great impact on rising social issues amongst the community of Benapole as the spatial and social aspects always complement each-other. Moreover, sensitive planning and design intervention in regional, municipal or community scale can bring immense positive changes in socio-spatial level. So, some relocation and sensitive new development alongside Jashore road can promote user diversity, accessibility, street-ground floor relationship, safety, public control and all these together can indorse the democracy of Jashore Road which will lead to an equitable Beanpole.

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UTILIZATION OF THE SPACE IN BETWEEN A GARMENT AND THE WEARER: A DISCUSSION ON THE GARMENT FIT

Usage of space and human interaction

[1]BEMINIWATHTHA D.M.L.C & [2] SENANAYAKA R.J.
[1,2]University of Moratuwa, Sri Lanka,
[1]lakshikacb26@gmail.com, [2]ruwandikas@uom.lk

Abstract

Garment is one of the links between the human body and the outer surrounding that acts as the intermediary for the two aspects. Humans seek for their personal space as the top most priority in the survival, hence before dealing with the external aspects, an individual seeks for their comfort in the personal space. For this the main element they control is their dress, for the dress can be used as an indirect boundary to satisfy their personal space. From the Fashion designer's perspective, garment is an artificially created boundary; achieved through a meaningful control on the space in between the garment and the wearer. From the wearer's perspective, they identify this controlled space as the fit of the garment. Therefore, garment fit variations done by 3 selected designers were brought into the discussion and thereby tried to identify the interaction of the human body and the personal space with reference to the garment fit. Accordingly, three main definitions were derived about the garment fit that plays around the personal space of the human body. They are:

1. Adaptation of the garment for the live human body allowing the customization of fit giving an adoptable personal space
2. Tailoring to perfectly match the measurements and the body curves enhancing the body shape and
3. Hiding the body shape through exaggeration of the garment from the human body giving an abstractly exaggerated space around the body.

Keywords: *Garment construction, Garment fit, Space utilization, Garment Construction techniques, Space in between*

Introduction

"Garments form the testamentary envelope that contains the body and presents it to the social world" (Twigg, 2009). Hence, garment can be referred as the outer boundary of an individual that defines the personal space occupied by that particular individual. At the stage of the creation or construction of a garment, a proper system is always needed based on the wearer and the context. Predominantly there are five main garment construction systems (Lindqvist, 2015) practiced around the world, namely, body wrapping, rectangular cut, flat Pattern making, draping and creative pattern cutting. Any system holds a correlation with the human body and the way of controlling the space in between the body and the boundary created by the garment.

This paper will refer „the dress form„ to a static human body and „body„ to a live human body.

THE CONCEPT OF GARMENT FIT

"With the progression of time, garments have fluctuated in varying degrees of fit ranging from close-to-body to away from the body" (McRoberts, 2000) Accordingly fit is given different interpretations by the wearer and designer both. "Fit typically refers to the comfort and appearance of a garment" (Boorady, 2011) The above mentioned explanation can be extracted as an explanation that commonly concerned about the visual appeal of the human body after wearing a garment and the comfort provided by the garment. Further, visual appeal is considerably high when a garment is proportionately placed on a body. The theories related to the origin of clothing itself are directly connected with the fit of the garments. By controlling the fit, the space occupation of the garment against the body and also the surroundings has also been controlled. Hence, it is clear that Fit has been the prior consideration for the construction of garments from the very early times.

"Clothing fit has been shown to be the most important element for consumers in determining their overall satisfaction with garments" (Shin, 2013) Designers has managed to control the personal space around an

individual by controlling the fit of the garment in various ways which will be analyzed next. In other words, designers control the fit of the garment against the personal space in order to achieve variations of the garments designed and constructed.

According to studies, garment fit can be defined in " two perspectives: designer-mediated and consumer" (Shin, 2013)

Garment Fit From Consumer's Perspective

The consumer's perspective about the garments depends on two factors; the visual and the tactile qualities of a garment. "The visual, when looking in a mirror or looking down at themselves, the tactile, when feeling the clothing as they wear it" (Frost, 1988). Accordingly, providing the comfort of the personal space in a visually appealing way for the particular consumer is important.

Garment Fit From Designer's Perspective

Garment fit from designer's perspective is the fit that is evaluated during the construction process. "Fit can be measured by a set of criteria known as a standard of fit (Shin, 2013) "The standard of fit which is defined as a set of physical characteristics of a fitted garment" (Frost, 1988). Accordingly the designer's perspective of a garment's fit is determined based on "five basic factors namely the grain of the fabric, the construction lines, set of the garment, balance and the ease" (Boorady, 2011).

Case Studies and Discussion

Three case studies; works of three veteran designers‟ were selected for a comparative analysis based on the differences on the silhouette, garment construction system and the signature garment fit of their creations. The designers for the case studies; Issey Miyake, Christine Dior and Cristobal Balenciaga are couture designers from the 20th century who have introduced revolutionary silhouettes to the fashion world.

CASE STUDY 1: ISSEY MIYAKE

“Fashion to me is like the wind, I like to stay constant. I put my mind to making a product that people enjoy.” Says Miyake as Ross (2011) states. Issey Miyake is a Japanese fashion designer who is still considered to be an icon who reinterprets the garment construction through his approaches (Hiramitsu, 2005). He who was a pioneer for introducing and following new methodologies and techniques for making garments which has cleared vision for numerous possibilities for constructing garments. According to Hiramitsu (2005) “To Miyake, making haute couture dress is comparable to serving the bourgeoisie and in complete opposition to his sensibilities.”, says Hiramitsu (2005). He thoroughly believed that that a garment should be created together with the feel of them.

Figure 1 : One Piece of Cloth Source : https://www.2plus3d.pl /artykuly/issey-miyake)

Issey Miyake refused the western garments that enhance the body shape through skilled tailoring and also the western clothes, which were constructed as structural packages. Most of the times Miyake uses basic shapes for the construction of his garments and then he let air flow into the garment to complete the silhouette. Therefore he has a prior consideration to control the space in between the body and the garment as well. The movements of the live human body will only reveal the body curves unless the body shape is not defined in his garments (Hiramitsu, 2005). His concept not only explores the relationship between the garment and the body but also the space in between.

Key Discussion Points

•Miyake’s starting point of the designs was the traditional Japanese Kimono which requires no real tailoring and fits the wearer regardless of the proportions.

•Miyake's garment constructions always followed the basic geometry which was the rectangular cuts for the cutting of the fabric.
•His designs include the systems of garment construction namely body wrapping, rectangular cut, body wrap and creative pattern making. Flat patterns were modified in his own way for the construction of the garments. •His designs always maintained his identity of not revealing the exact body shape when the body is still.
•His garments adopted the human body when they are put on a live human body.
•Miyake's designs interacted with the live human body without revealing its full body shape.
•He facilitated an adoptable personal space for an individual through his garments

CASE STUDY 2: CHRISTIAN DIOR

Christian Dior was a French designer who is considered as a revolutionary fashion designer who lived in the 20th century. "He used solid, rigid construction to achieve his delicate-looking "femme-fleur" look, sometimes requiring up to 15 yards of fabric for the skirts." (Williams, 2011) He always believed that a garment's beauty needs to be expressed both its inside and outside as the wearer sees the inside of the garment. Dior's most of the inspirations for the designs have been gained out through flowers, says Clinton, 2016 in the daring buds of Dior. Elfman further states that Dior loved feminine details like draping, laces and bows which can be seen even in today. This clarifies that Dior has been a brand that tries to bloom the female from a very long time. Dior has its signature with figure conscious silhouettes. Femininity is always a prior quality of Dior Silhouettes and played with the waist lines and hemlines. (BORELLI-PERSSON,2016) The brand often plays with construction lines, hence the garments are always well tailored.

Figure 2 : Junon Dress
Source :
http://www.metmuseum.org/toah/hd/dior/hd_dior.htm

Key Discussion Points
•Dior's garment construction includes skilled tailoring and intricate detailing of the garments.
•Drapery has also been involved with the garment construction.
•The curves of the female body has been given a higher priority through style lines.
•Multiple layers can be seen in the garments often to give the fullness especially for the lower torso of the wearer.
•When construction a garment Dior considered the beauty of both the inside and outside of the garment incorporating feminine details. •Dior embraced glamorousness, body shape and enhanced femininity.
•Dior's garments were embraced by the people who needs a limited but glamorous personal space around them which will control their postures and movements as well when wearing the garments.

CASE STUDY 3: CRISTOBAL BALENCIAGA

"Haute Couture is like an orchestra, whose conductor is Balenciaga" quoted by Christine Dior which explains a lot about who this designer is. Cristobel Balenciaga was a Spain born fashion designer who radically changed the fashion silhouette of women through his designs. He was able to experiment with the fashion silhouette of women towards a new silhouette. In Cristobel Balenciaga: A Timeless Legacy, Urgel quotes Balenciaga as "if the framework is good, one can build what one wants".(Urgel,2013) This was Balenciaga's philosophy for his designs. He used the female body as a living sculpture as the base of his designs.

Figure 3 : Cocoon Dress
Source:
https://www.pinterest.jp/pin/120541727496042298/

Balenciaga's designs handled the volume very skillfully which is filled with embroidery, prints and architectural volumes. (Urgel, 2013) Some of his voluminous creations through the designs were considered as master pieces even today. This is because he was known as "Architect of Haute Couture".Balenciaga's collections featured different heights and different fits

that played with the body, hence his designs expanded from body fitted to semi fitted garments. He was a pioneer to introduce the concept of space between the body and the garment which indirectly provided the wearer, an exaggerated personal space around them.

Key Discussion Points

•Draping is prominently used to create volumes in the garments, with supportive materials to lift off the garments from the body and create volume.

•Flat pattern making can also be seen in the garments that follow fluid lines to alter the way his clothes related to the human body.

•The garments were sometimes inspired and influenced from various historical styles specially Spanish.

•He used the female body as a female sculpture so that he can play with his creativity freely.

•Tailoring expertise has made his garments revolutionary and innovative

•His garments incorporated several construction techniques to give a conceptional outline and conceptionally exaggerated personal space around the human body by controlling the space in between the garment and the body.

Table 1 : Comparative Analysis Of Case Studies
Source: Author

	Issey Miyake	Christian Dior	Christobal Balenciaga
Nature of the fit of the garment	Semi fitted garments	Tailored to fit garments Exaggerated garments	Semi fitted garments Exaggerated garments
The final garment look	The final garment's look is unpredictable	The final garment's look is predictable	The final garment's look is predictable
Tailoring	Requires no advanced tailoring	Requires advanced and skillfull tailoring	Requires skillfull tailoring
Dress Vs. Body	Do not enhance the body shape	Enhance and exaggerate the body shape	Exaggerate the body shape
Main garment construc-tion system	Main construction system is Rectangular cut	Main construction system Flat Patter Making	Main construction systems are Draping and creative pattern making
Adaptation of the dress to the body	The garment adopts the wearer's body	The garment should have the spicific measurements of the consumer	Specific measurements are not needed but the garments dont adopt the wearer
Fit customization	Fit automatically customizes	Should be manually fitted	Exaggerated fit
silhouette definitions	Not figure concious and not defined silhouettes	Figure concious defined silhouettes	not figure concious but defined silhouettes

Conclusion

Personal Space is a mandatory thing needed by every individual. This can be created intentionally or unintentionally both. Also this is something where the nature of the need depends on person to person. Garments define the secondary outline around the body that defines the personal space owned by the wearer. This can be decided by the fit of the garment, hence; the fit of a garment is an often used term in the everyday life, but what exactly the fit of a garment means? This research was carried in order to find

out the relationships between the garment construction and the fit of a garment which defines the personal space provided by the garment to the wearer.

In the fashion industry, construction of garments plays the most important part. This can be called as implementation in other words. Accordingly there are a number of systems of garment construction that are being used to implement garments. Those are namely Body wrap, rectangular cut, draping, Flat Pattern Making and Creative Pattern Making. All of the five systems contribute to the construction of garments in various ways depending on the needs of the designer for the garment to be. The fit of the garment becomes a concern for the designer when constructing the garments because that is what that will define the final form of the garment, or in other words, the personal space. Accordingly, the criteria that will define a garment's fit from the designer's perspective include the fabric grain, the set of the garment, the construction lines, the balance and the ease of the garment which are discussed in detail in previous sections. The comparative analysis and the detailed analysis of the Case Studies clearly showed that designers control and utilize the criteria in different ways to achieve different forms of garments (Table 1). Hence, the parameters; the ease of the garment, the line of the garment, the fabric grain, the way the garment balances on the body and the set of the garment are especially controlled in different ways for the construction of garments. The initial research and the analysis of the case studies reveal that the incorporation of the systems of garment construction, followed by the designer along with the utilization of the criteria of fit in various ways, define the forms of garments and the nature of the personal space provided by the garment.

Comparing the case studies; Case study 1, Case study 2 and Case study 3, the nature of the fit of majority of the garments can be analyzed as three different types. Issey Miyake always followed the loose fitted concept for his garments, where the garment cannot be predefined until it is worn. But when considering Christian Dior and Christobal Balenciaga, both of them have garments with an exaggerated fit. Although they both exaggerate the garment to enhance the body shape according to the standard hour glass body shape but Christobal Balenciaga's designs tried to enhance the body shape with extremely exaggerated garments that has lifted off from the body. The final garment look is unpredictable for issey miyake's designs because those garments adopt the consumer with a customized fit with a less tailoring skill involved because of the simple cuts and straight lines involved. Cristobel Balenciaga and Christian Dior both have skillfully tailored garments where the final garment look is predicted from the initial step of the garment construction process.

Considering the construction systems used by the three designers in case study 1, 2 and 3, Issey Miyake can be seen always following the rectangular cut garment construction system prominently, giving priority to his signature style. Balenciaga follows the systems of draping and creative pattern making while Christian Dior follows Creative pattern making and Flat pattern making prominently. When considering each one’s garment construction systems they follow, these designers who are mentioned in the case studies, play with the ease, construction lines, balance, set of the garment and grain in different levels. They have their own interpretations on the personal space achieved through the garment for an individual and they have played with the paradigms of fit for the garment construction technique to achieve it. Issey Miyake changes the nature of the material so that he can control the fabric, this is executed using his pleats experiments but the other two designers utilize the grain of the fabric as they associate advanced tailoring in a higher extent. The lines of the garment in Christian Dior’s designs are extremely well defined as they enhance the body shape and involve advanced tailoring whereas Issey Miyake’s designs involve a minimum number of construction lines. Balenciaga’s designs also involve construction lines but not as defined as Dior’s as they do not enhance the body curves. This shows that the more the garment enhances body curves, the more the construction lines and the need for the construction lines to be defined well, is higher. Whatever the design is, or whoever the designer is, the set and the balance of the garment equally affect each and every design to be a practical one. A consumer’s perspective of fit over a garment depends on visual and tactile qualities of a garment. Accordingly, as designers who cater fashion universally, and as designers who broke away from conventionality and set

milestones in fashion industry, the designs have extreme Balance and the set of the garment is very well fulfilled. For example Issey Miyake's use of details and designs related with the pleats, Dior's feminine details and skillful distribution of layers in the garments and also Balenciaga's skillful utilization of volumetric details and architectural concepts that has been blended with the designs can be considered. Finally, when referring to the case studies, ease of the garments has played a major role when conquering the unique silhouette types for the garments. Issey Miyake's use of garment ease that makes the garment adaptable to any type of body, and Dior's control of ease of the garment with the body is what gives them their own definition of the garment fit. Additionally Balenciaga's designs extremely achieve garment ease and the volume is filled in order to redefine the body. Hence, the personal space given by the garment for the wearer.

Accordingly after analyzing the three case studies, it is clear that they have their own definitions of fit. Issey Miyake designs garments that have undefined silhouettes and not conscious about the body which makes the garments to have a customized fit where the personal space given by the garment adopts the wearer in various ways. Christian Dior has figure conscious and very well predefined silhouettes in which the garments need to be manually fitted. His designs provides the wearer with an exaggerated personal space but highly depending on the body shape too. Cristobel Balenciaga predefined silhouettes for garments where the figure consciousness is null which makes his garments exaggerated in fit. He has an extremely exaggerated personal space which is conscious about the proportions and balance only but not about the body shape at all. Hence, derives three definitions of fit provided by three designers as described above which result in three forms of garments. Also the garment fit can be manipulated by the method of construction. Accordingly this research proves that garments that enhance the body shape and body curves does not expresses the best fit it's a matter of the consumer's perception on the visual and tactile perception of the personal space and skillful utility of the design elements and criteria that involves in the fit of a garment.

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INVESTIGATING THE IMPACT OF NON-LOAD BEARING (NLB) WALLS ON THE BUILT-UP AREA AND DEAD LOAD IN MULTI-STOREYED RESIDENTIAL BUILDINGS

RASTOGI ABHIJIT[1] & PAUL VIRENDRA KUMAR[2]
[1, 2]Department of Building Engineering and Management, School of Planning and Architecture, New Delhi, India
[1]arabhijit@spa.ac.in, [2]vk.paul@spa.ac.in

Abstract
The Indian housing sector is transforming rapidly. Over the last decade, change is noticeable because we transformed from multifamily independent houses to multi-storeyed dwelling units. There are several reasons behind this transformation, like change in culture, work styles, lifestyles, etc. but the most significant is space availability.

A typical multi-storey house has a floor plate, which has multiple Dwelling Units (DU's). The same configuration of the floor plate is repeated over the floors above it. The structure type is commonly an R.C.C framed in which the walls are Non-Load Bearing functioning merely as partitioning member. The thickness of these Non-Load Bearing partition walls contributes significantly in reduction of Net-Useable area of dwelling unit. It also contributes in the overall dead load of the structure. Thus, this research aims to analyze the configuration of dwelling units (DU's) of different sizes ranging from 1 Bhk to 4 Bhk spread across different regions in India on the above two parameters.

The architectural layout of these DUs has been analyzed in relation to useable and non-useable areas, whose proportion is usually referred to as "Loading". The study revealed that the a) Internal Layout Design, and b) Partitioning Walls are the two main factors responsible for "Loading".

The outcome of this study will provide a baseline to support efficient space planning and decision-making for the designers and developers thus helps them to manage residential spaces more efficiently.

Keywords: *Non-Load Bearing (NLB) walls, Built-Up Area, Dwelling Units (DU's), Dead Load, RERA, Loading.*

1. Introduction

In India, residential housing accounts for almost 80 per cent of the real estate market in terms of volume and has been growing at 30 to 35 per cent annually (KPMG, Cushman and Wakefield, Knight Frank, CRISIL). Growing number of nuclear families, migration of rural population to urban are the two main reasons for this steep growth. As per the figures given by Ministry of Housing and Urban Poverty Alleviation (MoHUPA, 2012) the total housing shortage in India is 18.78 million, out of which 14.99 million dwelling units comprise dilapidated and congested houses. To meet this housing shortage the government had launched Pradhan Mantri Awas Yojna (PMAY) with an aim to provide housing for all till 2022. About 80 per cent of the total housing to be built under (PMAY) involves urban renewal, upgradation, regularization, redevelopment, rehabilitation and retrofitting.

Affordable housing has been largely the domain and responsibility of the Government. However, in the recent years, private developers have started exploring the opportunity to cater to this segment. One of the main hurdles in the growth of affordable housing is non-availability of land and ineffective land management practices (Kundu and Sharma, 2017). According to the Town and Country Planning Organisation (TCPO) to meet the housing shortage in the form of group housing on average density norms, 84,724 Hectares to 1,20,882 Hectares of additional land would be required. Land is the basic platform for housing and other activities. However, the acquisition of private lands has become extremely difficult under the Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013. Even if the land is acquired, still it is the most expensive component of housing cost (Jain, 2017).

Thus, to make social housing affordable and viable the FAR/FSI have been significantly increased by the development authorities over the past few years which opens the existence of multi-storeyed buildings. The land price plays a major role in pricing and affordability of dwelling units and on an average constitutes 30-50 per cent of the cost of an urban housing project (Chandra, 2017). The price of high-end

residential projects is largely guided by land costs, construction costs have a significant share in the price of affordable housing. During the past decade, construction costs have significantly increased due to the appreciation in prices of construction materials (Kundu and Sharma, 2017). In order to minimize the construction cost, the Building Materials and Technology Promotion Council (BMTPC) developed several innovative affordable housing technologies but facing various challenges in upscaling.

Due to the presence of private developers in the market, the homebuyers were facing various issues like timely possession of purchased unit, Construction Quality, Area of the DU, etc. Thus, to safeguard the interests of homebuyers the government enacted the Real Estate (Regulation and Development) Act, 2016 and created a Real Estate Regulatory Authority and Appellate Tribunal that will act as the watchdogs for the housing sector. The Act requires greater disclosure from the developer, accountability and removing the information asymmetries from the housing market. A major provision of the Act is the standardisation of area measurement, with carpet area to be the measure. In the real estate market, Built Up Area, Carpet Area and the Super Built Up Area are the three terms widely used amongst Developers and Buyers. After the implementation of RERA in, 2016, the definition of "Carpet Area" is slightly altered as 'the net usable floor area of an apartment, excluding the area covered by the external walls, areas under services shafts, exclusive balcony or verandah area and exclusive open terrace area, but includes the area covered by the internal partition walls of the apartment'. The "Built Up Area" includes the carpet area and the area occupied by the external walls, columns, ducts and, balconies of the dwelling unit (DU) and the "Super Built Up Area" also called as "Saleable Area" is the sum of the built-up area and common spaces which include the DU's proportionate share of the lobby, common staircase and lift, the corridor outside the DU.

Typically, before implementation of RERA, selling apartments based on super built up area was the usual practice by most of the developers. Due to this practice, the homebuyers were ended up paying a hefty amount without even knowing the exact usable area (Carpet Area). Carpet area is usually 25–35% lower than the super built up area. For instance, if an apartment is said to be the size of 2,000 sq. ft, the actual usable area, or the carpet area, will be 1,400–1,500 sq. ft.

However, after implementation of RERA the developers are bound to sell units on carpet area but still from the buyer's perspective the percentage of net usable area or carpet area may vary due to the layout design and internal partitioning walls. Apart from the buyer's problems, the builders also face many difficulties. Thus, the Act has defined a set of stringent norms for the real estate developer, the intermediary as well as the consumer, to encourage healthy and just relationships between the parties involved. From the developer's perspective, the focus is always on to minimize the overall project cost which can only be achieved by either reduction in land cost or construction cost or both. Out of land cost and construction cost, it is only the later one which a developer can control because the former comes directly under the purview of government.

Thus, the aim of this paper is to analyse the layouts of various configurations of dwelling units with respect to Built-up Area and Net Usable Area or Carpet Area, then quantify the contribution of walls (Non-Load Bearing Partitions) in Dead Load of the structure.

2. Background & Literature Review:

Housing is a key component in the sustainable development of a community (Dumreicher and Kolb, 2008). Economic, environmental, and social are the three terms associated with sustainable development (Keiner, 2005).

Various studies are available in the literature, concerning the selection of construction technologies, materials, partition members etc. based on Embodied Energy and Carbon Emissions, some of which are indicatively referred herein. (Venkatarama et al.), estimated the energy consumed for the production,

transportation and installation on-site of several traditional construction materials and concluded that an important amount of energy is spent for their manufacture and transportation. (Shams et al.) focused on a typical, five-floor residence in Bangladesh and examined the associated carbon emissions for different construction materials. (Wallbaum et al., 2012) suggests the most promising technologies for affordable housing based on sustainability indicators.

Embodied Energy and Carbon emissions are defined as the Energy requirements for production and processing of different building materials and the Carbon emissions and the implications on the environment (Buchanan and Honey, Suzki et al, Oka et al., Debnath et al., Reddy and Jagadish). In order to estimate the total embodied energy and the related carbon emissions of a building, a good material analysis, i.e. breakdown of the various building components to their constitutive materials is required. However, respective material quantities also have significant role in quantification of Embodied Energy and Carbon Emissions.

Various researchers suggest alternative materials in order to reduce the EE and carbon emissions but none of them focussed on reducing the material quantities itself. Debnath et al. estimated the energy requirement for different types of residential buildings in India and concluded that the bricks, cement and steel are the three major contributors to energy cost of building construction. In multi-storeyed buildings the cement and steel are majorly used in structural members i.e. column, beam, slab, foundation and bricks are used primarily as partition members which unnecessary add load to the structural members. Thus, this paper aims to investigate the contribution of different types of partitioning members on the dead load of the structure.

3. Methodology

A two-step process analysis was implemented, the first one focusses on analysis of useable and non-useable area and the second one focusses on dead load calculations. In the first step the layout plans of dwelling units having four different configurations i.e. 1 Bhk, 2Bhk, 3Bhk and 4 Bhk were analysed to calculate the percentage of wall area. Four cases in each configuration were selected based on different partitioning members, makes overall 16 cases. In the second step the dead load of partitioning members was calculated after multiplying the density of respective material with its calculated volume.

4. Scope and Limitations

In this study the calculations were based only on the four types of partitioning members i.e. Clay Brick Wall, AAC Blocks, Fly Ash Brick Wall, RCC Wall and EPS Core Panel System. The EPS core panel system is being promoted by the Government of India for the affordable housing and thus only be considered for 1 Bhk and 2 Bhk dwelling units due to the non – availability of case studies in 3 bhk and 4 Bhk DU's. The impact of dead load on the structural members is not calculated in this study and can be taken up further.

5. Case Studies

Sixteen case studies of four different configurations ranging from 1Bhk to 4 Bhk were selected. The details of all sixteen cases are presented below in Table 1. All the case studies are live projects registered under RERA and located in multiple locations across India. There is a mix of ongoing, proposed, and operational projects, which makes the huge variation in the selling price. The case studies are divided equally into four groups i.e A, B, C and D based on configuration of DU's.

6. Results and Discussion

For each case study, the value and the percentage contribution of the wall areas (in SqM) are presented in Table 1. Table 3 summarizes the wall area, Dead Load, as well as the dead load intensity values, i.e. values normalized per unit Built Up area.

Table 1 Details of Case Studies

Projects	Config.	Location	BuA (in SqM)	Wall Area (in SqM)	Net Usable Area (in SqM)	Wall Area (%)	Remarks
A.1	1 BHK	Bhubaneswar	28.13	3.35	24.78	12%	150 MM External and Internal EPS Core Panel
A.2	1 BHK	Pune	54.81	10.18	44.63	19%	230 MM External and 115 MM Internal Clay Brick Wall
A.3	1 BHK	Mumbai	49.51	7.4	42.11	15%	150 MM RCC Wall
A.4	1 BHK	Noida	66.96	10.6	56.36	16%	230 MM External and 110 MM Internal Fly Ash Brick Wall
B.1	2 BHK	Jaipur	97.82	20.35	77.47	21%	400 MM External and 200 MM Internal AAC Blocks
B.2	2 BHK	Gurugram	58.06	9.37	48.69	16%	230 MM External and 115 MM Internal Clay Brick Wall
B.3	2 BHK	Lucknow	74.78	7.99	66.79	11%	150 MM External and Internal EPS Core Panel
B.4	2 BHK + Study	Kolkata	139.04	17.29	121.75	12%	150 MM RCC Wall
C.1	3 BHK + Servant	Bengaluru	141.21	23.39	117.82	17%	200 MM External and 100 MM Internal AAC Blocks
C.2	3 BHK	Delhi	110.41	14.81	95.60	13%	150 MM RCC Wall
C.3	3 BHK	Chennai	102.3	19.60	82.7	19%	230 MM External and 115 MM Internal Clay Brick Wall
C.4	3 BHK	Mumbai	84.23	12.43	71.8	15%	230 MM External and 110 MM Internal Fly Ash Brick Wall
D.1	4 BHK	Kolkata	144.38	18.49	125.89	13%	150 MM RCC Wall
D.2	4 BHK + Servant	Bengaluru	187	32.76	154.24	18%	300 MM External and 200 MM Internal AAC Blocks
D.3	4 BHK + Servant	Pune	219.43	33.61	185.82	15%	230 MM External and 115 MM Internal Clay Brick Wall
D.4	4 BHK	Ahmedabad	170.76	27.92	142.84	16%	230 MM External and 110 MM Internal Fly Ash Brick Wall

According to Table 1, the percentage contribution of wall areas is ranging from 11% to 21%, lowest being the EPS core panel system having 150 mm thickness and highest being AAC blocks having thickness of 400 mm due to cavity in the external wall. As evident from the results the configuration and size of DU's doesn't have much impact on the net usable area. Although the thickness of RCC walls and EPS panels are same yet the wall areas ranging from 11 to 15%, this variation is purely due to the design layout. Similar, variation is also observed in the Clay Bricks, Fly Ash and AAC blocks ranging from 15% to 19%. Thus, it is evident that the layout design also contributes significantly in the net usable area. The table 3, calculates the extra amount paid by users for the non-usable area. The table clearly shows the huge variation in the premium paid by the users which is ranging from approximately Rs. 5,000 per sqm to 17,000 per sqm of built up area although it is also depending upon the selling price of the DU.

Table 2 Density of selected partitioning members

S.No.	Partitioning Member	Density (in Kg/M3)
1	150 MM External and Internal EPS Core Panel	1150
2	230 MM External and 115 MM Internal Clay Brick Wall	1665
3	150 MM RCC Wall	2450
4	230 MM External and 110 MM Internal Fly Ash Brick Wall	1350
5	400 MM External and 200 MM Internal AAC Blocks	825

The densities of selected partitioning members considered are summarized in Table 2. The density of EPS core panel system is calculated considering 80 mm thickness of EPS panel having density of 15 Kg/CuM, 35 mm thickness of concreting on both sides having density of 2400 Kg/CuM and steel mesh having density of 8500 Kg/CuM. Thus, the overall density calculated for EPS core Panel system is 1150 Kg/CuM. Similarly, the density of clay brick wall, fly ash brick wall, AAC blocks and R.C.C. walls were calculated as 1665 Kg/CuM, 1350 Kg/CuM, 825 Kg/CuM and 2450 Kg/CuM. The volume of the partitioning members was calculated considering the average height of the partition walls 3 M. The densities were multiplied with volume of the respective partitioning members to give overall dead load of the partitioning members. The overall dead load calculated was then divided by the built-up area to provide the dead load intensity per SqM. It is evident from the results that, despite having minimum density of AAC blocks among all, its contribution in dead load of the structure is at par with that of EPS core panel system due to the later one having lesser volume. Considering contribution in Built Up Area and Dead Load together the EPS core panel system performs well while comparing with other partitioning members.

Table 3 Summary of Results

Projects	Config.	BuA (in SqM)	Wall Area (in SqM)	Wall Area (%)	Selling Price (Rs/SqM)	Dead Load on Slab (Kg/SqM)	Amount paid by user per SqM for Non-Usable Area (in Rs.)
A.1	1 BHK	28.13	3.35	12%	₹ 43,000	411	₹ 5,121
A.2	1 BHK	54.81	10.18	19%	₹ 82,000	928	₹ 15,230
A.3	1 BHK	49.51	7.4	15%	₹ 95,000	1099	₹ 14,199
A.4	1 BHK	66.96	10.6	16%	₹ 60,000	641	₹ 9,498
B.1	2 BHK	97.82	20.35	21%	₹ 48,000	515	₹ 9,986
B.2	2 BHK	58.06	9.37	16%	₹ 72,000	806	₹ 11,620
B.3	2 BHK	74.78	7.99	11%	₹ 58,000	369	₹ 6,197
B.4	2 BHK + Study	139.04	17.29	12%	₹ 64,000	914	₹ 7,959
C.1	3 BHK + Servant	141.21	23.39	17%	₹ 84,000	410	₹ 13,914
C.2	3 BHK	110.41	14.81	13%	₹ 76,000	986	₹ 10,194

C.3	3 BHK	102.3	19.60	19%	₹ 81,000	957	₹ 15,519
C.4	3 BHK	84.23	12.43	15%	₹ 90,000	598	₹ 13,281
D.1	4 BHK	144.38	18.49	13%	₹ 74,000	941	₹ 9,477
D.2	4 BHK + Servant	187	32.76	18%	₹ 96,000	434	₹ 16,818
D.3	4 BHK + Servant	219.43	33.61	15%	₹ 88,000	765	₹ 13,479
D.4	4 BHK	170.76	27.92	16%	₹ 66,000	662	₹ 10,791

7. Conclusion:

The thorough analysis clearly indicates that the NLB partitions have significantly contributes in both Built up Area and Dead Load of the structure. This impacted both buyers as well as developers. On one side where buyers have to pay extra money for Non-Usable area, on the other side the additional dead load resulting in larger sizes of structural members thus impacting higher construction cost for the developers. Apart from impacting financially, selecting appropriate NLB partition may also reduce the embodied energy and carbon emissions of the building. A wholesome effort is needed incorporating the attributes like net usable area and dead load along with embodied energy and carbon emissions while selecting the NLB partitions.

The results obtained from the analysis provided valuable information for consultants and developers to support strategic planning and decision-making at the project initiation phase and thus help them to reduce the construction cost, environmental impacts and provide space efficient layouts to their customers.

Accordingly, it is suggested that the cost of impact of dead load on structural members can be carried out separately. An analysis to study the effect of NLB partitions on the structural performance of various comparative case studies might reveal more detailed results.

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IMPACT OF SPACE MANAGEMENT TO CORE BUSINESS OF SRI LANKAN HIGHER EDUCATION SECTOR: FACILITIES MANAGEMENT PERSPECTIVE

JAYASENA H.A.E.C.[1], ANUSHANGA B.A.H.[2] & GOWSIGA M.[3]
[1, 2,3] University of Moratuwa, Colombo, Sri Lanka
[1]ecjayasena@uom.lk, [2]heshananushanga1994@gmail.com, [3]gowgowsi9@gmail.com

Abstract
Education is a basic need of all human beings in the world as it turns a right of humans. Higher Education Institution (HEI) sector in any economy has responsibility to provide high skills professionals who participate to develop the economy. The outcomes of the HEI depends on satisfaction of occupants and effective environment in HEI. Thus, Space Management (SM) in HEI become an essential function in order to achieve the effective outcome from HEI. SM is one of the disciplines of Facilities Management (FM). However, Sri Lankan HEI sector has less concern to manage space in order to ensure the effective outcome from HEI. Therefore, this paper aims to investigate the impact of SM from FM perspective in Sri Lankan HEI sector to improving core business. This study was approached using the mixed method. Quantitative approach was applied to measure the satisfaction on existing SM in HEI sector and qualitative approach was to determine suitable SM concepts and strategies to overcome the causes of dissatisfaction on SM. Data collection was carried out through questionnaire survey from both students and academic staff of HEI's and semi structured interviews from both experts on construction designing and workplace planning. The gathered data were analysed through Statistical Package for Social Science Software (SPSS) in terms of content analysis and Relative Important Index (RII) to determine satisfaction against the existing SM. As the finding revealed that, different SM strategies under six main SM concepts which are healthy living, open space, key model space, modern workplace, universal design and common SM to overcome existing SM issues such as space allocation is not aligning with functional requirement, poor ventilation, poor visual and acoustic comfort, poor design specification and arrangements, unavailability /not enough space, insufficient parking and lack of disabled persons' space.

Keywords*: Higher Education Institution (HEI), Facilities Management (FM), Space Management (SM), Concepts, Sri Lanka.*

1. Introduction

Education is a primary necessity for humans to develop their socio-economic aspects and it might lead to turn out the knowledgeable humans for society (JICA, 2004), and it has been recognised as a principle way of fulfilling the ultimate goal of the country (University Grants Commission, 2013). Education can be categorized as four main stages such as early childhood development, primary education, secondary education and higher education (Ministry of Education, 2013). A successful evaluation to a skill-based economy depends on direction and contributions of HEIs especially universities, which must provide a knowledgeable and educated labour force (University Grants Commission, 2013). Thus, educated and skilled workforce is a valuable part of any economy and it may cause raising high productivity in economy (Glass, 2014). Because of that higher education faced unprecedented change within a short period of time (Daigneau, et al., 2005). As a result of rapid expansion of higher education, significant challenges were faced to ensure the quality of the higher education (Glass, 2014). Hence, universities should be functioning in an efficient manner of their resources to create the best use (Shahabudin, et al., 2012). However, space is one of the main challenges to ensure proper quality of higher education (Glass, 2014). Because mismatched usage of space and its design are led to facing common SM problem in most of HEI such as poor employment rate for teaching space, cost and productivity related issues (Shahabudin, et al., 2012). Therefore, space is most finite and valuable physical resource and it is considered as part of environment of any educational institution (Hashim, et al., 2013). Due to that, SM is a vital activity for all HEI and any other organizations (Ibrahim, et al., 2011).

FM concept consists of multi-disciplinary activities to manage the environment that affect to occupants and their places of work, thus, SM is one of the critical aspects of FM (Ibrahim, et al., 2011). As a key SM tool, FM aspects can be used to achieve maximum effectiveness and efficiency in day to day operations of the facility (Xia, 2004). Further, educational outcomes of HEI are partly the outcomes of the institutional-spacial qualities in which learning and teaching practices take place and disclose the institutional-spacial qualities to be partially identified by the educational facility services and

involvement of FM for making more value for education (Kok, Mobach, & Omta, 2011). Eventually, as a result of impact of SM in HEI, it can be considering as one of most vital elements in the FM (Shahabudin, et al., 2012). Therefore, proper SM is a vital cog in providing of quality higher education in any country. As a developing country Sri Lankan HEI has very few spaces and its quality depend on geographical locations of buildings. Thus, there are a lot of issues related to SM and it causes to poor performances of students and it leads to low quality higher education. In the modern built environment FM has become an integral aspect and SM comes under FM scope. Therefore, in other side poor SM partly represent poor FM in Sri Lankan HEI. Also, there are only very few research studies conducted on SM in HEI in Sri Lankan context. Hence, the aim of this research is to investigate impact of SM from FM perspective in Sri Lankan HEI sector to improving core business.

The structure of the paper opens with a literature review related to important concepts of the study. Then it presents the method used in achieving the aim of the study and finally it presents the discussion on research findings together with conclusions and recommendations.

2. Literature Review

Space is a physical sense (Haggans ,2015), however space can be discussed under mental and metaphorical aspects (Hod ,2017). “SM is an interdisciplinary endeavor that incorporates space, users, activities and technologies to plan and manage a working environment that effectively support core business goals” (Li, et al., 2017). Moreover, SM procedure has relationship between space with occupants and core functions of organization (Leung, et al., 2014). Thus, the requirement of practical SM of work environment can be considered as a major industry priority and due to that reappraisal of issues that recognize at SM is needed (Oluwoye & Ilozer, 1998) . Moreover, numbers of researchers are introduced different SM concepts by observing spaces utilization through different point of views, some of those SM concepts are narrative concept (Ropo, et al., 2015) , key space model concept (Steiner, 2006), modern workplace environment concept (Jylhä, 2015) , open space concept (Hanan, 2013) and the innovative concept of the “Educational Campus (Calvo-Sotelo, 2010) . FM is a profession that encompasses multiple disciplines to ensure functionality, comfort, safety and efficiency of the built environment by integrating people, place, process and technology (IFMA, 2019) . In addition, FM is wider than managing of non-core services in organisation and it aligned as “glue” between the core business and non-core services in organization (Pitt & Tucker, 2008). Moreover, FM has significant impact on the physical spatial environment in the organization, and it might result in increased the satisfaction level of organisational core business (Nik-Mat, et al., 2011; Silva, 2011). Therefore, arrangement of the spacial environment in organisation is a key function of FM (Kaya, et al., 2005) . According to Lozano, (2006) higher education is creating a mean to cultural and social changes through findings of researches and education of leaders, future makers and intellectuals. Accordingly, Sri Lanka is taking maximum effort to uplift the government university system to global level status while maintaining knowledge centre position of the South Asian. Therefore, now a day, higher education system in Sri Lanka is modifying their process to comply the modern-day necessities (Ushantha & Kumara, 2016). According to Den Heijer (2012), functional campus spaces are based on the requisite functions for a university’s processes and goals, which are academic spaces (for research and education), residential spaces (for housing to students and staff hostels), business-related space (for partners linked to academic goals and supporting processes), retail and leisure (sports, cultural and catering facilities) and infrastructure spaces (ranging from accessibility to car parks).

3. Research Methodology

This research aims to investigate the impact of SM from FM perspective in Sri Lankan HEI sector to improving core business and achieve the following two objectives;

- To investigate SM problems in Sri Lankan HEI sector.
- To investigate of suitable SM practices to mitigate SM problems in Sri Lankan HEI sector.

According to the nature of the research, it was built up with mixed approach, both quantitative and qualitative aspects. Quantitative approach was applied to measure satisfaction level on existing SM in HEI sector in order to determine impact of SM to core business of HEIs in Sri Lanka. Qualitative approach was applied to determine suitable SM concepts and strategies to overcome the causes of dissatisfaction on SM. Questionnaire survey and semi structured interviews were selected as the data collection techniques. Questionnaire survey with closed ended questions was carried out among students and academic staff members in government HEI sector especially universities. Only three universities from the western province were selected for the questionnaire survey due to the time constrain and availability. Questionnaires were distributed almost equally within those three universities (34 respondents per university). This survey was done by using random sampling method and the sample size was decided with the data saturation and along with rule of thumb, minimum requirement of respondents for a questionnaire is 30. The questionnaire was distributed to 102 respondents and 88.24% (90 respondents) of responded.

Sampling is considered with selecting individuals in a population to implement the practical data collection and research process (Palys, 2008). This research was adopted the non-random sampling method to select individuals for data collection, because of data was collected from the desirable experts in industry based on their knowledge, experience and convenience of the researcher. The selection of samples was based on the experts who are engaged in designing of university construction project implemented in Sri Lanka and the Experts who having over 5 years' experience on workspace planning and design in different facilities. Four expert semi-structured interviews were carried out and details of them are as Table 1. Data analysis was carried out through SPSS in terms of content analysis and RII was adopted to analyze quantitative data. Further, t-test and frequency test were used for validation of the research.

Table 1: Details of the interviewers

Interview Code	Designation	Experience
IC-PR-01	Senior Architecture	09 years
IC-PR-02	Senior Architecture	12 years
IC-PR-03	Senior Architecture	11 years
IC-PR-04	FM	6 years

4. Research Finding and Discussion

This session contains the questionnaire and semi structured interview findings and discussion. At first, questionnaire findings were discussed. In line with the questionnaire survey, frequency of the overall satisfaction on SM in HEI is presented as table 2. Not satisfied/ Not dissatisfied includes both satisfied level or dissatisfied level to some extent. Thus, by excluding that, 11.1% and 31.12% were responded respectively as satisfied and dissatisfied with existing SM in Sri Lankan HEI sector. However, this was presented only respondent percentages about overall satisfaction. Hence, overall satisfaction rate was measured to determine the satisfaction level of all respondents on SM in HEI sector in Sri Lanka by calculating RII value and which is 56.44%. Accordingly, more than half respondents were satisfied, but most respondents (57.78%) were responded as not satisfied/ not dissatisfied, which means most of them have neutral level of satisfaction. Then next most responds were given to dissatisfied level. Therefore, existing SM in HEI sector in Sri Lanka was not achieved expectation satisfaction level and it might be resulted in reduce the efficiency level of learning outcomes from the Sri Lankan HEI Sector.

Table 2: Frequency of the Overall Satisfaction on Space Arrangement in HEI

Satisfaction Levels	Frequency	Percentage
Extremely Satisfied	04	4.44%
Satisfied	06	6.66%
Not satisfied / Not dissatisfied	52	57.78%
Dissatisfied	26	28.89%
Extremely dissatisfied	02	2.23%

Six main functional areas were determined in Sri Lankan HEI sector through literature and questionnaire findings and important level of those areas were confirmed through t-test (Table 3). Accordingly, all the functional areas in HEI have important impact on learning and teaching outcome of both students and academic staff in Sri Lankan HEI sector by having all mean value more than 3.0 and positive t-values. Consequently, existing satisfaction levels on different functional areas were analysed through t-test. According to above results, excluding retail and leisure spaces, all other functional areas were resulted negative t-values whereas they were resulted mean value of less than 3.0. Therefore, excluding retail and leisure spaces, respondents were not satisfied with SM in all other functional areas in Sri Lankan HEI sector. However, retail and leisure spaces were resulted positive t-value but less than expectation level. Accordingly, all functional areas were resulted gap between the satisfaction level and expectation level.

Table 3: T-test- Important Level and Satisfaction Level of Different Functional Areas

One-Sample Test, Test Value = 3, Sig.(2-tailed)				
Functional Areas	Level of Important t-value	Level of Important (Mean Value)	Level of Satisfaction t-value	Level of Satisfaction (Mean Value)
Academic Spaces	13.871	4.4000	-2.646	2.7889
Retail and Leisure Spaces	11.185	3.9222	0.108	3.0111
Infrastructure space	8.647	3.9556	-7.351	2.2444
Business Related Spaces	7.548	3.7000	-0.732	2.9222
Residential Spaces	7.468	3.8556	-4.284	2.5556
Administration Spaces	5.306	3.5444	-1.539	2.8444

Existing SM issues in functional areas in Sri Lankan HEI sector were determined through frequency test and along with that, existing SM issues in functional areas in Sri Lankan HEI sector can be categories according to the Criteria for Categorization of Existing Issues presented in Table 4. Additionally, at the end of questionnaire data analysis, summary table was prepared based on this categorisation in order to find out the suitable strategies to overcome existing SM issues in Sri Lanka HEI sector, which is presented in Table 5.

Table 4: Criteria for Categorisation of Existing Issues

Frequency Levels	Category of Issues
$25 > X$	Minor
$25 \leq X \leq 50$	Moderate
$50 < X < 75$	High
$75 \leq X$	Critical

Table 5: Categorisation for existing SM Issues based on frequency

Functional Areas	Minor Issues	Moderate Issues	High Level Issues	Critical Issues
Academic Spaces	• Poor Space allocation for staircases • Acoustic comfort issues • Poor design specification	• Visual problems due to long distance from projection	• Poor Furniture arrangement • Poor ventilation due to compact building/ room designing	• Not enough space for inside activities • Lack of Moving Space
Residential Spaces	• Poor Space allocation for staircases	• N/A	• Unavailability of additional living/ cooking facilities • Lack of Moving Space • Poor ventilation due to compact building/ room designing • Not enough space for inside activities in the building • Poor Furniture arrangement	• N/A
Infrastructure Spaces	• N/A	• Lack of space between urinals	• Not having Car/ Bike parking slots separately • Poor ventilation due to compact washroom designing • Not having separate spaces for disabled persons • Not having enough spaces in the washroom • Insufficient spaces within parking slot • Lack of Moving Space	• Not having specific place for student parking
Retail and Leisure Spaces	• Poor ventilation due to compact building/ room designing • Unavailability of enough retail and leisure facilities	• Lack of Moving Space • Poor furniture arrangement	• Not enough space for inside activities in the building	• Not enough space for different sports in playground and gymnasium
Business Related Spaces	• Not design to accommodate for huge numbers of students at once a time	• Poor Furniture Arrangement • Poor ventilation due to compact building/ room designing	• Not enough space for queuing in peak time • Not enough space for inside activities in the building • Lack of Moving Space	• N/A
Administration Spaces	• Poor Space allocation for staircases	• Not enough space for inside activities in the building • Lack of Moving Space • Poor ventilation due to compact building/ room designing • Poor furniture arrangement	• Space allocation is not align with functional requirement	• N/A

SM strategies should be immediately given, according to the level of criticality. Even though, there is no critical issue in residential spaces, students and academic staff were expected all residential facilities and their expectations were not limited to bed, table, chair and cupboards. So, unavailability of additional living and cooking facilities with adequate spaces for free movements are the main SM issue in residential spaces in Sri Lankan HEI sector. Different SM issues were determined in different functional areas in Sri Lankan HEI from the above analysis. Some common issues were identified in different functional areas but their behavior is varied according to functional area. Therefore, expert interviews were carried out to find out suitable SM strategies to implement in different functional areas in Sri Lankan HEI sector in order to overcome existing SM issues. six main SM concepts which can apply for Sri Lankan HEI sector were determined via literature survey and semi structured interviews, and also the applicability of those concepts to overcome the existing issues in order to recommend the suitable SM strategies under each concepts were illustrated in the Figure 1 and Figure 2. All SM strategies were proposed from FM perspective because of those were validated by the IC-PR-04 (FM in HEI Sector).

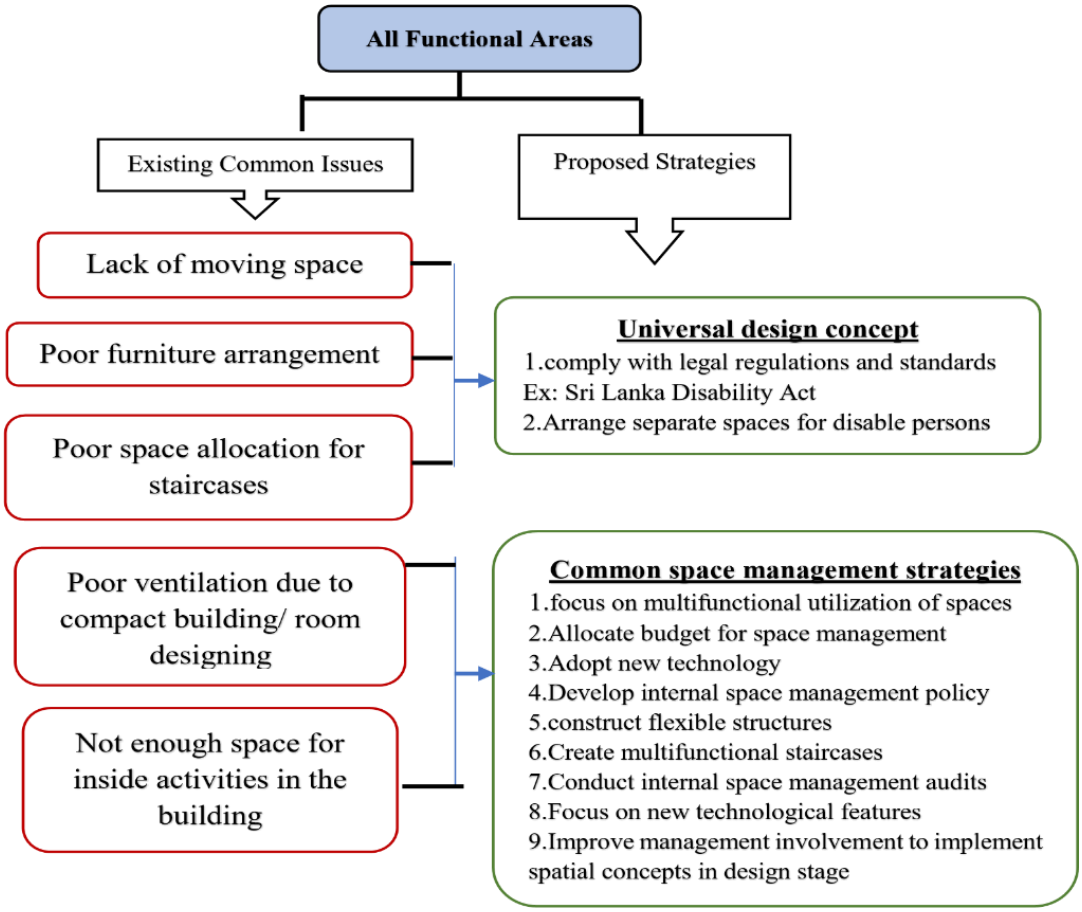

Figure 1 : All Functional Areas SM Common Issues and Suitable SM Concepts and Strategies.

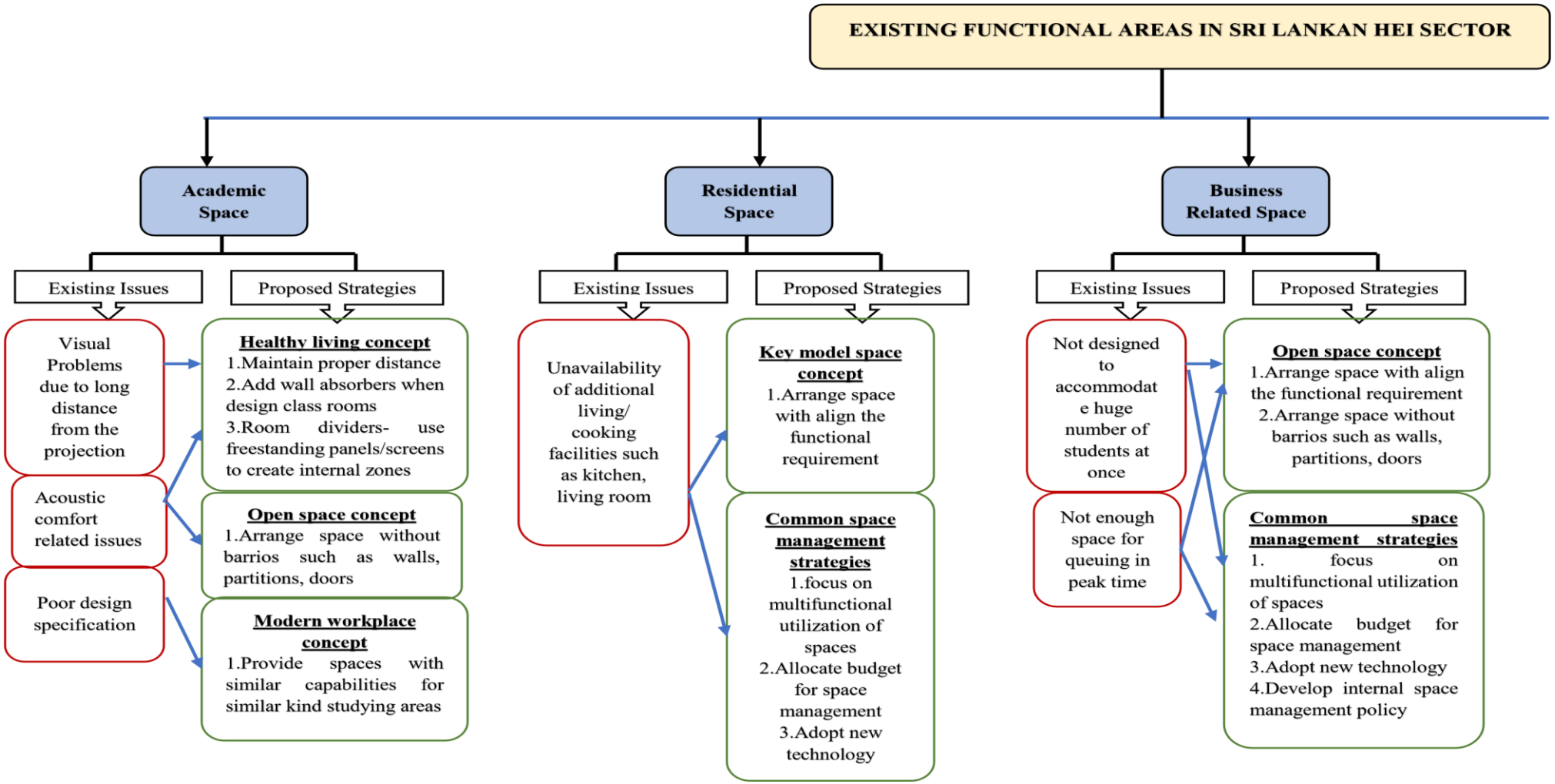

Figure 2 : Different Functional Areas SM Issues and Suitable SM Concepts and Strategies

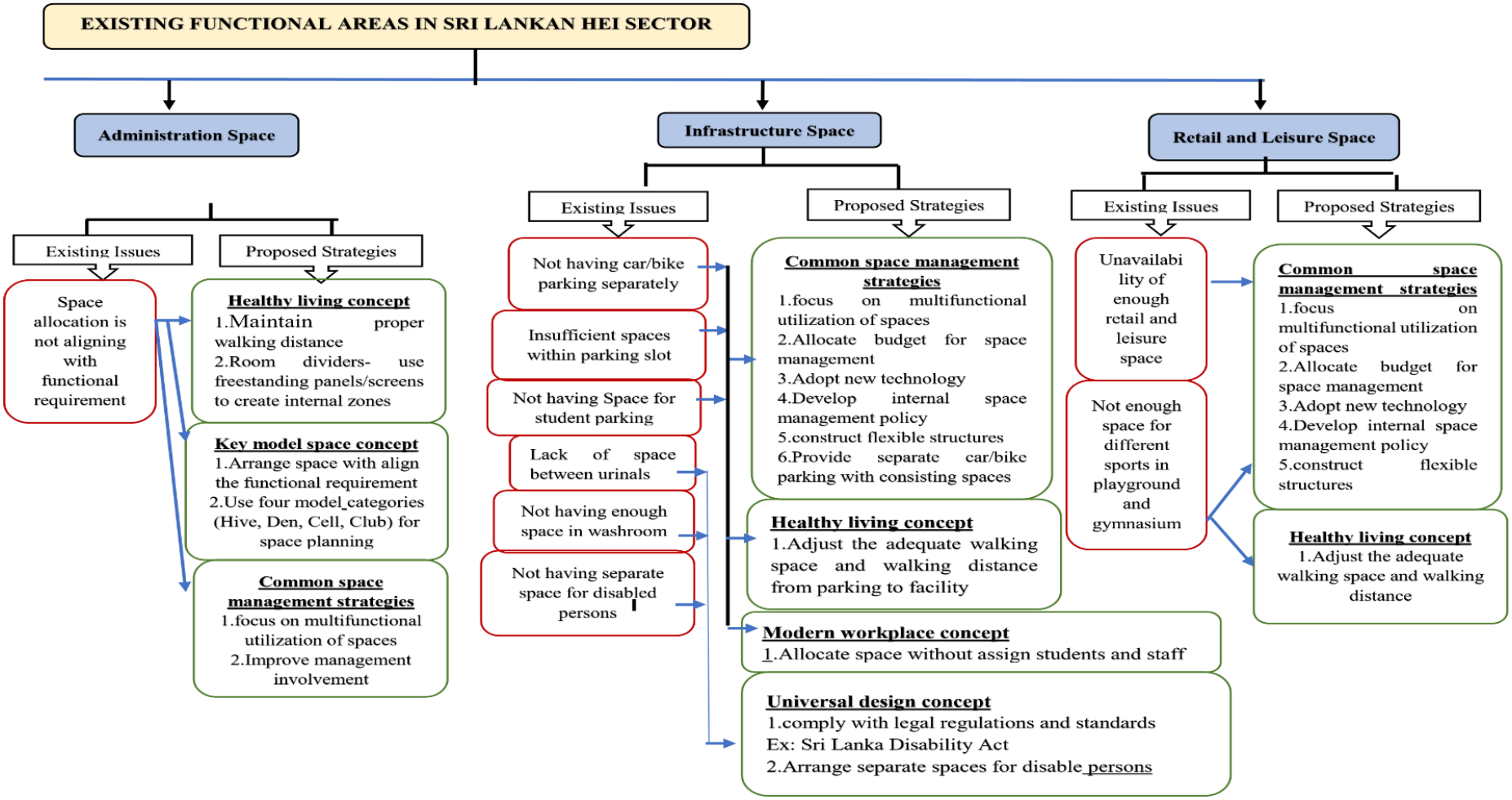

Figure 3 : Different Functional Areas SM Issues and Suitable SM Concepts and Strategies(Continued)

5. Conclusion

SM has significant impact on success of core business in Sri Lankan HEI's sector. Existing SM issues in different functional areas of HEI's are disturbed to achieve expectation level of core business in Sri Lankan HEI's sector. Lack of moving space, poor furniture arrangement, poor space allocation within building and poor space allocation for staircases are common issues in Sri Lankan HEI's sector. In addition, different specific SM issues in different functional areas in HEI's sector are determined through this study. FM has a significant role to provide suitable strategies to manage space in HEI in order to overcome the existing issues in Sri Lankan HEI. Therefore, suitable SM strategies and concepts such as healthy living, open space, key model space, modern workplace, universal design and common SM from FM perspective to overcome the existing SM issues in Sri Lankan HEI sector were given in order to investigate the impact of SM to core business of Sri Lankan HEI's sector.

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A STUDY OF ICONIC FEMALE SLEEVE STRUCTURES DURING THE COLONIAL PERIOD OF SRI LANKA.

BANDARA. A.M.H.N
University of Moratuwa, Colombo, Sri Lanka
hansanibandaran@gmail.com

Abstract
The research seeks to the evolution of the sleeve detail which is a completely exotic element of Sri Lankan female clothing culture and its structural evolution with the time and the lifestyle of the women. Sri Lanka had its own clothing culture for the females, which was influenced by the Indian attire based on "uttariya and antariya". It was a two-piece garment that could be worn with a specifically required draping method. It was upheld to the constructed garment with the colonial invasion and the European cultural imprint on Sri Lanka. With the colonialism, Sri Lankan society was driven based on the social class and caste domination, which needed to be interpreted with the attire. Based on that, the sleeve became a more identical element of women's attire in different social levels, which were existing in that time. According to the social hierarchy of Sri Lanka the society has been structured into 3 social classes, such as high class, middle-class and the working-class. The females of these high- and middle-class deliberately had been worn delicate attires that have prominent sleeves. The research will be focused on 'the sleeve' and its structural evolution with the colonial invasion. The research was based on the hypothesis that the lifestyle and social hierarchy was being iconized through the sleeve and its structure. The research is a qualitative driven and sampling was done with the purposive sampling method. In conclusion, it was realized that the aristocratic women had opportunities to inspire European new trends to stylish themselves, yet the lower caste women were lived with restricted clothing styles. The process was conveyed as descriptive researches as the methodologies were used are observations, analytical studies, field visits, and secondary data.

Keywords: *Lifestyle, Colonialism, Evolution, Social-classes, Women's sleeve, Fashion*

1.0 Introduction

1.1 CONTEXT AND BACKGROUND

The history of Sri Lankan female clothing culture goes back to ancient times. The history reveals that female clothing has been evolved by using the technique of draping and wrapping clothes over the waist.

During the Portuguese period, Sri Lankan female clothing was developed under specific terms such as Kabakuruththu cloth, Baju hattaya, saya, and bachchuwa.The saluwa was an item of dress and beeralu (bobbin) was a handmade lace technique. During the Dutch period, Sri Lankan clothing acquires different terms, tunics, and gingham skirts. During the British period, these dress styles were modified and developed with the British sartorial elements.

1.2 RELEVANCE AND JUSTIFICATION

Mainly focused on the colonial fashion influence in sleeve designs female clothing and the impact. After became a vassal state of Europe, the clothing culture became more structural and systematic.

The scope is to research on the alterations and imitations from European fashion culture for the female sleeve designs and its structural evolution with the time and the lifestyle of the women.

1.3 OBJECTIVES

Most prominent objective of the research is to study the unique sleeve details and their structures of day to day lifestyle the and investigate the impact towards the social hierarchy in the colonial period

1.4 THEORETICAL FRAMEWORK

The research will be done based on grounded theories of fashion adoption to probe the facts to analyze how the European clothing culture acquired by the Sri Lankan society.

The “Trickle Down Theory” coined by economist Thorstein Veblen in 1889, the trickle-down theory of fashion adoption assumes that fashion begins in the upper echelon of society. Styles worn by the wealthy change, and those changes are gradually adopted by the middle and lower classes. “ (Powell-Smith, 2019)

In Trickle Up theory the trend pushes its way up to the higher-income groups, and then to the runways of high fashion shows. Based on those theories the research will be carried out thoroughly.
“A more appropriate way to explain the trickle up theory is that it’s, a fashion that originates from the streets, or the lower-income groups” (Trickle-Up Fashion, 2019).

As the trend flows, women followed Victorian and Elizabethan styles to cover up their bodies to elaborate their class, wealth and beauty.

1.5 METHODS AND METHODOLOGY

The data gathering for the research will be done involving primary and secondary data resources. The data was gathered separately about the colonial influence of details in female clothes and its adaptation and evolution.

Secondary data will be gained from historical data, journals, actual time-related photographs in chateaus (*walawwa*) books, newspapers, academic research papers, and wall paintings in the British period (*Kathaluwa, Karagampitiya*), etc. The research is done based on the qualitative method

2.0 Literature Review

Evolution of Female Sleeve Jacket

2.1 WOMEN’S ATTIRE IN PRE-COLONIAL SRI LANKA

As the written and verbal relevance’s shown, the precolonial women’s attire was based on the “antariya and uttariya” even in the royal families in Sri Lanka. Before the colonial period, most of the *sandesha kawya* has revealed about the breast clothes that women have worn and the Uttariya that was thrown over the shoulder to cover the breasts. Though they have used such materials as cotton and silk. Silk clothes were most probably imported, and cotton was produced locally (Dian Gomes, K.G.D.Wimalarathne, 2001).

After the colonialization the Sri Lankan women were chosen to wear as the European style, so the attires became more civilized and controversial.

In ancient Sri Lanka had a weaving culture which is most related to the clothing of that period such as “*pada hela*” , lansolu (women), *Diya kachchiya*, etc. The sizes and shapes of the clothes woven by village weavers by their own (Dian Gomes, K.G.D.Wimalarathne, 2001).

Figure 1 Lansolu (draped over the shoulder) and Cloth made from Somana cloth

2.2 INTRODUCTION TO THE SLEEVE AND ITS BEHAVIOR IN SRI LANKA

2.2.1 What is a sleeve?
The sleeve is a "part of a garment which covers the arm, or through which the arm passes or slips" (Sleeves - Sleeve Definition - Definitions for the Clothing & Fabric Industry, 1999-2017).

During the Kandyan era, women wore a cloth which can be identified as the basic idea of *ohoriya*. The cloth has draped around the waist area and then the other edge of the cloth has thrown across the shoulder to cover the breast area and tucked again in the waist area.

Figure 2 Kandyan woman Image source - http://www.serendib.btoptions.lk

In the 19th century, a Czech artist Travik Frantisek (1877-1947) has done a painting series of sceneries of Kandy- *Dalada Maligawa* and around. The women who appeared in that paintings wearing a cloth across the shoulders (which can be considered as *Uttariya*).

Figure 3 Kandy Ceylon, oil-painting-three-women at the temple of candy-Ceylon - Image Source- http://www.tfsimon.com/Oilpaintings-in-miniatures.htm

As the literatures have shown, the majority of Sri Lankan women was being topless and there are no evidences of sleeve details during the pre – colonized Sri Lanka.

2.3 WOMEN'S ATTIRE IN COLONIAL SRI LANKA
Within the colonial imprint on Sri Lankan Society, it became more rebellious. "Especially among the higher echelons of society, there was no need for compulsion as there was an enthusiastic shift to Western dress. …the women embraced layered Victorian dresses with crinolines (stiffened petticoats) - also unsuited to the climate - and accessories such as hats, gloves, and umbrellas" (Island Dress, 2016).
Some puritanical influences came with Western colonial rule and the imposition of Judeo-Christian culture on the liberal tradition of Hindu-Buddhist culture that prevailed in ancient Lanka ."In the mid-seventeenth century under the influence of the puritanical Dutch, lace collars, frills, cuffs, and hemlines began to be freely used. Lace-making was introduced as a cottage industry " (Wickramasinghe, 2003).

3.0 Research Methods

To identify the parameters for the data collection the idea of qualitative research was purposefully selected. Documents or visual materials or both types which will provide the best answers to the research question.

3.1 OBSERVATION

In the research, multiple observations were done. The observations were recorded as descriptive notes with descriptive sketches, notes included a description of the physical setting, important features of the painting, or sculpture, photographs. With some sketch's series and toil experimentations distinctive details, parts, features, forms, and shapes were identified.

3.2 COLLECTION OF DATA

Data Collection Type	**Options within Types**	**Advantages of the Type**
Observation	Observer as participant	Can be recorded information as it is represented in the actual site.
Visual materials, Photographs, Mural paintings, Sculptures, Carvings	Unobtrusive method of collecting data. Provides an opportunity for researcher to share the reality with the objects.	Can observe the behaviors holding on to the actual time
Books /Documents	Publication documents such as minutes of meetings, newspapers Private documents as journals,	Can be accessed at a time, an unobtrusive source of information

4.0 Sleeve Type Analysis in Colonial Sri Lanka

4.1 ANALYSIS OF THE SLEEVES ACCORDING TO THE LENGTH LEVELS

According to the anatomical structure of the human body, the arm is an extended part which is built up for holding and grabbing support. The human arm can be divided into three main levels as its bending positions. As a fashion element, the sleeve is the part which is decorated or cover on purpose. As the sleeve originated to covers the arm, yet the sleeve has become the way of being fashionable which is more impact on the silhouette.

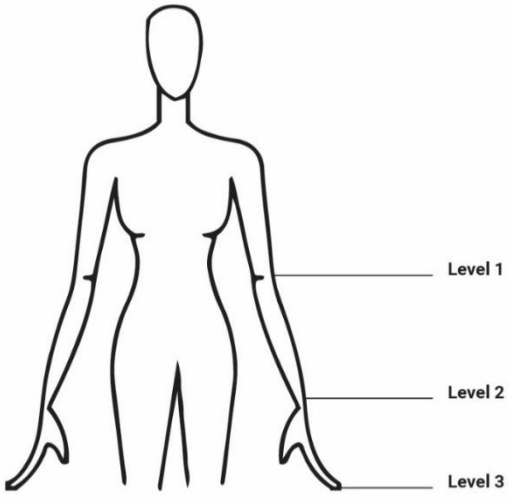


Figure 4 the levels of the sleeve length

According to the figure 05, the fashion silhouette of the female upper body, the arm can be divided into three levels.

- Level 01 - from shoulder end to the elbow
- Level 02 - from elbow to the wrist
- Level 03 - beyond the wrist

The method is used due to the behavioral qualities and the bending positions of the physical body.
Rather than the levels, the construction methods were depending in each era and will be described as below.

4.2 FOREIGN INVASION AND ITS IMPACT ON WOMEN'S ATTIRE

Portuguese landed in 1497 and during that era the middle-class people who were more dragged themselves to the tailored cut and sewn clothes in stylish way to European influence.

As a design element the bobbin lace techniques have been introduced in the Portuguese time and it was more mixed up in the southern coastal area. The name "beeralu" derives from the Portuguese word bilro (bobbin) (Cassim, 2016)

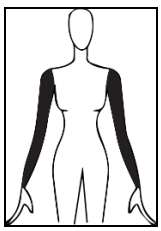
The sleeves used to be larger than the arm among the high-class women as royals. But it reflects the royalty, the pride and her royal lifestyle through it. (Figure 06)

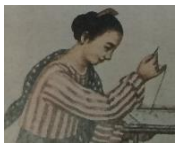
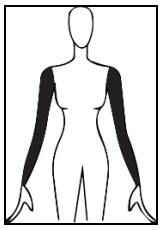
British period left the European cultural aspects for the Sri Lankan. The British turned the Lankan people to be Live as English. The people who belonged to the middle class instantly dragged and imitated the styles of British people and show their affection for the British.

Women transferred themselves to be worn as British ladies and tried to maintain "hourglass shape", especially in the "upper and urbanized "middle-class women enthusiastic towards the British influence.

The Ceylonese upper-middle and middle-class women chose the richest fabrics did unique add-ons such as the lace and embroidery work which was available at that time. They used the Victorian and Elizabethan style as the most iconic image and followed. The layers of dress and suiting required were impractical, sometimes uncomfortable but always beautifully fashionable. As the style came to the lower class as a result of the trickle-down theory only some elements were trans passed as sleeves, fabrics and trims.

5.0 Pictorial Analysis Based on the Three Sleeve Categories in Accordance with its Construction Basis

Time Period	Sleeve Level	Special features	Sleeve Type
Portuguese	 Level 2	- Way bigger than the arm - Shaggy lower part - Not much constructed	 Figure 5 Combination of Bishop and Mameluke sleeve

		-Simple sleeve structure with up turned hem	Dona Catherina - Image source – A true and exact description of Ceylon – Phillip Baldeous, 1672  Figure 6 Long sleeve with a turned-up hem- Baju Hettaya and camboy
Dutch	 Level 2	-Open at the hem -Simple sleeve structure	 Figure 7 Long fitted sleeve Native woman in Redda Hatte Image source – Hand colored engraving from Haafner, 1808. Galle-V.O.C. Vestinging in Ceylon, Lodewijk Wagenaar)
		-Fitted sleeve - Pufed upper arm expresses many layers had been worn underneath - Opened hem	 Figure 8 – Long Fitted Sleeve - A mestice woman - Image source – Hand colored engraving from Haafner, 1808. Galle-V.O.C. Vestinging in Ceylon, Lodewijk Wagenaar)
		-Fitted Sleeve -Not much constructed with the body measurements (Loosen upper arm)	 Figure 9 Long fitted sleeve A mestice woman (European and native mixed) -Image source – Original Engraving by Cornelis de Bruins,1711, Illustrations and views of Dutch Ceylon 1602-1796

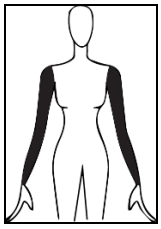
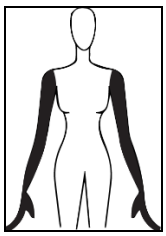
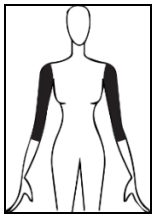
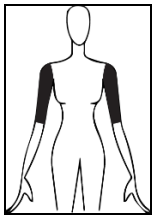
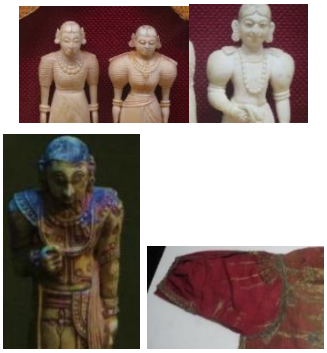
British	 Level 02	-Puffed sleeve usage -More identical part of the whole attire - Much fabric usage for the sleeve structures -Smocking, ruffles, gatherings make the sleeves unique from one to another - Variation of sleeves with unique elements Virago, Leg-o-mutton, Trumpet	 Figure 10 Long fitted sleeve- Image Source - Hindagala Temple  Figure 11 Long fitted sleeve- Image Source - Mulkirigala Temple  Figure 12 Leg-o-mutton sleeve- Image Source – The Twentieth Century Impressions of Ceylon  Figure 13 Leg-o-mutton sleeve- Image Source – The Twentieth Century Impressions of Ceylon  Figure 14 Puffed Trumpet Sleeve Image Source – The Twentieth Century Impressions of Ceylon
	 Level 03	-Sleeve structure made beyond the arm -Flowy silhouette -Edges finished with lace -Bias cut usage for frills -Puffing and gatherings made sleeve more larger	 Figure 15 Flounce sleeve- Image Source – The Twentieth Century Impressions of Ceylon

			 Figure 16 Two layered puff bell s sleeve- Image Source – The Twentieth Century Impressions of Ceylon  Figure 17 Angel sleeve- Image Source – The Twentieth Century Impressions of Ceylon
	 Intermediate level	-Sleeve stays between elbow and wrist -Puffed sillhouette -Used to start the sleeve with lace ruffles (at the shoulder area)	 Figure 18 Trumpet sleeve- Image Source – The Twentieth Century Impressions of Ceylon  Figure 19 Puffed trumpet sleeve- Image Source – The Twentieth Century Impressions  Figure 20 Marmeluke sleeve- Image Source – The Twentieth Century Impressions of Ceylon

	 Level 01	-Identical sleeve in the Kandyan era -Puffed look has got with the gatherings in the shoulder - Used to add extended ruffle part from the shoulder\ - Emboidery were used	 Figure 21 Puffed sleeves - Image Source- National Museum – Colombo, Kandy. Taken by Author
		-Puffed look gained from the to and the hem of the sleeve -Hem finishing was done with longer ruffles	 Figure 22 Puffed sleeves – Image source- The Twentieth Century Impressions of Ceylon
		-Fitted sleeve construction -Hemline was finished with embroidery	 Figure 23 Short fitted sleeves- National Museum- Colombo, Line drawings of the sleeve details – Taken by author

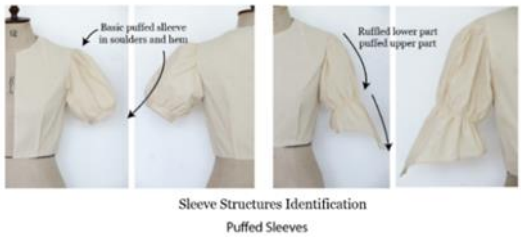


Figure 24 Figure 25 Studying the constructions by making toiles -Puffed Sleeves

Figure 26 Studying the Construction by making Toiles -Long Fitted Sleeves and Flounce Sleeve

Figure 27 Sleeve Construction with Single Pattern

Figure 28 Sleeve Construction with Two Patterns

Figure 29 Sleeve Construction with Three or many Patterns

6.0 Conclusion

The colonialization took the country to a different level which is more mixed, with the western cultural aspects, not only the clothing, also the religion, thinking patterns, philosophy, and the whole social network.

During the Portuguese era, the women's attire became more constructed rather than the pre-colonial clothing due to the cut and sew method which came from the Portuguese culture. Ex. The jacket and the cloth (baju, camboy) As a result of its simple sleeves were added to the jacket. With the culture, cut and sew method combined with the attitudes and willingness to be changed. The social status was shown with the structure of the sleeve. Even though the sleeve length remains the same, the level was iconized with the puffy look.

After the invasion of the Dutch, the Ceylonese people again conjunct with its culture. But the silhouette seems not to be more different from the Portuguese time sleeves. The sleeve of the Dutch era in women's clothing kept longer till the wrist. To express the class classification upper-class mestice women have worn the sleeve bit puffed which is more related to the leg-o-mutton sleeve yet the lower-class women worn the long-fitted sleeve.

The British cultural imprint took the women's sleeve to more complicated and garnished level. The sleeve was the most elaborate detail in the costume rather than the Portuguese and Dutch era clothing. The sleeves are more differentiated from one to another and each detail has given uniqueness to each sleeve. All the sleeves typically imitated the Victorian style of clothing which was arisen in Europe.

The Kandyan era has brought separately due to its uniqueness of clothing. Kandyan women used to drape a cloth as the "ohoriya" without a jacket during the pre-colonial era. But after the colonial impact, the women in the Kandyan Kingdom used to follow the foreign clothing adaptations. The sleeve types of Kandyan clothing was imitated the puffed sleeves and long sleeves. Even though the Kandyan era lasted from the Dutch period to the British period, the Kandyan culture has kept the limitations

dragged the suitable essence of the European culture. ”They patterned the jackets with different types of sleeves, necklines, collars, fastenings, and decorative trimmings such as frills, and ornamental cuffs with traditional designs and motifs.” (Karunaratne, 2014)

As a conclusion, the sleeves of the normal woman were done with an awareness of the social responsibilities which was expected from the society to be done. Due to that reason, the sleeve kept neutral. Even the sleeve was long or short, it kept flexible with the movements of the arms. The women who were in aristocratic families followed the fashion and the new trends which brought from Europe to stay stylish. As it comes to the British era the sleeve fashion was identical and stylish at its best. Most of the sleeves in low country aristocratic women kept the sleeve length, sometimes it was longer than the arms. The lifestyle of the aristocratic women always got the backup for their day to day life from the slave women who were willing to become slaves and lower caste women.

As the topic is about the lifestyle and social hierarchy of the woman were being iconized through the sleeve and its structure development (during the colonial period); the study is limited to the sleeve and not going further on analyzing the clothing styles in the colonial era. There is visible evolution on the sleeve part from the beginning to the end of the colonization.

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RELATIONSHIP BETWEEN CITY, CAMPUS DESIGN AND SOCIAL INTERACTION IN CAMPUSES OF HIGHER EDUCATION: A CASE OF GERMAN UNIVERSITIES

MITTAL YASH KUMAR[1], MITTAL SOBHAGYA[2]
[1]Malaviya National Institute of Technology, Jaipur, India
[2]Consulting Engineers Group Ltd., Jaipur, India
[1]*ar.yashmittal@gmail.com*, [2]*sobhagyamittal27@gmail.com*

Abstract
The relationship of an individual to the built environment is influenced by planning and usage of space. A higher education campus can be considered as a small city on an experimental scale. This paper presents a study of German campuses of higher education offering interaction between the city and campus occupants. The comparative analysis includes the examination of the campuses based on parameters like context, land use pattern, connectivity, walkability, social interaction, landscape, etc. The expression of a place in urban settings can be determined through the composition of buildings, open spaces, alleyways and the relationship between density and openness. The conscious creation of public space can harbor human interaction and encourage an environment, which reduces conflict and insecurity. It was observed that campuses that are closely interwoven with the city fabric provide many opportunities for social interaction and cultural exchange among scholars and city dwellers. On the other side, campuses that are located in the city outskirts have lesser degree of human interaction. This paper concludes that it is critical to determine and understand the behaviour and interaction of humans with their social and architectural environments. Inclusion of urban design principles during master planning, zoning, and phasing of campuses can enhance the quality of space and result in healthy interaction of users with built environment. This inter-disciplinary approach requires sensitivity towards societal changes and anticipation of future demands to create new spaces, transform existing ones, or connect new with the old.

Keywords: *Built Environment; Higher Education Campus; Campus Design; Public Space; Human Interaction.*

1. Introduction

An asset called education determines the level of prosperity, security, and welfare of residents of society. National ambitions, technology, urbanization have led us as a society where higher education enjoys a special place. Education is essential to achieve the national objectives of increased productivity, political and social integration, cultivation of moral as well as spiritual values, accelerated modernization, and raised living standards for all.

As a consequence, growth in the number of institutions imparting technical education was observed in Germany. Programs like engineering, technology, town planning and architecture, management, applied arts & crafts, etc. are covered under technical education.

Campus for Technical education requires infrastructure to sustain academics, administration, residential, recreation, and other requirements. Four to six important years of an individual are spent in campus environments. They are the years of maximum potential development and preparation for a life of service to the nation. University campus is a place where a student is confronted with realities of living and working with other people. It is an environment that provides wide variety of conditions for good relationships. Thus, it sets the stage when a student enters mainstream of life, bears his own responsibility, and makes his contribution to society.

Ideally, a university campus is a quiet, comfortable oasis apart from the busy, noisy, congested world. A campus can be compared to a city on a small scale because it provides for most of the needs of the community. Since campus is for people, it must be designed to measure of man himself, his physical dimensions, his senses, his habits, responses, and impulses. A well-designed campus enriches one's life not just through education, but also through non-academic experiences and other activities associated with college life. The physical setting of a campus undergoes evolution over a period of time with

changes and advancement in pedagogy. Various types of campuses respond differently to evolution in learning systems.

2. Need of the Study

A university campus is an environment where students with diverse social and cultural backgrounds live, study and interact. Being significant functional areas of the city, universities with sensible campus design thrive to accomplish both their academic and personal endeavors.

Previously, research and studies have been done about the perception of students regarding the physical development planning of their campuses (Razak, Mustafa, Che-Ani, Abdullah, & Mohd-Nor, 2011). Also, extensive work has been done in the domain of campus legibility (Turk, Sen, & Ozyavuz, 2015). Another study has discussed the major impacts of campus form on university objectives like learning outcomes, sustainability, student satisfaction, and safety. (Hajrasouliha, 2015)

Over the past few decades, campus design strategies have undergone evolution. This change has come in response to many reasons. The evolution of the methods of imparting knowledge in various disciplines has resulted in the development of a new vocabulary of the academic zones within a campus. One common example is the replacement of naturally lit lecture halls by lecture halls totally dependent on artificial light. This case can be considered as a change at the building level. Similarly, further changes can be identified both at micro and macro level.

The establishment of a university campus requires a considerable parcel of land where the university objectives could be achieved. The allocated parcel of land for a university and the location of that allocated land in the city or town also governs campus planning. The campuses established in the past have experienced growth and witnessed development in phases with time. The current study aims to determine the relationship between the city, campus design and social interaction in campuses of higher education in Germany.

3. Methodology

In order to understand the relationship between the city, campus design and social interaction in campuses of higher education, the methodological approach followed in this research is to first study the campus design literature. Common themes are distilled from the literature and specific parameters are considered for the analysis of case studies.

For the purpose of campus planning study, there is a wide range of elements that can be considered. Some of these include age of the institution, location of campus in the city, whether the institute is private or public, area of the campus, configuration of the campus, growth pattern within campus boundaries, scope of expansion, and surrounding.

4. Scope and Limitations

For the purpose of campus planning study, there is a wide range of elements that can be considered. Some of these include age of the institution, location of campus in the city, whether the institute is private or public, area of the campus, configuration of the campus, growth pattern within campus boundaries, scope of expansion, and surrounding.

5. Literature Study

(Hoeger and Christiaanse, 2006) discussed close relationship between campus and the city. Their book presents the case of transformation in the relationship between campus and the city. It discusses the concept of evolution of knowledge cities from the conventional university campus and host city. Apart from the direct contribution in development of city from social, economic, and cultural perspective,

universities were compared with thinking laboratories. It discusses the transformation of universities with an aim to rejuvenate and integrate themselves in the functioning of the host city. In addition, countries in Asia are witnessing increase in number of universities and these developments are leading to an evolution of different campus typologies characterised by innovation and synergies outside the academic context.

Chronological development of campuses was studied by Andrea Deplazes to highlight the potential of turning into a city. In a study with a similar approach, Kees Christiaanse mentioned the role of university campuses in growth and development of urban centres. The cases of Stanford and Silicon Valley were presented as case examples to validate the contribution of university campuses as a catalyst in city growth. Bindels and Lampugnani focused on the significance of spaces of public realm in urban areas. The presence of well-conceived public spaces in terms of connectivity, accessibility, and opportunities for exchange of ideas plays a key role in shaping a campus. Corneil and Parsons commented on the scope of public universities and private institutions to lead a major revitalization in campus and city. Henn, Wenyi and Yamamoto investigated the prospects of achieving a transparent and interactive campus using architecture.

The considered studies mention two contradictory trends. On one hand, the approach of designing campuses in synchronization with the urban setting and surrounding urban fabric is observed. This includes characterization of project elements in tune with the features of the surrounding. Such an approach values the transparency and open spaces for social and cultural exchange. The other school of thought mentions the gated community campuses, which function as self-dependent sub-cities.

Based on the literature review, both standalone and mixed campuses of Germany have been selected for the purpose of case studies. The following section comprises of description and comparison of identified aspects from literature study for different German campuses.

6. Case Studies

The Federal Republic of Germany enjoys a rich economic and cultural status with its efficient system of education. The technical universities have a significant contribution as the largest and most important part of this system. In Germany, the higher education system and research landscape are richly-structured.

TU9 in Germany is the association of leading institutes of Technology. The TU9 universities were founded in the age of industrialisation. An excellent reputation is enjoyed by these universities as they have played an important role in the development of science, engineering and technology. There has been a continuous growth in the number of students, a range of courses and the scientific potential of the universities over a span of almost 200 years.

6.1. RWTH AACHEN UNIVERSITY

RWTH University is located in the city of Aachen, located in the most western part of Germany. On the verge of this city, borders of three countries congregate, which makes this a unique centre for cross border knowledge and this constituency is noted for world-class higher studies in science and engineering. This university was established in the year 1870. It faced destruction during World War. RWTH Aachen University is mixed with the city fabric of Aachen and is spread at different locations of the city. The university contemplates the noble objective of transforming creative culture for the progress of society and innovation. The university is moving ahead on the policy of achieving global challenges and determined to place itself at the apex.

6.2. RUHR UNIVERSITY BOCHUM

The Ruhr University in Bochum was established in 1962. It was a time when the German higher education system was on a path of radical change. Also, it was the first new university to be established in the Federal Republic of Germany. Equal opportunity and democracy, as well as practical applicability

and interdisciplinarity, were taken into consideration by the founders of the Ruhr University. (Bode, Becker, & Klofat, 1995)

The establishment of Bochum University illustrated the transition of university life in Germany. Bochum region witnessed the beginning of remarkable development when the Ruhr University was established. Presently, the highest number of higher education institutions are concentrated in the largest industrial region of Europe, Bochum University being the centre.

The closely-knit configuration of faculties provides for healthy interaction between the scholars. Bochum University does not believe in independent and isolated functioning of the different faculties. The University is a firm believer in the idea of interdisciplinarity. Interdisciplinarity is strongly practiced and followed by the University. Bochum University has proved to be the origin of institutionalised technology transfer. This University has been successful in retaining both the determination to reform as well as the openness for innovative ideas.

6.3. BIELEFELD UNIVERSITY

Established in the year 1969, Bielefeld University is located in Bielefeld in the state of NRW (North-Rhine Westphalia) in Germany. Bielefeld University is located in the North-West part of the city close to a thick forest region. Earlier, Bielefeld was a linen-producing town located close to the Teutoburg forest. It was founded as a merchant town in the year 1214. Presently, the headquarters of Europe's largest social welfare institutions are situated in Bielefeld.

The University was started in the year 1969 with an aim for imparting research objective higher-level education with long term goals in transformation of learning and teaching. The University has contributed significantly to German Educational Restructuring with innovative approaches. In the decade of the 1990s, application-oriented disciplines and faculties of technology were introduced in the University. The University offers a wide range of subjects apart from Medicine through its 13 faculties. The University serves as a learning hub for more than 24,000 students including approximately 2000 international students.

7. Parameters for Assessment of German Campuses

7.1. CULTURAL AND SOCIAL CONTEXT

In early times, a majority of the universities were privileged and only special citizens coming from the noble class were obtaining education. Gradually, universities were made open to all citizens through large expansions in the academic scenario making them socially integrated. In the present context, university has become a part of everyday life. Although, a few institutions are still introvert.

In view of the cultural context of the university campuses, the structural organisation and spatial structures are of the same kind all over the world. However, weather conditions and regional-culture impart them few specific architectural characters, which is due to the traditional architectural styles and aesthetic implications.

7.1.1 RWTH Aachen University

RWTH Aachen University can be broadly zoned into three campuses namely Campus Mitte, Uniklinik and Campus Boulevard. These campuses are located in different parts of the city. Campus Mitte is closely interwoven with the city fabric of Aachen whereas Uniklinik and Campus Boulevard are located in city outskirts. Some of the key features of the university in terms of cultural and social context are:

- The campus doesn't have its own defined boundary in the city. Different faculties of the university are scattered throughout the city but the walkable city of Aachen and its efficient public transport system ensures smooth connectivity between them.

- RWTH Campus coexists with the city fabric and it provides ample opportunities for social interaction and cultural exchange among the scholars.
- The market area, restaurants, shops, cafes, places of leisure activities are in close proximity to the university area and therefore create liveliness on the campus.
- There is a high degree of interaction between the city and the university. The city plays a key role in fulfilling a number of basic needs of the student community.

If the standalone campuses and city campuses are taken into consideration, the recent development in the city campuses is happening close to natural landscape setting. Campus Boulevard is a new development in RWTH Aachen University. In campus boulevard, the existing countryside landscape has not been taken into consideration.

RWTH Aachen is featured with an iconic building known as 'Super-C'. This building exists in a nearby location of the main RWTH building. It is iconic for its specific features and sets the trend of adopting contemporary architectural style standing side by side of Neo-Classicism architectural styled RWTH Main building.

7.1.2 Ruhr University Bochum

Ruhr University Bochum has always lacked in terms of social interaction. People don't really meet each other and make friends in the RUB campus. Mostly, people meet each other in the mess. If RUB is compared with RWTH Aachen campus, then RWTH Aachen being a scattered and city campus provides ample opportunities and locations to people for social interaction.

According to Zaaijer (2007) - "Emptiness kills public space. So, it needs to be filled with life and charged with a variety of activities. The surrounding buildings provide this charge. Consequently, public space should always be a little cramped rather than too big, like pubs and kitchens."

Some of the key features of the university in terms of cultural and social context are:

- The Bochum University with its standalone campus is located in the outskirts of the city. This does not give the campus occupants an opportunity to interact with the city.
- The University and the city function individually as separate entities. The University campus exists as an isolated entity in the city and therefore the element of liveliness in the campus goes missing. Particularly, after the academic hours, it has been observed that the campus becomes a no man's land.
- The lack of vibrancy and liveliness in the university campus has resulted in unfortunate consequences. A number of suicidal cases have been reported in the past while becomes an alarming issue.
- For RUB, a designated area with the name Unicentre is located on the other side of the transit line. This place serves the basic needs of university scholars. It accommodates shopping centres, restaurants, shops, and cafes.
- The transit station for the university and mess are some of the few places on the campus with some degree of liveliness which provide opportunity for social interaction and cultural exchange.

7.1.3 Bielefeld University

Some of the key features of the university in terms of cultural and social context are:

- Bielefeld University is very different from RWTH Aachen University in terms of context, configuration of the campus, and opportunities of social interaction.
- It exists as an isolated standalone campus that limits interaction of campus occupants with the city. During the academic hours, the scholars remain confined within the university campus.

- Bielefeld University has got a unique feature of lively central zone which connects different faculty/department buildings of the university. There is a central area known as 'Uni-Hall' which connects different faculty/department buildings of the university.
- 'Uni-Hall' is accommodated with facilities like shops, restaurants, cafes, banks, exhibition areas, and uni-theatre. One end of the 'Uni-Hall' connects to the sports complex of the university.
- A swimming pool also finds a place in this hall. The central zone is well connected with the lecture halls and seminar halls. The library is also accessed through 'Uni-Hall'.

7.2. ASSESSMENT INDICATORS

The selected case studies are assessed *(Table 1)* on the basis of compliance with indicators including interwoven with city fabric, standalone campus, public spaces for social interaction, interaction with the city, provision of student accommodation within campus, mass attraction quality.

Table 1, Cultural and Social Indicators *(Source: Author)*

S.No.	Aspect	RWTH Aachen University	Bochum University	Bielefeld University
1.	Interwoven with City fabric	✓	X	X
2.	Standalone Campus	X	✓	✓
3.	Public spaces for social interaction	✓	X	✓
4.	Interaction with City	✓	X	X
5.	Provision of Student Accommodation within campus	*✓	X	X
6.	Mass attraction quality	✓	X	X

*Since, RWTH Aachen University campus is interwoven with the city fabric, therefore few options for student accommodation are available in the nearby vicinity of the city campus. *(Table 2)* shows comparative assessment for cultural and social context for the three case studies.

Table 2, Comparative assessment for Cultural & Social Context (Source: Author)

S.No.	Aspect	RWTH Aachen University	Bochum University	Bielefeld University
1.	Proximity to student accommodation			
2.	Proximity to market area, restaurants, cafes etc.			
3.	Degree of liveliness in campus			
4.	Proximity to amenities			

High Medium Low

8. Conclusion

Universities at Aachen, Bochum, and Bielefeld are the only universities in these cities and offer different courses of study in addition to technical courses. A number of cities in Germany are known for the existence of Universities in those cities. Such cities can be called as University cities. The student population in these universities constitutes a significant part of the city population. In case of Aachen, 18.45% population of the city is student population enrolled in RWTH Aachen University. The economy of the cities is also governed by the presence of this student population in the city. The city fulfills a number of basic needs of the student community and the expenditures incurred by the students form a part of the city economy. The city housing is also contributing to a large for the student accommodation, their lodging & boarding, leisure activities and fulfillment of fundamental needs.

It is also significant that German universities are good promoters for the intake of students from foreign countries, which in turn attracts foreign currency and contributes to socio-economic development. In Germany, if the densities of a city and campus are compared, it can be clearly seen that the campus has quite high density of students as compared to the overall density of the city.

Table 3, Population, Area and Population Density (Source: Author)

S.No.	City	Population	Area (sq.km.)	Population Density (persons per sq.km.)
1.	Aachen	2,45,885	160.85	1500
2.	Bochum	3,64,742	145.4	2500
3.	Bielefeld	3,33,090	257.8	1300

Table 4, Comparison of Universities on the basis of Student Strength and Campus Area (Source: Author)

S.No.	University	Student Strength	Campus Area (sq.km.)	Student Density (students per sq.km.)	Available Area per student (in sq.m.)
1.	RWTH Aachen	45,377	1.7	26,470	37.4
2.	Ruhr University Bochum	43,015	1.16	37,081	26.9
3.	Bielefeld University	24,875	0.78	31,891	31.3

9. Learnings for Practitioners and Researchers

- Campus buildings should be planned in such a way that they are having their self-identity so that they do not create any confusion among the users.
- Vehicular traffic should be designed in such a way so that it does not create any kind of sound or air pollutions to the university occupants.
- Faculty blocks should be so placed that they do not form isolated islands and should provide for creating chances of social interaction among the scholars and inter-department faculties.
- Recreational and Public spaces should be so placed so that they are functioning with closer cooperation between university and city.
- A network of paths between University Buildings and free spaces should be designed in such a way, so as to provide a pedestrian approach to any place within 10 minutes or 700 meters.

- Accommodation facility within or outside the campus should be well considered according to the changing socio-economic environment.
- A number of German Universities have tried to distinguish themselves by introducing Iconic buildings and it is unfortunate that they have neglected spaces available between these buildings, which should be well considered while designing a new campus or redesign of any existing campus.
- Empty spaces should be charged with a variety of actions and filled with life, through surrounding buildings and little cramped Public Spaces.
- The consideration of vehicular movement is a key component for the designing of campuses and in order to minimize the private car traffic, universities are well connected with the public-transit network of the city.
- Universities being a big establishment occupies large areas of land, often stands as strong organ of the city and becomes largest employer, should be designed to form a strong link with the urban format so that it could generate a strong base for regional development.

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ENHANCE THE DISASTER MANAGEMENT PROCESS THROUGH SOCIAL MEDIA

SHANDRASEHARAN A.[1], KULATUNGA, U.[2] & RATHNASIRI P.[3]
[1,2,3]University of Moratuwa, Colombo, Sri Lanka
[1]*mvarchchana@gmail.com*

Abstract
Disasters endure the economic and human losses emphatically around the globe in each year. Impacts of disasters are expeditious in the last decade due to the insufficiency of existing traditional Disaster Management (DM) tools. Social media as an internet-based platform and it is used as a critical tool for effective communication during emergency situations. This proposed research is mainly considered on Facebook and Twitter in terms of social media. Because, during the literature review and the preliminary expert interview, it is identified that the use of Facebook and Twitter is very much higher in Sri Lankan context compared to other available social media. Social media discovered as a vital factor to enhance DM in all over the world. To refer, Social media demonstrated its value as a viable complement to Indonesia's comprehensive disaster information management system for governments, by informing the public and creating public value through its communication speed, reach and information quality. However, the use of social media is not extensively explored in the Sri Lankan context. Hence, this research focuses on enhancing the natural DM in Sri Lanka and improve the quality of assistance provided to people related to natural DM through the use of social media.

A comprehensive literature review has been carried out to investigate the concept of social media and its relationship with DM. The literature findings contributed to develop the conceptual model pertaining for the study which highlighted that social media can be used in almost all stages of DM to enhance the process. This conceptual model will be used to develop the framework representing the method of social media application for natural disaster management in Sri Lanka. The use of social media for DM has number of benefits such as real-time communication, low level of capital investment requirement, provides useful situational awareness, early warning and supports the psychological well-being of disaster victims. However, limitations such as violates social policies, affects the social customs, quality and veracity of information could be compromised, and monitoring of accuracy of information transmission is complex were also reviewed from the study.

Keywords: *Disasters, Disaster Management, Social Media, Sri Lankan Concept*

1.0 Introduction

Disasters are celestial intervention in disguise. It is an extreme level of destruction and adversity that affects the social fabric emphatically (Rautela, 2006). A proper DM is required to safeguard from such disasters. Traditionally, DM was based on predetermined disaster plans while they were insufficient (Lauras, Benaben, Truptil, & Charles, 2013). Hence, Hartama et al. (2017) and Lauras et al. (2013) stated that, issues involved in the traditional DM systems (DMS) can be resolved through the incorporation of new information technologies. Nowadays, the DMS is in the pinnacle of popularity in DM which has incorporated information technologies in order to improve the DM (Lauras et al., 2013).

However, these techniques are only effective up to certain level. To refer, warning alarms will disseminate the massages to the nearest affected places only. Even though several modern techniques available for DM, challenges regarding them are inevitable too (Reyes, Corona, & Peña, 2010). Pathirage et al. (2012) argued that, those challenges need to be managed appropriately in order to consummate future disasters successfully. Recently, researchers have drawn much attention on social media as it is identified as one of the major solutions for the enhancement of DMS (Chik, 2011). Kim et al. (2016) explained the social media as an internet-based platform and it is used as a critical tool for effective communication during emergency situations. Also, Kim et al. (2016) demonstrated that, social media is potentially vital to enhance the effective communication in DM, as it promotes the information sharing and dissemination in a rapid manner.

The Government of Sri Lanka was not effectively assimilated with natural disaster management, prior to the Indian Ocean tsunami on 2004 (Careem, Silva, Silva, Raschid, & Weerawarana, 2007). In addition to the above statement, requirements of an effective national DMS for Sri Lanka also emerged as an

important concern after the tsunami disaster (Disaster Management Centre [DMC], n.d.). Disaster Emergency Warning Network (DEWN) is the first mass alert Early Warning System (EWS) in Sri Lanka, inaugurated by the DMC together with Dialog (Dialog, n.d.). Though, the idea of integrating social media with the DM could be an effective process, it is not highly focused in Sri Lanka (Kodippili , 2014).

Accordingly, this paper is aims to enhance the natural disaster management in Sri Lanka through the social media by recommending a framework representing the method of social media application for natural disaster management in Sri Lanka This paper is structured as follows. First a discussion on the disaster, DM and social media is given in detail. Then it is followed up with Sri Lankan context of DM and the use of social media in DM. through this discussion, the need for the social media in DM in Sri Lankan context and the importance of this paper is validated.

2.0 Disasters

2.1 DEFINITION OF DISASTERS

Disasters are damaging events that end in requirement for a good vary of emergency resources, to help and make sure the survival of the stricken population (Geale, 2012). McEntire (2014) defines disasters as hazard which overwhelms and causes imbalance to the human's magnanimity. In fact, disasters can happen without any prior notice and can be classified as a dangerous and catastrophic incident, which devastates and disrupts infrastructures (Salamati Nia & Kulatunga, 2017).

2.2 TYPES OF DISASTERS

According to Shaluf (2007), disasters can be categorized mainly into three types such as natural, man-made and hybrid. Natural disasters are, catastrophic event caused by natural causes, where humans cannot control, whereas man-made disasters refer to non-natural violent upheaval that can be an abrupt or more long-term (Shaluf, 2007). Shaluf and Ahmadun (2006a) explained, disasters which occurred due to the combination of both human error and natural forces as hybrid disasters. Among the three types of disasters such as natural, man-made and hybrid, natural disasters carry major consideration in depth in this proposed study. Because, Natural disasters have become inevitably important issue in urban areas (Hartama et al., 2017).

3.0 Disaster Management

3.1 DEFINITION OF DISASTER MANAGEMENT

Disaster management (DM) is defined as a whole process which is related with planning and responding to disasters, including pre-disaster and post-disaster activities (Shaluf & Ahamadun, 2006b). DM process is a combination of administrative decision making, the operational procedures, the actors and technologies that integrate with each phases of disasters (Lettieri, Masella, & Radaelli, 2009). In addition, this process also encompasses the risks and consequences of disasters as well (Shaluf & Ahamadun, 2006b). Natural disaster management is a kind of a cured process which diminish the curses of a community because of these devastated natural disasters, relative to its pre-disaster condition, as much as possible (Chatfield & Brajawidagda, 2013).

3.2 STAGES OF DISASTER MANAGEMENT AND ITS EVOLUTION

According to the study of Moe and Pathranarakul (2006), DM includes five phases such as prediction, warning, emergency relief, rehabilitation and reconstruction. However, McLoughlin (as cited in Hartama et al., 2017) stated that, preparation, response, recovery and mitigation are the four main stages established for DM operations. Preparation refers the preparedness activities like early warnings which are designed to give a proper alert prior to the destruction and to ensure that organizations and communities are ready to respond to disasters in a timely and effective manner (Chatfield & Brajawidagda, 2013). While in the response stage evacuation has been carried forward combined with sudden activities like search and rescue to provide emergency assistance to victims (Hartama et al.,

2017). Recovery can be done as a short term or a long-term recovery process to indemnify the victims who are affected by the disasters to at least their pre-disaster situation (Chatfield & Brajawidagda, 2013). Mitigation is the process which includes the activities that are undertaken in the long-term time period between two disasters where one has gone with much destruction and the other one is yet to come and designed to prevent emergencies and reduce damage caused by emergencies (Hartama et al., 2017). Khan and Ali (2001) pointed out the stages of DM as prevention, mitigation, preparedness, response and relief, rehabilitation and reconstruction. However, Levinson and Granot (2002) summarized these stages of DM as warning, impact, emergency and recovery. Shaluf (2008) endorsed the statement of McLoughlin, however, the terms used for the interpretations of stages is used as preparedness, mitigation, recovery and response.

3.3 FACTORS AFFECTING DISASTER MANAGEMENT

Develop a framework of technique for evaluating the influence of natural disasters in a systematic manner is imperative (Hashem, et al., 2016). By doing a proper forecasting on these threatful natural disasters accommodated with an effective DM process, we can reduce the consequences from the natural disasters up to certain possible extent (Shaluf & Ahmadun, 2006a). Further, proper DM will afford a timely, effective, culturally sensitive, and gender-appropriate response (Geale, 2012). In order to have such proper DM, the factors influencing DM should be clearly identified.

Disaster knowledge factors are defined as facts that improve the knowledge of managing disasters successfully (Moe et al., 2007). Therefore, they will directly or indirectly have an effect on the method and outcomes of DM. Moe et al. (2007), categorized these knowledge factors as technological, social, environmental, legal, economical, managerial, institutional and political DM process integrates the technological factors in it's all stages itself. Each of these factors have their own challenges in DM. How those factors pretend as the challenges in DM are discussed below.

3.4 TRADITIONAL DISASTER MANAGEMENT

The traditional strategy to DM has been to treat it as variety of phased sequences of action or a continuum (Al Kilani & Kobziev, 2016). The traditional approach consists the series of humanitarian activities starting from rescue teams, materials and medical services very quickly once the disasters have created damages to the particular place (Alazawi et al., 2014). According to Alazawi et al. (2014), in a traditional DM, selection of a network path carried randomly while this random selection will be the least hectic routes and adopted by most of the decision makers as their familiar path.

3.5 CHALLENGES OF TRADITIONAL DISASTER MANAGEMENT

Pathirage et al. (2012) stated that traditional DM has to be improved a lot in order to cater its challenges as it is lacking with most of its effectivity to deal future disasters successfully. As the disasters cannot be predicted earlier, it is impossible to neutralize their negative impacts, though the consequences from those impacts can be prevented with proper strategies (Moe et al., 2007). These strategies consist of understanding on DM strategies, collectively with sensible practices and sophisticated lenitive measures and readiness designing (Moe et al., 2007).

Traditional DM systems are ineffective with the dissemination of disaster information as the random selection of a network route is consuming ample time when processing and makes the emergency strategies more difficult to be implemented (Alazawi et al., 2014). Here, network rout refers the method through which the information is disseminated. Oloruntoba (2005) stated that, technology is one of the major concern which affects the effectiveness of DM where, traditional DM is lacking in particular and traditional DM system should incorporate with cost effective and proactive technologies which will enhance the performance of the DM.

Pathirage et al. (2012) stated that, technological integration on the DM should be enhanced in terms of its decision making to implement an effective DM system. further, Pathirage et al. (2012) mentioned

that, the relevant knowledge and skills on the DM should be empowered with much excellence and also align with its needs as well. In order to validate the above statement, Wilkinson (as cited in Pathirage et al. (2012)) opined that laws related to the DM shoud express the humanitarian aspects anf if not so, it will become unsuccessful and ineffective. Further, Pathirage et al. (2012) highlighted the lack of detection and warning systems, need for powerful schooling, requirement for frequent updating of disasters associated laws, loss of price range for financial making plans measures and bad conversation as the key challenges in traditional DM.

Hartama et al. (2017) stated that, DM should deal with technological resources for the effective result. Further, lack of information inside the occasion of a disaster can cause to slow access, useless and negligent post-catastrophe recuperation (Ang & Seng, 2016). Following section discusses about evaluation in traditional DM with respect to overcoming the challenges.

3.6 MODERN APPROACH FOR DISASTER MANAGEMENT

Information technology helps the maintenance of natural resources and improved first-class of life (Walravens, 2015). Hartama et al. (2017) endorse service discovery and reservation engineering for cell ad-hoc community designed to assist disaster restoration and army environmental operations. Sensor structures can generate huge catastrophe records, human beings, environments, and so on from smartphone gadgets that have exceptional capacity to convert city communities (Ang & Seng, 2016). The system is constructed to forecast public mobility or evacuation in affected towns and may inform future DM techniques (Granell & Ostermann, 2016). However, this system will be ineffective when there is a miscalculation from the satellites used in Global Positioning System (GPS) transmitter (Hartama et al., 2017).

According to the literature, though modern techniques are evolved, they are not providing solutions for all the issues of traditional DM. To refer, Geographical Information System (GIS) applications, which are used to assist the use of information collected from GPS, still place a secondary specialise in knowledge preparation and exploration of unfortunate impacts (Granell & Ostermann, 2016). Because, the performance of the systems become unreliable due to the inaccuracy of GPS transmitter (Hartama et al., 2017). Further, DM uses a multi-institutional method as coordinated multidisciplinary response will verify that the required assistance arrives at the proper location at the right time (Geale, 2012). This improvement is highly expected in the warning stage of the DM. Because, effective and efficient warning stage minimize harm, damage and build resilience (Cinnamon, Jones, & Adger, 2016).

4.0 Social Media

4.1 INTRODUCTION TO SOCIAL MEDIA

The use of social media in disasters around the world has been well documented and established all over the world (Palen, Vieweg, Liu, & Hughes (2009); Queensland Police Service (2011)). Social media are continuously developing communication tools and connections in all regions of existence (Taylor, Wells, Howell, & Raphael, 2012). Social media technologies are with the aid of their very nature decentralized, distributed, and networked in form, with millions of customers at a couple of points of records manufacturing and consumption (Chatfield, Scholl, & Brajawidagda, 2013). They are acting as a conduit in terms of positioning human beings to legit sources of records and magnifying these messages to a broader target audience media (Taylor et al., 2012).

The growing use of ‘smart phones’ has been recognized as an essential factor enabling access to social media (Taylor et al., 2012). Because, social media refers to an internet-based platform that permits users to engage with every other via introduction of content such as textual content and video (Mergel & Bretschneider, 2013). As Dufty (2012) stated, social media depend on peer-to-peer networks which are corporative, decentralised and network pushed. Involvement of social media may be seen as the interplay of components of the both technical and social systems (Oliveira & Welch, 2013).

4.2 IMPORTANCE OF SOCIAL MEDIA FOR DISASTER MANAGEMENT

Social media promotes information sharing and dissemination which can support the psychological well-being of disaster victims (Taylor et al., 2012). A few case studies show that social media played positive roles in information sharing and dissemination in disaster responses (Dufty, 2012). Further, Samarajiva and Waidyanatha (2009) validated the importance of social media by recognizing it as the primary means of public warning. Social media tools not only useful for sharing disaster information but also emotionally supporting affected communities and victims under disasters situations (Dufty, 2012). One important aspect of social media is that it does not always require huge capital investments by the organization (Oliveira & Welch, 2013). During the 2011 series of natural disasters in Australia, New Zealand and Japan, the importance of social media emerged sharply as a powerful communication channel for emergency management and response media (Taylor et al., 2012). Examples of social media include blogs, discussion forums, chat rooms, wikis, YouTube, Channels, LinkedIn, Facebook, and Twitter (Dufty, 2012).

According to Taylor et al. (2012), there are two aspects of social media of particular relevance to their use in the context of natural disasters. Namely, their ability to provide access to timely public safety related information from official and informal sources and other one is their ability to enable connectedness. Where, both of these characteristics are expressing about the existence of real-time communication in social media. As the concept of Early Warning (EW) is also related to such real-time communication, the above discussed features of Social media hiddenly interpret its suitability for the EW process. Social media allows users to report information about emergency situations to emergency management organizations and users in real time (Kim et al., 2016). The strengths of social media were highlighted during the Japanese Earthquake response (Kim et al., 2016).

4.3 CHALLENGES IN USING SOCIAL MEDIA

Historically, the public has trusted traditional media outlets like television news, local newspapers, and local radio to get critical information regarding local emergencies (Kim et al., 2016). Although social media is being popular in all over the world, there is still a strong interest for emergency information via traditional forms of media, especially television media (Taylor et al., 2012). Because, there are several limitations in social media communications.

Kim et al. (2016) identified, trustworthiness of information delivered via social media as one of the administrative challenges in DM. Allowing users to easily edit and manipulate the content of information, requirement on checking the violation of policies, and need of monitoring to avid inaccurate information transmission are the challenges identified in MD. Dufty (2012) and Lindsay (2011) also stated that, there are potential issues of trust and misinformation that will need to be managed by emergency agencies when using the more ‘open’ social media. Hence, this raises the question, is it worthwhile to use social media technology to improve the resilience. According to Kim et al. (2016) public and emergency management literature pays attention to the potential or actual roles of social media. While there are various types of social media, this study focuses on Facebook and Twitter which are identified as popular social networking and blogging systems by Kim et al. (2016). However, there are several researches carried out to interpret the use of social media. Following section will identify such researches and their key outcomes to validate that social media is effectively usable for DM.

4.4 EXISTING USE OF SOCIAL MEDIA

The use of social media is an evolving phenomenon and it has become widespread and can serve a variety of purposes (Lindsay, 2011). This section will discuss the existing use of the social media all over the world for the DM and EW by elaborating the key outcomes of researches.

Queensland Police Service (2011) described the social media as the vehicle to reach the public and the media in the shortest time frame. The Queensland Police are world leaders now in the use of social media in disasters. Lindsay (2011) considered the use of social media for emergencies and disasters on

an organizational level may be conceived of as two broad categories. First, social media can be used somewhat passively to disseminate information and receive user feedback via incoming messages, wall posts, and polls. Second approach involves the systematic use of social media as an emergency management tool. Systematic usage might include, using the medium to conduct emergency communications and issue warnings, using social media to receive victim requests for assistance, monitoring user activities and postings to establish situational awareness, and using uploaded images to create damage estimates, among others.

McEntire (2014) found that flood-related tweets that contain more useful information for situation awareness are significantly closer to flood-affected regions than others. Chatfield et al. (2013) stated that, while the type of social media use studied varies widely from Facebook, Twitter, blog, web forum, photo sharing, microblog and SharePoint, it appears that Twitter is the most frequently used social media channel in disaster situations. According to Chatfield and Brajawidagda (2012), twitter-based warning system demonstrated its value as a viable complement to Indonesia's comprehensive disaster information management system for governments, by informing the public and creating public value through its communication speed, reach and information quality.Kim et al. (2016), analyzed the provision of disaster information on social media such have a positive effect on the perceived level of organizational resilience. Further, Kim et al. (2016) found that, if community members are widely connected via a social media network, the effects of information sharing and emotional support through social media use will be heightened. If most residents do not follow the information on the social media website currently, emergency response organizations need to educate and encourage residents to be connected to the social media websites.

5.0 Sri Lankan Context

It was pointed out that the occurrence of disasters from almost all kinds of hazards is among the highest in Asia and the Pacific (Shaluf & Ahmadun, 2006a). Further, Dutta and Basnayake (2018) in the recent research, validated the importance enhancing the EWS in Southeast Asia. The 2004 Indian Ocean tsunami that claimed the lives of 35000 of Sri Lankan people and displaced one in twenty has highlighted the critical importance of an effective National Early Warning System for Sri Lanka (DMC, n.d.). Because, Warning is a crucial component of the overall risk management system that failed in the 2004 Indian Ocean tsunami (DMC, n.d.).

Further, Kurita et al. (2006) stated that, this created an umbrella organization called the National Council for Disaster Management and provides a framework for disaster preparation and response in Sri Lanka. Sahana is a free and open source software application adopted in Sri Lanka, for relief operations, recovery and rehabilitation (Careem et al., 2007). However, according to Careem et al. (2007), Sri Lanka is not potentilly capable in terms of incorporation of information and communication technology for DM solutions. DMC is the main focal point responsible for coordinating EW in Sri Lanka which operates its performance through the Emergency Operation Centre (Samarajiva & Waidyanatha, 2009). In the present, EW dissemination is performed through Nation-wide Emergency Communication System used in Sri Lanka (DMC, n.d.).

Dutta and Basnayake (2018) stated that, the sequence of events has shown that although DMSs are in place in the region but the effectiveness of these systems in terms of timely and meaningful dissemination of warning information have been found to be considerably weak resulting in considerable gap between warning dissemination and response. Further, the literature found with respect to DM is validated by an interview with experts in DM. Through this interview, it was identified that, there is a requirement for a usable social media application for the DM. Hence, it is evident that, there is a requirement and expectation by the relevant organisations for the adoption of social media in DM.

6.0 Conceptual Framework

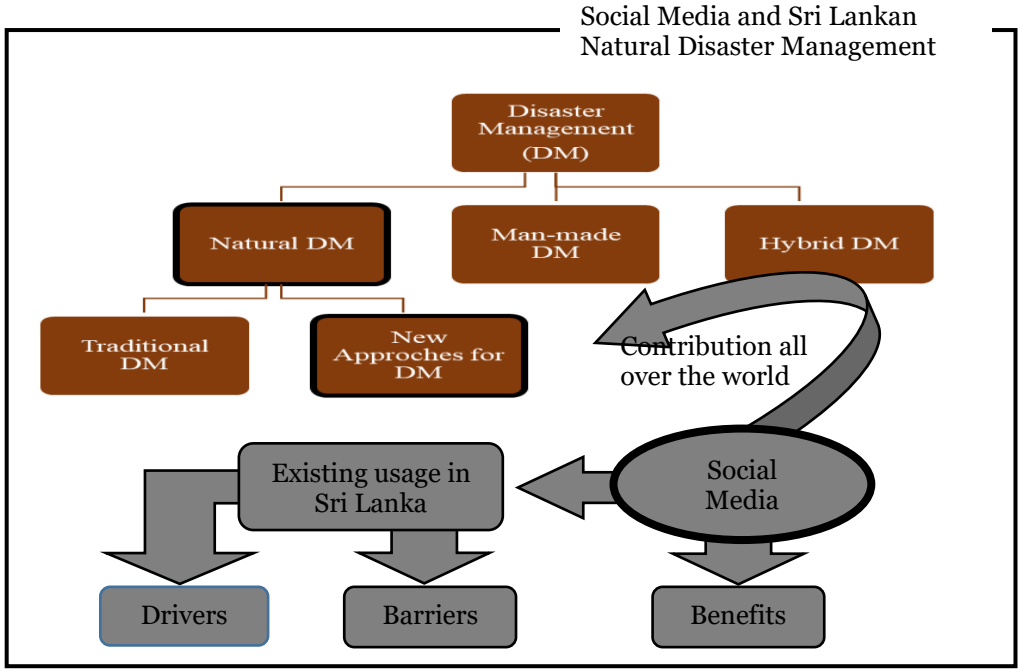

Figure 1 : Conceptual Framework

Figure 3 interprets the conceptual framework that is presented for the study under consideration. It is prepared based on the knowledge prepared through the literature review. As interpreted in the Figure 1, this proposed research's key areas are natural DM and the social media. Hence, by discussing about the DM, the importance of consideration on natural DM is discussed. Further, followingly, the traditional method of natural DM and modern approach are discussed. Later, the concept of social media and its contribution to the natural DM supported with literature findings.

7.0 Conclusion

Disasters are severe distractions of the society, and it causes many adverse effects. These adverse effects by disasters over the past decades are extensively corroborated by many researches. Thus, a proper DM is required to safeguard from such disasters. There are several challenges in traditional and even the existing modern DMS. Social media has been identified as one of the major solutions for the enhancement of DMS. All over the world, use of social media for DM enhancement is well established. Though social media is used in SL, it is not effectively utilised for DM yet. Social media will contribute to DM by enhancing the flow of disaster notification in efficient and effective manner within a short period of time to huge number of audiences.

As a way forward, to focus on the Sri Lankan context, the existing usage of social media and barriers and benefits related to adoption of social media for natural DM in Sri Lanka will be analysed through the data collection and analysis. Finally, to achieve the aim of the study under consideration, framework will be proposed to by addressing the analysis results to enhance the natural DM in Sri Lanka through the use of social media. Ultimately to achieve the aim of this study under consideration, a framework will be proposed by addressing the analysis results to enhance the natural DM in Sri Lanka through the use of social media.

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A STUDY ON MOST ABUNDANTLY UTILIZED TIMBER FOR STRUCTURAL APPLICATION IN SRI LANKA

SUDESHIKA D.M.P.[1], MENDIS M.S.[2] & HALWATURA R.U.[3]
[1, 2, 3]Department of Civil Engineering, University of Moratuwa, Sri Lanka
[1]*pavithrasudeshi@gmail.com*, [2]*malsharesearch@gmail.com*, [3]*rangikauh@gmail.com*

Abstract
Day to day demand for timber is increasing as a natural construction material due to its performance, stability, aesthetic, durability and been environmentally friendly. Different timber species have distinct characteristics and those are selected for different applications based on their characteristics. Value of timber varies with physical and mechanical properties and their quality can be improved by thermal and chemical modifications. An industrial survey was conducted to identify most abundantly utilized timber for structural applications in Sri Lanka. Industrial survey was conducted as two distinct surveys such as clusters-based survey and the company-based survey. Under cluster-based survey, 23 clusters; saw mills and treatment plants which were located in Moratuwa, Moratumulla, Koralawella, Pannipitiya and Swarapola were selected. For company-based survey, 3 companies in Colombo district following international standards contributing on large scale were selected. Research discussion conveys demand for application of imported timber has been increased because the availability of locally sourced structural timber is rare and expensive. Treated local timber has been popular due to its high durability resistance to the pests and their dimensional stability. From the industrial survey data, brushing, spraying, kiln drying; dipping and impregnation were identified as utilizing preservative techniques which have been using in Sri Lanka. Different species have been popular for different structural components in structural application. Based on cluster-based survey for the results revealed different timber species for different timber applications; rafters- Palu timber, beams- Kempass timber, reapers- Alastonia timber and door/ window frames- Jak timber were mostly utilized. And results from company based survey mostly utilized timber are Jak timber for rafters, Jak timber for beams, Ginisapu timber for rafters and variety timbers such as Ketakela, Mahogany, Jak and Teak for door window frames.

Keywords: *Industrial survey, structural timber, thermal modification, chemical modification*

1. Introduction

Lumber or timber is well known to be a structural wood that has been turned into planks to be used as building material and carpentry works. So does the day to day demand for timber is increasing as a natural construction material due to its performance, stability, aesthetic, durability and environmentally friendly. Timber has been categorized as hard wood; Jak, Mahogany, Teak, Alastonia, Rubber and soft wood. Examples for hardwoods are and for soft woods are Pine, Fir and Cypress. In Sri Lanka, timber species have become popular for various applications and functions based on its unique characteristics. Quality of timber varies according to physical and mechanical properties and their quality can be further improved by chemical and thermal modifications. Different chemical and thermal techniques are available all over the world. Either to be chemical or thermal treating is decided on based on effectiveness, timber specie and cost. Under chemical treatment three methods are available; under surface applying brushing and spraying, dip and impregnation (Townsend, 2016). The available thermal treatments are Thermo wood process, Rectification process, Les Bois Perdure, Plato process and OHT (Oil Heat Treatment) process (Sidorova, K., 2008).

1.1. TIMBER

Wood is fibrous material with heterogeneous and anisotropic properties which is the main substance of the trunk and branches of the tree (Nairn, 2008). Lumber or timber is a structural wood that has been turned into planks to use as a building material and ready for carpentry works (Osuji and Nwankwo, 2017). Sawing pattern depends on axial and radial density variation of wood.(Mendis, Halwatura, Somadevaa, Jayasinghe, & Gunawaardana, 2019 December) Sapwood is the living outermost portion of a wood trunk or a branch, while heartwood is the dead inner wood (Snyder, 2017).

Wood cell walls are composed of micro fibrils of cellulose, hemicellulose and lignin (Praveen, 2012).

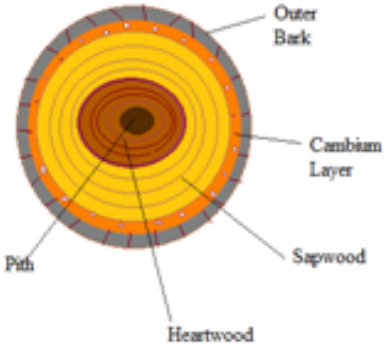

Figure 1, Macro structure of wood (*source: Ramage, Burridge, & Busse-Wicher, n.d.)*

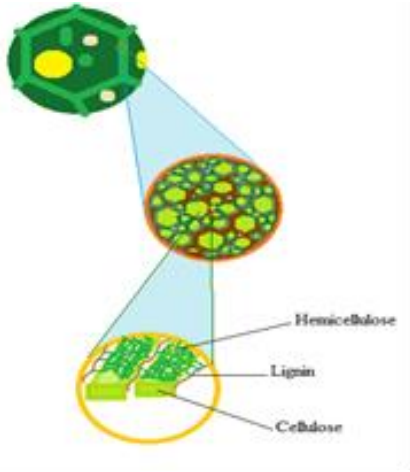

Figure 2, Micro structure *(source: Praveen)*

1.2. MECHANICAL AND PHYSICAL PROPERTIES

Physical properties of wood refer to macro structure of wood that includes colour, texture, odour, moisture, cracking, swelling and shrinkage. The mechanical properties refer to strength characteristic of wood. Mechanical properties are stiffness and elasticity, tensile strength, crushing or compressive strength, shearing strength, bending strength, toughness, hardness and resilience (Mendoza, 2014).

1.3. CHEMICAL MODIFICATION OF WOOD

Main function of chemical modification is the reaction between chemical agents and polymeric components of timber forming a strong bond between the chemical reagents and cell wall polymer. Except the monomers polymerization in the basic structure of lumen which will engage in cell wall penetrating but not the wall cross linking. Lumen filling is well known that would influence the improvement of the properties of timber specially the mechanical (Rowell, Roger M., 1983). Chemical modifications by externally applied chemical reagent react with hydroxyl and phenyl groups of the cell wall polymers and reduce hygroscopicity by blocking hydroxyl groups (Ramage et al., 2016).

1.4. THERMAL MODIFICATION OF WOOD

By thermal modifications, pyrolysis of wood is controlled at elevated temperature (>180°C) in different conditions such as nitrogen, steam and heat oil environments (Homan W.J., Jorissen A.J.M., 2004).

1.5. TIMBER INDUSTRY

Timber has higher structural efficiency as carried load per unit weight compared to reinforced concrete and steel structure (McGar, 2015). Many timber species has higher natural durability or can be enhanced durability by treating. And also it's an environment friendly natural construction material. Compressive strength is similar to general purpose concrete (Bolduc, 2017).

Figure 3 shows that wood designs are more sustainable other than steel and concrete designs because timber are less in fossil energy, resource use, global warming potential (GWP), acidification, eutrophication, ozone depletion and smog potential. Deforestation is huge problem in utilization of timber heavily. So, it can overcome by increasing forestry to supply more timber and as must be well planned and the forests well managed in order to maximize their broad and far reaching benefits (Ramage et al., 2016).

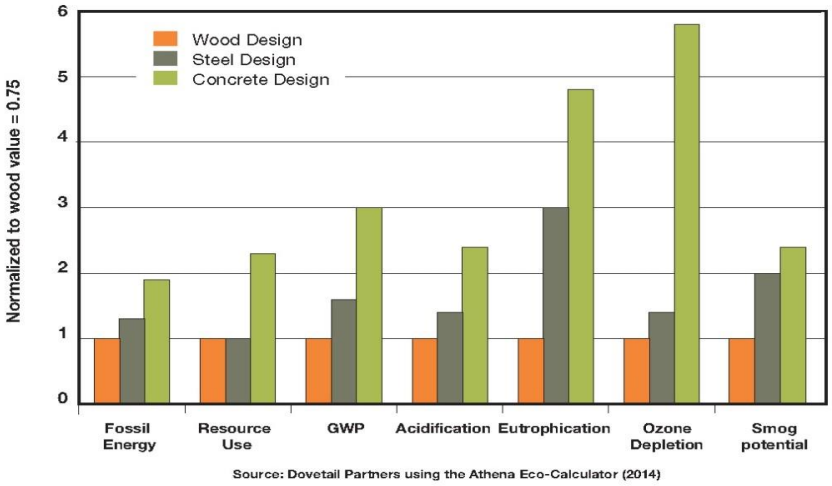

Figure 3, Comparison of timber, steel and concrete designs (Source: Dovetail Partners)

2. Methodology and material

Industrial survey was conducted to identify most abundantly utilized timber for structural applications in Sri Lanka. It was done in two distinct methods. One was based on clusters and other as the company based. For cluster based survey, 23 clusters; saw mills and treatment plants which are located in Moratuwa, Moratumulla, Koralawella, Pannipitiya and Swarapola are selected. For company based surveys, 3 companies in Colombo which were following the standards and doing in a large scale were selected. Questionnaire was based on most utilized timber for rafters, beams, reapers and window/ door frames and most utilized treatment.

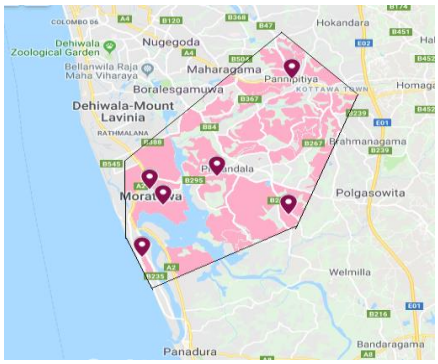

Figure 4, Clusters based survey locations

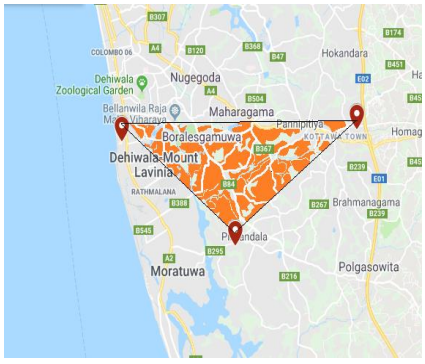

Figure 5, companies based survey locations

3. Results and discussion

3.1. CLUSTERS BASED INDUSTRIAL SURVEY

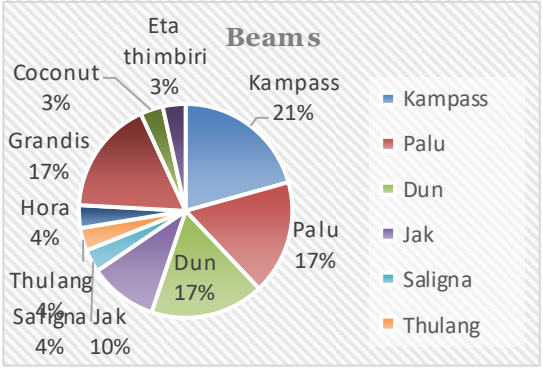

Figure 6, Utilization of timber for beams

For beams, the most demanded timber was Kempass timber about 21% and next Palu timber and Dun timber about 17% respectively. Kempass timber is an imported timber that has a slight high market in Sri Lankan timber industry. Palu timber and Dun timber belong to high rated rare timber species and mostly found in forests (Amarasekara, 2000). Palu timber belongs to special class upper and Dun timber belongs to class 2 according timber classification by state timber cooperation.

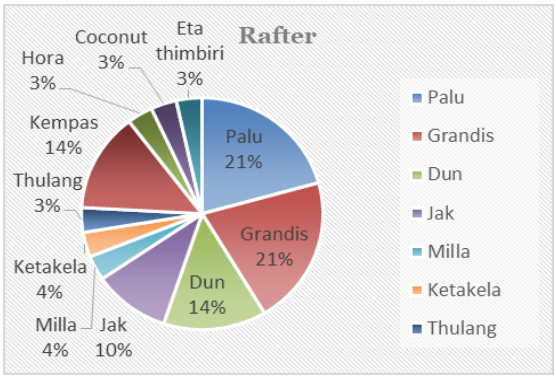

Figure 7, Utilization of timber for rafters

For rafters, the most demanded timber species are Palu timber and Grandis timber about 21%. But Availability of Palu timber was rare in the timber market. So timber industry has to rely on alternative timber species which are highly available and cultivated timber species. Grandis specie is common home garden specie (Ruwanpathirana, 2008). Grandis timber belongs to class 2 according to timber classification by state timber cooperation.

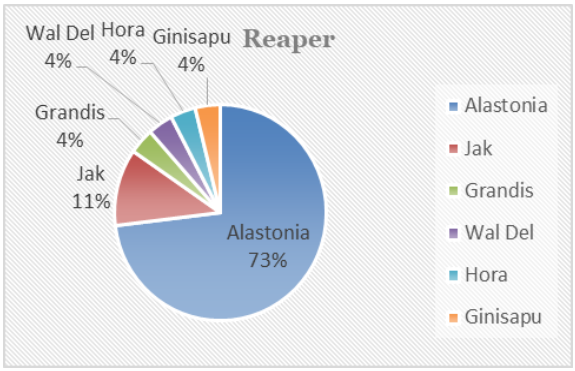

Figure 8, Utilization timber for reapers

For reapers, the most demanded timber was Alastonia timber about 73%. Alastonia is fast growing specie and has a very high adaptability to different soil types in wet zone (Subasinghe, 2010). It belongs to class 2 according to timber classification by state timber cooperation.

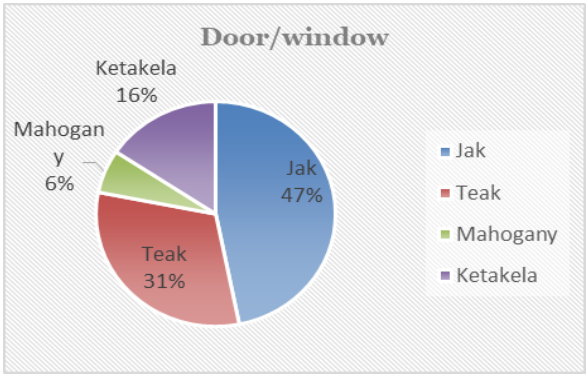

Figure 9, Utilization of timber for door/ window frame

Here we observed about 47% demand is for Jak timber while it contributes heavily on the total timber produced in home gardens (Ruwanpathirana, 2008). Jak belongs to luxury class according to timber classification by state timber cooperation

3.2. COMPANIES BASED INDUSTRIAL SURVEY

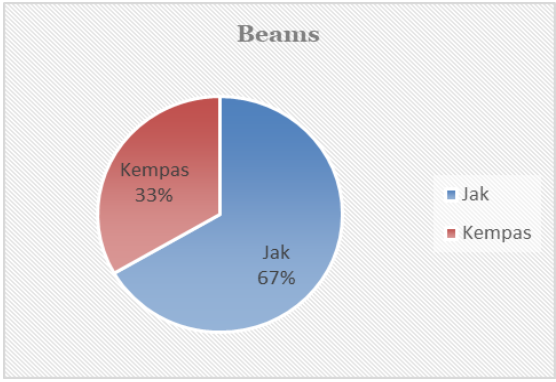

Figure 10, Utilization of timber for beams

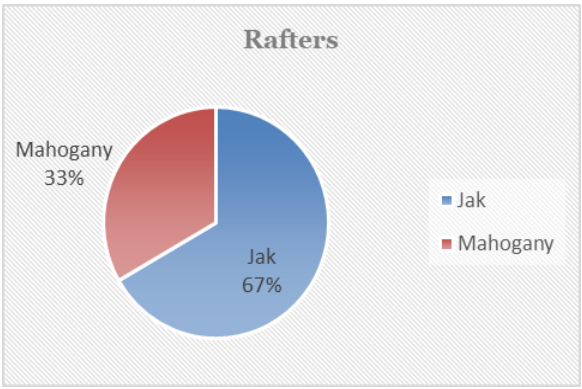

Figure 11, Utilization of timber for rafters

Jak is the most popular for rafters and beams.

For the reapers, Ginisapu timber was the most demanded among other species according to the field survey. And also Ginisapu timber is classified under class 2 according to state timber cooperation.

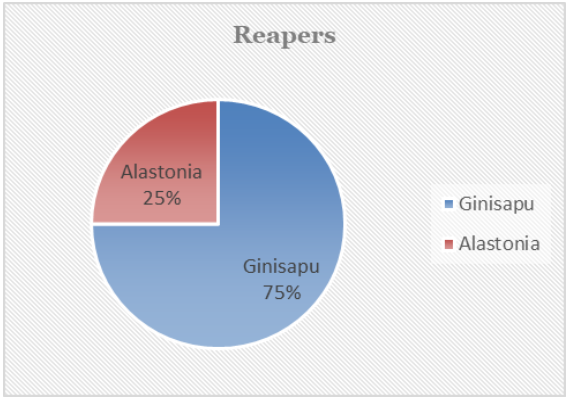

Figure 12, Utilization of timber for reapers

Variety timbers such as Ketakela, Mahogany, Jak and Teak are mostly utilized for door window frames. Teak timber belongs to super luxury class, Mahogany and Jak timber belong to luxury class and Ketakela timber belongs to class 1 according to state timber cooperation.

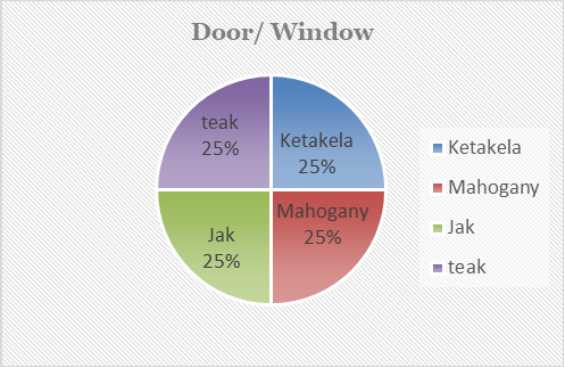

Figure 13, Utilization of timber for door/ window frames

Obtained results from the companies are quite deviated from the results from the clusters. According to company based survey Jak timber has a significant demand for different structural applications than other timber species. And also Jak timber has been utilizing for different structural applications in clusters as well. Timber species utilized for door / window frames are same for companies and clusters but only change of the demand for the each timber specie.

3.3. PRESERVATIVE TECHNIQUES

With the massive development of the construction sector in Sri Lanka, the demand for timber as a construction material is projected to increase over the next half century.(Dissanayake et al., 2019) Main objective of preservation of timber is to increase the life time of timber, ensure long life and enhance quality (Gérardin, 2017). Durability and dimension stability of the timber are increased by preservation methods such as thermal modification and chemical modification (Rowell et al., 2009).

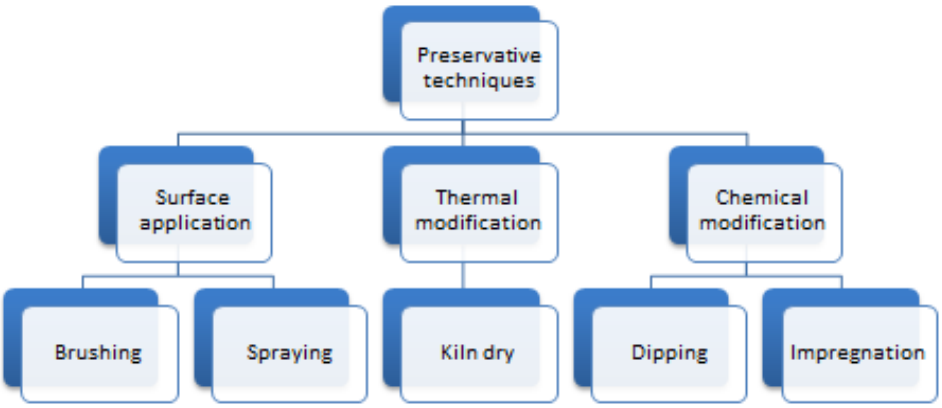

Figure 14, Identified preservative techniques in Sri Lanka

From the industrial surveys, above mentioned preservative techniques were identified. Those techniques are practiced currently in Sri Lanka for selected timber species under different conditions such as treated duration. Example for Alastonia timber kiln dry and for Rubber timber chemical modification (dip or impregnation) are utilized generally as the preservative techniques. In clusters, all methods are commonly used and kiln dry and impregnation are done in small scale. For brushing and spraying, water base, kapuru & diesel and wood preservatives are used. And also boron treatments are done by dipping or impregnation process. In the industry kiln dry process is conducted around temperature 45°C- 60°C. In companies, kiln dry and impregnation methods are mostly utilized and more consideration has been given for quality assurance when processes are continued. Example during kiln dry, gradually increase temperature or pressure inside the kiln for minimize impacts on wood.

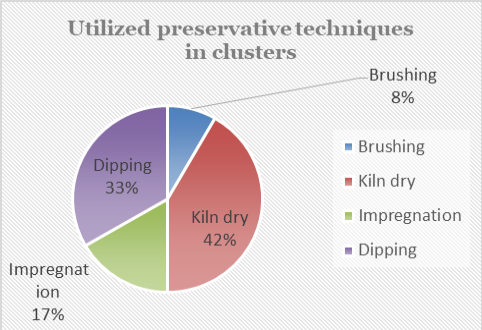

Figure 15, Utilized preservative technique in clusters

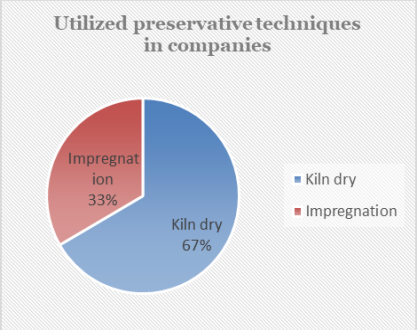

Figure 16, Utilized preservative technique in companies

In both clusters and companies kiln dry is the mostly utilized preservative technique.

4. Summary

Table 1 : Summary of demanded timber

Most demanded timber specie	From clusters based survey	From companies based survey
For beams	Kempass	Jak
For rafters	Palu/ Grandis	Jak
For reapers	Alastonia	Ginisapu
For doors and windows	Jak	Jak/ Teak/ Ketakela/ Mahogany

Table 2 : Summary of most demanded preservative techniques

Most demanded preservative technique	From clusters based survey	From companies based survey
	Kiln dry	Kiln dry

5. Conclusion

The research concluded the following as Palu timber for rafters, Kempass timber for beams, Alastonia timber for reapers and Jak timber for door/ window frames were mostly utilized in clusters. While from the company-based survey, mostly utilized timber species were Jak timber for rafters and beams, Ginisapu timber for rafters and variety timbers such as Ketakela, Mahogany, Jak and Teak for door window frames. Kiln dry was identified as the most utilized preservative technique performed as a thermal modification in both cluster and company based survey.

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MINIMIZING PROBLEMS IN CONVENTIONAL LPG CYLINDER MANIFOLDS USED IN APARTMENT BUILDINGS IN SRI LANKA

JAYANTHA BASNAYAKE[1] & NAYANTHARA DE SILVA[2]
[1,2]University of Moratuwa
[1]*jayanthakbsl@gmail.com*, [2]*endds@uom.lk*

Abstract
Apartment users are heavily depended on conventional type LPG supply systems for their cooking purpose. However, this system identified many drawbacks in terms of user safety. This finding alone justifies the need for the LPG industry to find ways to work with LPG suppliers, distributors and building contractors to develop commercially sustainable safe business models for supplying across apartment buildings. Alternatively, liquid withdrawal LPG cylinder manifolds are recommended as safe, effective and efficient system for apartments. In the same time the proposed system can be shown as a solution for limited space in apartments for storage of cylinders. The paper discusses existing issues in conventional LPG cylinder manifolds and presents a liquid withdrawal compact LPG supply system for apartment buildings as a solution for issues in conventional LPG supply systems

Keywords: *LPG supply system, Safety, Apartments, Risks, Liquid Withdrawal LPG cylinder manifolds*

Introduction

Liquid Petroleum Gas (LPG) have been identified as the most economical and environmentally sustainable fuel over other fuels (Amuzuvi & Ashilevi, 2016). Electricity and gas are found to be the dominant fuels used by urban residential apartments (Kim, Cho and Kim, 2019). The use of LPG has seen a tremendous increase in recent years for residential buildings due to its inherent cost and environmental advantages (Wan & Yik,2004). In Sri Lanka, cylinder manifolds are used as a common system of LPG supply. In this system, two or more cylinders are interconnected together to a common gas line in a cylinder manifold to use in higher LPG consumption applications (Mariani & Vallerotonda,2008). As seen in Figure 1, Carbon steel or Galvanized Iron pipes, regulator, pigtail, isolation valves and pressure relief valve are identified as critical accessories of a manifold to regulate the safety of the system.

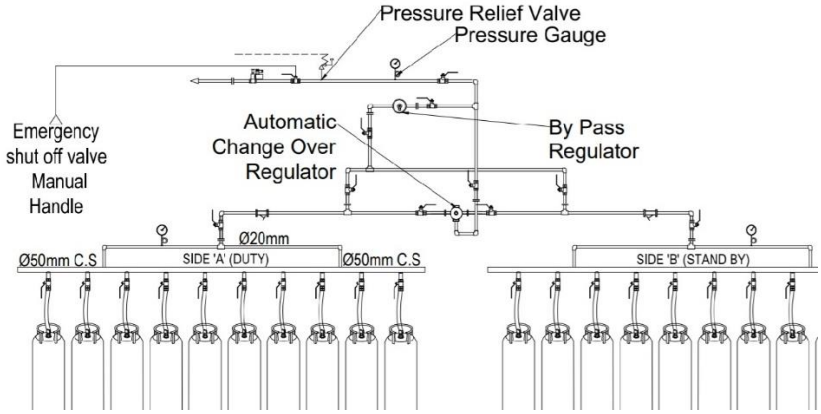


Figure 1: Typical LPG manifold of an Apartment Building

LPG manifolds have their inherent safety risks and thus fire hazards in apartment buildings are at a greater level. Loss of primary containment (LOPC) arise from spillage of liquid from a pressurized container or from a pipeline resulting in instant total dispersion and evaporation, is identified as the main fire risk causing factors in the LPG distribution system (Rasbash,2010). LPG leak creates risks for occurrences of "Vapor Cloud Explosions (VCE)", "Flash Fire" and "Boiling Liquid Expanding Vapour Explosions (BLEVE)" as illustrated in Figure 2 (Tasneem & Abbasi, 2006).

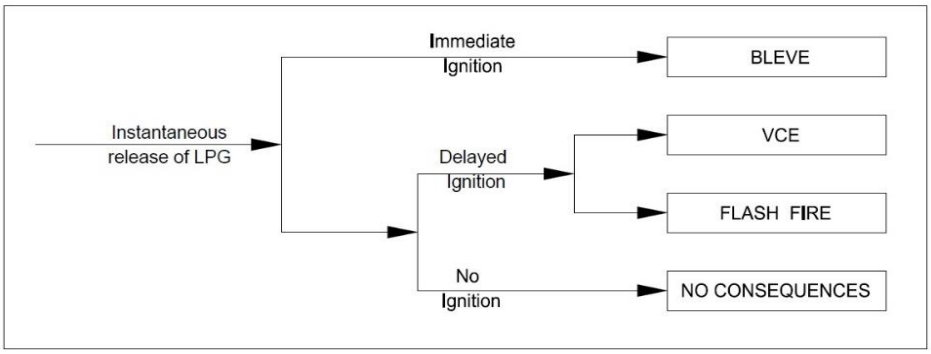


Figure 2: Consequences of LPG leaks
Source: Jung, Ng, Laird & Mannan,2010

To understand the issues in apartment LPG distribution systems, factors such as geographical location of the LPG supply system and surrounded environmental information (Poon, Tsz-ho, William,2008), Plot plan, Process and Instrumentation Diagrams (P&IDs), Process Flow Diagrams (PFDs) (Islam & Sultana, 2017), Installation layout, Operation procedures, physical and Chemical specification of the material, (Dormohammadi, Zarei,Delkhosh and Gholamib,2010) etc., are to be examined. Safety distances kept in storage and pipelines transmitting LPG is determined considering the possible outcomes of an accidental event associated with fuel gas release from pressurized transmission systems (Sklavounos & Rigas, 2012). According to SLS 1196(2000) every LPG manifold should be separated from a building, boundary, or fixed source of ignition and tanks should be situated outdoors, in a position that will not allow accumulation of vapour at ground level. Ground features such as open drains, manholes, gullies and cellar hatches, within the separation distances given in standards should be barricaded, sealed or trapped to prevent the passage of LPG vapour.

Existing Problems of Conventional LPG Supply Systems in Apartments

Despite the benefits of the LPG, high rates of LPG leak incidents are reported in apartment buildings, increasing the risks of causing explosions or fire(Beheshti, Dehghan,Hajizadeh, Jafari & Koohpaei,2018; Bruce et al., 2015; Nisanci, Yildirim and Erbas,2009). Further, direct exposure to LPG vapour gases, cold burn due to contact of liquid LPG to the skin are critical secondary impact of those leakages (Chatier et al.,2016). Among them, fire is the most common hazard, while explosion is more critical in terms of its potential damage (Faisal I. Khan, S.A. Abbasi,2002).

Barriers to increase number of cylinders in the manifold to cater to the demand due to space constraints (Spyros Sklavounos, Fotis Rigas,2006), limitations in maximum LPG evaporation rate of a cylinder (Tauseef1, Abbasi, Thiruselvi and Abbasi,2017), high cylinder replacing frequency(Inkoon & Biney,2010), cylinder sweating (Malviya &Rushaid,2018), design and installation failures, LPG left over cylinders (Santoli,Paiolo,Basso, 2017), non-availability of liquid LPG withdrawal facility (Stawczyk,2002), high rate of regulator replacement (Krzysiak et al, 2017), high rate of accessory damages (Demichela, Piccinini & Poggio, 2004), vulnerability for leaks in the system are identified as common practical problems of present cylinder manifolds for enhancing safety of the system (Rizuwan & Wahab , 2010). As per LPG supplier's complaint records, more than 100 LPG leak incidents have been reported in last year leading to 4 major fire incidents in apartment buildings in Sri Lanka.

Lack of awareness among users regarding safety measures, poor knowledge on safety procedure and lack of authority involvement are identified as common root causes for accidents (Paliwal, Agrawal ,Srivastava, Sharma ,2014;Wahab,2010) reported relate to LPG supply systems of apartments.

Methodology

Forty apartments were randomly selected from 72 apartments which use LPG from a central manifold in Colombo district for data collection. Those apartments have been built between 1997 and 2019. Monthly average consumption of LPG was obtained from the records of central manifold meter readings.

To assess the level of safety risk in LPG supply systems of selected apartments, interviews were conducted with the respective maintenance managers. Additionally, site surveys were conducted to view the site conditions. As per the literature findings on safety issues of LPG systems, following aspects were studied during the data collection as follows;

- Insufficient number of cylinders in the manifold (Armenakis & Nirupama ,2011),
- Cylinder sweating during operation (Quedat, Guarnieri, Gablino & Rigurd ,2015),
- Pressure drop in the system (Kimemia & Annegarn ,2016),
- Flame fluctuations & yellow flames (Gallab et al.,2017),
- Constraints in separation distance,
- Lack of LPG storage and manifold area utilization
- Lack of provisions for further expansions (Erameh and Iruansi ,2014),
- Mismatches in hourly LPG consumption analysis (Boult,2000),
- Non-availability of liquid withdrawal LPG systems,
- Insufficient distance to the nearest ignition sources (Ono & Silva,2000)

Criticality levels of those safety issues were calculated using the mean rating of Hazard Rating Index $(HRI)_{apartment}$ as follows;

$$HRI_{apartment} = HCN * \text{Existing Level of Risks} \quad (1)$$

$$\text{Where HCN} = (\sum_{k=1}^{n} W_k)/N \quad (2)$$

N= number of experts
W= given Likert scale ¥= 1,....5

Twelve (12) experts were interviewed to establish “Hazard Critical Number (HCN)” which was derived from 1-5 Likert scale. These 12 expert’s committee is a composition of more than 10 years industrial experienced engineers in the field of LPG and petroleum. Based on their individual scoring, HCN numbers were derived for all existing issues in conventional LPG system.

Existing levels of risk were calculated based on the finding of field observation data calculation and results are discussed in below.

Results and Discussion

Existing issues of LPG system

Seven existing common issues were analyzed using the equation 1 and ranked according the their HRI (Table 1).

Table 1: Existing issues in conventional LPG system

Issue	HCN	Risk level	HRI	Rank
Insufficient storage space for safe operations	5.0	0.72	3.6	1
Non Availability of Area for further Expansions	4.0	0.90	3.6	1
Cylinder sweating During Operation	4.0	0.80	3.2	2
Insufficient number of cylinders	3.0	0.50	1.5	3
LPG Supply and demand mismatch	2.0	0.67	1.34	4
Yellow Flame	2.0	0.5	1.0	5
Pressure Variations	3.0	0.175	0.525	6
Flame Fluctuations	1.0	0.425	0.425	7

- **Insufficient storage area for operations**

As per SLS 1196 part 2 the maximum LPG capacity store in a well ventilated single location is 1000Kg. 70% of selected apartments had a dedicated location for LPG storage. Area allocated for LPG storage was not enough for 72% of apartments and risk level is considered as 0.72. Firefighting measures were not available in 40% of apartments. Empty and filled cylinders were kept adjacent to the cylinder manifold area those who didn’t have a storage facility.

- **Non Availability of Area for further expansions**

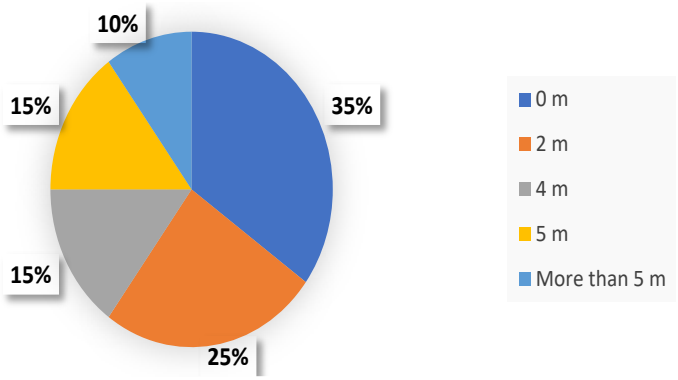


Figure 3: Space availability for further expansions

Figure 3 represents the availability of area for further extensions in LPG manifold installation area. Area availability is a compulsory requirement for manifold installations. As per SLS 1196 there is a minimum distance requirement to install a cylinder manifold from a source of ignition. Thus, at least 5m distance to be kept free to have a smooth manual operations of cylinders. Thus, the existing risk level 90% is a result of calculation based on 5m minimum separation distance.

In addition, ventilation issues were commonly seen in storage areas due to congested storages. Impact protection and emergency access to LPG facility is a compulsory requirement identified at risk minimization stage.

- **Cylinders Sweating During Operation**

Due to supply and demand mismatch, the phase conversion of the LP gas from liquid to gas absorbs heat from the surrounding area and makes the tank colder where it contacts the liquid inside the tank. Sooner the tank gets below dew point; it'll start to see condensation on the side of tank which is termed as sweating. Due to supply and demand mismatch, out of 40 apartment manifolds, 32 (i.e. 80% of risk level) were seen sweating mainly during the night operation. Figure 4 further illustrates period of occurrences of the sweating.

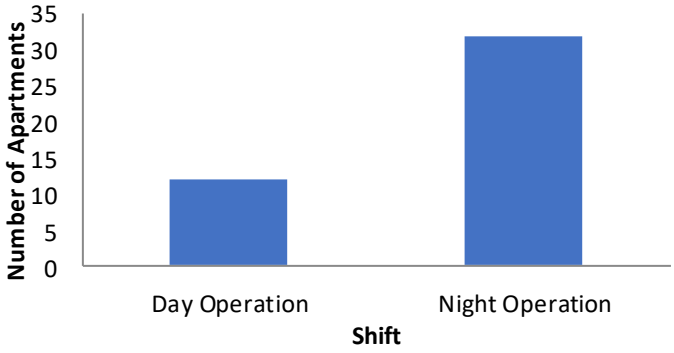


Figure 4: Cylinder Sweating During Operation

Sweating is resulted due to design failures, use of partial standards at the design stage and neglect of basic design parameters such as operational pressure, temperature, ambient environment conditions, maximum demand which leads to pressure fluctuations, incomplete burning and system inefficiencies.

- **LPG Supply and demand mismatch**

Hourly peak LPG consumption in all 40 apartments are shown in Figure 9. There are 5 apartments who has more than 50Kg/Hr.

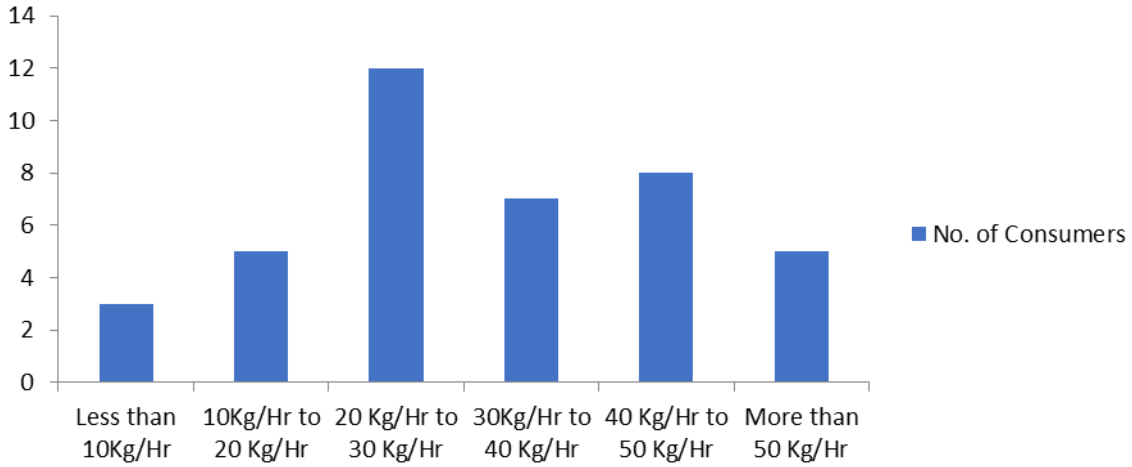


Figure 5: Hourly peak LPG consumption

Peak hourly LPG consumption vary from 40 to 50 Kg were taken for further evaluation. 6 apartments who had 40Kg/Hr consumption data were further evaluated and below required vs actual LPG supply data are presented in figure 6. Actual Hourly peak LPG consumption requirements and system designed maximum hourly LPG consumptions are shown varied in many places. 67% of under designed manifolds are operating in selected 6 apartments who had 40Kgs/Hr peak LPG consumption.

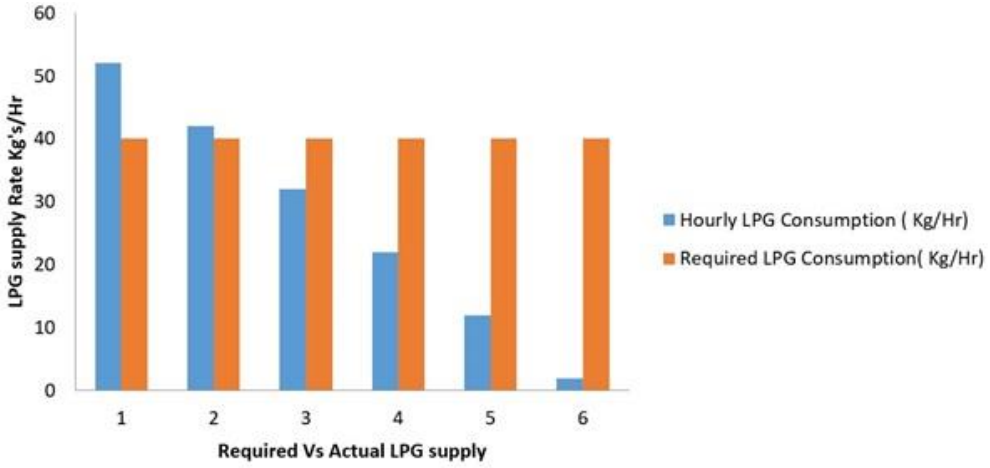


Figure 6: Hourly actual vs required LPG supply rate

- **Insufficient number of cylinders in the manifold**

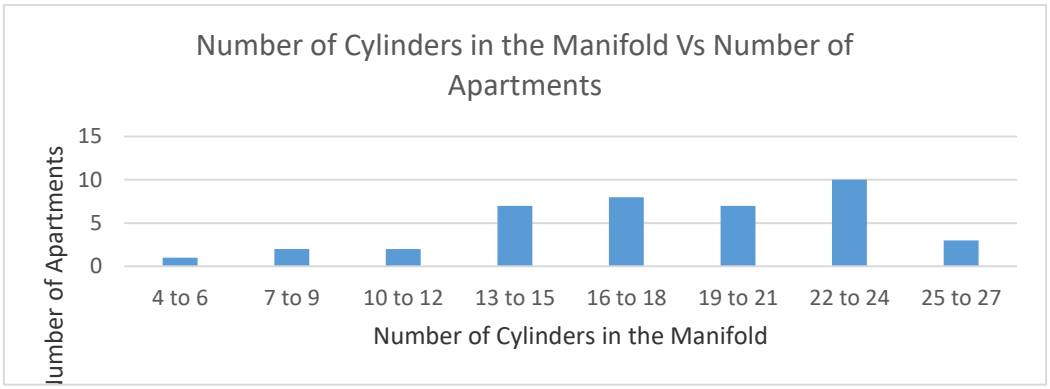


Figure 7: Number of cylinders in the manifolds installed at apartments

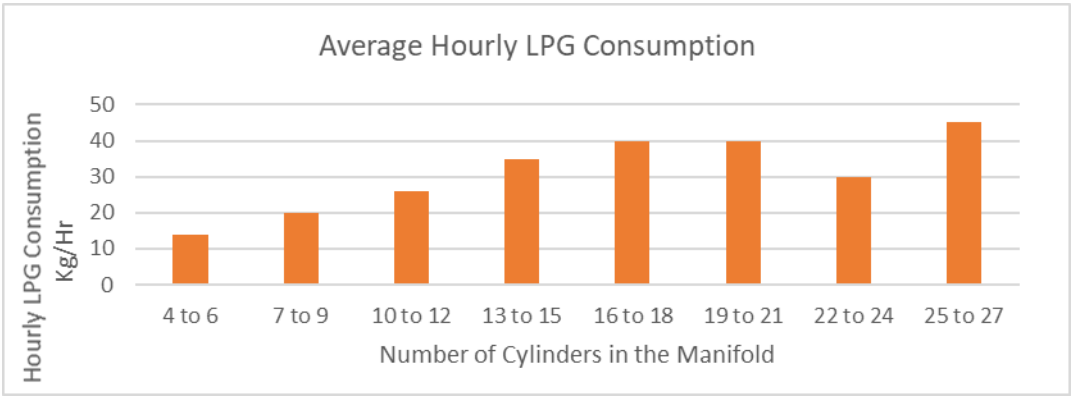


Figure 8: Hourly LPG consumption Vs number of cylinders in the manifold

Figure 6 and 7 illustrates number of cylinders in the manifolds and the average hourly consumption in the apartments. As per the NFPA 54 standard/guideline, industrial and domestic cylinder can produce a maximum of 2Kg/hr LPG demand. Figure 7 illustrates number cylinders in manifolds. Thus, the % of insufficient cylinders in apartments is 50% (i.e. 20 apartments) which leads to many operational issues such as cylinder sweating, flame fluctuations, yellow flames, pressure drops etc.

In some apartments, LPG consumption have been increased from its planed consumption after fixing. and the number of cylinders have not increased proportionally.

- **Pressure Drop during peak operations**

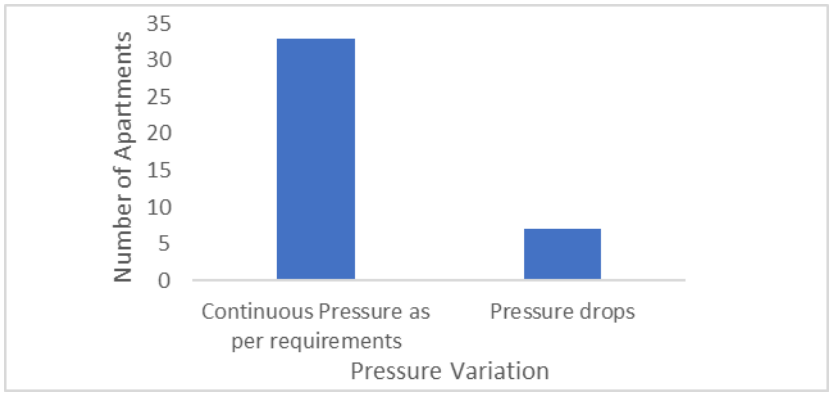


Figure 9: Pressure Drop in the system

Average operating pressure of domestic oven is .5psi. Due to design failures, 7 apartments out of 40 face pressure drop incidents between the peak hours. Long cooking cycle time, Burner switch off, High fuel consumption due to incomplete combustion are the consequences of this.

- **Flame fluctuations & yellow flames**

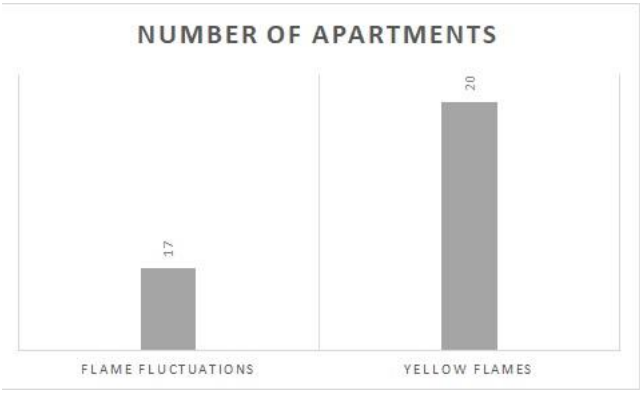
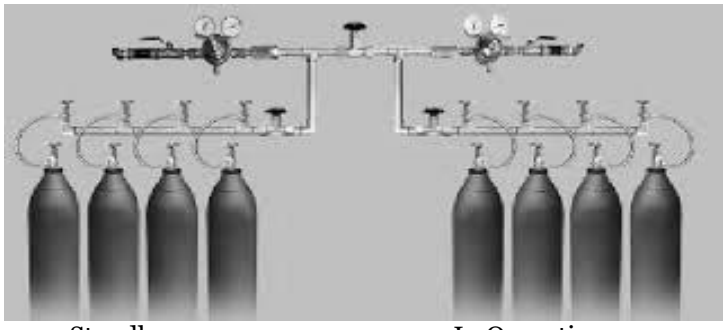


Figure 10: Uncontrolled flame conditions

Almost half of the households of apartments facing flame uncontrolled conditions (Figure 10). Yellow flame generates due to partial and this is caused by lower supply rate. This is also a consequence of design failure of manifolds. Under sized manifolds supply lower than the required rate of LPG demand. This can directly affect the cooking cycle time.As per the key findings of the survey the main issues of conventional LPG vapour withdrawal are summarized as higher area reservation for LPG storage and operations, limitations in consumption rate, high replacing frequency, cylinder sweating, LPG Left over cylinders, non-availability of liquid withdrawal facility, high rate of accessory damages, barriers to increase number of cylinders in the manifold, vulnerability for leaks in the system.

In most of the above observation Cylinder sweating was reported. As per expert field verification data, the maximum evaporation rate of 1 feet diameter cylinder for a tropical country like Sri Lanka is 2Kg/Hr. As per SLS 1196 part 2 (2000), the maximum LPG cylinder storage in capacity of a facility is 1000Kg's. To maintain this standard, maximum of 26 cylinders are recommended to install in a LPG supply system by keeping one stand by and one in operation



Standby In Operation

Figure 11: Standby & Operation cylinders

Maximum number of cylinders can install in the single side of the manifold is 13.
So the maximum vapour flow rate produce by a single manifold = Max. No. of Cylinders * Flow Rate (3)
Which equals to 26 Kg/Hr.
But as per observations of the survey, when the liquid level goes down in a cylinder the flow rate also goes down proportionally as given in figure 12 below.

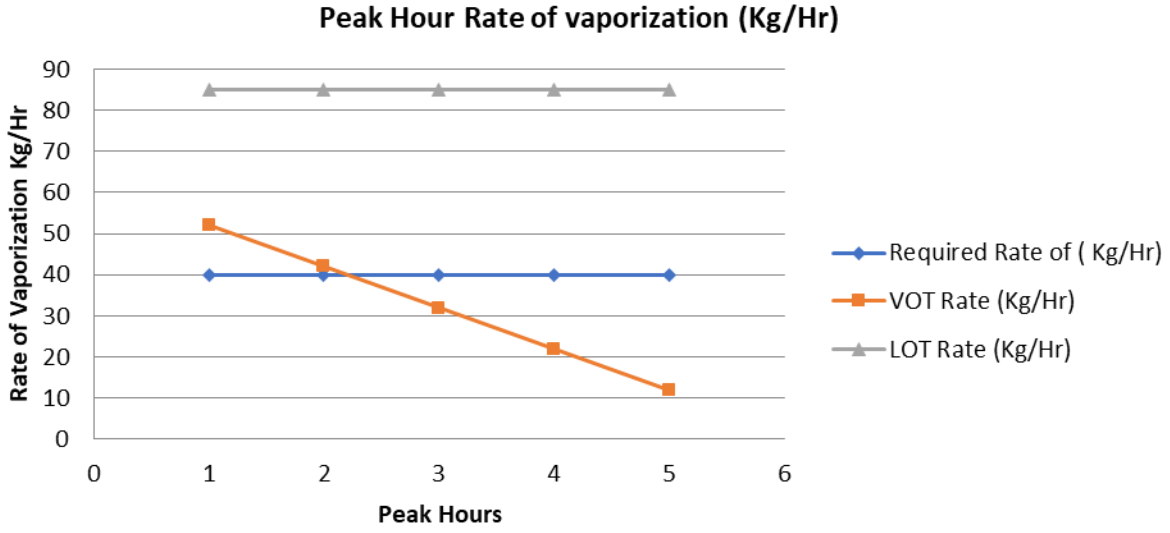


Figure 12: Rate of vaporization in peak hours

There is a requirement of a liquid offtake system which can produce the continuous rate of vapour demand. Another issue is that when the application demand is higher than the natural vaporization rate, liquid tries to get the heat from the outside environment. Then due to heat absorption from the air, it

gets condense the air and moisture deposits on the surface of the cylinder metal. This can create a barrier for heat transfer and leads to pressure fluctuation of the system.

Average area requirement for 13-cylinder manifold is 20.4 square meters. Due to high demand for lands in urban areas finding a considerable area for LPG supply system is a big challenge.

Proposed Liquid Withdrawal System

Liquid withdrawal system is an advance concept in multi cylinder installations which overcomes lots of demerits of conventional cylinder Manifold systems. Liquid withdrawal system withdraws liquid LPG using Liquid withdrawal valves & is converted into vapour using a vaporizer. LPG off take per cylinder can go up to 10kg/hr which is comparatively much more than the normal Vapour off take cylinder of 0.6 kg/hr. Liquid withdrawal systems are compact, safe & highly cost effective as liquid is completely drawn from the cylinder and there is no residual loss.

Liquid Off-take (LOT) LPG systems have become popular in apartment buildings in most of the countries. This system offers the strength of Bulk LPG Installation and easy functionality as that of cylinder manifold. LOT LPG System withdraws Liquid LPG using the LOT valves.

The LOT System can cater to Volumes up-to 250Kg per Hour and occupies less space. They are easy to handle and provided with high safety standards. The LOT LPG systems are highly cost effective as there is no residual loss. Advantages of this system would be; constant pressure (application pressure less than 18 Psi.), convenient to handle, cost Effective, no loss on account of residue, requires lesser space etc.

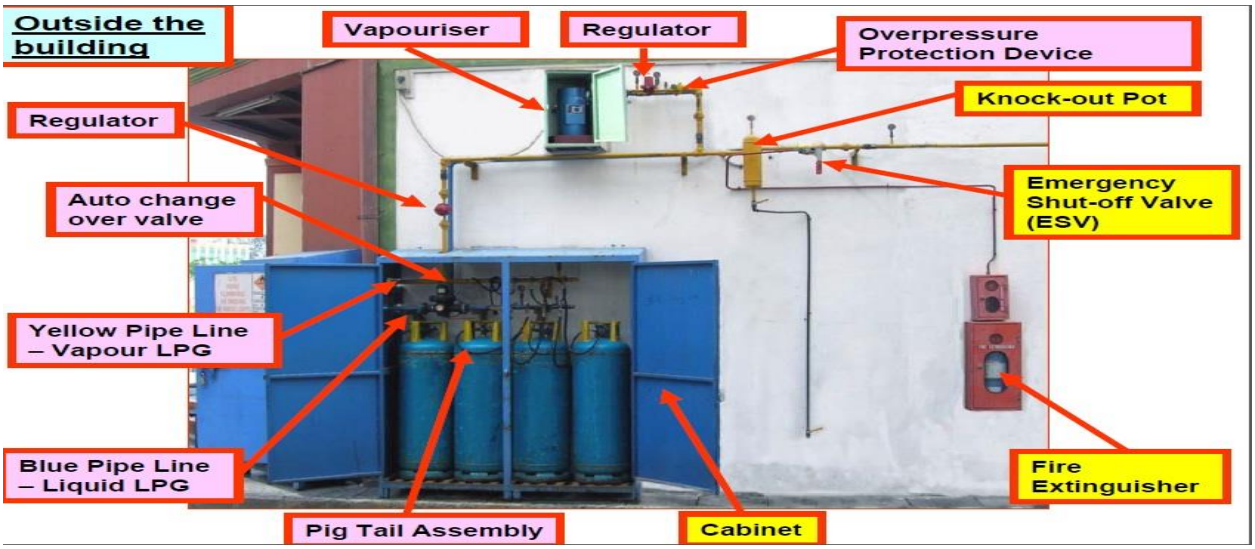


Figure 13: Typical Liquid Withdrawal LPG system

Out of the above list of accessories, NRV & Vaporizers are the additional items compare to vapor off take system.

Figure 14: Liquid withdrawal manifold with Vaporizer

By addressing the issues of the conventional LPG vapour withdrawal systems, proposed liquid withdrawal cylinders have the advantages such as No sweating in cylinder surfaces, No pressure drops in the system, Continuous same flame conditions, Minimum intervention, No burner failures and specially less area requirement as given below.

Less space requirement for liquid withdrawal LPG supply system

a. Area Required for 13 cylinders 20.4 m2 (a)
b. Area required for 4 LOT cylinders for same demand 9.6 m2 (b)

Space utilization with the new liquid withdrawal facility (a – b)/ a * 100 (4)
equals to 53%.

Additional cost for vapourizer installation and electricity cost at the time of operation are identified as the demerits of proposed liquid withdrawal cylinder installations.

Summary of Safety Features of new Liquid Withdrawal Cylinder Manifolds are given in Table 2 below.

Table 2: Comparative advantages of LPG liquid withdrawal system

Issues of Conventional LPG Vapour Withdrawal System	**Solutions From New LPG Liquid withdrawal System**
1. Non Availability of Area for Operations and Expansions	Comparative less space requirement. High space utilization
2. Cylinder sweating During Operation	Only liquid withdraws from cylinder
3. LPG Supply and demand mismatch	Select the correct vaporizer capacity
4. Insufficient number of cylinders	Require less number of cylinders 13 reduce to 4 cylinders.
5. Pressure Variations	Set the required pressure after vaporizer
6. Yellow Flame	Blue flame due to efficient supply
7. Flame Fluctuations	Pressure control features of vapourizer out flow

Conclusion

As per the research findings, there are many practical issues in current apartment LPG installations. The major practical problems of present cylinder manifolds identified in the survey are; Higher area requirement for LPG supply facility, Limitations in consumption rate, High replacing frequency, Cylinder sweating, LPG Left over cylinders, Non availability of liquid withdrawal facility, High rate of accessory damages, Barriers to increase number of cylinders in the manifold and Vulnerability for leaks in the system. Theoretically there is a maximum limit of vapour supplied by natural vapourization which creates barriers to cater to peak demands of many apartments. There is a need for continuous steady vapour supply system like in a liquid withdrawal cylinder manifold system to minimize safety hazards in the existing conventional systems. It identified as a safer system than the conventional LPG supply system. In the same time the proposed system can be shown as a solution for limited space in apartments for storage of LPG cylinders.

When considering the urban demand for space, liquid withdrawal cylinder option that utilize small space gives the best solution to the apartments. The propose system requires approximately 9.6 m2 space to install 4 cylinders which is a has a capacity of 13 cylinders that utilize 20.4 m2 space, in the conventional gas withdrawal LPG systems. Thus, it reduces the utilization space by 53%. Thus, propose system could be a novel solution for future apartment developments in highly dense areas in Sri Lanka

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AN EMPIRICAL INVESTIGATION ON FACTORS INFLUENCING TO CONSUMERS' PURCHASING DECISION TOWARDS THE LUXURY APARTMENTS IN COLOMBO AND SUBURBS, SRI LANKA

MADUSHANI K. H. A [1] & PIYADASA R. U. K.[2]
[1,]Colombo Municipal Council, Colombo 07, Sri Lanka
[2]University of Colombo, Colombo, Sri Lanka
[1]*anjalimadu88@gmail.com,* [2]*ranjana@geo.cmb.ac.lk*

Abstract
Urban vertical luxury living is becoming particularly widespread, and the abundance of luxury apartment buildings in Colombo continues to transform the city. The main objective of the study is to identify the factors that significantly influence the purchasing decision of customers in respect of luxury apartments with reference to Colombo and suburbs and further investigation of the level of importance of the attributes of identified factors on the customers' point of view. Through a comprehensive literature review, 08 main factors and 53 attributes were identified to examine the customers' purchasing behaviour in luxury apartments. The study has revealed that the most influencing factor is Financial feasibility of the consumer while the Physical factors and Locational importance are equally significance. Basic Amenities, Environment, Goodwill, Emotional and Recreation have ranked accordingly. The 53 attribites were deeply exposed the contrast of the customers' consideration and preference. In addition to the financial attributes, dwelling type, dedicated parking units, and floor area of the apartment, electricity backup, security, greenery spaces, and developer have shown the more than 80% of customers' attention and predilection as the most important attributes which influenced to customers' purchasing dececision on luxury apartments.

Keywords: *Luxury apartment, consumers' purchasing decision, influencing factors, attributes, Sri Lanka*

1. Introduction

Urban living space is derived as a result of the urbanization. It is fuelled by population growth and institutional expansion. It is a social process which describes the manner in which cities grow and societies become more complex. As a result, the living spaces from suburbs to urban areas have changed, especially with respect to limited spaces. Urban living space has vast diversity. It includes luxury apartments, middle income flats and everything in between which urban living focuses on building urban residential spaces. Vertical living has become increasingly popular in Sri Lanka over the past few year Luxury vertical living is becoming especially popular, and the vast number of luxury apartment buildings in Colombo continues to transform the city. As the country's infrastructure improves to accommodate new inhabitants, Colombo is becoming increasingly popular for luxury property.

During last few years, skyscrapers have begun to dominate the Colombo's skyline, an attestation to the pulling power that the country is developing with domestic and international investors. This is transformation over the years has triggered an increase in luxury apartments, hotels and retail outlets. Though the key focus has been within the economic hub, Colombo, several residential and commercial projects have gradually begun targeting the suburbs and other districts. Buying an apartment is one of the most significant economic decisions that people make, and it requires gathering a lot of information regarding its features (Kiefer, 2007). People tend to buy an apartment rather than buying a land and build a house. The property purchase is a complex decision-making process as evidenced by costly acquisition, infrequent purchase, riskiness, high self-expressiveness, and awareness among buyers of significant differences among product alternatives. Buyers are very particular about the property attributes that they are contemplating, thus, giving rise to differences in attribute preferences among them.

The broad objective of this study is to identify the factors that significantly influence the purchase decision of customers in the order of significance, from the most significant one to the least significant one of luxury apartments with reference to the city of Colombo and suburbs. Further it investigates the level of the important of the attributes of each influencing factors on the customers' point of view to the residential apartment developers to improve customer satisfaction and to enhance their service quality

and product as per the expectations of the customer as revealed on the basis of this study. The eight factors namely Physical, Basic Amenities, Environment, Location, Goodwill, Financial, Emotional and Recreation were identified as the main influencing factors and there were 53 attributes coming under the selected 08 factors which were used to study the customers' buying behaviour towards Real State Sector especially in condominium apartments in global and local context.

2. Literature Review

The Particular remarkable changes have been taken place in the Real Estate industry that have changed buyers' buying attitude and created opportunities for the Real Estate sector. Real Estate developers, marketers, policy makers able to use the outcomes to better understand, segment and satisfy the customers. The land problem, urbanization and population pressures have created opportunities for Real Estate industry and that have significant impact on customers' buying attitude excluding the cultural changes and raising price level (Kamal et al, 2016). It has similarly found that buying intention is strongly influenced by buying attitude of the customers.

Consumer behaviour is usually being defined as 'those activities directly involved in obtaining, consuming and disposing of products and service, including the decision processes that precede and follow these actions' (Engel et al, 1995). The consumer behaviour is 'the behaviour that consumers display in searching for purchasing, using, evaluating and disposing of product, service and idea which they expect will satisfy their needs' (Schiffman and Kanuk, 2010). Due to the ever increasing intensity of competition, more aggressive competitors emerging with greater frequency, changing bases of competition, geographic sources of competition are becoming wider, niche attacks are becoming frequent, pace of innovation is rapid, price competition becoming more aggressive and product differentiation is declining are the importance of consumer behaviour.

Consumers consider only the scheme in which a property is eventually bought, and they are very satisfied with their purchase (Martin, 2006). Customer Satisfaction is the overall feeling of contentment, fulfilment or satisfaction of the home-buying customers on purchase of the house, when he has ultimately achieved all what he wanted-his needs, desires or expectations on the residential building (Ahamed and Sakthivel, 2013). What a customer would be expecting in a house; residential satisfaction has been used as a key predictor of an individual's perception of general "quality of life" (Ahamed and Sakthivel, 2013). Customers always were preferred to purchase real estate product that has reinvestment value. The reinvestment value can be obtained from renting the real estate product or by selling them (Rahadi et al, 2013). Reinvestment value related with almost all of the factors contributing to price, including brand, reputation, location, and other related factors. Cultural changes have been taken place such people would like to intend in single family unit, get project facilities and enjoy apartment culture (Kamal et al, 2016). The government has much to do to attract foreign buyers to Sri Lanka in significant numbers (Jayasundera, 2017). Developers are seeking to sell more new apartments to buyers from overseas, taking advantage of Colombo's growing attraction as South Asia's most cosmopolitan city.

3. Research Methodology

3.1 STUDY AREA

The city of Colombo is the financial centre of Sri Lanka and also the largest by population which is known for being a popular tourist destination, with tourism fuelling the local economy. Due to the economic growth and infrastructure development, Colombo has experienced urban migration. Colombo and its suburbs are consisting with heavy traffic jam, mix land use pronominally commercial and industrial land uses, higher ratio of built up area and further in environmental aspects air pollution less green spaces, solid waste issues are taken place. The daily commuting population is about 1 million people entering the city of Colombo from outside crossing the boundary.

A quantitative approach was used to achieve the objectives of the study. A questionnaire survey was conducted to collect primary data for a convenience sample of 120 respondents who were willing to purchase luxury apartment within the study areas and inquired from related persons in luxury apartment market. The profiles of the respondents' personal histories covered the categories of gender, age, family size, highest educational qualification, occupation, family's total disposable income per month, current resident and purpose of buying an apartment. This study had been conducted with the quantitative method of data analysis. Weighted Average Method used the data to determine the most important factors that affect the buying behavior criteria. Spatial Analysis Technique-Geographic Information System (GIS) is used to understand the preference of the location. In addition, maps have been created to define location preferences, and visual displays of findings have been used under the quantitative data analysis method of the customers while they are going to purchase the apartments.

4. Results and Discussion

4.1 RANKING OF THE FACTORS

The factors influencing purchase decision of customers in the order of significance, from the most significant one to the least significant one are presented in fugure 01.

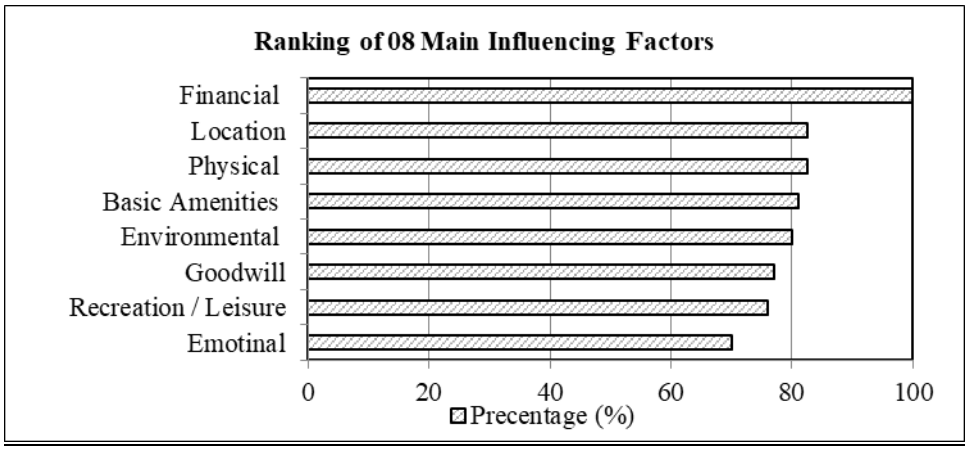

Figure 1: Ranking of 08 Main Influencing Factors (*Source: Developed by Author, 2018*)

Figure 1 illustrated the main 08 influencing factors in the order of significance for the customers purchasing decision, from the most significant to the least significant. The study has revealed that Financial is the most influential factor, followed by equally significant physical and location factors. Basic Amenities, Environment, Goodwill, Recreation and Emotional factors were ranked by the respondents accordingly.

Customer consideration and preference of influencing factors described by the level of importance of the attributes of the particular factor, according to the customers. The following graphs were depicted a total of 53 attributes which used to analyze respondents' interest and desire.

4.2 THE ATTRIBUTES OF FINANCIAL FACTOR

Unit price, Payment terms, Interest rate, Mortgage, Monthly payment, down payment and Payment structure security are the most important factors affecting the purchase of the apartment according to the customer's responses for financial factors (figure 2). A significant proportion (more than 80%) has showed that consumers were considering the Unit price, Payment terms, Mortgage, Monthly payment, down payment and Payment structure security.

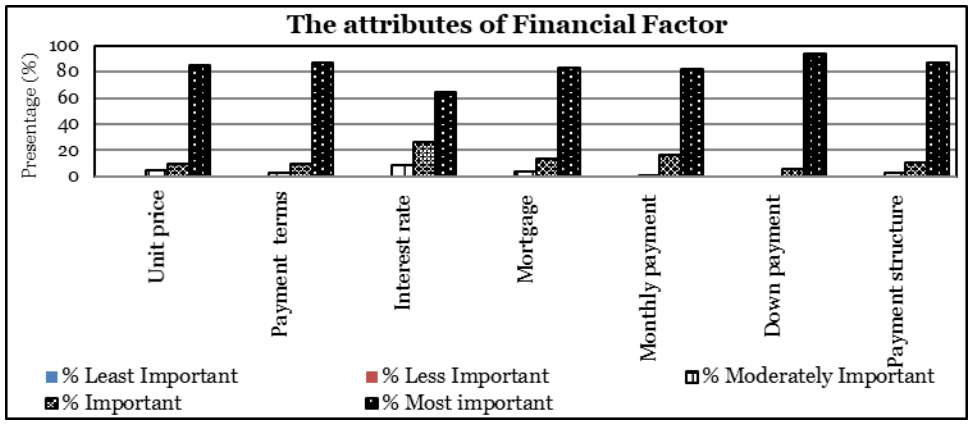

Figure 2: The Attributes of Environmental Factors (*Source: Developed by Author, 2018*)

Table 1: Results of Unit price - LKR. Millions (*Source: Developed by Author, 2018*)

Unit price - LKR. Millions	Frequency	Percentage
Less than 10	37	31%
10-20	51	43%
21-40	18	15%
41-60	8	7%
61-99.9	4	3%
More than 100	2	2%

According to the table 1, around a half (43%) of customers were interested in apartments that cost 10 to 20 million rupees per unit. There are 2% of customers are interested the apartments which is cost of per unit more than 100 million rupees. In the unit price range of 20–more than 100 million, condominium apartment properties exist and it is highlighted that there are affordable customer base for such residential properties is in Colombo, Sri Lanka.

Table 2: Monthly payment -LKR (*Source: Developed by Author, 2018*)

Monthly payment (LKR)	Frequency	Percentage
Less than 99,999	50	47%
100,000 - 149,999	35	33%
150,000 - 199,999	23	8%
More than 200,000	12	5%

According to table 2, apartments that have a monthly payment less than Rs. 99,999.00 are involved in 47 percent of customers. There are 5% of customers are stated that they are able to pay the monthly payment more than Rs. 200,000.00. Depending on the monthly payment, 53% of customers were able to pay more than Rs. 100,000.00 for the monthly payment for the apartments. It can therefore be concluded that customers have Monty income in excess of Rs. 300,000.00 who are interested in buying the condominium apartments.

4.3 LOCATION

It is observed that the customers prefer to purchase luxurary apartments adjacent to major emergency services, road and other aminities. It can be seen the customers preference for the apartment location based on the accessibility and distance to the central business district (CDB). The selected locations are directly connected with the road network and intersections of highways.

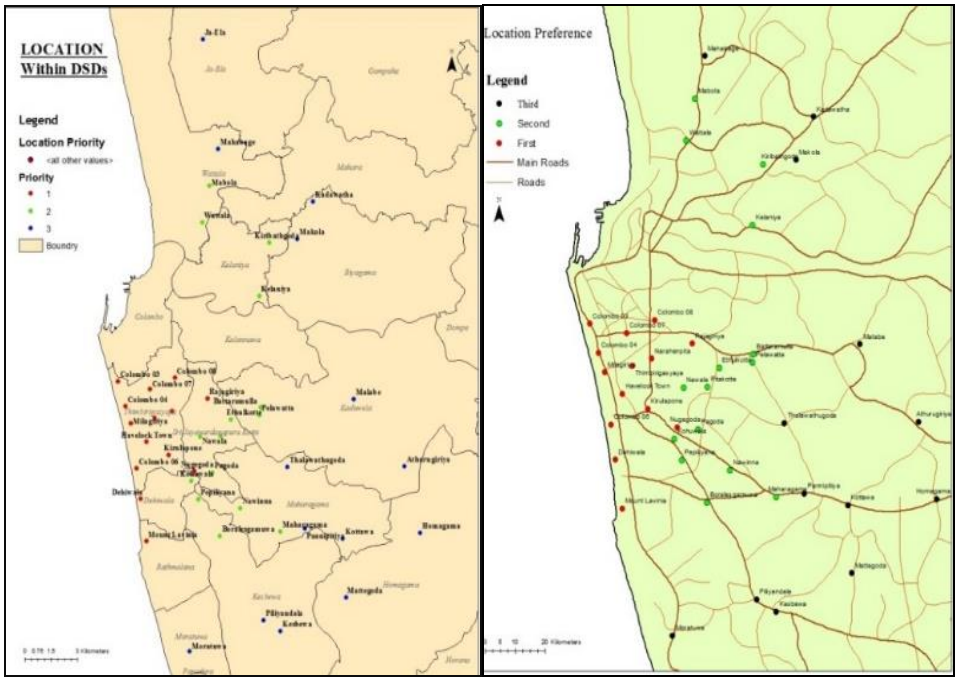

Figure 3 & 4: Preferred Locations within the Administrative Boundaries & Preferred Locations and Road network *(Source: Developed by Author, 2018)*

According to the figure 3, the customers' preferred locations for apartments were lower part of the city of Colombo and especially within the Thimbirigasyaya DSD. Other than that most of the locations were identified within Dehiwala – Mount Lavinia municipal area and part of the Sri Jayawardhana-Kotte municipal area. Further Prestige identities found in the past in places such as Cinnamon Gardens in Colombo may not be the purchaser's prime decision. The figure 4 is shown the clear connection between the preferred locations and road network specially A class and B class roads within the Colombo area.

4.4 THE ATTRIBUTES OF PHYSICAL FACTOR

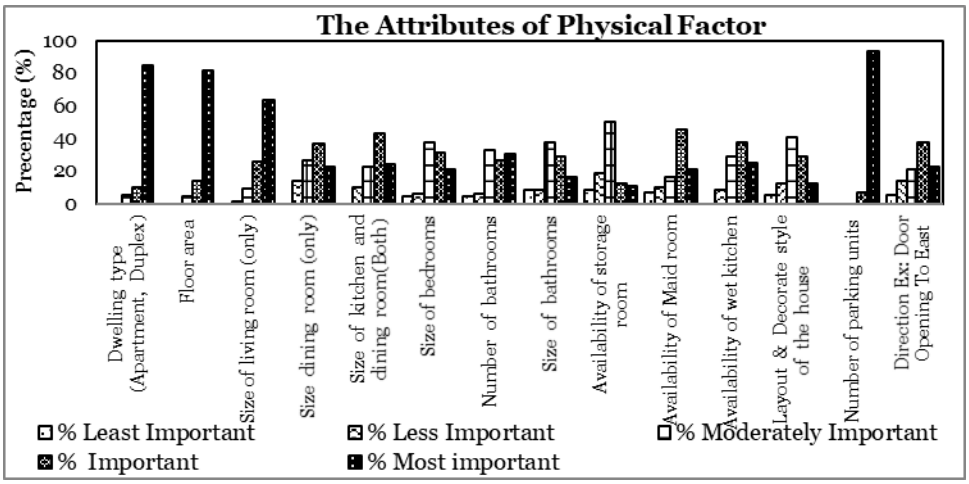

Figure 5: The Attributes of Physical Factor (*Source: Developed by Author, 2018*)

According to the customer responses for physical factors (figure 5), the number of parking units (93%), dwelling type (apartment, auplex) (85%), floor area(82%) are the most important factors influencing to purchase the apartment. There are 43% of customers considered Size of kitchen and dining room (both), 46% of customers considered Availability of Maid room and 38% of customers considered Availability of wet kitchen are the important influencing factors to purchase the apartment.

Under the physical factor, no. of parking units, dwelling type and floor area of the apartment have shown the more than 80% of customers' consideration as the most important. Parking is one of the significant attribute coming under the physical and basic amenities factors and following parameters namely Availability of parking, visitors' parking, common parking, dedicated no of parking lots for per apartment, size of the parking slot, total no of parking slots and mechanical parking for different types of vehicles influence to customers to purchase the condominium in Colombo and suburbs.

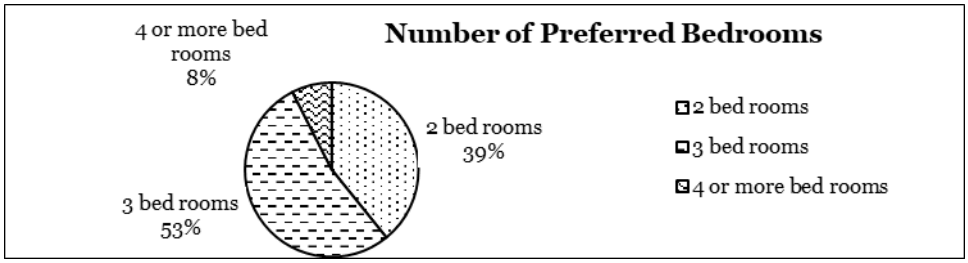

Figure 6: Number of Preferred Bedrooms (*Source: Developed by Author, 2018*)

The majority of 53% of customers preferred to have 3 bedrooms, 39% preferred to have 2 bedrooms and 8% preferred to have 4 or more bedrooms, according to figure 6. There is therefore a high demand in the real estate market for the 3-bedroom apartments relative to 2-bedroom apartments.

4.5 THE ATTRIBUTES OF BASIC AMENITIES FACTOR

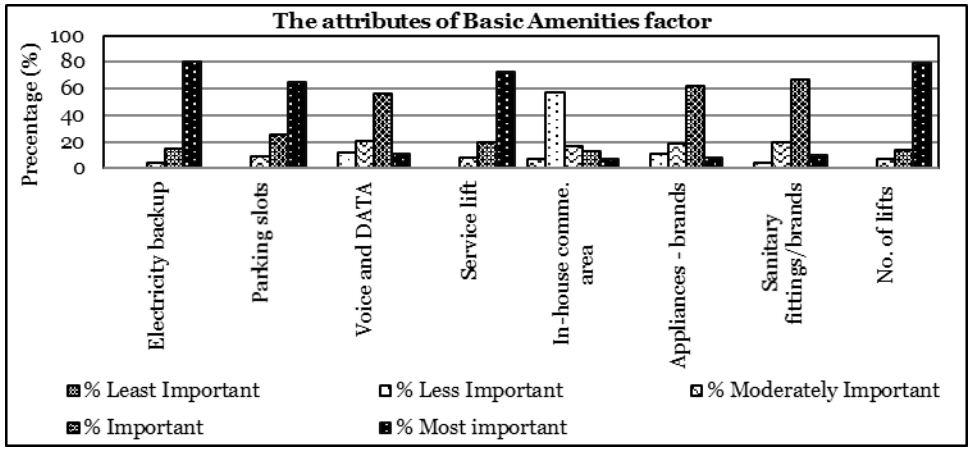

Figure 7: The Attributes of Basic amenities' factor (*Source: Developed by Author, 2018*)

According to the customer responses for basic amenities (Figure 4), there are 81% of customers considered Electricity backup and 79% of customers considered Number of lifts as the most important influencing factors to purchase the apartment. There are 57% of customers considered the availability of Voice and DATA and 59% of customers considered the in-house commercial area is less important factors to influencing the customers when purchasing the apartment. As per the customer responses for basic amenities, Electricity backup, Parking slots, Service lift and No. of lifts are the most important factors influencing the purchase of the apartment.

4.6 THE ATTRIBUTES OF ENVIRONMETAL FACTOR

Customer responses for environmental factors (Figure 8) measured green spaces and scenery by 80% and 81% respectively. There are 57% of customers who found the availability of solar power is of moderate significance, and Rain Water Harvesting (RWH) is less important in determining the purchase of the apartment. The most important influencing factors in buying the apartment are greenery spaces, traffic, scenery and neighborhood. The main driving factors are the low leve lof air quality and ambient

noise. Solar power availability is of moderate importance, and RWH is less important to purchase the apartment.

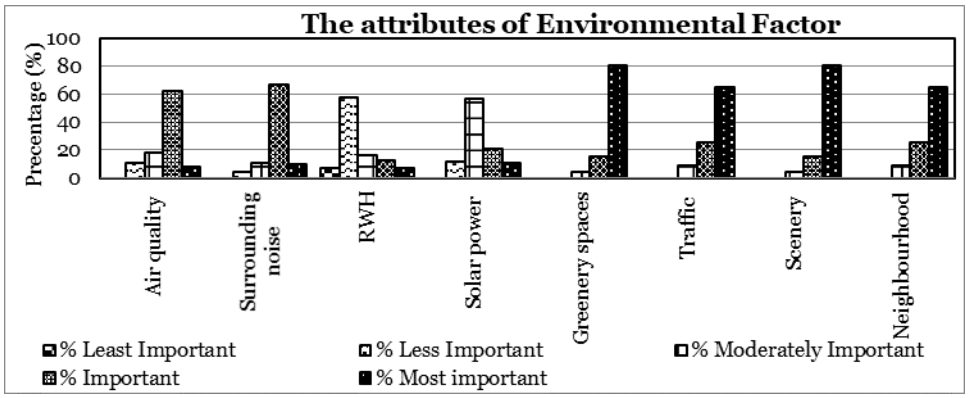

Figure 8: The Attributes of Environmental Factor (*Source: Developed by Author, 2018*)

4.7 THE ATTRIBUTES OF GOODWILL FACTOR

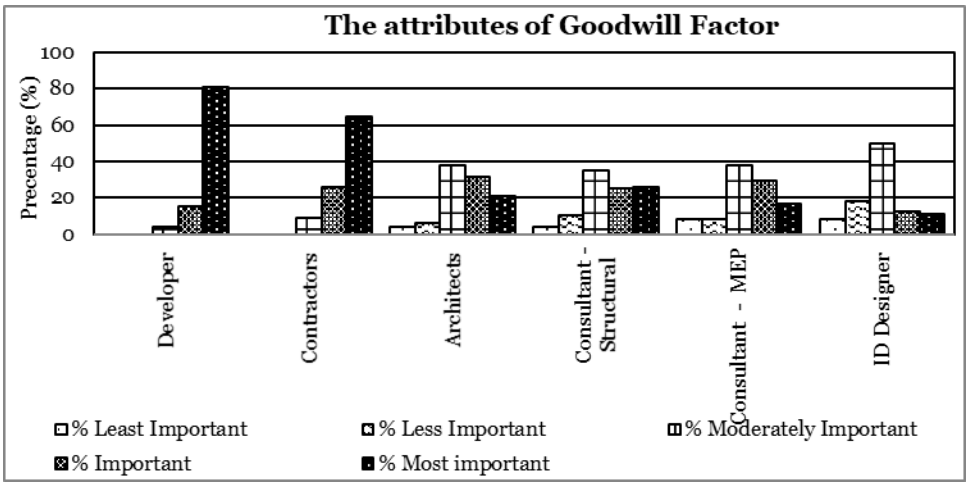

Figure 9: The Attributes of Goodwill Factor (*Source: Developed by Author, 2018*)

According to customers ' views on emotional factors (Figure 9), 80% of customers have been inspired by Developer. Consultant - Structural, Interior Designer and Consultant-MEP (Mechanical, Electrical and Plumbing) are the moderate influence to purchase the apartment. As per the customer responses for emotional factors, Developer and Contractors are the most important influencing factors. Architects, Consultant - Structural, Interior Designer and Consultant - MEP are the moderate important factor to purchase the apartment. The reputation of the developer in the real estate industry and the contractor in construction industry are able to positively influence to the customer purchasing decision.

4.8 THE ATTRIBUTES OF RECREATION FACTOR

Figure 10 shows that 63%, 67%, 58% and 57% of swimming pools, gymnasium, sitting areas and play areas were considered important factors when purchasing the apartment. There are 35% of customers considered Water features are the moderate important factor to purchase the apartment. Based on customer responses for recreational reasons, swimming pools, gymnasium, play areas and sitti ng areas are the main influencing factors and water features are the moderate important factor.

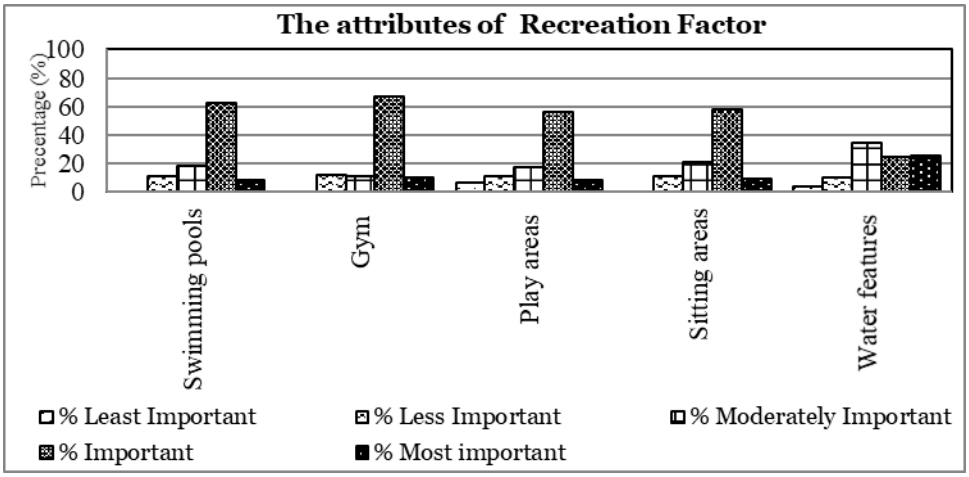

Figure 10: The Attributes of Recreation Factor (*Source: Developed by Author, 2018*)

4.9 THE ATTRIBUTES OF EMOTIONAL FACTOR

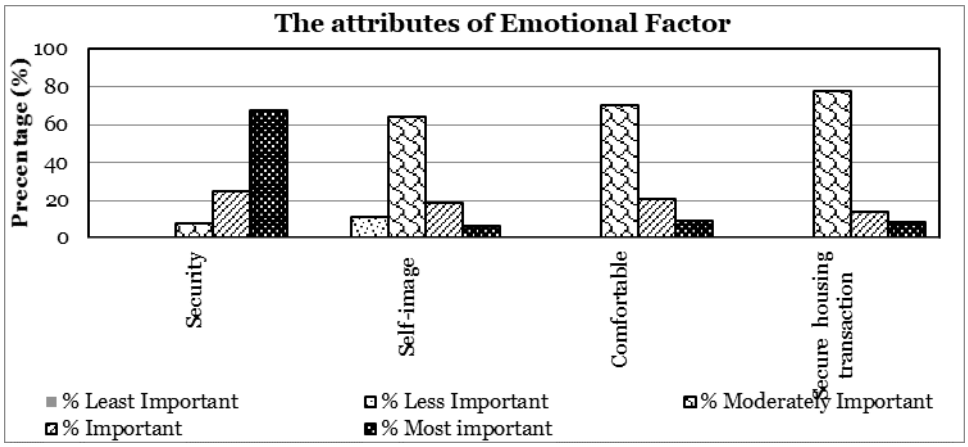

Figure 11: The Attributes of Emotional Factor (*Source: Developed by Author, 2018*)

The security is considered the most important variable by 65.7% acccording to consumer perception (Figure 11). There are 64.2 percent of customers considered the self-image, 70% of customers considered the comfortable, and 77.5% of customers considered the secure housing transaction to be the moderately important factors in buying the apartment. Security is the most important factors, according to the customer's perception, and self-image, comfortable and secure housing transaction is the key factor when buying the apartment.

5. Conclusion

The study has explored the perception of the potential buyers who have enough capabalility to influence directly to the local real eastate industry. Their financial capability and demograpich profile status (education and professional qualification and occupations) show the positive ispriration towards the growth of the local luxury condominium apartments market. The contemporary lifestyle of potential buyers have demended their comfort headed of to urban residential spaces. In addition, coustomers satisfaction is clearly indicated through physical, Location and basic aminities factors. The environmental sensitivity of buyers was depicted by environmental and recreational factors alone with its attributes. Goodwill and emotional factors provided the evidence of customers' perception of social aspects and consideration of social well being. In recapitulate, the collective impact of economic, physical, environmental and social aspects are governed by the customers purchasing decisions on luxury condominium apartments with reference to Colombo and suburbs. Both investors and urban planning professionals may take benefits from this research to understand the customer behavior in

providing spaces for apartments in urban areas. Town planners can use the results of this study to determine the connection between the prevailing regulatory framework (planning and building regulations) for the real estate market – in particular the luxury apartment sector – and the customers ' expectations to make a vital decision on life. In order to evaluate the change in behavior and factors affecting the use of apartments after the purchase decision, the comparison of pre and post purchase of the apartments could be analyzed. This study would indeed be useful in assessing the goals of sustainable development and the rate of achievement of the luxury apartment market by urban areas.

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ARCHIVING 'NAGAR KASHBA'
A study on the present condition and the architectural features of an evanescing historic settlement

FERDOUSI NABILA[1], GAURAB ANINDYA[2] & ADNAN ENAM RABBI[3]
[1, 3] University of Asia Pacific, Dhaka, Bangladesh
[2]Form.3 Architects, Dhaka, Bangladesh
[1]nabilaferdousi@uap-bd.edu, [2]anindyagaurab@yahoo.com, [3]enamrabbi@uap-bd.edu

Abstract
Bangladesh-a small country enriched with prestigious history possesses an enormous number of unrecorded heritage buildings which act as the raconteur of tangible-intangible cultural and historic identity. 'Nagar Kashba'- a row of magnificent courtyard houses on both sides of a narrow alley built in British Colonial style is a precedent of heritage edifices situated in Munshiganj (Bikrampur) - the first capital of ancient Bengal. During the Colonial period, it was built near Mirkadim river port as residential settlements of elite Hindu Merchants adorning the fusion of British Colonial and Mughal style adapting the local context and spatial formations. The buildings were encroached illegally after the liberation war of 1971 by local influential people and now when the buildings fail to please their contemporary needs, the owners are willing to demolish the edifices and erect multi-storied buildings. Reluctance towards heritage conservation, random alteration, weathering, etc. are accelerating this process of decay. Unfortunately, this living archaeological site is still neglected by scholars. The heritage buildings and the surrounding area should be conserved and prior conservation, documentation is necessary. This paper endeavours to archive an overview of the architectural features and spatial formations of this evanescing historic settlement through documentation, assess the context and present condition, which will help to re-evaluate the historic site for conservation and adapt further strategies to rejuvenate the glorious historic identity of Nagar Kashba.

Keywords: *Nagar Kashba, historic settlement, architectural features, heritage conservation*

1. Introduction

Architecture that traversed from the historic timeline connects the past to the present and future. They are undeniable historical and cultural resources for a country. Though Bangladesh is enriched with a lot of architectural heritage of different periods, unplanned development in urban, suburban and rural sectors is engulfing historical settlements, architectural and cultural heritage. Such a historical settlement is Nagar Kashba in Munshiganj. In the early 19th century, during the colonial rule when Hindu merchants of this region had a promising business in Munshiganj started to build a small township at Nagar Kashba area, over an older ruined settlement. (Rahman, 2017)

The pattern is referred to as 'Street front houses' mostly concentrated along narrow Hindu *Para* (street) or Nagar Kashba street and previously were surrounded by canals/moat (*khals*). Although the actual owners were gone long ago, people are still living there amongst dilapidated situations without realizing the historic value of their residence. This endangered heritage carries the legacy of a romanticized architecture of the Colonial period. Thus this evanescing living archaeological site should be preserved properly before it is too late to conserve.

2. Historical context

Nagar Kashba is located at Mirkadim *Pourashava* of Munshiganj District (officially known as Bikrampur until 1986). Bikrampur, the first capital of ancient Bengal (from early 10th century AD to mid 13th century AD) started to lose its administrative value, as Sonargaon became the capital of Bengal in the 13th century. The importance of Sonargaon lasted for a long period even after the capital shifted to Dhaka in the 17th century. Similarly, Bikrampur also continued to hold an important position among the traders during the Sultanate, Mughal and Colonial period due to its favourable geographical location. It was bounded by the rivers *Dhaleshwari, Ichamati* & *Padma* merging with the *Meghna* River and acted as a trade centre for the then businessmen.

Figure 1, Location of Nagar Kashba (Source: Google map, Author)

The term '*Kashba*' refers to the administrative units of the Sultani rulers (1342-1576). Nagar Kashba is one of the thirty-seven *Kashba*s in Bangladesh, though there are hardly any visible remains of the Muslim period now. While trading to Sonargaon, the *Komla Ghat* and *Katpotti Ghat* of *Mirkadim* acted as important river transits and were used as the anchoring place for the boats from the heavy tidal surge of the river (Figure 1). Location of *Katpotti launch Ghat, Komola Ghat, Abdullahpur, Ramgopalpur, Gopalnagar, Rikabi Bazar, Firingi Bazar, and Bou Bazar* clearly expresses the importance of the place in the development of a business centre and settlement of elite businessmen (Rahman, 2017).

The architectural remains of Nagar Kashba refer to the colonial establishment in this area from the 18th to the 20th century and define a new era of architecture that continued in Bengal till the British left. Thus Kashba is considered to be rebuilt as a residential area of Hindu merchants (locally known as Shahas and Poddars) who traded through Mirkadim river port. After the partition of India in 1947, most of the Hindu merchants abandoned the area and went to India. (Adnan, 2018) Those who decided to return, left again because of the Hindu -Muslim communal riots and those who struggled to stay, left the land during the liberation war of 1971. After remaining vacant for a long time, the houses had been unlawfully encroached by the local influential people but they managed to create false paperwork of their ownership. The descendants of these activists now own the heritage property and some of them had already sold the houses to other people. This is the historical context behind the houses that look like they were purposely built for Hindu owners now adorn the names of Muslim people (Figure 2).

Figure 2, Gates of the Hindu houses adorning the name of Muslim owners. (Source: Author)

3. Methodology

The architectural remains of Nagar Kashba failed to attract the attention of architects and proper authority as the inhabitants are not influential in the present socio-political context and are ignorant about the value of their architectural, archaeological and historical culture and buildings. Many of the edifices have already been defaced and severely threatened by occupational activities. This paper is a qualitative and descriptive study about the architectural features of the heritage site. Present condition of the study area and the future prospect of Nagar Kashba will be narrated through the description of the site.

The overall study has been conducted in several phases. The data have been collected from field surveys, heritage building assessments, photographic documentation, oral surveys among the inhabitants, analysing the surrounding environment, and infrastructure. Then a comparative analysis was done with secondary data from other colonial structures of the traditional houses, their forms, spatial zoning, and architectural features. Finally, it was aimed to archive the documents gathered and evaluate the potential methods to conserve the historic settlement.

4. Evolution of the settlement of Nagar Kashba

From the structural pattern of the heritage buildings, the chronological development of the area could be traced.

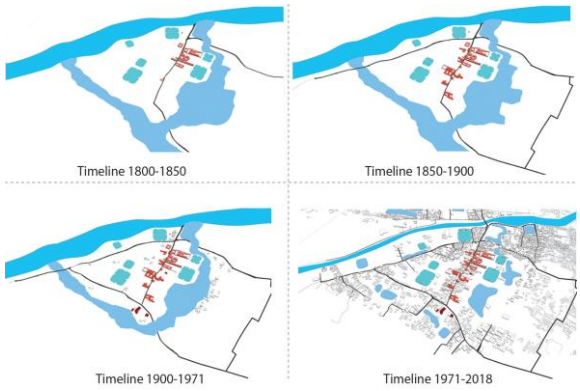

Figure 3, axonometric view of chronological evolution of the area in Nagar Kashba (Source: Author)

Rafter and purlin, made of wood or steel determine the time-period of the settlement.(Rahman, 2017) With the expansion of the settlement, the canal surrounding it has been abolishing slowly. The whole area is transforming into a massive urban jungle (Figure 3).

5. The Present condition of the study area

The actual number of heritage buildings remaining in the study area could not be traced completely due to the lack of evidence. Twenty-one buildings could only be found in Nagar Kashba during the study period in extreme dilapidated conditions (Figure 4).

Figure 4, Location of the heritage buildings in the settlement of elite Hindu businessmen of Nagar Kashba (Source: Author)

5.1 CONDITION OF THE HERITAGE BUILDINGS

During the colonial period, the elite merchants built these double-courtyard buildings. Now the present owners occupied the land unscrupulously, as the original owners migrated to India permanently. Some owners also bought this property from those who encroached the buildings. Some of the present owners, living in Dhaka city or foreign countries, are enjoying their ownership by giving rent of their portion. Previously one building had one owner but with the extension of the family, the ownership has been distributed among the heirs. With an increasing number of owners and a limited number of rooms, the buildings are failing to meet the contemporary needs. The people who have been living in the buildings for a long time want to demolish the edifices and erect multi-storied buildings. Even if they could realize the value, they are not capable enough to maintain it due to their socio-economic condition. Unscrupulous interventions and low maintenance have endangered the survival of the heritage buildings (Figure 5). Thus the identity of the entire culture and region will get into oblivion. With the booming economy and being situated in a demanding area, the trends of giving rent to businessmen, students, service holders, shop owners are on the increase. Because of the ever-increasing population, increasing land value, negligence of the authority and an act of commercialization the total character of the place is changing constantly.

Figure 5, Demolition of house 3 in 2017(Source: Author)

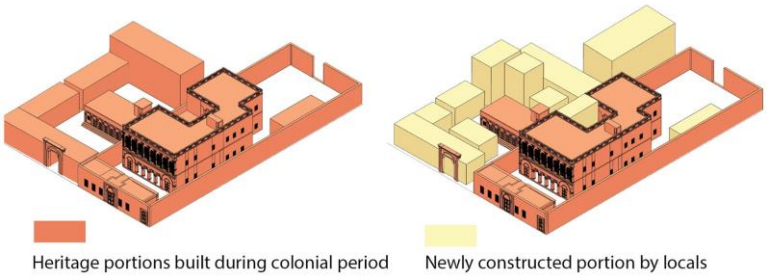

Figure 6, 3d view of the modified situation of house 13 & 14(Source: Author)

By dismantling some portions of the heritage, the owners erected and extended rooms immoderately. They added toilets inside the buildings or in the courtyard, built partitions or dismantled walls inside, added windows or doors or erected walls eliminating the openings (Figure 6 & 7). The owners, who are not wealthy enough to built new structures are doing these alterations and the wealthy ones have already constructed new buildings demolishing the historic buildings. These valuable historic resources are perceived as unfit and unproductive and thus replaced with the buildings that seem to be more contemporary and efficient in terms of new functions. Moreover, they are not willing to put the tag on them of living in the heritage buildings, as they know they may lose their belongingness because of the law that will be imposed on them.

Figure 7, Unscrupulous interventions in the heritage buildings (Source: Author)

5.2 CONDITION OF INFRASTRUCTURE AND ENVIRONMENT

The environmental and infrastructural conditions are ironically getting worse. The canal was seized by dishonest powerful persons in the area. The lands located in between the buildings are also utilized to erect multi-storied buildings impacting the harmony of this area brutally.

Figure 8, Images from road representing poor conditions. (Source: Author)

The historic road of Nagar Kashba is 358 meters long and the width varies between 1.8-3 meters. This narrow alley is used by the vehicles like rickshaw, tempo and CNG autorickshaws and acts as a short-cut road to reach other *mahallas* making the road adverse to the pedestrians. Because of this situation, the facade of the heritage buildings are defacing. Open electric wires, poor system of storm water drainage and littering are making the area chaotic. The whole fabric is now in endangered condition and will be vanished soon.

6. Elite Hindu Merchants' Houses

Nagar Kashba was a settlement with rows of magnificent houses, mostly of two floors, though not too large, built in British colonial or Indo-European styles. None of them are in perfect condition now, but are still carrying the architectural features of their original condition. Some of the buildings are so altered that the original portion and typology cannot be determined. These houses also vary in size and shape. Two types of buildings can be found - Courtyard type houses and Bungalow type houses.

Figure 9, Ground plan of the houses (Source: Author)

6.1. COURTYARD TYPE HOUSE

The houses in Kashba consist of two courtyards- the outer court for public activities and the inner court for private activities. Building no. 1, 3, 4, 5, 8, 11, 14, and 18 consist two courtyards (Figure 9). From the trace of the previous locations of the foundation, it is assumed that building no. 12, 13, 16, 17, 18 also had two courtyards .

6.2. BUNGALOW TYPE HOUSE:

These types of houses have no courtyard. These are of one or two-storied buildings having yards in the front or in the back. No uniformity is found in the organization of the rooms among the buildings. Building no. 2, 6, 7, 9, 10, 15 are considered to be bungalow type houses (Figure 9).

7. Spatial Organizations

Common physical properties found in these buildings of Kashba help to determine the physical as well as the spatial characteristics of these buildings. Courtyards of the houses define the spatial organization according to the functions (Figure 10).

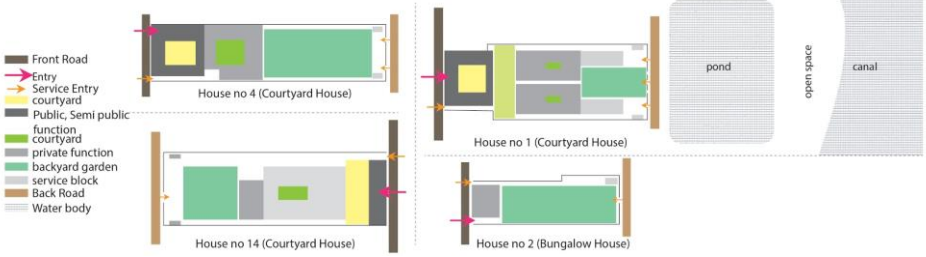

Figure 10, Diagrammatic spatial zoning of some of the houses-Courtyard house and Bungalow (Source: Author)

In most of the courtyards, the block facing towards the street acted as the gate-house and used to accommodate the public or semipublic functions. The rooms facing the courtyards contain temples, guest rooms, living rooms, and dining rooms. The front courtyard was also used for cultural activities like Jatra, folk music and dance shows. The second (private) courtyard is accessible through a passage and the bedrooms and other private zones were faced towards it. Colonnaded circulations formed by rectangular or circular piers with arches surrounded the courts. There is a backyard for the kitchen garden, toilets and restrooms situated adjacent to the boundary. All the backyards are accessible through a narrow alleyway. There are two service entries from both the front and back of each house. Beside the pathway, there were the shared ponds for the inhabitants of the houses. Then there was a canal which surrounded the settlement where the elite merchants lived, and served as a service route for the buildings and also acted as a moat for security purpose.

8. Architectural Elements

The architectural language of Bengal has emerged over several periods of socioeconomic and political development. The manipulations of forms and spaces of British style had a vast appeal to the neo-elite of Indian society. (Rahman, 2009) Thus a new hybrid style named Indo-British or the Colonial style emerged (Mowla, 2000). The architectural features of Nagar Kashba represent an amalgamation of occidental and oriental ornamentation. Decorative features like grand and huge columns, decorative arch, different arched openings, pediment, and other ornamental elements are the main architectural elements of the elite houses of the Colonial period (Figure 11). (Adnan, 2018)

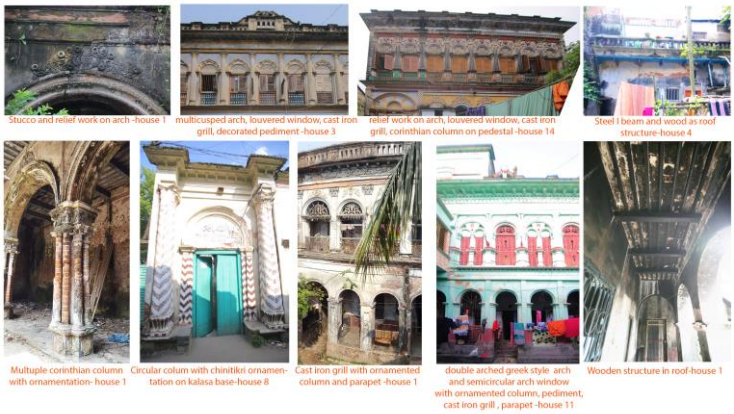

Figure 11, Architectural elements at buildings of Kashba (Source: Author)

Load-bearing brick masonry and lime plaster finish were used to raise the walls of 15 to 24 inches in width. Facades were built with exposed brick or painted. Different types of ornamentation (geometric, organic, floral etc.) of Indo -European style can be seen. In the flat Roof of comparatively older buildings, the rafters are made of wood and in the other ones, the rafters are steel I- section joist. The timber purlins are placed upon the rafters to support the roof tiles and lime concrete. The top floor cornice is enclosed with an ornamental parapet and also has pediment in some houses.

Various types of structural elements are observed in different buildings. Round and square-shaped pillars, pilasters, piers, and clustered piers are found in classical character with ornamental features, like base, shaft, and capital. The foliages of leaves are an integral part of the decoration.

Most of the courtyards are enclosed by arched corridors or arched doors and windows. Semi-circular, segmented, multi-foiled, multi-cusped, Greek- style double arch, and flat arch, etc. are found in different buildings.

Floral patterned cast iron railings are visible. Operable louvers are used in the corridor of the balconies and are also used as doors and windows to maintain the ventilation and prevent rain.

Entrances with simple large wooden doors are usually designed with columns, pediments, arches and various other decorative elements that show a complete fusion of Colonial and Mughal style.

9. Recommendations

The unique settlement of Nagar Kashba is struggling against the contemporary developments, climatic and financial adversaries. It is mandatory to conserve the area now. Detail documentation of the historic features and surroundings at their existing state is the first step towards any conservation strategy.(Mowla, 2008) In most cases, it is seen that government-driven conservation freeze the life of the conserved area and become a burden for its future maintenance, so the conservation program must recognize and accommodate the cultural fabric and social needs of the inhabitants to make it sustainable. Policies should be initiated to invite private and public bodies to share responsibilities. Proper adaptive reuse, community-based tourism activities incorporating the residents of the area and integrating contemporary additions when needed with the assistance of heritage specialists can be the perfect way to breathe new life into the old buildings while preserving resources and historic value.

10. Conclusion

From the study above, it is quite discernible that the quality of spaces and the assemblage of a large number of historic residential buildings situated on both sides of the street in Nagar Kashba make it an absolute contender for area conservation. In this paper the documented features and analysis of the area and historical context may act as a testament of the socio-cultural, political, economic, climatic and functional factors of the then vibrant days of Bengal.

The study will undoubtedly open scope for re-evaluating the spaces of an evanescing living archaeological area full of historical value by proper conservation.

11. Acknowledgements

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INFLUENCE OF NEIGHBORHOOD STREET PATTERN FOCUSING DEAD-END STREETS AS SOCIAL COHESION OF NEIGHBORHOOD: DELINEATING PHYSICAL ATTRIBUTES OF DEAD-END STREETS IN MOHAMMADPUR, DHAKA.

AFROZ S.[1] & TALUKDER R.[2]
[1]Dhaka University of Engineering & Technology (DUET), Gazipur, Bangladesh
[2]State University of Bangladesh (SUB), Dhaka, Bangladesh
[1]salima.arch@duet.ac.bd, [2]toma@sub.edu.bd

Abstract
With the accelerating growth rate of rural-urban migration, Dhaka is teeming with dense urban formal and informal settlements. To aggravate the situation, numerous housing projects are sprouting without expert opinions and overlooking the need for open public place and proper connectivity. The changing nature of the physical characteristics of Dhaka City is caused by the prevalent urbanization process where open spaces and water bodies are being converted into built-up areas. The paucity of open spaces related to the very liveability of Dhaka threatens community, culture and social value of inhabitants, thus compelled them to look for new resolutions. The intention of this study is to contribute to how physical characteristics of dead-end streets adjacent to housing areas and inadvertent organic as well as inorganic patterns of the neighbourhood streets, particularly the dead-end shape the public space quality. The spatial analysis based on current gathering points of inhabitants in murky neighbourhood streets of Mohammadpur, Dhaka is carried out via Space syntax using depth map and behaviour mapping. The research is deeply concerned with the quality of life in these areas, from a perspective of sufferer, like the elderly and children. The findings will focus on (1) to analyse changing behaviour pattern at different dead-end street comparatively and also (2) to identify the major driving forces behind the changes in street connectivity applied in evaluating the street as a great public space.

Keywords: *Urban public space, Street life, Behaviour mapping, Space syntax, Accessibility*

1. Introduction

Dhaka, the capital of Bangladesh, one of the densely populated cities in the world, the city of culture and diversity is being saturated day by day because of migration and population growth. Millions of population is adding with the existing number of population per year. Leaving their poor rural surroundings, they migrate to Dhaka with the high hope and aspiration for an opportunity of having a decent and modest living. Dhaka with the municipalities making the greater Dhaka have a total population of 18 million and the population growth of this megacity is of about 4.2% annually. (World population review.) This extra population is creating more problems in urban conditions like housing problem, shortage of drinking water, lack of proper sanitation, traffic jam and so on. To solve the problem of proper shelter facilities, there developed many formal and informal settlements in different areas for different groups of people of which most of these are unplanned and developed randomly. These housing projects without proper planning and supervision create many problematic features in urban condition. Lack of enough open spaces, poor connectivity from one block to another, insufficient spaces for public gatherings, linear road networks for motorized/non-motorized vehicles, insufficient/no pedestrian access to the housing etc. are very common problems derived from these unplanned housings. Moreover, the open spaces and the water-bodies are converted into build up areas to meet the growing need of housings without considering the need for open spaces for the neighbourhood. This changing nature of the physical characteristics of this megacity has agitating tremendously the appropriate urbanization process which has been threatening the liveability of community. The paucity of open spaces in the neighbourhood is affecting the culture and the social value of the inhabitants which are creating the new resolutions for the need. In this study, it is shown that how the physical characteristics of the neighbourhood street patterns specifically the dead end streets adjacent to the housings created spontaneously in an inorganic way shape the physical conditions of the public space quality. The connectivity and accessibility of dead and streets will be identified using space syntax and the behaviour map will let to understand the actual possible events happening in the dead end streets of the neighbourhood.

2. Literature Review

2.1. NETWORK OF STREETS AND STREET PATTERN

The concept of a microscopic street networks developed by Marshall (2005). The city to city and connection over a substantial portion of the city is considered as The Macro-level(continuous).The neighborhood street network for residents travel which are not continuous are considered as the Micro-level. Marshall (2005) then combines the four types of Citywide Street network types (linear, tributary, radial, and grid) with the two types of Neighborhood Street network (tree and grid) to describe the street hierarchy in a city (Marshall & Garrick, 2010, 2011).Another approach to classify street pattern in a community is formed by Southworth & BenJoseph (2003).They classified street patterns into five categories: gridiron, fragmented parallel, wrapped parallel, loops and lollipops, and lollipops on a stick.

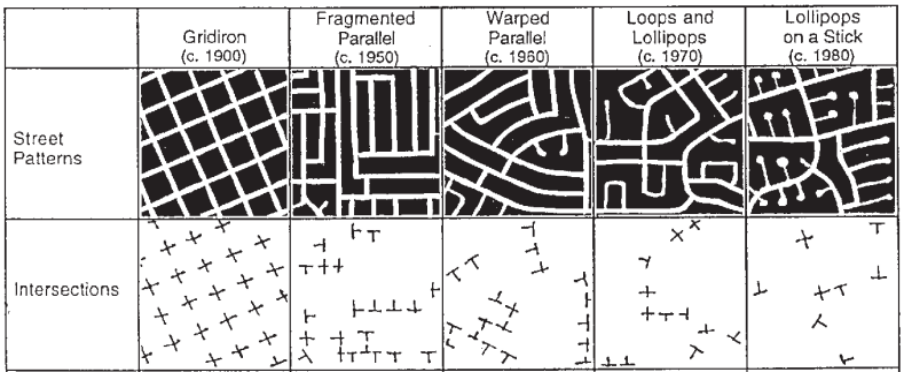

Figure 1, Types of Street Patterns (*Source: Southworth and Ben-Joseph, 2003*)

The loops and lollipops pattern is characterized by the presence of loops and cul-de-sacs. Loops and lollipops create a non-directional pattern of streets that tend to loop back on themselves. Interconnection is limited to several through streets not readily apparent in the plan. As this pattern has limited route choices and few access points, it creates quiet streets that are relatively safe for children. It also limits pedestrian access and increases auto trips but concentrates them on the few existing arterials (Southworth & Owens, 1993).

The lollipop on a stick street pattern is formed by branching off dead end cul de sacs from a few easily recognized through streets. It maximizes privacy but limits intersections, route choices and access points substantially. This limited access design maximizes the number of house lots on short dead-end streets and hampers pedestrian movement to a great extent (Southworth & Owens, 1993)

Planners are seeking alternatives to the contemporary network practice where a branching hierarchy is used so that local streets only link into connectors, while connectors only link to arterials (CNU, 2012). The circular bulb used to enable the uninterrupted turn of an automobile at the end of a cul-de-sac is the defining characteristic that makes it distinguishable from a traditional dead-end street. Cul-de-sacs were first created as short and straight streets, and were designed to form a common public space for residents, while they also provided a safe environment that inhibited through traffic and limited the speed of vehicles (Othman & Said, 2010).

The walkability within neighborhood is compromised as walking distance desired by residents are generally far from 5 minutes walking distance. Walkability demands both a conducive street pattern and a land use arrangement that make amenities accessible to pedestrians. Pedestrian friendly streets are crowded and disconnected and frustrated the drivers.

Our research involves exploring existing planning and sociological literature to identify the key points concerning the public space activities could be performed in dead end streets in case where accessible open public spaces is limited. The study is the assessment of how social interaction is enhanced by dead end streets in a dense neighbourhood condition of Dhaka city where the unplanned dead-end streets have an enormous impact on their social life.

2.2. STREET AS A SOCIAL PLACE

The origin of street is linked to the evolution of public and private spaces. Street works as micro level network of communication in between neighborhoods and macro level communication system within the city. In neighborhood the linkage provide social interaction and exchange, empowering the quality of a community. In addition to being one of the most noticeable elements of the built environment and the foundation for numerous modes of transportation, street networks connect destinations that are spatially separated to facilitate the movement of people, goods, ideas, and wealth (CNU, 2012). The quality of a street depends on both physical and operational attributes .Operational attributes depend on Street life, visual interest, social status and population density whereas the physical attributes ensures the safety, security and comfort. Thus ensuring the physical and social attributes a resident in neighbourhood gets a memorable image of living within a city. Sadly,the sociability largely affected by car traffic. Although a wide and well-connected street in a neighbourhood invites traffic. To enhance sociability, particularly with regard to children's safety and play, most traffic experts recommend discontinuous street patterns of the kind found in conventional loop and cul-de-sac suburbs. Such street patterns consistently show a lower rate of accidents and a higher level of perceived security. Hochschild (2014) displays evidence that strong social networks on cul de sacs may create a greater sense of neighbourhood interconnectedness than is typically found on grid streets.

3. Methodology

3.1. SPACE SYNTAX AS A TOOL FOR CONNECTIVITY MAPPING

Space syntax is a method for analyzing the relation between spaces and the use of that space. Space syntax is a kind of graph theory which describes and measures quantitatively the configurational properties of urban spaces and urban morphology (Hiller & Hanson, 1984). Space syntax aims at categorizing the rational properties of urban open spaces on basis of the use of individuals of different open spaces and the relationship among the spaces. This theory hypothesizes that the built environment as well as the system carries movement from one space to another within the system. For example, a better physical connection from one space to another and longer lines of sight cause better densities of movement. Movement is that kind of syntactic property of space which can be testified by implementing space syntax theory (Peponis & Wineman, 2002). Space syntax generates the theory of understanding the usage and activities of spatial configuration by means of social and cultural attributes and these social and cultural configurations shape the social interaction in the built environment (Dursun, 2007)

This methodology has been widely used for analyzing city structures and connectivity. In Space syntax, the spaces are considered as voids (streets, squares, rooms, Field, etc.) between buildings, walls, fences and other obstructions that restrain (pedestrian) traffic and the visual field. Among several methods for analyzing a city via space syntax methodology a common way is to prepare an axial map for further analysis. An axial map is an appropriate representation of spatial structure of the quantitative syntactical measure like road networks. This map is a network of intersecting lines that consists of the longest sets of lines of sight that pass through all the open spaces of the study area (Kim & Penn, 2004). An axial map shows the least number of straight lines covering study area. All combined syntactical measures of axial lines of an axial map represent connectivity, control and integration among the open spaces (Baran, Rodr1´guez & Khattak, 2008).

In this study, space syntax is working as a tool by generating an axial map from the site plan of the two neighbourhood dead end streets with peripheral area (study area). This axial map will indicate the probable connectivity and spatial conditions of the streets both regular and dead end streets. The axial map will identify the different location of dead end streets at that area and stipulate the necessity of the connection among the street pattern and also determine the probable dead end streets can be redefined as public open space of that neighbourhood.

3.2. OBSERVATION: WALK-BY OBSERVATION AND BEHAVIOR MAPPING

Observation and behaviour mapping as a combined technique in studying the environment-behaviour relationship has been a known and used method for some decades (for example, Ittelson et al, 1970).For

behaviour mapping, walk-by observation was done in two different neighbourhood dead end streets of Mohammadpur to record the stationary and residual activities of people at those locations where people gather and perform different types of activities. In recording and gathering the walk-by observation data, several methods were used in different structured and non-structured way. Physical survey was done at several times and the activity, usability and spatial capacity of the spaces were recorded and addressed accordingly. Duration of stay and gathering activities were also recorded on survey. The walk- by observation will address the behaviour mapping of those dead-end streets at various times from morning to evening. . Data from the dead-end streets were collected in August 5, 2019. A day observation has two sections: morning (10.00-12.00) and afternoon (14.00-16.00).A good overview across a place was provided. The onsite physical evaluation was done by walk through the dead end streets and observing the physical attributes of the spaces in particular three criteria: (1)access and linkage of the dead end streets, (2) uses and activities of the dead end streets and (3) sociability :social interaction.

4. Study Area

The study area consists with two different neighborhoods in Mohammadpur. The neighborhood develops in a private housing named Chand Mia housing LTD. They deliberately filed the nearby canal from the Buriganga river and encroached the riverbed. To gain more profits they developed an unplanned zoning without considering the social cohesion of a sustainable neighborhood. As a result this private housing developed in an unplanned way only to consider more buildings and profits. Hardly any private housing in Mohammadpur considers the need for public spaces for the residents. Therefore, within 5 minutes and 10 minutes walking distance there is no park or playground accessible publicly.

Streets in these neighborhoods don't follow any standard neighborhood design standard. Random streets are connected each other and created dead-ends where another plot located. Maximum road width of connectors streets are 20-22 feet. Neighborhood 2, Baitul aman housing is comparatively old. Yet this housing also exhibits similar issues regarding street pattern and neighborhood street activity.

Case studies represent two urban neighborhoods with similar characteristics such as size, density, cultural significance. Both neighborhoods is located in Mohammadpur thana with a highly dense urban condition without necessary open spaces for gathering. In this respect, they have a similar atmosphere in terms of their daily routine.

Lack of planning, illegal encroachment of land has been reduced the public open spaces for gathering and social activities. Together with vague standards, irregularities and guidelines for open space, this resulted in low quality of new residential developments, lacking communal open spaces to accommodate the outdoor activities.

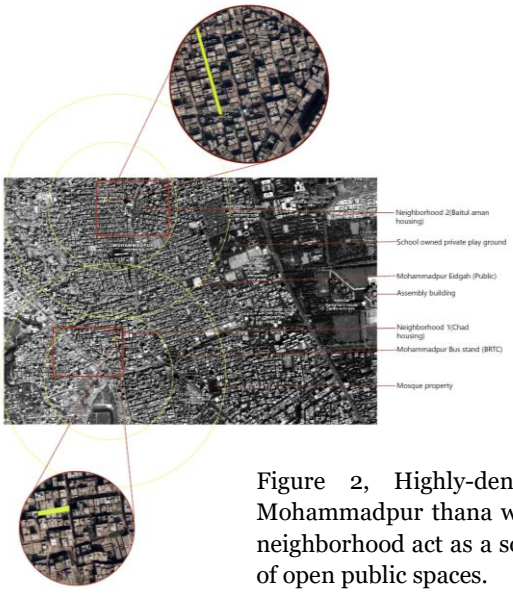

Figure 2, Highly-dense urban condition is shown in Mohammadpur thana where dead-end streets in two different neighborhood act as a social platform for gathering due to lack of open public spaces.
(*Source: Google map*)

5. Findings and Discussions

5.1 IDENTIFYING CONNECTIVITY USING SPACE SYNTAX

The axial map generated in space syntax indicates the connectivity and spatial conditions of the study area. There is different colour coding to identify the actual spatial condition of the streets. The bluer coding indicates less or poor connectivity of that street as well as open spaces. And accordingly bluish green, green, greenish yellow, yellow, orange and red indicate less to extreme connectivity of that area. After generating the axial map, the connectivity and usage condition of the dead end streets are identified and from that simulation, two particular dead end streets have been selected for further survey which is behaviour mapping.

This axial map indicates the actual movement condition and connectivity of study area and identifies the possible dead-ends which can be used as public spaces at different times.

Figure 3, Axial map in Space syntax (Study area 1, Study area 2)

5.2. WALK-BY OBSERVATION AND BEHAVIOUR MAPPING

From observation in different dead-end streets, behaviour maps have been produced to illustrate different activities in dead-end streets. The distribution of behaviours throughout the space has been analyzed. The behaviours of residents in the neighbourhood changed frequently at the dead ends. During day time at the morning from 10.00-12.00 and at the afternoon from 14.00-16.00 social activities among different age groups has been noticed. Children, an age group from (4-16) years has been noticed to play during afternoon. Elderly and adult age group (40-70) years have been seen to walk around on the dead-end streets. The evaluation of this quality indicates that the study areas appear to be lively with activities that are distinctive in its way. Lots of activities take places along, and within the dead-end streets simultaneously. The activities are visible in a particular time during the day, and residents enjoy the character of theses streets .The changing activity pattern appears to be very dynamic providing a sense of public place, where people tend to meet, bring friends and family and to interact with one another.

Observed dead-end street activities in neighborhood, Mohammadpur (Table 1)

Observed Activities	Study Area 1	Study Area 2
Walking in the evening (different Age group people)	✓	✓
Children Playing in the Afternoon after school	✓	✓
Walking with a child	✓	
Free hand Exercise	✓	✓
Chit chatting with one another	✓	✓
Standing in front of the gate	✓	✓
Standing and Observing from the balcony of the neighborhood buildings	✓	✓
Standing beside the boundary wall	✓	
Sitting and Gathering beside boundary walls	✓	

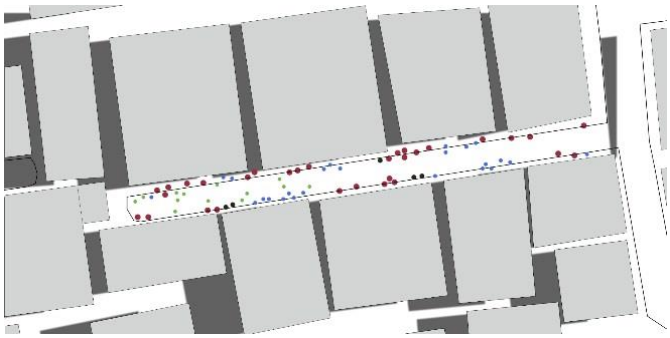

Figure 4, Observed activities that reflect social linakge performed in dead-end street : Study area 1 (*Source:Authors*)

Mapping Legend : Red Dot- standing and chit chatting with others; Blue Dot- Walking and Gossiping; Green Dot- Playing (different aged children); Black Dot- Parking of various vehicles such as motorbikes, car, bicycle etc.

Figure 5, Observed activities that reflect social linakge performed in dead-end street : Study area 2 (*Source:Authors*)

Mapping Legend : Red Dot- standing and chit chatting with others; Blue Dot- Walking and Gossiping; Green Dot- Playing (different aged children); Black Dot- Parking of various vehicles such as motorbikes, car, bicycle etc.

The evaluation on the diversity variables within dead-end streets.The residents in neighborhood engae themselves in passive and active activities such as sitting,listenning,chatting,streeat food eating etc.Most of the activities are seen to perform in a group with neighbors,family and friends with a happy environment. Social interactions have seen vivaciously performed at every dead-end streets.Though there is “dead” in the word of “dead-end”,yet these dead-end streets are bustling with life.From observation the data provides and empirically shows that these dead-end streets could be place to meet public open space demand in case of unplanned zonning and organization of forms.

Figure 6, Neighborhood 1 and neighborhood 2 exhibits with similar activities in each dead-end streets.(*Source:Authors)*

Physical characteristics of dead-end streets in neighbourhood, Mohammadpur (Table 2)

Attributes	Condition	Study area 1					Study area 2				
		5	4	3	2	1	5	4	3	2	1
Access and Linkage of the dead-end street	Street condition		❍				❑				
	Accessibility in respect of different vehicular mode		❍					❑			
	Pedestrian facility				❍				❑		
	Pedestrian leads to adjacent area				❍				❑		
	Vehicular interruption with pedestrian		❍				❑				
	Pleasant walk	❍						❑			
	Sufficient room for walk	❍						❑			
	Enough arrangement for sitting					❍					❑
	Enough space for playing for the children		❍					❑			
Uses and Activities of the dead-end street	Uses different age people at the same time		❍					❑			
	Space used throughout the day	❍					❑				
	Space used as shopping from vendor			❍						❑	
	Place for parking facilities	❍					❑				
	Different activities happening at the same time		❍					❑			
	Suitable for public gathering	❍					❑				
	Space appears special at times			❍					❑		
Socialability : Social Interaction	Allows interaction of different age group people	❍					❑				
	Uses as meeting point		❍					❑			
	Space for evening gathering with friends and neighbours	❍					❑				
	Space used for chit chatting		❍				❑				
	Space used as shopping from vendor			❍						❑	
	Do people sleep at that place					❍					❑

Evaluation Format 1: (5) Very Good; (4) Good; (3) Satisfactory; (2) Poor; (1) Very Poor
Evaluation Format 2: (5) Extremely Likely; (4) Very Likely; (3) Neutral; (2) Unlikely; (1) Not at all

The table focuses on pedestrian comfort and their relation with the streets. It clearly signifies the physical attributes of these dead-end streets and co-relates the activities with the pedestrian.

6. Conclusion

The study finds out, the lack of proper parks and public open spaces compelled the neighbours towards a different approach of using dead-end streets differently. The unnoticed dead-end in these neighbourhoods are becoming a place-A social gathering space for the residents. Unplanned and arbitrary development forced these residents to find a replacement for social bonding and togetherness. Certainly, it is undeniable truth that the culture and context of urban Dhaka needs social cohesion for the safety and security of neighbourhood as well as fulfilling the necessity of public open spaces. The research finds out the changing nature of the dead-end streets and behaviour of the residents. The physical attributes and functions clearly shows that these extemporaneous streets could be an effective public place. The study area has more potentiality to be further studied to enhance the social life of urban neighbourhoods in Dhaka. Surprisingly no dead-end streets have been found without social activities during observation. The outcome of the mapping shows the overall physical qualities of the street appears to be good to encourage social interactions and to investigate factors in transforming public space sociability.

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IDENTIFICATION OF THE POSSIBILITY TO REUSE THE CERAMICS GLAZED TILE WASTE AS A ECO FRIENDLY RAW MATERIAL FOR THE MANUFACTURING INDUSTRY IN SRI LANKA

S.U.LIYANAGE.[1] & DILSHANI RANASINGHE. W. M. N. [2]
[1,2]Department of Integrated Design, Faculty of Architecture, University of Moratuwa, Sri Lanka.
[1]*samudikaumayanga@gmail.com,* [2]*dilshaniranasinghe80@gmail.com*

Abstract
According to industrial waste can be affected by the environment and human. Reason of that lots of companies concern about their benefits, Because of them not concern about environmental damage and life cycle of goods. Subsequently, ongoing years have seen rising social worry about the issue of waste administration by and large, and modern waste and waste from the development business specifically. This research is mainly considered to give the solution for ceramic glazed tile waste in Sri Lanka. Royal Ceramic Lanka PLC (RCLPLC), Lanka Tiles PLC (LTPLC) and Mack tiles Lanka, used as a case studies to find the data. The objective of this investigation is to study and analyzing these three ceramic tile factory waste (squaring dust and polishing dust) properties and discussing how to re-use the ceramic glazed tile waste as a raw material for the production industry in Sri Lanka. This study is analyzed in the three factors mentioned above manufacturing process, Properties of tile, Source of tile waste, Current Methods of tile waste recycle and ingredients of tile waste. Similarly, laboratory testing of waste effluent samples from the factory will identify the components involved. That waste can be used to produce sanitary ware or tableware, bricks manufacturing, water purification, and different type of concrete unit, it can be a long duration and high strength. The amount of silica present in the chemical constituents is relatively high and can be used to increase bond strength. Not only that but also it does not have any heavy metals so it's harmful to plants and animals, it can be used for conservation such as coral and algae.

Keywords: *Ceramic waste, recycled ceramic aggregates, squaring dust, coral*

1. Ceramic Industry

"The word Ceramic is derived from the Greek word 'Keramos' meaning 'potter' or 'pottery'. Keramos, in turn, was originated from a Sanskrit root – meaning 'to burn'. Hence, the word Keramos was to infer 'burned substance' or 'burned earth' (CERAMICS, 2010)". Archeologists have revealed human-made earthenware production that goes back to at any rate 24,000 BC. These earthenware productions were found in Czechoslovakia (Vandiver, Soffer, Klima, & Svoboda, 1989) and were as creature and human dolls, pieces, and balls. There are main three types of tiles are manufacturing in Sri Lankan tile industry. Ceramic tiles, Porcelain tiles and Red clay tiles.

The Island is endowed with raw materials used in the ceramic industry such as kaolin, ball clay, feldspar, silica quartz and dolomite. The excellent quality and purity of these omaterials which is available in abundance contribute to the high standards of the products. Domestic value addition has become an essential factor when exporting products utilizing duty advantages offered under trading arrangements.

Being over 60% value addition, the ceramic industry ranks high amongst the locally manufactured export products. Excellent quality and purity are the hallmark of natural resources in Sri Lanka. The Kaolin, Feldspar, Ball clay, Silica, Quartz, Dolomite that is used in manufacture of ceramic products are the best that can be found. This industry has some significant operational strength, including a highly skilled workforce, competitive labor costs, and excellent management at factory levels, state-of-the-art technology, research and development facilities, high ethical standards and confidentiality of design integrity, in contrast to Asian competitors. Sri Lanka's biggest purchasers of flatware and elaborate product are the United States and the UK. Other significant purchasers are Germany, Italy, Canada, Spain, Belgium, and Japan.

2. Identification of the Tile waste in Sri Lanka

The man is proceeding with industrialization, but the road is very badly marked. It has become a serious crisis that causes many of the environmental, health & psychological problems that it faces. Solid waste is the black spot in that human history or the next century that we all belong to. Environmental and living beings can be affected by industrial waste. Reason of them not concern about environmental

damage and the life cycle of goods. This is in the same situation in Sri Lanka it is, unfortunately, insufficient to focus on the Problem locally rather than other countries. This is because the ability to acquire modern Technology and the time it takes to reach the third world countries and the problem has increased as the time it takes increases. In Sri Lanka, ceramic waste has been very little focused. But it is becoming an environmental issue that has a long-term impact, because ceramic stocks in the world can survive over 2000 years without any decay

“In the recent classification of Chinese Ceramics found in Sri Lanka those from the period* of Tang dynasty’s (618-906 A.D) are listed as the earliest one (Flad et al., 2005)”.In the past, it was a domestic industry and used to manufacture several types of daily items. Today, a large range of products with a range of consumer needs have grown to include professions and profitable ventures. Late decades have seen a checked upsurge in fashionable and financial development, adding to improved personal satisfaction and prosperity for natives. Nevertheless, we tend to ought to not dismiss the method that every generation framework makes results and waste things which might influence the planet.

These impacts might happen anytime within the item's life-cycle, within the case of between the underlying periods of effort crude materials, the amendment, and generation stage, among item dispersion or once the top the client should discard things that square measure nevermore needed. This issue is winding up progressively intense because of the developing amount of modern, development and decimation squander produced in spite of the measures which have been taken lately at Sri Lankan Community, national and provincial dimensions went for controlling and directing waste administration, as per manageable advancement strategies and the Kyoto Protocol(Juan et al., 2010).

In Sri Lankan context, tile waste disposal method is very harmful to the environment. That type of waste does not reach the environment, because ceramic products are produced from natural material containing and processing of dehydration and controlled firing at a temperature between 700C and 1200C(Juan et al., 2010) It is called fired clay. There is no known proper way to dispose or recycle ceramic waste. All country have use to the private sector and try to filing abandoned mines, filling low land and things like that(Koyuncu, Guney, Yılmaz, Koyuncu, & Bakis, 2004).

The recent boom in the construction industry in Sri Lanka has created a huge demand for the tile industry. Therefore, the capacity of tile factories has increased and the flow of imported tiles has increased rapidly, and tile manufacturing plants have been operating all year. Producing a wide variety of waste during their manufacturing process, and are seen to be reused to some degree.

The tile manufacturing process can be mainly divided into two parts, the before and after kiln. In this case, the before kiln stage is the process that goes before the oven and the after kiln is burned in the oven. The raw material that was discarded before the killing is returned to the production process. Tile related problems in the country as well as in the world are the impact of the waste caused by burned tiles. Tile pieces and tile squares that cannot be used during this after-killing process are disposed of as tile waste, resulting in approximately 20 tons of garbage being generated daily in Sri Lanka(Dissanayake, 2015).

There is very few research done in Sri Lanka and there are no practical applications to date. This ceramic tile waste can have a major impact on the environment in short term as well as long term. Most of the workers who work at tile factories are at risk of respiratory illnesses due to exposure to ceramic tile waste. The accumulation of this waste in the vicinity of the factory has also caused problems for people living in the surrounding areas during the winds and rainy season. This has a tremendous impact on living beings. The use of ceramic waste to reclaim various mining sites and marshy areas does not grow plants. Although it does not cause much chemical damage, it has become a major environmental problem due to the accumulation of air, water and destruction of plant cover on the earth.

3. Important of the Study

In the world, industrial waste is used repeatedly, and the classification is often inherited in some regions or countries such actions are largely done by government and government licensed privet companies. In

developed countries such as Japan, rigorous environmental laws will guide these companies. However, developing countries have a very low level of focus on industrial waste management. The inadequacy and ineffectiveness of legal system in Sri Lanka had a great negative impact on waste management. The information and solutions obtained from this study can be used for other ceramic tile manufactures in island. In Sri Lanka, it will be able to utilize the following ceramic solid waste and other waste management methods similarly. Therefore, this study will helps to make solid waste management with ecosystems and make necessary legislation for future activities. But it is very important to look at how much products can be tailored to Sri Lankan production process.

4. Scope and limitations

Ceramic tiles were the dominant place in the ceramic industry and contributed too many foreign exchanges and employment opportunities in Sri Lanka. There are three main makers commanding the earthenware tiles industry in Sri Lanka in particular, Royal Ceramic Lanka PLC (RCLPLC), Lanka Tiles PLC (LTPLC) and Mack Tiles Lanka. This research is intended to consider how the identification of the possibility to reuse the ceramic tile waste as a raw material for eco-friendly design. It is hoped that by examining the chemical compounds present in the samples, they will be better understood for the select production process. Sieve analysis dry test, Density, viscosity and Residue calculate is help to identify what is the physical properties of waste materials.

5. Research Objective

This study aims to re-use ceramics glazed tile waste as an environmentally friendly sustainable solution and to consume the best of natural resources as well as expected to achieve some specific objectives such as, identify how ceramic glazed tile waste produce in Sri Lanka, identify the physical properties of ceramic glazed tile waste, What are the economic feasibility and existing methods of ceramic glazed tile waste reusing and also study the possibility of reusing ceramic glazed tile waste as a new material for the Sri Lankan society.

6. Research Methodology

6.1 CASE STUDY ONE: ROYAL CERAMIC LANKA PLC : HORANA

This is due to the fact that the rocell Horana factory is a large and ceramic glazed tile manufacturing company which generates tile waste during dry squaring, wet squaring and tile polishing. Both dry squaring and wet Squaring plant are operational there. Most of the waste is generated through these, we can consider this factory as a good sample.

6.2 CASE STUDY TWO: LANKA TILES PLC : HANWELLA

Lanka tile Hanwella Factory is the only factory that manufactures floor tiles and uses only two types of wet squaring and polishing. The factory, Lank Tiles they use water for the tile squaring and the polishing, because of that those waste are in the wet form. There generate various kinds of Wastes in like Ceramic powders, Tile pieces, Sludge and glazed. Among those, there is a considerable amount of wet squaring wastes and polishing wastes.

6.3 CASE STUDY THREE: MACK TILES LANKA : BANDARAGAMA

The Tile Factory at Bandaragama is the only tile manufacturing factory in Mac tile which currently produces no polished glazed tile and only dry squaring is used for tile squaring. So those wastes can't use back in the manufacturing process. For these experiments, used 4 samples from those because the process use in each factory is different from each other. Those samples are as follows,

6.4 ABOUT WET TILE SQUARING PLANT - (ROCELL / LANKA TILE)

Water is used for this process. Water diluted wastes are drained to large tanks. Alum ($Al_2(SO_4)_3$) is added to accelerate the waste depositing speed. After that those are discarded by filling to large bags.

Fine particles in the water are extracted by sending them through the filterers. They are used again after the wastewater treatments. Those filtered particle waste are like the gray mud and they tend to form cubes when they are dried. They are so much like the ordinary lime form the outer appearance.

6.5 ABOUT DRY TILE SQUARING PLANT - (ROCELL / MACK TILE)
Water is not used here for the squaring. This is like the dust and is generated through the compound chambers and form the large scale vacuum cleaners. These waste can differ according to the factory and tiles produce at the moment. This waste is like a white fine powder, more like cement. Samples are used to identify the chemical composition and other chemical properties of the waste.

6.6 ABOUT TILE POLISHING PLANT - (ROCELL / LANAKA TILE)
Aforementioned waste is generated through by cutting off the edges of the tiles for the finishing and also generated from polishing the glaze for the shine. So there are special characteristics for these wastes. This is done with using the water and drained to the tanks as mentioned before. In those factories, those polishing waste and Squaring waste are collected to the same tanks. Therefore those two are considered as one.

7. Case Studies and Data Analysis

7.1 CASE STUDY 1 : ROYAL CERAMIC LANKA PLC

Sample 01: Dry Squaring Waste Plant (8 - RSQ)
The squaring plant uses small tiles, such as 30 "x 30", 40 "x 40", which are not polished. Squaring these tiles in closed chambers. This process is done in a dry environment, where the amount of waste removed is very low compared to wet squaring. Due to the small size of the tile, the amount of waste produced is relatively small. It is stored in a factory underground chamber where a large quantity of bags are collected and then stored in the company premises. It was started a few months ago and currently disposes of about 3 tons of waste powder per day. With the expansion of manufacturing activities this amount may increase in the future. The ceramic tile waste here is dry. The distinctive characteristic of this powder is its fine white powder. Such features can be seen here.

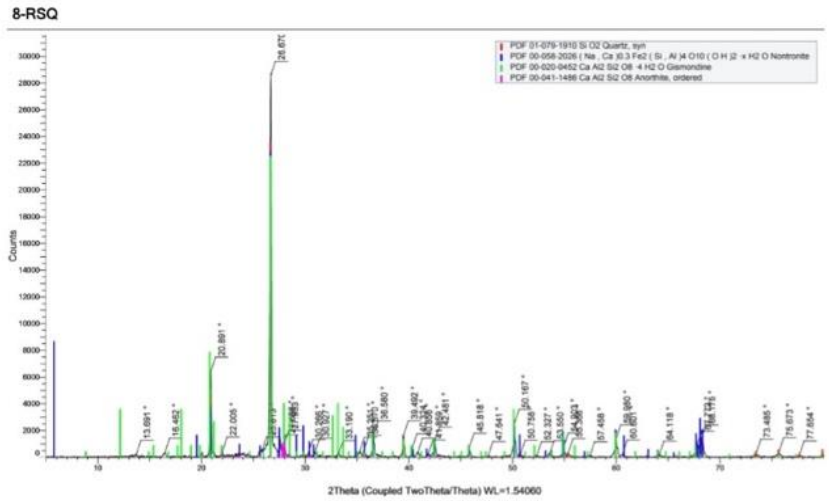

Figure 1 X-ray Powder Diffraction (XRD)

Table 1 Sieve analysis test

Standard Values		Detail	Scale
500 µm	30	The remaining powder on the filter	0.76 g
425 µm	40	The remaining powder on the filter	0.40 g
300 µm	50	The remaining powder on the filter	0.60 g
250 µm	60	The remaining powder on the filter	0.75 g
180 µm	80	The remaining powder on the filter	2.30 g
125 µm	120	The remaining powder on the filter	2.70 g
	fine	Powder passing through the filter	92.43 g

Table 2 Physical property of waste

Detail	values
Density	**1.6**
viscosity	**-**
Residue	**2.11 g**

Sample 02: Wet Squaring Waste Plant + Polishing Plant (9- RSQ+P)

This is other tile squaring plant in rocell Horana complex. The water that is removed from the plant and the polishing plant is dumped in large pools away from the factory. The constituents of the ceramic west of the water, which come into the pools, use alum to quickly deposit the bottom. There are five pools, one after the other, where the water passes through. The ceramic waste powder is deposited in the bottom of the pool with the action of alum. The difference is that the weight of the constituent c

Components changes as they move from the first pool to the last pool. The heavier particles are deposited in the first pool and the lighter ceramic particles are deposited in the last pool. The final pool sends the remaining ceramic water through the filter press to separate the ceramic and water from it. The treated water is directed to the water treatment plant and used for other purposes, such as squaring and polishing. Ceramic tile waste that is removed from these pools is placed in large courtyards and inside the premises. These ceramic tile waste have different characteristics than dry squaring waste, which are grayish liquid depending on the aggregation and the action of the alum.

Among the highlights found here

- The appearance of a gray liquid
- Made of clay and sand particles of various sizes
- Although tile squaring and chemicals are not used, but small chemicals percentage are used in the polishing process. A quality check of the above samples will help to understand which products are best for what type of product range.

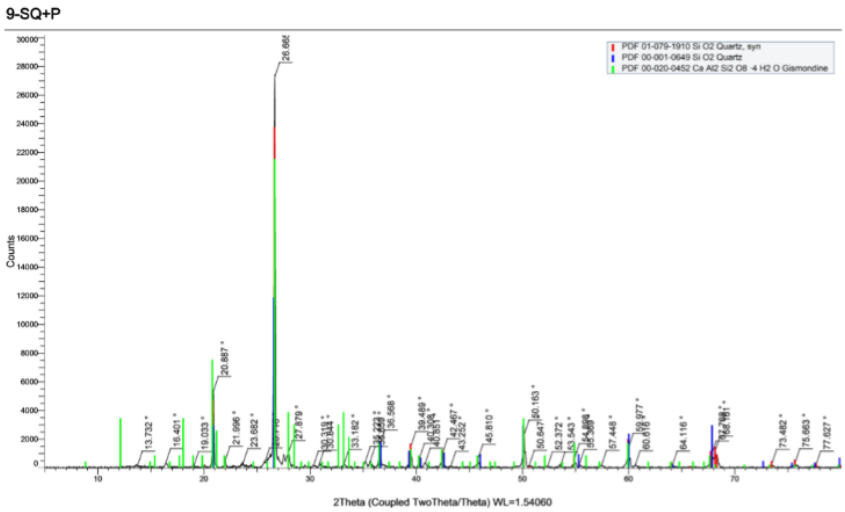

Figure 2 X-ray Powder Diffraction (XRD)

Table 3 sieve analysis test: 9- RSQ+P

Standard Values		Detail	Scale
500 µm	30	The remaining powder on the filter	3.10 g
425 µm	40	The remaining powder on the filter	2.50 g
300 µm	50	The remaining powder on the filter	3.30 g
250 µm	60	The remaining powder on the filter	2.30 g
180 µm	80	The remaining powder on the filter	5.90 g
125 µm	120	The remaining powder on the filter	7.30 g
	fine	Powder passing through the filter	75.80 g

Table 4 Physical property of waste: 9-RSQ+P

Detail	values
Density	**1.6**
viscosity	**-**
Residue	**6.82 g**

7.2 CASE STUDY 02: LANKA TILES PLC (LTPLC) HANWELLA

Sample 03: Wet squaring, polishing and glazed line waste (5 – LFP)

This also operated as the rocell and Squiring waste and polishing waste are collected separately draining through sewage. But the capacity is relatively low and when it exceeds the limit it enters to the main tanks. Ceramic waste is collected there. The special thing here is that glazed waste also collected here in the same tank. In 18/19 6900mt of filter cakes are released from here.

That equivalent to 75% of the total generated waste. This waste is like a muddy look. Most of the waste is deposited in the sewage because there is a considerable distance from the tanks. Color is white or gray and grace adds muddy color to it. Here waste is not reused in the manufacturing process and waste generated through filter press is stored separately. Damaged tile pieces are crushed to tiny pieces and give them to another factory for the making of the Wall block bricks. The little amount of filter cake is also used and most of the filter cake is used in the landfill of the ball mining centers.

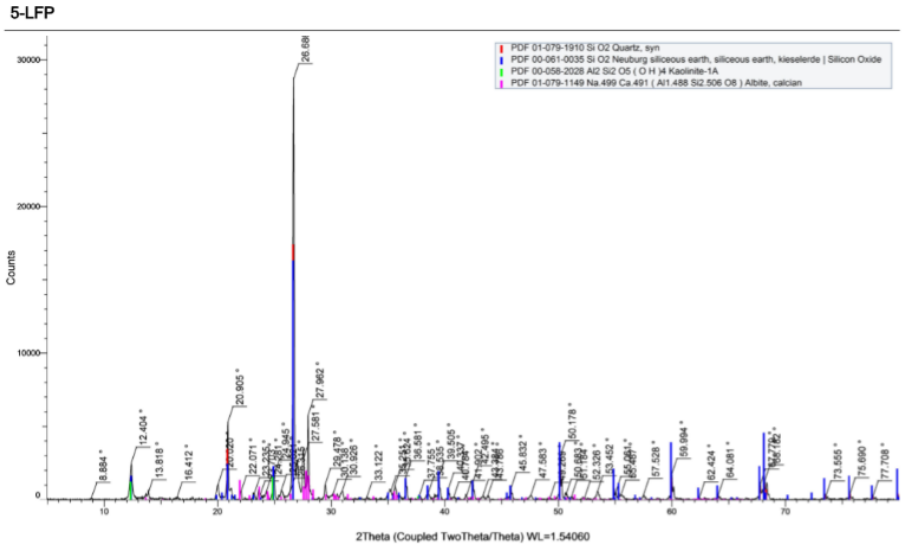

Figure 3 X-ray Powder Diffraction (XRD)

Table 5 Sieve analysis test: 5-LFP

Standard Values		Detail	Scale
500 µm	30	The remaining powder on the filter	33 g
425 µm	40	The remaining powder on the filter	11.1 g
300 µm	50	The remaining powder on the filter	20 g
250 µm	60	The remaining powder on the filter	5 g
180 µm	80	The remaining powder on the filter	9 g
125 µm	120	The remaining powder on the filter	6.6 g
	fine	Powder passing through the filter	11.6 g

Table 6 Quality of waste: 5-LFP

Detail	values
Density	**1.61**
viscosity	**-**
Residue	**1.64 g**

7.3 CASE STUDY 03: MACKSONS TILES LANKA BANDARAGAMA

Sample 04: Dry squaring waste plant (1 – MSQ)

The sample in this method is similar to the Rocell dry squaring waste. The factory does not use a wet squaring plant and does all the squaring through here. Also, the Rocell Company uses an open workspace for their large scale tiles. The discarded ceramic powder is placed in an adjacent yard. Approximately 6 tons of waste is generated per day. The external features are similar to sample 1.

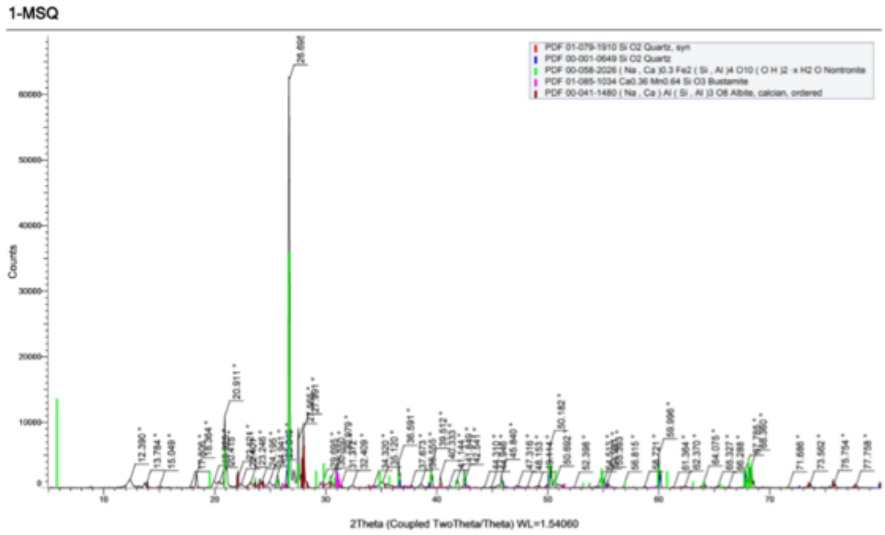

Figure 4 X-ray Powder Diffraction

Table 7 Sieve analysis test: 1-MSQ

Standard Values		Detail	Scale
500 µm	30	The remaining powder on the filter	18.60 g
425 µm	40	The remaining powder on the filter	9.60 g
300 µm	50	The remaining powder on the filter	13 g
250 µm	60	The remaining powder on the filter	4.70 g
180 µm	80	The remaining powder on the filter	14.70 g
125 µm	120	The remaining powder on the filter	10.30 g
	fine	Powder passing through the filter	28.50 g

Table 8 Quality of waste: 1-MSQ

Detail	**values**
Density	**1.61**
viscosity	**-**
Residue	**1.64 g**

8. Conclusion and Recommendation

Ceramic tile factories in Sri Lanka produce waste products such as ceramic powder, ceramic glaze, and sludge and there is no mechanism to deal with that waste locally. Every factory had been made an effort to provide a better solution, but there arises a requirement of a common solution to dispose of these wastes. This is not only important for countries like Europe, India, China who are the giant in the manufacturing field of ceramic but also for Sri Lanka which is an island where there aren't many factories are situated and this is being a very severe problem in the long run because this ceramic waste will decay for many years and will not be added to the environment. Tile fragments were not considered in this study. The main focus has been on squaring and polishing waste.

To simulate the interest, to re-use the ceramic waste, it should be cheaper to re-use than dispose of. Tile pieces are often used after a process of remaking. But due to the powdery nature of tile-squaring, it can be used to manufacture other products profitably. Although there are advanced techniques for waste management in the world, those are not properly utilized in Sri Lanka. Reusing the maximum amount of waste without damaging the quality of the tile can prevent the wastage and by utilizing other waste in more suitable industries, we can maximize the use of natural resources as well as protect the environment. XRD testing can make it clear that it does not contain any harmful substance for the

environment and organisms. Durability, strength, and heat resistant properties of this ceramic powder make it ideal for producing economically important products.

According to many other study references, these are being used in concrete mixing. Also, the amount of waste removed from dry squaring is subtle. These can be used to create small ceramic products manufactured under ceramic casting. It can also be used with concrete as well as tar for road construction. Tile pieces can also be used for this purpose, but the sharp edges of the tiles can damage the vehicles traveling on the road after the deterioration of tile and cement.

This ceramic waste has the potential to cover a large area of production. In addition to this, for further experiments, some field investigations are being carried out to use this waste for the growth of marine organisms. Within a short period of two months, we could observe a variety of algae appeared on it. The burnt ceramic powder which is the disposal of the ceramic squaring and polishing plants has a high potential to be used in a new manufacturing process with the use of proper methodologies and new experiments to minimize the environmental damages. That waste can be used as an ecofriendly material for environmental conservation project.

Figure 5 after 1 month

Figure 6 after 2 month

Figure 7 after 6 month

9. Reference

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CITY FORM AS A STRATEGY FOR CITY BRANDING:
A Comparative Study of Kandy and Galle

SANDAMINI. R.G.P[1] & HERATH. H.M.K.D[2]
[1,2]Department of Architecture, University of Moratuwa, Sri Lanka
[1]*prabuddhikaghsk@gmail.com*, [2]*kavi_dh@yahoo.com*

Abstract
City branding concept is based on marketing the city's history, culture, natural resources, architectural values, social opportunities and lifestyle. This research will investigate the impact of city form or the physical layout of a city as a city branding strategy with respect to two well-functioning cities; Kandy and Galle. Landscape architectural character is mainly expressed through the city form. The analysis was carried out through the experience of the residents, commuters and tourists of the city. The data was collected under two questionnaire surveys to determine the current brand of the city and to analyse the impact due to each of the selected city form elements landmarks, parks and streets. The positive and negative attributes of the selected spaces were further analysed to evaluate the extent of the impact. According to the findings, the impact generated by the landmarks were high when compared to the parks and streets. And the impact of city form was higher in Kandy than Galle. These findings emphasize the factors which affect the different levels of impact from the city form to the development, establishment and endurance of a city brand.

Keywords: *City branding, Form, Landmarks, Parks, Streets*

1. Introduction

Most cities in the world consist of a naturally built foundation that they are known for. It could be a geographical feature, a historical event, a diverse culture or legends and myths of civilizations which creates this foundation. And this foundation with time tends to develop and variate depending on the external and internal forces that affect the city such as environmental, economic or social forces which tends to change the cities identity. This identity helps to generate an image for the city for better or worse. This created identity used by the stakeholders of the city to generate a brand for the city. This brand would promote economic, environmental, social, political, and cultural values by enhancing positive qualities of a city and attracting investors into the city. "City branding can indeed be considered as a strategic tool which takes into account and promotes the economic and cultural values in the cities and furthermore as a marketing tool which conveys the message focusing on the quality of place, history, lifestyle, standard of living, and culture as competitive advantage assets in cities."(Oguztimur, & Akturan, 2015).

Simply because of globalization, the world has become an interconnected place where international trades are made with the aid of information technology. This process has effects on the environment, on culture, on political systems, on economic development and prosperity, and on human physical well-being in societies and people around the world. "Globalization is increasing with shifting in resources, capital, and people around the world and intensification in competition among cities for investment, business, tourists, and different events is considerable." (Zhang and Zhao, 2009). "Globalization intends to help the developing cities to compete more easily with early established cities which are in a more stable situation." (Pfefferkorn, 2005)

With such circumstances, the cities become competitive with one another while trying to stay ahead in the development and promotion paths. "To prove their individuality in achieving various economic, political, social or psychological purposes, cities have long sought to separate from each other." (Kavaratzis and Ashworth, 2005). This promotion of cities finally leads to competitiveness between them. Much like different brands which try to sell products, cities came in to branding themselves so that they would be in the top of the competition.

Branding can be described as the process of providing a meaning to a specific product, service, company or organization by generating and shaping a brand in the consumers mind. This is basically a strategy designed to help the user to identify and experience each of the things that the owners want to promote and to hand them with a good reason to select their products over the others. If the brand quality and identity are good, the chances of being recognized more by the users are high. The objective is to attract and retain loyal customers and other stakeholders by delivering a product that is always aligned with what the brand promises. The process involved in creating a unique different name and image for a product in the consumers' mind, mainly through advertising campaigns with a consistent theme. Branding aims to establish a significant and differentiated presence in the market that attracts and retains loyal customers. When it comes to cities, it is important to follow the same tactics in creating this brand and continuing it without fallbacks.

There are strategies when it comes to branding a city much like in branding a product. If these strategies are established with more clarity and reason in order to convert the visual image into a brand image a better outcome can be expected. “Along this historical route and increasing competitiveness of cities it is expected to see city branding role as action resulting from a consensus among the public and the officials about the identity of the city and also as a strategic instrument for spreading competitive advantages of cities used by many of them around the world to enhance competitiveness” (Zhang and Zhao, 2009).The branding will have a better success if they properly communicate city stories and market its’ values to the users through their brands while generating sustainable urban cities.

2. Research Methodology

The methodology was based on how the city form, one of the strategies in city branding impacted on creating and maintaining a city brand. There were two different surveys used in the research. As shown in the Figure 1, the research started by analyzing how the urban design becomes a part of city branding. Then next stage was carried out to identify the strategies used in the city branding. Among these strategies, city form was taken into further analysis. City form is built up from the urban design and how it evolves over time generates and improves the city form.

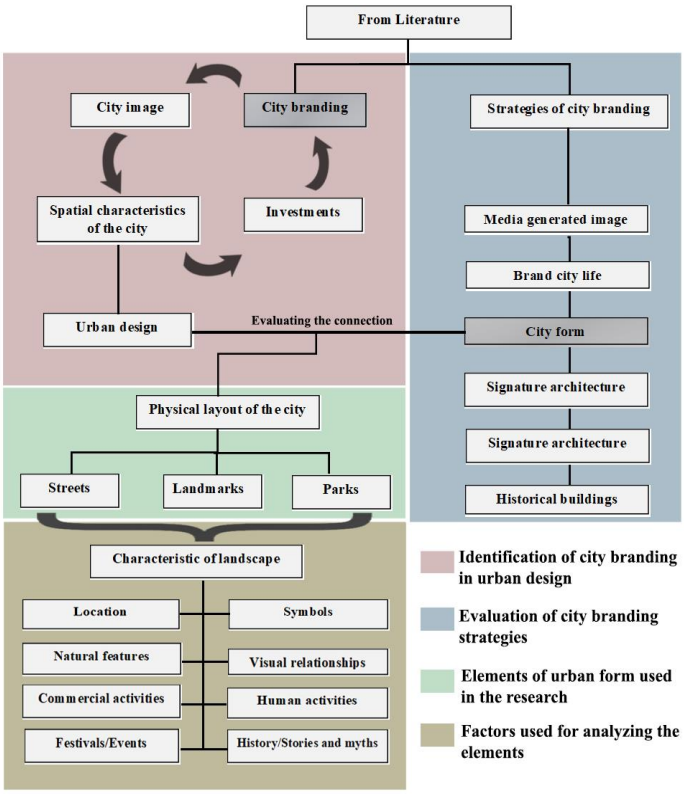

Figure 1 - Research design of the study (*Source: Author*)

The research was carried out in two cities which were selected as case studies. Among the physical layout the selected cities, few elements, namely three elements; streets, parks and landmarks were selected. These elements of urban fabric were then analyzed further by carrying out two questionnaire surveys. The data collected through each survey was analyzed through a developed sequence in order to identify the negative and positive attributes of the city form impacts.

3. Questionnaire survey

The data collection process through the survey basically focused on the perception of users. There were two surveys carried out in the sequence.

3.1 SURVEY NUMBER – 01

This survey was carried out among 30 participants from each city (total number of participants from both cities were 60). These participants included tourists, residents and commuters. There percentages differed as the city branding was a relative measure and it varied only depending on the idea, they had on the city rather than their gender variation or occupation.

Each participant was provided with a questionnaire survey to state the city brand they believe the selected cities hold (Kandy or Galle). After analyzing the results, the brand which is identified by most of the participants was selected for each city. Then in the same questionnaire, they were asked whether the city form impacted city branding. The question was explained to the participants who were less familiar with the terms. Depending on their answer, they were to select the most suitable element of the city form; a street, a park and a landmark from the given list, which supports the brand they selected at the very beginning.

From this stage the answers from the participants who selected the brand which was selected by majority of them was separated and forwarded into the next questionnaire.

3.2 SURVEY NUMBER – 02

This survey was used to further analyze the park, street and the landmark selected by the participants from each city. Here the characteristics of the places which were identified through previous literature was used to determine the reasons for the participants choices. From these outcomes, the negative and positive attributes which impacted the city form was finalized and reached to a conclusion.

4. Strategies of city branding

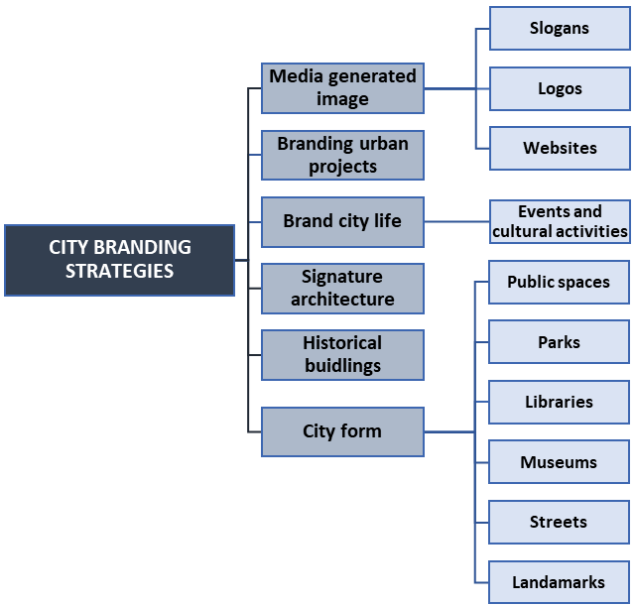

Figure 2,Strategies
(*Source: Helmy.M*)

The making of a good city image is a meaningful synthesis of activity and structure. The use of image planning strategies has become an essential need for cities in order to survive in the global economy. Since successful brands give benefit beyond the physical aspect of the cities, there is a big desire to transfer the visual image into a unique brand image .There are different urban branding strategies that could be developed based on diverse city development objectives and visions, such as large-scale urban projects, signed architecture, events, media, etc. (Helmy.M,2008)

4.1. CITY FORM

City form has a powerful influence on human interactions and how the value is crated within the city. This is a critical measure of cities' infrastructure cost, sustainability and energy efficiency. It impacts on economic value creation and underlies the city's livability and social and economic resilience. City form is the physical layout and design of an urban area, town or a city. This basically contains component patterns and processes involved with the formation and transformations of those patterns. Generally physical layout includes street patterns, plot patterns and building patterns etc.

4.1.1 Landmarks

Landmarks are an objects or features of a landscape or a city or an area which helps to memorize the specific region. Wikipedia defines a landmark as "including anything that is easily recognizable, such as a monument, building, or other structure.". Landmarks often bear very important significance either in design or in history. Landmarks are usually of two types. Natural landmarks and man-made landmarks. Both usually become the attractions or direction providing points of a city or a region.

4.1.2 Parks

Parks are recreational spaces allocated for the people. They visit these places to stay fit and healthy while enjoying the surrounding. Generally, parks are known to provide economical value, social importance and health and environmental benefits to the communities. The very first park was known to be created in 19th century. A high-quality park will have an impact on a city while playing an essential role in attracting investment to the city.

4.1.3 Streets

Streets are the main transportation element of a region where all the spaces in a city gets interconnected. It runs across built environment and across natural environment where people may freely assemble, interact, and move about. Streets are either simple with just foot paths or sometimes complex with hard paved materials with more crowd gathered around. Streets could either be main streets with broad and high level of activities and side streets where it feels calmer and quieter with lot of residential character rather than commercial.

5. Selecting city brands and city form elements

From the two selected case studies, following brands and places were selected by the 30 participants from each city who faced the first survey.

5.1 CITY BRAND SELECTION

So as for selecting the city brands, the following two brands were identified for each city.

Kandy: Cultural City

According to the survey, following were the mainly stated reasons for the selection of Kandy as a cultural city.

- Attraction of tourists into the country
- Presence of Perahera event; a major cultural event
- Temple of the tooth – a sacred place of worship
- Combination of different ethnic groups

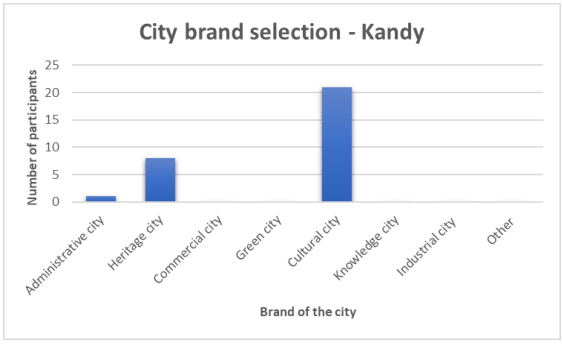

Figure 3, Selection of a city brand for Kandy (*Source: Author*)

Galle: Heritage City

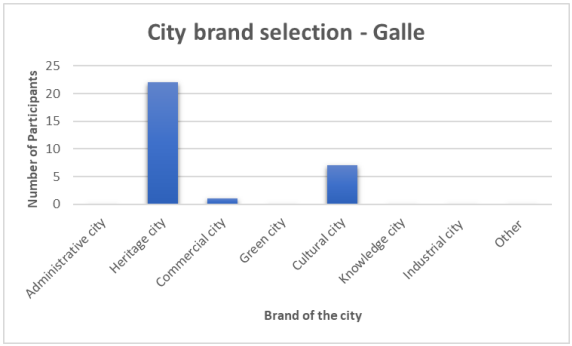

Figure 4, Selection of a city brand for Galle (*Source: Author*)

According to the survey, following were the mainly stated reasons for the selection of Galle as a Heritage city.

- Influence of Dutch, Portuguese and British in the past centuries.
- Presence of Galle Fort as a heritage site
- Unique culture present within the Galle fort
- Tourist destination

The reasons they stated for this selection were always not as specific as listed above. But they were further modified and classified as above to state the most accurate reasons.

5.2. CITY FORM ELEMENT SELECTION

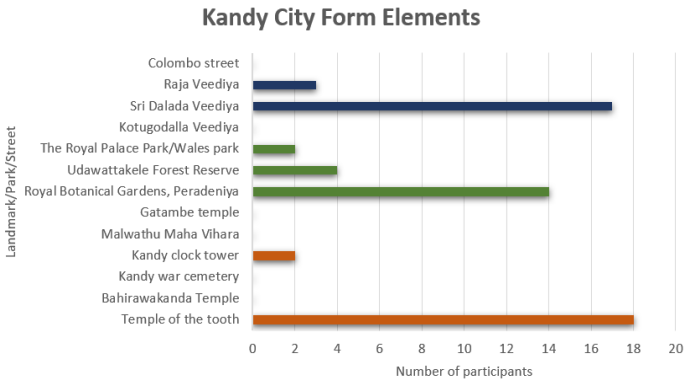

Figure 5 , Selection of city form elements in Kandy (Source: Author)

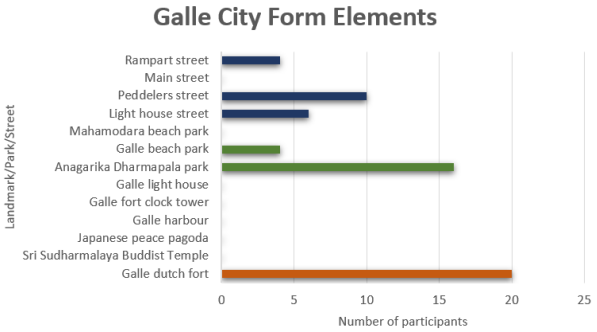

Figure 6 , Selection of city form elements in Galle (Source: Author)

The next stage of the survey was carried out to determine the city form components which impacts the city brand. Participants were provided with a series of images of places representing each selected components of the city form landmarks, parks and streets. They were asked to select the most suitable place that supports in generating the brand they selected. And since the brand of the cities were chosen after the survey; the answers of the participants who chose the brand Cultural city for Kandy and Heritage city for Galle were taken into consideration. And from both cities 20 questionnaire surveys were selected to constant the outcome result. The spaces and places given for the selection and their outcomes were as follows (Table 1).

Table 1 - Selected city form elements Source: Author

	Kandy	*Galle*
Street	Sri Dalada Veediya	Peddlers street
Park	Royal Botanical Garden	Anagarika Dharmapala park
Landmark	Temple of the tooth	Galle Fort

6. Analysis of Data

So, the places selected from the above surveys were used to analyze the characteristics (Table 2) which impacted the choice of selecting these places as the city form elements which impacts the most to the city branding.

Table 2 - Characteristics of urban places and their impact on City brand Source: Author

	Kandy			**Galle**		
	Land marks	**Parks**	**Streets**	**Land marks**	**Parks**	**Streets**
Location	✓	✓	✓	✓	✓	✓
History/Stories and myths	✓	-	-	✓	✓	✓
Festivals/Events	✓	×	✓	-	×	✓
Natural features	×	✓	×	✓	-	-
Symbols	-	×	✓	×	×	×
Human activities	✓	-	-	✓	×	✓
Visual relationships	✓	✓	✓	✓	×	✓
Commercial activities	×	✓	✓	✓	×	✓

When the impacts of both cities were taken as an overall outcome, it was clear that the impacts were not similarly distributed.

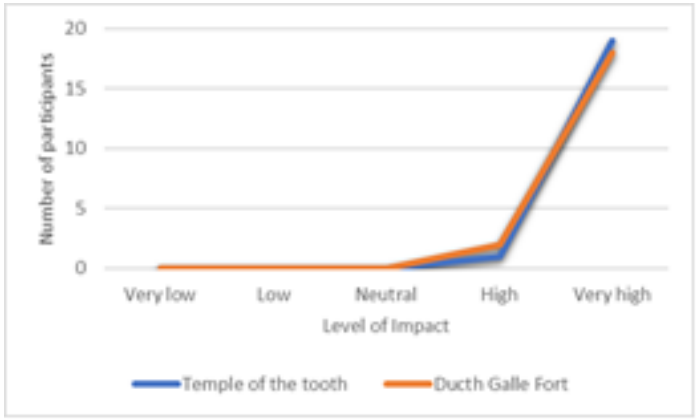

Figure 7, Impact of Landmarks (*Source: Author*)

Both the landmarks seem to have a greater impact when calculated as an overall outcome. All the participants voted that the overall impact is higher when it comes to landmarks impact on city branding as a part of the city form. The reason for this impact was the value of these landmarks with their long histories, and locations which induces various human activities and the special events which revolve around these places.

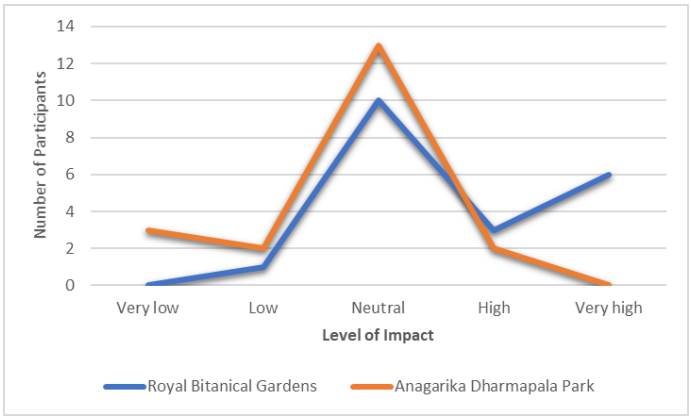

Figure 8, Impact of Parks (*Source: Author*)

The overall impact of both parks of the two cities are given in the graph below**.** According to these values the impact of the parks was mostly neutral in both the cities. There was no impact on the city brand by these parks. The main reasons were the parks were not actually delivering the city brand to the user. Parks are used as places of enjoyment rather than value.

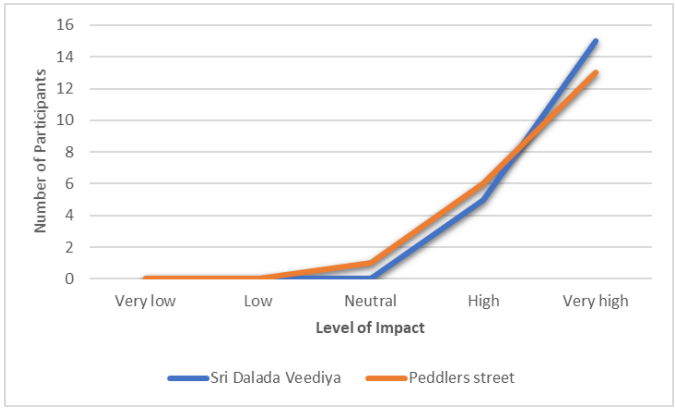

Figure 9 , Impact of Streets (Source: Author)

According to this result the street have an impact to a certain level, but not as much as that of landmarks and definitely not lower than the impact the parks has. The streets are the gathering places and places where the cities talk takes place.

It is where the city people reside, and busy streets have a way of delivering the stories to the visitors and the residents in a beautiful way. The visual connections and the features of the streets helps in achieving this.

When all three elements are compared, the impact can be summarized as follows.

As an overall impact of the city form elements, landmarks have a higher impact when compared with the other two elements. The impacts of the parks were neutral. It showed the lowest impact on city branding, while the streets also impacted on the city brand to a higher level than parks. But that impact was neutral in some cases as well. The general idea of the currently branded city images are as follows for both cities Kandy and Galle with landmarks being the prominent element in branding both the cities.

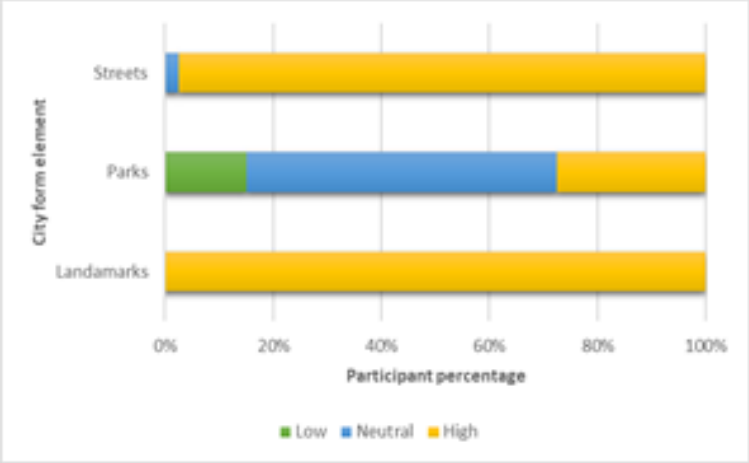

Figure 10, Summarized impact of the city form elements on city brand (*Source: Author*)

Among the city form elements, Temple of the tooth had a higher influence on branding the Kandy city as a cultural city rather than the impact of the Galle Fort on branding the Galle as a heritage city. Between Anagarika Dhramapala Park at Galle and Royal Botanical Gardens of Kandy, yet again the Kandy had a better influence by its' park than Galle. When it comes to streets Dalada Veediya impacted on branding the Kandy city as a cultural city than the Peddlers streets' branding of the Galle as a heritage city.

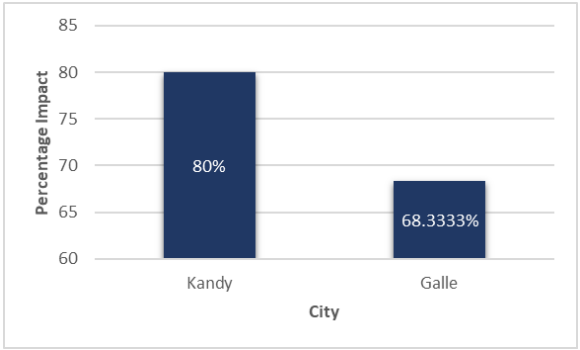

Figure 11 - The overall impact on Kandy and Galle (*Source: Author*)

When it comes to the impact of the city form as a strategy for city branding, the Kandy city had a higher impact when compared to Galle city.

7. Conclusion

City branding is a concept used by most of the cities in the world to promote their cities in order to gain investments into the city. In order to brand a city, the values of the city must be identified first. They could either be historical, cultural, heritage, social, natural or even economical values. And the organization of spatial and non-spatial characteristics of a city which makes up the image of the city should be investigated. These identified values can be fostered in a city through branding. When a city brands itself, the values become the main focal points of the residents, visitors and even tourists of the country. This in turn multiplies the investment of a city which will then be utilized for the development of the city assets which adds up the value to the city brand.

The city branding should be carried out in sequential stages in order to gain the best outcome. According to the city branding strategies explained by Rehan,M (2013) , there are six ways of promoting a brand strategically .The researched focused on one specific strategy; The city form. City form generally refers to the physical layout of a city. This form is generated through urban designing. There are large number of elements which makes up the city form and according to literature places such as libraries, landmarks, museums, parks, streets, public spaces all makes up a part of the city form. The study predominately focuses on the impact generated by landmarks, parks and streets in branding a city through the city form. Characteristics of the places were explored in depth in order to measure the level of impact by each of the elements.

The research was carried out in Galle and in Kandy city. Through the research, it was found out that most of the people brands the Kandy city as a cultural city and Galle as a heritage city. When the impact of the elements was analyzed for the above brands, it was clear that the highest impact was generated from the landmarks compared to parks and streets. The main reason for this impact was the rich historical backgrounds of the landmarks and the activities that circulated around these landmarks. The people view the landmark as a part of the city in a sense that, without it, the cities would not have been welcomed by many people as it is today. The unique locations of the landmarks also made an influence on the value it creates.

When it comes to streets, the impact created by streets were also high, but not high as the landmarks. The important character for the people to choose streets were the activities which were carried out in them and the visual relationships the streets had with the selected landmarks. Most of the activities and events in the streets had a connection with the landmark. When it comes to parks, the impact of parks on the city branding was neutral. The parks were mostly viewed as places which were designed to spend the leisure time and a place which indicated a green area in the city. The park did not add value to the city values or had much impact in branding the city. The parks were designed not in a way that it expresses the city values here as in the landmarks and the streets had various means of adding value to the city which created a high impact on the city brand. When it comes to both cities, the Kandy city had 80% impact through the city form elements to brand itself as a cultural city while Galle had an impact of about 68% from city form elements to brand itself as a heritage city. Yet none of the cities had a full impact from the city form elements.

The two-hypothesis formed at the beginning of the research were; that the city form has a great influence in branding a city and among the analyzed city form elements, streets have the most impact on city brand. Finally, it can be concluded that having a proper meaningful city form has a considerable impact on the city brand. But the landmarks have the highest impact on the city brand more than parks and streets. When designing cities, it is better to focus more on having spaces and places with characteristics which influence the city users in a way that it will help them to memorize and promote the city. A proper city brand will not only promote the city, but it will also help to protect the city assets and values created by them for the generations to come.

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HIDDEN COSTS OF MOBILITY IN URBAN AREAS

MOURYA AMITESH VIJAY[1] & VATS SHIVANGI[2]
[1]Architect, Urban planner, Researcher and Faculty (GGSIPU)
[2]Architect, Educationist and Blogger
[1]arch.amitesh@gmail.com, [2]vats_shivangi@yahoo.com

Abstract
The densification of an urban core forces outward growth of the city to suburbs. The movement towards the suburbs is mostly residential for various reasons including economic, environmental or leisure. The sprawl creates segregated work, live and play zones which require connectivity in the form of roads. Due to, mostly, lack of strong public transport facility, connecting the suburbs, in most of the cities a rise in the private vehicle ownership is seen. With increasing expansion, increased travel distance and increase in number, too, the vehicle users demand more roads. This cyclic nature of demand of road leading to increase of cars and again demand of road to accommodate excess vehicles is observed. The transportation is integral part of our daily life but as important as it is, comes with various issues of which some are direct such as congestions, air pollution, etc. and others are indirect such as health issues, temperature rise, etc. The cost of using transportation is paid by the users as well as non-users. This nature of this cost may be tangible i.e. Monetary or intangible i.e. mental peace & Health. This paper attempts to synthesize the studies on the direct and indirect issues related to transportation system and analyze the hidden costs paid by the users & non users. The outcome of the paper is consolidation of physical, environmental and social aspects of issues faced by the urban population due to increased private vehicles.

Keywords: *Roads, Traffic, Paved surface, Pollution, Environment*

Introduction

The cities have emerged as the commercial and industrial hubs. The dense urban fabric of the city center is the most sought after land for the commercial and institutional activity due to the obvious fact of high footfall. This has led to the high density development in the city center with bare minimum or no infrastructure for the populace. As well as the price of land goes skyrocketing.

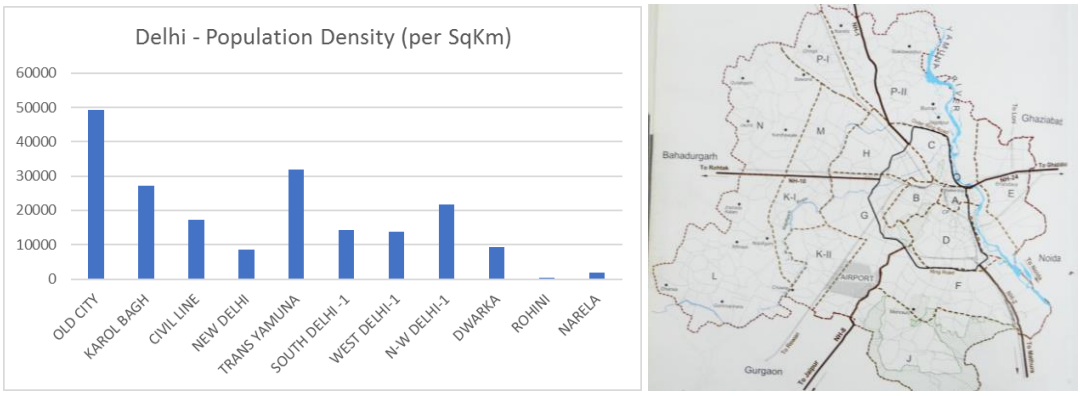


Figure 1 : zonal population density in Delhi (Source: Author)

On the other hand suburban development gives an affordable, uncongested and green area to live. But this increases the distance from the leisure and sometimes work place too.

The desirability of the city center and the livability of the suburbs is always a dilemma for the residents to choose. The driving factors of choice can be economic, environmental or the travel. The city cores are the commercial hubs of the system then city suburb is devoted to industrial areas too. The cost of land, the green areas with clean air or less commute to the industrial areas are few factors which lead to the settlement of people in the suburbs. The garden city proposed by Ebenezer Howard in his book 'garden cites of tomorrow (1908)' was envisioned as concentric layers of such activities. The Radburn city planning segregated the residential apart from commercial and industrial for comfortable living and suburban environment. And Le Corbusier theorized that city should have three separate zones for living, working and leisure.

The modern cities are built on similar concepts, where huge residential area with unified commercial hubs & leisure and the industries are located outside the city. People move/ travel to work, to shop, for leisure and back to homes. A huge sum of time, money and fuel/ energy is spend in doing so. But travel is an important aspect of life. In a study it was revealed that travel distance does not depend upon the income. In a metropolitan city like Delhi on an average a person may spend several hundred per day on travel.

Issues related to transportation

As essential it may be but transportation comes at a price. This cost is paid directly and indirectly in various ways. The payment mode may be tangible .i.e. monitory or intangible i.e. mental peace and health. Some of the important direct and indirect costs paid by users is discussed herewith in following points:

A. DIRECT ISSUES

i. With rising distances demand for vehicles rises;

Since the planning favors segregation of living, working & recreation places and the economics forces people out of the city to periphery or the adjacent satellite towns the in-evident travel comes into play. With this the need to connect distant places with motorable roads arises so as to enable commuters to reach their destination. But the huge number of users in transit everyday puts a tremendous pressure on public transport under which it crumbles forcing more and more people to opt for private vehicles.

ii. Increasing number of vehicles create more traffic and pollution;

The roads laid out in the city have a definite carrying capacity and can handle limited number of vehicles at a point of time. In last decade total Indian road length has increased about 200 percentage but due to finite availability of land in the city and continuous rise in the number of vehicles issues of traffic congestion has been prevented. Increase in number of vehicles puts these limits to a test under which the existing roads get chocked. High and slow traffic gives way to congestions leading to inefficient engine performance resulting in fuel wastage and air pollution in form of CO_2, NO_2, SO_2, etc. toxic gases. Delhi is ranked 2nd most polluted city in the world. This leads to loss of time and fuel enormously. The study has shown that Average speed of vehicles in peak hours in Delhi city is 6 km/hr as compared to suburbs 50km/hr.

The only way to reduce the pollution is to decongest the traffic. At this point of time these additional vehicles demand for additional space to move and park.

iii. With rising number of vehicles demand for wider roads is rising;

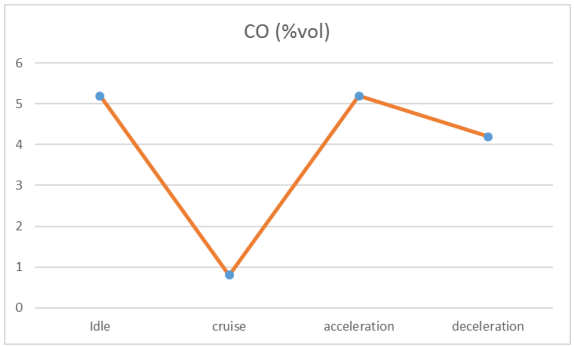
To accommodate the ever rising number of vehicles roads are widened wherever possible. Government spends several thousand crores from their annual budget on road addition and maintenance. Number of flyovers and underpasses get added to smooth out the traffic. This encourages new users to buy private vehicles which are added in the road traffic creating additional burden. Over time the renewed road network also becomes insufficient and requires addition.

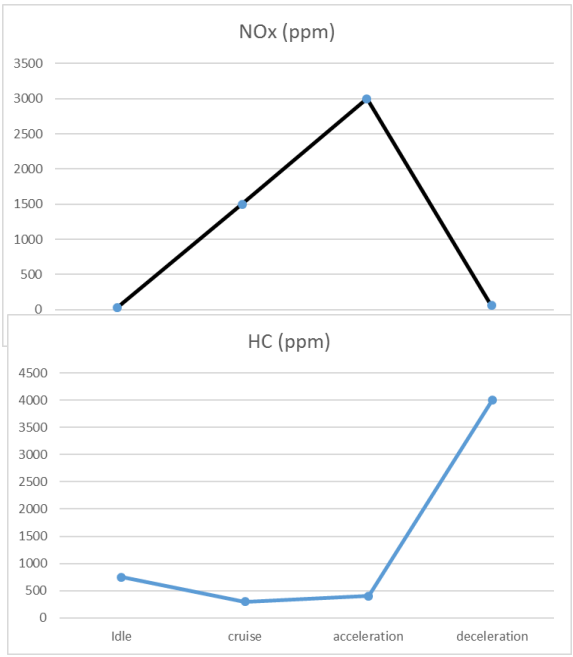
iv. Increasing number of vehicles also puts pressure of providing parking spaces.

The increasing number of vehicles pose a great problem of parking space. The inner or old city areas and other urban villages and unauthorized colonies without any regulation for parking face this problem immensely. The regular sight of vehicles parked on the neighbourhood roads leading to clashes between residents. The local bodies are also put under stress to provide parking spaces at commercial and public areas. The procuring land and building multilevel parking is an additional cost to government. On an average government spends approximately Rs. 7.5 lakh to create parking (multi-level) for each car.

v. Increasing air pollution increases chronic diseases related to lungs; (diseases related to pollution and traffic)

Automobile engines produce approx. 50% of airborne contaminants. Major pollutants are carbon monoxide (CO), hydro carbons (HC) & nitrogen oxides (NOx) with % sharing as 68%, 60% & 49% respectively. In cities due to traffic congestion, vehicles accelerate and decelerate regularly resulting in incomplete combustion and release of unburnt HCs.





Driving mode	HC (ppm)	CO (%vol)	NOx (ppm)
Idle	750	5.2	30
Cruise	300	0.8	1500
Acceleration	400	5.2	3000
Deceleration	4000	4.2	60

Figure 2 Emission in various modes of driving ((Source: Perkins)

Regularly inhaling the polluted air with toxic gases increases chances of chronic diseases related to lungs. The number of patients of lung diseases have increased multiple folds in last decade only.

B. IN-DIRECT ISSUES RELATED TO TRANSPORTATION

It is evident that with every inch of road expansion we lose same amount of natural ground, most of the times green too. As per the technical standards (Neufert architects' data) one car requires around 23 square meter of paved space for parking in an open lot alone. This gives rise to some more problems totally not related to transportation but to the living environment of users. These are not evident instantaneously but they affect our lives and living in the urban area. Few of the issues are discussed hereunder:

i. Less green and less trees;

The trees and green areas act as heat and pollution sink as they absorb carbon dioxide (CO_2) and hence limiting its presence in the atmosphere. The green areas are mostly cultivable land or fertile land to grow trees. Road expansion comes at a price, which is losing natural/green land and trees. Worst cases are scenarios of roads cutting through a forest or reserved area e.g. Mumbai-Pune e-way, Taj expressway through forest in Agra, etc. Tree felling, several thousands in numbers to make way for road accounts for significant factor for deforestation. Due to which we lose the only natural defense against air pollution and carbon dioxide (CO_2) increase in the atmosphere.

ii. More heat island effect;

Another problem due to paving only urban areas experience. The large paved and concrete surfaces absorb heat and increase the ambient temperature of the surrounding. On a regular afternoon paved concrete surfaces can be 27-50 degrees Celsius higher than the air temperature. This is increased exponentially in absence of trees to shade the surface and to balance the heat by absorbing it. This results in higher temperature inside the buildings and higher use of air-conditioning to lower the temperature for comfortable indoor environment in day time as well as in the night when the concrete surfaces radiates back the heat. The resultant expenditure of energy and money to do so for a metro-city like Delhi or Mumbai, if accumulated for million families will run into huge numbers.

iii. More rain water run-off and lower water table;

Very serious effect of large paved surfaces is rain water run-off in the storm drains eventually to the rivers, instead of percolating in the earth and recharging the water table. The retention capacity of soil is the property of soil, when fully wet, to contain some water between its particles. Larger the particles smaller the retention capacity of soil. Hence sandy or loose soil have least water retention. The studies show that loam and clay soils have highest water retention capacity in inches of water per

foot of soil i.e 2-2.5 and 1.5-1.7 respectively. With plants and trees the retention capacity of soil increases upto 200%. This percolated water becomes the part of the water table for future use by plants and humans. The paved concrete surfaces have no water holding or percolation property. Due to this urban areas face water scarcity with low water tables as well as flash floods in monsoons as the water cannot be dispersed into the ground. Metropolitan cities like Delhi and Mumbai face the above problems of acute shortage of water as well as flash floods.

Available Water Capacity by Soil Texture

Textural Class	Available Water Capacity (Inches/Foot of Depth)
Coarse sand	0.25–0.75
Fine sand	0.75–1.00
Loamy sand	1.10–1.20
Sandy loam	1.25–1.40
Fine sandy loam	1.50–2.00
Silt loam	2.00–2.50
Silty clay loam	1.80–2.00
Silty clay	1.50–1.70
Clay	1.20–1.50

Figure 3 : Available water capacity of soil texture

Measures taken in recent years

To ease the presence on the demand of private vehicles and reduce the effects of increasing vehicles govt. has taken a few measures as discussed under:

- *Public transport system- BRTS & MRTS*
  Bus Rapid Transport System commonly known as BRTS was implemented in Delhi unsuccessfully. The system was borrowed from BOGOTA where it is the lifeline of the city and known as greater trans-milenio. Its success can be verified from the fact that it provides transportation for 69% of the city population amounting to approx. 2.4 million riders. This system prioritizes bus movement by allocating exclusive bus lanes. An example of Mass Rapid Transport System or MRTS is metro rail in Delhi or the local trains of Mumbai. This is the rail network serving the city population to move around the city only. For instance the metro takes an approximate time of 2hrs to ply b/w Noida and Gurugram or 1hr either way from Rajiv chowk. But same distance if travelled with private vehicle or bus may take upto 2 hrs. Both the systems when working efficiently reduce the time of travel and expenditure too resulting in serving large population and reducing the number of vehicles on the road.

- *CNG and electric operated vehicles*
  The toxic fumes emitted by fossil fuel operated vehicles can be reduced by using alternate green fuel options. Buses and autos/taxis are a major source of toxic fumes in the city due to their considerable numbers. Buses running on CNG and battery operated rickshaws have been implemented so far in various cities. The level of increase in pollution have been reduced considerably with these implementations.

Measures to be taken

- *Strengthen public transport with new dimensions*
  The majority of population in a city requires low cost transport to travel daily. Hence the bus/rail users get the largest share of all the commuters. Due to which these transport system needs to be constantly updated to cater the needs of the increasing users. This requires periodical increase in the fleet size, monitoring and allocation of new buses/rails on high demand routes for maintained frequency of buses/rails at peak hours. The cost of travel also requires to be optimized because as soon as the travel cost difference decreases users prefer personal vehicles. Travel comfort is another factor for digressing to private vehicles from public transport. Apart from climatic condition, quality of mode and distance travelled to reach the mode is also important. Considering the climate of Delhi AC buses were added to the fleet. Which increased the comfort of the users who could afford to pay a

bit higher price. Last mile connectivity with adequate modes is the key to divert people towards the public transport systems.

- *Policy to limit number of vehicles*
  The second stage succeeding the strengthening of public transport is to limit the number of private vehicles on the road. The implemented and successful example of Singapore is available. In Singapore the number of vehicles on the road at a time is fixed. Old vehicles get disposed in order to get new ones. No private person can buy any vehicle without approval from the government authority. While in Greece ODD EVEN rule is followed in few of the cities. Vehicles with ODD/EVEN number are allowed to be taken out on ODD/EVEN dates respectively.

- *Adopting new road construction technology*
  Since the wider roads mean more paved area, which means more water run-off to the drains instead of seeping in to the ground water resources, new type of road construction technologies or the materials must be adopted. One of the materials around is porous concrete. Other elements can be regular water recharge provision in the road construction policy. Optimizing the road width for specific area or in the urban context.

- *Stricter norms to save green cover*
  Road construction and widening comes at a great price of green cover/forest. Urban areas are the worst hit with these actions. In some cases the most critical and important green areas come under the axe. Norms state that 500-600 new trees are required to be planted for each kilometer of road constructed through forest. But a thousand new trees cannot compensate for one fully grown several decade old tree. The importance of road cannot out-weight the importance of forest. For example "Mumbai – Pune highway planned in Sahyadri mountain ranges".

Conclusion

The expansion of the city is inevitable so is the increase in the distance of travel. The vicious circle of increasing demand leading to longer and wider roads leading to increased vehicle leading to the demand for more roads gets created. In this insatiable need of roads for connectivity city loses its connection with the nature and becomes diseased. Diseases such as water scarcity, increase in ambient temperature, polluted air and most of all loss of greens & trees. The cities are the engines of growth but also these engines require maintenance in the form of planning and upgradation with time. Use of technology and techniques in planning and policy can help us reduce the rate of spread of illness of the city and maybe stop it.

But the question remains "is there any alternative to the large scale movement of population everyday; can we plan the growth in such a way to curb the compulsive movement of the populace"?

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COOLING EFFECT OF ROADSIDE URBAN SHADE TREES
An analysis on urban fabric of Dhaka

MOULY A.R.[1] & TRINA N.A.[2]
[1, 2]Rajshahi University of Engineering & Technology, Rajshahi, Bangladesh
[1]*moulybuet.24@gmail.com*, [2]*124arch0801046@gmail.com*

Abstract
The rapidly growing population and consequent unplanned and uncontrolled urbanization of Dhaka, the capital city of Bangladesh, has resulted in the gradual loss of green spaces in the city. However, the city possesses enriched quality of urban fabric contributing towards varied forms of environmental benefits. Mounting empirical evidence shows that the roadside urban vegetations are effective in mitigating the heat emission and pollution of built environment. The shade trees have impact on the built forms, in terms of radiative cooling, pedestrian thermal comfort, temperature control and reduction of air pollution by absorption of the pollutant. This study focuses specifically on the 'cooling effect' of the roadside trees and plants of Dhaka city, analyzes their impact on air temperature under the shaded and unshaded areas on roads including the comparison between two important primary roads with and without mutual shading, and proposes solutions for maximizing the cooling effect. For proposed research query, temperatures under the tree canopies of a shaded road and an unshaded road were measured repeatedly at mid days without precipitation and then an evidence based microclimatic software simulation is used. Finally, multiple regression analysis is done to analyze the contribution of vegetation characteristics to the cooling effect.

Keywords: *Urban vegetations; roadside trees; air temperature; cooling effect; vegetation characteristics.*

1. Introduction

Rapid urbanization and population growth have led to the change in the earth system, accelerating the flows of energy and materials. Changes in meteorological patterns (e.g., air temperature, air quality) creating alteration of heat and water exchange within urban ecosystem. As a result, various environmental issues have arisen including the formation of urban heat island and degradation of environmental quality. To promote adaptive capacity of cities to global changes, it is of crucial importance for researchers to look for urban heat mitigation strategies. The plantation of trees has emerged as a popular solution to control temperatures and to mitigate the effects of the "urban heat island" by alleviating the excessive thermal stress in cities. Among multiple biophysical functions of trees in the urban ecosystem, radiative shading and evapotranspiration (ET) are predominant in regulating the thermal environment.

At any point near the ground the air temperature is dependent upon the amount of heat gained or lost at the earth's surface and any other surfaces that the air is directly in contact with. During the day as surfaces are heated by solar radiations, the air nearest to the ground acquire the highest temperature. In calm condition the air within two (02) meters of the ground remains stratified in layers of differing temperature. However, trees and vegetation form an intermediate layer between the earth's surface and the atmosphere. By covering the ground with vegetation, the surface of contact can be elevated by four to twelve times. By means of shading and transpiration, plants can significantly reduce air temperature. They also increase the humidity whereas it is already too high. In a hot and humid climatic condition, the ideal situation is to have a high canopy of trees for shade, but no low plants that could block the breeze.

2. Statement of Problem

From the very beginning of urbanization, the built environment and infrastructure of Dhaka city has been developed in a way where the environmental issues were barely addressed. As a result, Dhaka has failed to create a comfortable dwellers' experience comparing to most other well-planned cities. For instance, a minimum 25% of forest cover is suggested for a healthy living (Mowla, 1984) where at present in old Dhaka (old part of the city) only 5% and in new Dhaka (new part of the city) 12% of the land is green and open (Mowla, 2011). Another data says that 10.46% area of Dhaka city corporation is hard surface that consists of the roads and the highways. Use of excessive exposed hard surfaces like

brick and concrete pavements, and pitched roads is responsible for raising urban air temperature. This situation is alarming for a city such as Dhaka that aims towards ensuring a healthy living condition.

To alleviate the situation, the roads, paved ways and footpaths should be planned in a way that will invite more people for outdoor activities providing a comfortable environment for them. There are several criteria for a weather to be considered as comfortable such as air temperature, humidity, wind flow, wind velocity etc. Among these, air temperature is an essential criterion which can be moderated by roadside trees that provide shade on roads and surrounding surfaces. This study firstly focuses on the impact of roadside shade trees on roads, paved ways and built forms in terms of air temperature. The next phase of this study is to analyze tree properties that maximize the cooling effect and then to suggest some trees for roadside plantation in the context of Dhaka.

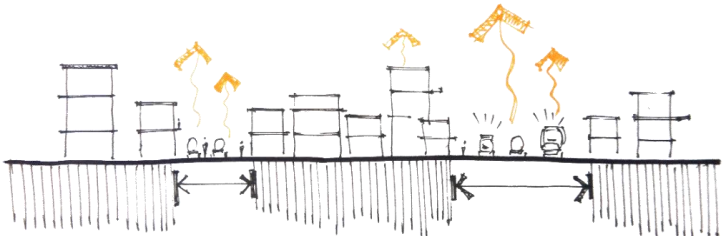

Figure 1. Hard saufaces and builtform are emitting heat which increases air temperature.

3. Objectives

In brief the objective of this paper can be summarized as follows:

- To analyze the influence of roadside shade trees on roads, pavements, footpaths and nearby hard surfaces in Dhaka city in terms of air temperature.
- To figure out the configuration of the trees required to improve the cooling effect on roads.
- To provide a suggestion of trees for roadside plantation according to their configuration.

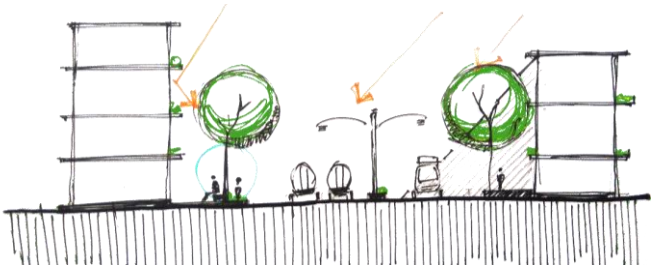

Figure 2. Roads with trees can create pedestrian level activity more comfortable by reducing air temperature.

4. Methodology

The methodology of this study can be described in three major steps.

4.1. STEP 01: LITERATURE REVIEW

In the literature review the morphological change of Dhaka city is studied. With time the conversion of land into built form and hard surfaces and simultaneously the drastic change in the amount of vegetation is discussed. Then the impact of vegetation and roadside trees in the comfort level is analyzed from different books, papers, articles, journals etc. The tree properties are taken into consideration and a list is made for roadside plantation in the context of Dhaka city prioritizing the quality of making the roads and surroundings cooler.

4.2. STEP 02: FIELD SURVEY

A short field survey in two major primary roads of the city is carried out in the present condition of the roads. Before selecting the two roads several major primary roads are practically overviewed to understand the layout, orientation and the number and species of trees planted in previous years alongside those roads. The first road taken into consideration for examination is the North South road

that connects the 'Noya bazar' bus stop and the 'CBS-2 bus terminal'. This is a mixed used development area and the road connects two node points. The second road is the Azimpur road that connects the Azimpur bus stop and the Nilkhet bus stop. Both the roads are laid in the north south direction and consist of both pitched surface and pavement. The only difference is that there are tall trees on both sides of the Azimpur road when the roadsides of the North South road is full of built forms. This survey will help us understand whether any variation of the air temperature takes place due to the presence of roadside trees.

The survey was conducted on June 2018 at noon. June was selected as the hottest month of the year when the shade is mostly needed. In order to measure the air temperature, 5 equidistant observation points on an imaginary line along the road in the north south orientation was taken for both roads. The distance between two successive observation points was taken as 100ft. Kestrel 3000 Pocket Weather Meter was used to measure the air temperature and all the measurements were taken 1m above the ground level.

4.3. STEP 03: SIMULATION

ENVI-met software has been used to do the microclimatic simulation for a comparison with the survey data. The weather data of Dhaka is used for simulation with the survey data. Data input was provided separately for the two roads and separate model is made for each simulation.

5. Literature review

The physical changes that Dhaka went through were not only in terms of vast territorial expansion, but also through internal physical transformations. The urban built-up area of Dhaka increased by 88.78% in the past 20 years from 1989 to 2009 (Ahmed,2014). Figure 3 shows the physical development of Dhaka City at different stages of its growth.

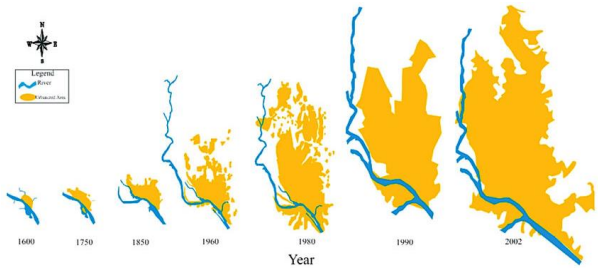

Figure 3. The historical growth of Dhaka City (not to scale). Source: Urban Planning Department, Dhaka City Corporation, 2007.

Urban population in Bangladesh is 52.56 million of which Dhaka city consists of 40% (Ahmed, 2018) making it one of the largest mega cities in the world. The necessity to meet the need of space for housing, business and industries for this large population has resulted in the rapid conversion of agricultural land to urban use. These kinds of meteoric urbanization trend results in tremendous scarcity of trees affecting the natural environment of urban areas. It has been reported that one of the major causes of the continuing environmental degradation in Dhaka city is deforestation (Islam, 2002).

There is a very close relationship between trees and improved urban environment since trees play a vital role in mitigating urban heat island (UHI) effect. While finding solution for maximizing the cooling effect of trees, in practice, designers and planners often have difficulty demonstrating their cooling properties. The most effective way to measure the cooling effect of roadside trees would be to compare the urban air temperature between two roads with and without mutual shading. For a credible comparison, we need to have a clear understanding of the physics of heat flows in our cities, and the scale of the measurements we are taking.

Theoretically, trees can help provide cooling in two ways: by providing shade, and through a process known as evapotranspiration. Locally, trees provide most of their cooling effect by shading. Like a Parasol, A tree's canopy can block out up to 90% of the sun's radiation and increase the amount of heat that we lose to our surroundings by cooling the ground beneath us. According to Wardoyo (2011), Individual leaves allow 20% radiation to be transmitted through them, absorb 55% and reflect the rest 25%. So, Trees can be used to tackle the problem of the urban heat island. During periods of calm, sunny weather, the air temperature of urban areas can be raised above that of the surrounding rural areas by up to 6°C, especially at summer seasons in Bangladesh (Mowla, 2005). In cities, the hard, dark asphalt and brick surfaces absorb almost all the incoming short-wave radiation from the sun, heating up to between 35°C and 40°C, and storing energy which is released into the air during night, when it can be trapped in the narrow street canyon.

Urban trees can impede this process by intercepting the radiation before it reaches the ground and using the energy for evapotranspiration. Evapotranspiration occurs when the sun's rays hit the trees' canopy, causing water to evaporate from the leaves. This cools them down – just as sweating cools our skin – thereby reducing the amount of energy left to warm the air. Evapotranspiration effects can be quantified in two ways. Firstly, one can measure the temperature of the tree canopy, which is typically much cooler than built surfaces – only 2°C to 3°C above air temperature. However, it cannot be claimed that this temperature difference is evidence of cooling capacity; leaves would be cooler than built surfaces even if they weren't losing water, because they are cooled more effectively by convection. A better method is to calculate the cooling effect of a tree directly on the air temperature change by comparing two different zones.

Simultaneously, the climatic data and environmental criteria of Dhaka city is also necessary to run this survey. Dhaka city is in warm humid tropical region. Considering the air temperature, humidity and the amount of rainfall, the climate of this area can be divided into four seasons. According to Hossain and Nooruddin meteorologically the climate of Bangladesh is categorized into four distinct seasons Winter (cool dry), Pre-Monsoon (hot dry), Monsoon (hot and wet), Post-Monsoon (hot and wet), where Winter months (December to February) temperature 21-26 C, Pre-Monsoon (March to May) temperature max 34 C, Monsoon (June to September) avg. 31 C, Post-Monsoon (October to November) temperature bellow 30 C (Ahmed, 1996). Average Relative Humidity is 60-80%. Radiation on a horizontal surface 5.00 kWh/ m2 and Air Flow 4.1 m/s (Ahmed, 1996).

6. Considerations for roadside plantation

The following are the factors which should be considered for roadside tree plantation in urban area.

6.1. SPECIES SELECTION:

The climatic condition in the city streets is different from the residential areas. The species therefore selected for a given road must be adopted to it. Soil characteristics is an important factor for tree selection. Some trees grow in alluvial soil like Jarul, Kadam, Aam, Jam,Babla,Shishu, Shimul, raintree etc. Jam, Malina, Gulmohor, Shal, Aam, Kathal, Shimul, Hartaki, Karai grow in clay soil. Shisham, Shimul, Jhau, Babla grow in sandy soil while Jarul, Arjun, Hijal, Tarcharbi grow in water clogged soil (Mowla, 2005). Bueno-Bartholomei and Labaki found that, the structure of the crown, dimension, shape and colour of vegetation leaves influence reduction level of solar radiation (Bueno-Bartholomei and Labaki, 2005). Scudo (2002) establish that geometry, height, permeability and crown of the vegetation are the structural vegetal characteristic that influenced the controlling air movement and air temperature.

6.2. SPECIES COMPOSITION

Every attempt at plantation should aim at establishing polyculture forests consisting of the best kinds of trees. The highways can have 3-4 rows of trees whereas the primary roads can have single or double rows on either side. To contain more trees of the right kind, saplings should be planted following a good plan.

The lowest ebb of the roadside may have jarul saplings along with some babla and hijal. These plants can thrive in water. Aam, mahogoni, gorjan, debdaru, rendi koroi, jaam etc. may be planted in the middle. Kathal, shimul, segun, redwood etc. cannot withstand water, so they should be planted along the highest ebb.

6.3. SPACING OF TREES

Street trees are precise and require different type of planting as regards to availability of space, potential interference with curbs, side works, driveways, overhead wires, underground facilities, traffic signals, etc. Timber or flowering trees which are planted alongside primary roads require spacing from 10m to 20m according to species types. Spreading of roots, plant height, canopy shape and diameter are some parameters that determine tree spacing.

7. Field Survey

Road 01: The North South Road The North South road is one of the major primary roads in Dhaka city. There are several banks, office, shops and other commercial activity zones beside this road. Building height alongside the road varies from two storied to seven storied. This is a wide one-way road with a divider in the middle where a few trees are planted. The trees do not provide any shade and the people on the pedestrian level are not benefited with the trees. As a result, temperature is higher in this road, roadside pavements and the nearby built forms.

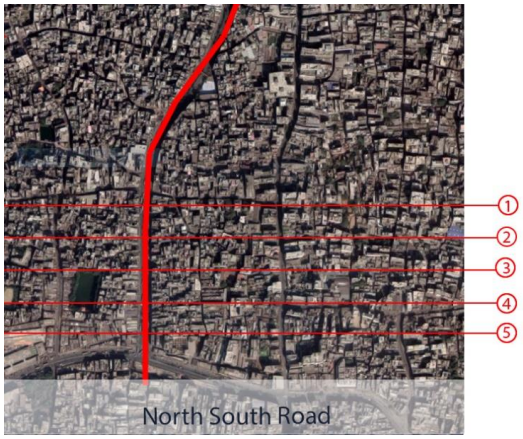

Figure 4: North South Road top view


Figure 5: Point 01


Figure 6: Point 02


Figure 7: Point 03


Figure 8: Point 04


Figure 9: Point 05

Road 02: The Azimpur Road The Azimpur road connects two important nodes of this area, Nilkhet moor and Azimpur bus stand. This is also a wide road which remains busy throughout the day. There are public institution and public housing facilities alongside the road. There are tall and mid height trees which keep the temperature of road, paves and surroundings lower. This makes the pedestrian level more comfortable there.

The average temperature of North South road without shade trees is 37c whereas the average temperature of Azimpur road of same width with roadside shade trees is 32c.

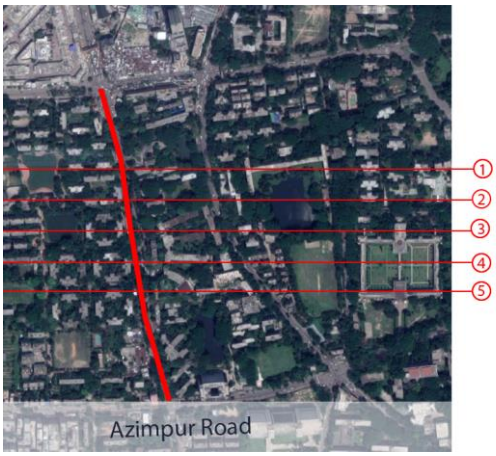

Figure 10: Azimpur Road top view


Figure 11: Point 01


Figure 12: Point 01


Figure 13: Point 03


Figure 14: Point 04


Figure 15: Point 05

8. ENVI-met simulation

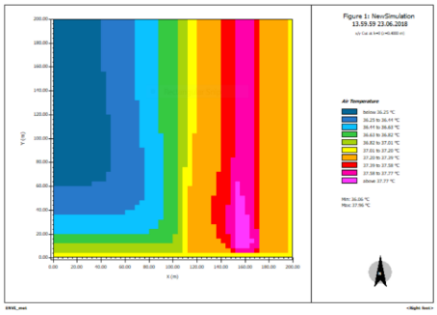
Figure 16. Thermal image of North South road

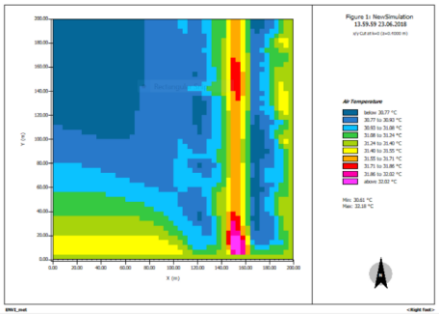
Figure 17. Thermal image of Azimpur road

Here the two thermal images of the two roads show the difference of temperature in the stated roads. The maximum and minimum temperatures in the North South road are 37.96 C and 36.06 C respectively while the maximum and minimum temperatures in the Azimpur road are 32.18 C and 30.61 C respectively. The difference of temperature is almost 5-6C which is determined from the simulation.

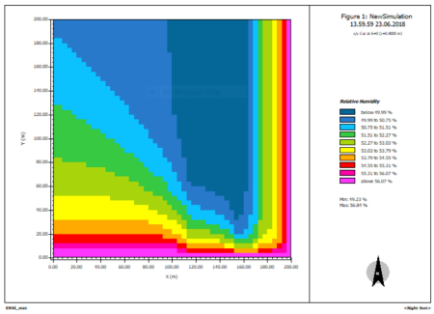
Figure 18. Relative humidity image of Azimpur road

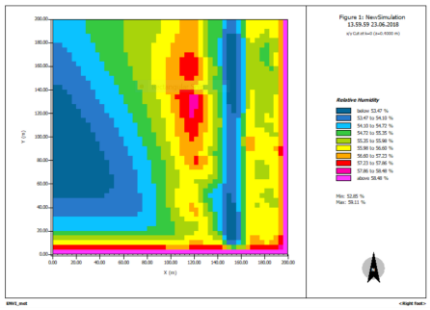
Figure 19. Relative humidity image North South road

Both roads have a relative humidity within comfortable range (25 - 60%) though the humidity in the North South road is lower by around 3%. Hot air has the capacity to hold more water than cooler air. Therefore, as the temperature rises with no extra moisture added to the air, the relative humidity decreases.

9. Impact of tree configurations

From the two case studies it is found that shade trees contribute in reducing the air temperature. Temperature at roads with trees is much lower than the roads without shading. Here are some configuration which help in maximizing the cooling effect provided by the shade trees.

9.1. MATURE HEIGHT

Tree height is a factor that is directly connected with shading properties. In case study 02 Weeping Debdaru, Babul, Mahogany, Bakul, Neem etc. are planted along the Azimpur road. Most of them are timber producing tree with a mature height of 7m to 30m. A few of them are not very high shade trees but can afford pedestrian thermal comfort.

9.2. SHAPE OF TREE

During daytime shade trees provide reduced temperature by blocking sunlight, increasing air humidity and by providing shade. The shade offered largely depends upon the shape of the crown of the tree. Crown shape varies from tree to tree such as round shape, oval shape, pyramid shape, weeping, spreading, free form etc. Round, oval or spreading shaped crown provide better shade though shade also depend on foliage density. In case study 02, the Azimpur road has Debdaru trees in the median which has a columnar crown shape and do not produce much shade. At the same time sidewalks have Mahogany, Bakul trees having round crown providing better shade.

9.3. CANOPY DIAMETER

Tree crown size is a key variable in this context as it correlates with the space a tree occupies. Canopy with large diameter can provide shade and block sunlight from reaching the ground to a great extent. Average crown diameter of timber type trees covers a wide range from 10m to 60m according to the tree types. For the studied roads, the Azimpur road has both small crown trees such as Debdaru (3m) and large crown trees such as Mahogany (15m).

9.4. GROWTH RATE

In terms of growth rate of a tree, the designation slow means the plant grows 12” or less per year; medium refers to 13 to 24” of growth per year; and fast to 25” or greater (Manual of Woody Landscape Plants, by Michael Dirr). Most of the trees planted by roadside are fast growing. Within three of four years they become suitable for providing shade at pedestrian level.

9.5. SHADE PROVIDED

The results of our field survey and simulations proves that the strategic selection of tree can play a vital role to ensure human comfort. It is assumed that tall trees with dense foliage will provide dense shade but there is a possibility for hazards when they are placed too close to a structure. The structural damage by this kind of phenomenon disqualify the benefits by those trees (McPherson et al. 2005). Therefore, a balance between the size and the shade provided by the trees is needed. The Azimpur road trees are neither very tall nor do they have very dense foliage. Still they manage to produce a desired thermal condition. Here is a list of trees and their configuration which are planted by the roadsides of Dhaka city.

Scientific name	Common name	Shape	Mature Height	Canopy Diameter	Growth Rate	Shade Provided
Saraca asoca	Ashok	Rounded	7–10 m	15-20 m	fast growing	Medium shade
Acacia auriculiformis	Akashmoni	rounded	15–30 m		fast growing	dense shade
Albizia richardiana	Albizzia	rounded	10-15 m	5-10 m	fast growing	dense shade
Mimusops elengi	Bakul	rounded	16 m/ 15 - 30 m	10 m	medium rate	Dense shade
Michelia champaca Linn.	Champa	conical to cylindrical	up to 50 m	6-10m	fast growing	light shade
Peltophorum	Goldmohur	umbrella-like	15–25 m	15-20 m	fast growing	Dense shade

Pterocarpum						
Polyalthia longifolia	Debdaru	narrow columnar	10- 18 m	15-20 m	slow growing	light shade
Lagerstroemia speciosa	Jarul	round, vase, upright	to 20 m	15-20 m	fast growing	Medium
Albizia Procera	Korai	irregular ovoid	10 to 20 m	5-10 m	fast-growing	light shade
Delonix regia	Krishnachura	umbrella shaped	10 - 18 m		fast-growing	moderate shades
Swietenia mahagoni Linn	Mahagoni	rounded	30–35 m	13-20 m	fast growing	dense shade
Mesua ferrea	Nageshwar	pyramidal-shaped	10-20 m		slow growing	moderate
Azadirachta indica	Neem	roundish	15–20 m	20–25 m	fast-growing	dense
Butea monosperma	Polash	irregularly shaped	5-20m	15-20 m	slow growing	light shade
Enterolobium saman Prain	Rain tree	umbrella-shaped	15–25 m	30-60 m	Moderately fast	dense shade
Dalbergia sissoo Roxb	Sishu	Oval	up to. 30 m		fast growing	Dense shade
Cassia fistula	Sonalu	irregular, vase- or oval-shaped	10 – 15 m	15-20 m	fast growing	light shade
Madhuca longifolia	Mohua	rounded,	16-20 m	15-18m	fast-growing	dense
Eucalyptus camaldulensis	Eucalyptus	irregular	20 -45 m	Upto 20m	fast growing	light shade

Source: Field survey and reference 8,9,10 and 11

Historically, planting different invasive alien species like Eucalyptus, Sissoo and Akashmoni throughout the peripheral areas of Bangladesh did not have a good impact. These trees were planted as fast-growing, shady trees with commercial value. However, the thirst of their roots and how the trees would cause a fall in the underground water level had not been properly anticipated. Even when it comes to planting trees in avenues, we should have a strong precedence of native trees, as pointed out by the eminent botanist Dwijen Sharma (2015).

10. Conclusion

This study focuses on the impact of roadside shade trees on roads, paved ways and built forms in terms of air temperature, analyzes tree properties that maximize the cooling effect and then suggests some native trees for roadside plantation in the context of Dhaka city. It has been found by means of field survey and simulation that roadside trees reduce direct solar radiation, provide shade and by this way contribute producing a lower temperature (5C-6C lower). We note that most of the primary roads are in the north south direction and wind flows from south east direction in our country. As a result, trees alongside these roads invite air flow and block the sunlight. One of the drawbacks of this study is, the result of this study implies on north south oriented roads, but result may vary where it is otherwise. Impacts of buildings alongside these roads can also be considered for further studies for shading purpose in urban context. This work maybe beneficial and approaches can be taken in future in landscape and urban planning with a preference of pedestrian level comfort.

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IMPACTS OF CULTURE TO THE POST DISASTER RECONSTRUCTION PROJECTS IN SRI LANKA:RESEARCH METHODOLOGICAL PERSPECTIVE

U. KULATUNGA, APARNA SAMARAWEERA, S. VIDANA GAMAGE & R.S.S. DISARA
Faculty of Architecture, University of Moratuwa

Abstract
Post Disaster Reconstruction (PDR) is a very important, complex and highly demanding process, including well-planned set of activities done by well experienced construction professionals. One of the main challenges that affects the success of PDR projects is not managing the cultural aspects of the community. Lack of consideration for community culture end up with cultural incompatible solutions that lead to failure of PDR projects. Sri Lanka has a unique culture with a vast cultural diversity, therefore a detailed study on the impact of culture on PDR projects needs to be carried out to identify the reasons for the failures. Since the community cultural impact on the PDR projects in Sri Lankan context is different from other countries, this study should be carried out by following a proper research methodology that has the capability of addressing the research problem in detail. Accordingly, this paper highlights the aspects which have been covered when designing a feasible research methodology for the study under consideration. Choice of methodology mainly depends on the research topic and the specific research question. Methodological perspectives of managing cultural expectations of PDR projects in Sri Lanka are composed of research philosophies, research strategy, research design, and research techniques. This paper demonstrates how these methodological components are achieved by using the case study research strategy. The importance of case study design in gaining the maximum outcome from the study has also been discussed. Furthermore, the paper reveals the experience of the researcher in addressing the challenges faced during the study.

Keywords: *Methodology, Case Study, Research Philosophy*

1. Introduction

Post Disaster Reconstruction (PDR) is not only a good opportunity to convert the destructive area into a sustainable community with a long-term developmental guidance, but also a favourable moment to get prepared for the next disaster (Ye & Okada, 2002). Therefore, it is a very important, complex and highly demanding process, including well-planned set of activities done by well experienced construction professionals (Bello, 2006). The successful performance of a PDR project depends on how well the initial decisions respond to the needs of the affected people. Improper management of community cultural impact and the lack of consideration given to social and cultural concerns in PDR projects serve to reinforce and sometimes-even increase the vulnerability of local communities (Boen & Jigyasu, 2005). Therefore, construction professionals, who involve in PDR projects should pay much attention to identify community cultural impacts to their projects and develop strategies to make those impacts into enablers to complete the project successfully (Wardak, Coffey, & Trigunasyah, 2014).

Sri Lanka has a very unique culture with a vast cultural diversity and it is highly exposed to various natural disasters such as Tsunami, landslides and floods (Amaratunga, Haigh, & Ingirige, 2015). Strength in terms of sustainability, particularly in the PDR of developing countries like Sri Lanka, is undoubtedly still not at an adequate level (Sridarran et al., 2008). There is a huge problem of failures of PDR processes due to different issues (Wardak et al., 2014). The same mistakes are repeated over and over again and most of those mistakes point to lack of understanding of social and cultural capacity, while undertaking PDR. This issue needs to be carefully addressed by studying the cultural context of the country (Jaygasu, 2002). The previous researches have been highlighted that one of the main challenges is to reinforce cultural continuity through development opportunities that are afforded through PDR, so that one does not end up with cultural incompatible solutions, which are unsustainable in the long run (Boen & Jigyasu, 2005). But, a detailed study on the impact of culture to PDR project performance in the Sri Lankan context has not been done yet to identify the real reasons for those challenges. Furthermore, there is a necessity to identify that, to what extent a cultural impact can affect to a PDR project success (Ismail et al., 2014). In order to successfully implement these PDR projects in Sri Lanka, construction professionals should find out the social-cultural impact to the project properly and they should have proper knowledge to manage them. Since the community culture impact on the PDR projects in Sri

Lankan context is different from other countries, carrying out a study to analyse this impact will be very important for the success of the future PDR projects in Sri Lanka (Sridarran et al., 2008).

Within this background, devising an appropriate research methodology to address the research problem of the study is important. Research methodology is the procedure of how research should be undertaken, which provides the overall guidance to answer the research problem (Saunders, Lewes, & Thornhill, 2009). Moreover, it provides the specific techniques, which is used to identify, select, process and analyse information about the specific study. Accordingly, the aim of this paper is to review the methodological stances adopted for the study which investigates the impacts of culture towards post-disaster reconstruction in Sri Lanka. Within the scope of this paper, research philosophy, research approach and research strategy pertaining to the study have been discussed with appropriate justifications for their selections.

The paper is structured as follows: First, it discusses the research philosophies. This is followed up by different research stances adopted in the study.

2. Research Methodology

Research is the process of collecting, analyzing and interpreting data in order to answer specific questions, solve a particular problem or test a hypothesis (Leedy & Ormrod, 2010; Naoum, 2007). Research methodology elaborates the process of achieving the aims and Objectives, for the established research problem using a methodological framework including research design, research approach, and research process and research techniques. Kagioglou et al (1998) has identified research methodology as a hierarchical model where the research techniques are under the research approaches and the research approaches are under research philosophy.

2.1. RESEARCH PHILOSOPHY

Research philosophy has been identified as the base for effective research design and argues that failure to adhere to philosophical issues can affect the quality of the research negatively (Smith, Thorpe, & Lowe, 2012). There are three main reasons for the importance of the philosophy to a research according to the authors as follows:

- It helps to clarify the research design.
- It helps the researcher to identify which research designs will work and which research designs will not work under different circumstances.
- It helps the researcher to identify and create research designs that may be outside his past experience.

There are three types of assumptions as ontology, epistemology and axiology.

Ontology- Assumptions about the nature of reality. There are two ends of ontology as realism and idealism. According to Burrell and Morgan (1979) in realism, the individual is seen as being born into a living, within a social world that has a reality of its own, which exists out there. Idealists believe that reality is originated with the ideas or thoughts and individuals have differing viewpoints. Thus, what counts for truth can vary from place to place and from time to time. In this study, identification of community cultural expectations of disaster-affected community and classification of those impacts based on the disasters of PDR, exploring comparison based on the different disasters, and identification of strategies to manage the PDR projects in cultural perspective depend on the disastrous situation, the community and their usage. The researcher analyzed the subject matters by being an observer of the project. Thus, the study on community cultural expectations towards PDR projects research favors to idealistic nature.

Epistemology- Assumptions on the acceptable and valid knowledge and the way of communicating the knowledge to others (Burrell & Morgan, 1979). This builds up the relationship between the researcher and the reality. There are two classifications of epistemology as positivism and social constructivism. Positivism suggests that the reality is an observable phenomenon, with evidence it is said to be objective. According to Saunders et al (2009) in positivism, the researcher can replicate the findings and emphasize quantifiable observations that offer themselves to statistical analysis. The other classification of this philosophy is social constructionism which uses the people and their opinions rather than using objective or external factors to determine the reality (Smith, Thorpe, & Lowe, 2012). Hence while positivists believe that observer must be independent, human interest must be irrelevant and explanations demonstrate casualty, social constructivists believe that the reality is socially constructed, where social scientists should welcome and encourage the different views and meanings that people place upon their experiences. However, this research is more towards to social constructivism considering the research aim and objectives. This research aims to identify, classify, and manage community cultural expectations and its impact, so that the construction industry can deliver successful outcomes from PDR projects in Sri Lanka. Since this study is conducting based on PDR projects related to several disasters and with the people deal with different cultures in different regions, the researcher has to become part and parcel of the environment. Therefore, it builds the reality through the relationships with the external environment.

Axiology- "refers to the set of values and ethics throughout the research process which incorporates questions about how we as researchers, deal with our own values and also with those of our research participants" (Saunders et al, 2009, p.151). Positivists believe that science and the process of research is value-free, in contrast to the social constructionists' viewpoint of research, which admits values. In value-free research, the choice of what to study and how to study is determined by objective criteria, while in value-laden research, the choice is determined by human beliefs and experiences (Smith et al, 2012). Accordingly, this research necessitates the researcher to be a part of the environment, and interconnected with the community is needed to unearth the viewpoints related to PDR projects.

Apart from the main three assumptions, there should be a consideration on human nature and methodology too.

Human Nature- the subject and object of study. This reviews the opinions of human beings to the situations encounters in the external world (Burrell & Morgan, 1979). Considering this study, there are a variety of stakeholders who have several cultural expectations vary from one to the other. These expectations may depend on education and socio-economic background, values, and attitudes. Hence the human nature is affected by the situation, environment, or organizational factors, in this research.

Methodology- Methodology is the technique used by the researcher to investigate the reality and obtain the knowledge (Burrell & Morgan, 1979). For this study, it is the mechanism by which the research is carried out.

It can be summarized as in the philosophical point of view, this research would take the social constructionism stance in terms of the epistemological undertakings, idealism stance in terms of ontological undertakings and value-laden stance in terms of axiological undertakings.

3. Scope and Limitations

It is needed to clarify the accepted range of the study. Limitations are constraints which limit the extensity to which the study can go (Simon & Goes). This research is focused only to analyse the post-disaster housing reconstruction projects which have been constructed due to tsunami and landslide disasters. The community cultural impacts to post-disaster reconstruction projects are intended to investigate within the Sri Lankan context only. Data collection is focused on the end-users and professionals who engaged in PDR projects.

4. Research Approach

Research approach has been identified by Thurairajah, Haigh, Amaratunga (2006) as a procedure of organizing research activities and integrating data collection in order to achieve aims and Objectives. Generally, there are three research approaches followed by researchers. They are quantitative, qualitative and mixed approaches (Creswell, 2012).

Quantitative approach is the fact-finding process, which is based on the collected records and the evidences (Naoum, 2007). In addition, Creswell (2003) stated that statistical procedures are the major activities within the quantitative approach. The quantitative research would be more appropriate for the researches, for which the research question starts with 'who', 'what', 'where', 'how', 'many', 'how much' (Smith, Thorpe, & Lowe, 2007).

Qualitative research approach is the best method to be used in cases of assessing opinions and the behaviours related to subjective, attitudinal and exploratory (Naoum, 2007). Qualitative approach requires more details and in-depth information and it is significant in terms of focusing on specific group of people, representing the views and perspectives of the people and in-depth study on topics (Yin, 2011). Ritchie and Lewis (2003) further explained that when the research problem is a 'why', 'what' and 'how' type question, qualitative approach is suitable (Smith et al., 2007).

Mixed approach is not a replacement for the quantitative and qualitative approaches, but an extension of both approaches, which avoids the negative points of two approaches (Johnson & Onwuegbuzie, 2004). This research intends to analyse community cultural impact on Post Disaster Reconstruction (PDR) project performance in Sri Lanka. Since the research problem "How does the community culture impact for the PDR project performance in Sri Lanka?" is putting the research in an assessing opinions and behaviour approach with the question starts with "how", qualitative approach is more appropriate (Smith et al., 2007). Moreover, Kumar (2011) have described the qualitative approach is suitable if the researcher is interested in studying values, beliefs, understandings, perceptions and meanings in order to observe new findings. This research intends to do a comparison of community cultural impact for the PDR projects based on the disaster which requires subjective and attitudinal information. Considering the above facts, qualitative approach has been selected as the main approach due to the intention of the research is to study cultural values, believes and behaviours and focusing on experiences of disaster-affected people related to PDR projects.

Nevertheless, the subsequent objective of recommending strategies to improve project success of PDR projects through the understanding of the impact of community culture adopted a quantitative approach. According to Naomi (2007) quantitative approach is based on collected records and evidences. Therefore, this approach is used to grab information from the stakeholders of construction industry in order to clarify the adaptability of the recorded strategies through literature review and the qualitative study. Hence, it can be concluded that the research adopted a mixed approach, with the expectation of strengthening the rigor and enriching the research analysis and findings, and to proceed with this research.

5. Research Strategy

Research strategy refers to a set of procedures which is used to generate and analyse the research material (Verschuren, 2014). According to Yin (2011), there are three conditions that should be considered when choosing the most suitable research strategy for a study. They are the type of research question posed, the extent of control an investigator has over the actual behavioural events, and the degree of focus on contemporary event. Moreover, research philosophies like ontology, epistemology, axiology, human nature and methodology play a huge role while selecting the research strategy. The author further has been identified case studies, surveys, experiments, archival analyses and histories as the most popular research strategies. Among them, case study is identified dominantly as a qualitative

research method which is intended to use as the strategy in order to accomplish the aims and objectives (Kumar, 2011).

6. Case Study as the Research Strategy

Case study is an experiential analysis that investigates a current phenomenon within its real life context using multiple sources of evidence (Baharein & Noor, 2008). According to the authors, case studies focus on a certain issue, feature or unit of analysis. Due to the open-ended inquiry used in case studies, it is suitable to build theory and generate hypothesis (Amaratunga et al, 2002). Researcher becomes a part and parcel of the environment being studied as a participant observer interacting with social groups (Amaratunga et al., 2015).

When the research problem comprises of 'how' or 'why' questions, undertaking case studies is the most suitable method since an in depth investigation is required to find answers (Yin, 2011). Therefore, case study may be more appropriate on this research (which has a research problem comprising "how") which needs in depth study with multiple source of evidences on current and real situation of the PDR projects in Sri Lanka using the experiences of social group of people who are affected to disastrous conditions like Tsunami, landslides and floods. Moreover, case studies are more suitable for researches where the boundary between phenomenon and the context is not clear (Yin, 2011). In this research, the context which is PDR projects and the phenomenon which is community cultural impact, can't be separated clearly with the boundary. Since the structure of PDR projects highly affects for the results of the research, context specific information is very important for the study which can be easily gathered and analysed through case studies. Furthermore, the selected research philosophies like social constructionism, idealism and value-laden stances lead together with their characteristics to adopt a case study as the strategy. Considering all the above facts, the most appropriate strategy for this research will be case studies.

6.1 CASE STUDY DESIGN

Yin (2011) has introduced basic types of case study designs, determining the choice between single versus multiple case studies. A single case study is appropriate over a multiple case studies when the situations are critical and unique (Amaratunga et al., 2015). This study does not fall under this category and thus multiple case studies have been chosen over a single case study mandated to conduct cross-case analysis and to enable findings through global context cases. Multiple case studies provide a rich ground for the usage of replication logic through multiple sources of evidence (Yin, 2011).

6.2 IDENTIFYING THE UNIT OF ANALYSIS

The main entity, which is being analysed, is known as the unit of analysis (case) in the research. The author further stated that selecting the unit of analysis is directly related to the research problem (Yin, 2011). The research question of the study mainly reflects the impact of community cultural expectations, in PDR leaving the impact of community culture as the main unit of analysis. The disaster which has been based on the reconstruction projects form the boundary of the study since the community cultural impact for PDR projects is analysed based on the disaster. Therefore, post-disaster reconstruction projects done due to landslides, Tsunami and floods have been selected as three separate cases for this study.

6.3 DEFINING THE NUMBER OF CASES AND SELECTION CRITERIA

Yin (2014) highlighted that criteria for selecting a case depends on the convenience, judgment, time and cost constraints. Purposive sampling enables the researcher to select items for the sample deliberately, which is fit for the study, whereas probability sampling provides an equal opportunity for every item in the population to be included in the sample through random sampling (Kothari, 2004). Purposive sampling is generally used in case study research as the sample should be strategically selected (Creswell, 2012).

In the research, the case refers to PDR projects conducted due to each disaster. Since the selection of cases is constrained by limited accessibility and time, cases for this study will be limited to three disasters (Tsunami, landslides and floods). The PDR projects within the disaster are selected using purposive sampling as the cross-case analysis should be conducted on the basis of the disasters. Accordingly, eight (8) respondents from each case (four respondents per project) have been selected as per the involvement for the PDR projects to each disaster. Data collection for decision making is also considered while selecting the respondent.

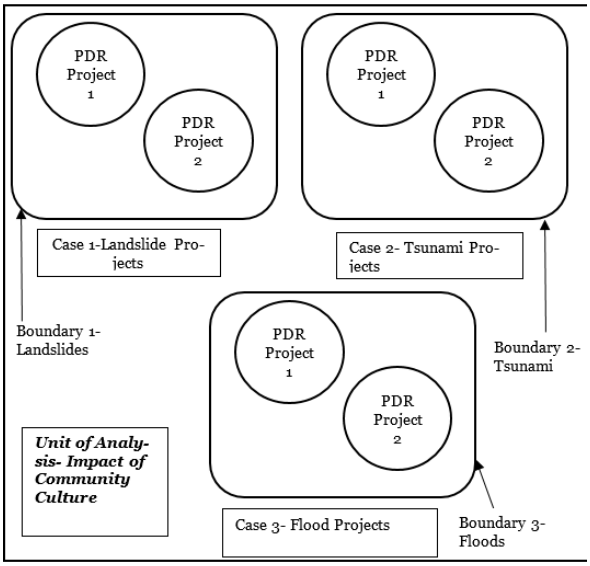

Figure 1 - Case Study Structure

7. Methodological Framework

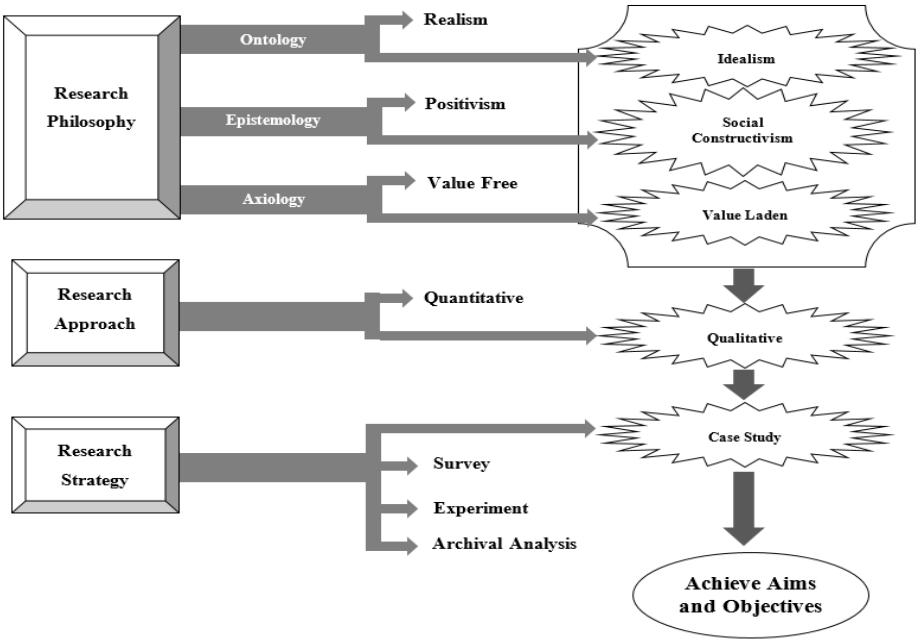

Figure 2 - Conceptual Framework

The summary of the research methodology which leads to achieve aims and objectives of the study, impacts of culture to the post-disaster reconstruction projects in Sri Lanka is mapped together using the above conceptual framework.

As illustrated in the framework, in accordance with the philosophical point of view, this research has been taken the idealism stance in terms of ontological undertakings, social constructionism stance in terms of the epistemological undertakings, and value-laden stance in terms of axiological undertakings. The qualitative research approach is adopted over the quantitative approach and case study research strategy is undertaken among the research strategies like survey, experiment and archival analysis. Finally, through above selected philosophies (Idealism, social constructivism and value-laden), research approach (qualitative) and research strategy (case study) the researcher can achieve the aims and objectives of the study.

10. Conclusion

This paper identified the need for developing a research methodology in fulfilling the aims and objectives of a study and thereby addressing the research problem. Research philosophies are the core of a seminal piece of research. This study follows social constructivism, idealism and value-laden stances as philosophies that lead the research to adopt the research strategy as a case study. It can be recommended to researchers in selecting the most suitable philosophies and through that, finding the appropriate research strategy lead the research to a success. The case study design and unit of analysis has been selected in order to conduct a cross-case analysis.

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INTEGRATING ENTERPRISE RESOURCE PLANNING SYSTEM WITH LEAN CONCEPT TO MINIMISE WASTE IN SRI LANKAN CONSTRUCTION INDUSTRY – A THEORITICAL REVIEW

RASANJALI W A.[1], DISARATNA V. & WITHANAGE K.T.
[1,2,3]Department of Building Economics, University of Moratuwa, Si Lanka
[1]*ayesharasanjali99@gmail.com*

Abstract
Construction industry is currently facing severe challenge that producing high rate of waste at the end of the construction process. Lean philosophy has arrived and expanded over the various industries by providing an imperative solution for most of the challenges facing by the industries. Accordingly, construction industry accommodates lean concept to provide the modest output in the shortest possible time, while attaining maximum value and quality at reasonable cost. Enterprise Resource Planning (ERP) system is developed as an approach that integrates all business functions into a single process to enhance the efficiency of all activities by supporting organizations to uphold the competitiveness within the industry. ERP system affords accurate data of current performance in a single database with more transparency for the users who demands them. Construction companies used to adopt ERP system with the intention of enforce supply chain partnerships, enhance organizational flexibility, improve decision making capabilities and reduce project completion time and costs. The ERP system diminishes labour-intensive processes and eliminate the root causes for waste production in construction industry and already offers lean support in their software. This paper highlights the literature findings on the lean philosophy and synchronizes ERP system and lean principles in the course of lean ERP route. These basic findings will aid to assessing the possibility of integrating ERP system with lean principles in order to eliminate construction waste. Sri Lankan construction industry practitioners can directly use these findings of the research to eliminate the challenge of producing high rate of waste at the end of the construction process.

Keywords*: Enterprise Resource Planning, Lean Principles, Construction Waste, Construction Industry*

1. Introduction

The construction industry is an inestimable sector which plays an important role in converting the various desires, needs and requirements of the people into reality by physically executing various construction projects (Ibrahim, et al., 2010). When it comes to Sri Lankan context, the construction industry makes a significant contribution to the development of the economy in Sri Lanka (Silva, et al., n.d). In the developing world, the construction industry is always facing problems and challenges, because of the limited resources, population growth and economic expansion within the country (Jayalath & Gunawardana, 2017). According to Subramani, Khan, Raj, Najeeb, and Rajan (2018) construction industry is generally recognized as one of the largest amounts of waste generating sector. Therefore, minimising construction waste is a key factor to be concerned within the industry today (Ayemba, 2018).

The concept of lean production was possessed by the Toyota Production System (TPS) (Dinesh, et al., 2017). Subramani et al. (2018) defined lean concept as a set of principles that was implemented in order to minimise the material wastage and time effort required to generate the maximum amount of value within the construction industry. Successful implementation of lean concept for the construction may help to gain a significant cost advantage by minimising wastage and eliminating the most cost consuming activities (Senaratne & Wijesiri, 2008). Thus, Macomber & Howell (2003) identified lean construction as one of the best solutions to overcome wastage in the construction industry.

Koskela, Bolviken, and Rooke (2013) stated that these concepts are defined to eliminate waste and manage resources which connected with time, activities, inventory and waste of space and deliver high quality products as per the client's requirement. Li, Liu, & Li (2012) has identified the Enterprise Resource Planning (ERP) system is identical to manage all these resources by integrating all the information from different areas such as product planning, inventory control, purchasing, financial resources, and human resources.

ERP system is one of the most substantial technological developments introduced during the last decade (Nwankpa, 2015). It can be used for planning, organizing, managing and utilizing organization resources effectively, to obtain the absolute output from their resources (Ghosh, 2012). Olson, Johansson, and Carvalho (2018) defined the goal of ERP system is to integrate and combine all the systems across an organisation into one system that can meet and serve each department's unique needs and tasks. ERP acts as an important backbone of the organisation since it integrates the business activities of different departments by providing a proper circulation of information within the organisation (Osnes, et al., 2018). Implementing good practices of waste minimisation methods on construction projects will help to reduce the significant amount of construction waste and create the base for making a sustainable environment (Wrap, 2014). Thus, Peddavenkatesu and Naik (2016) described that this can be achieved by using new technological applications that evolve with innovative designs for construction management, construction scheduling, and online monitoring while considering the durability and design life of the construction products.

Esa, Halog, and Ismail (2015) found that one of the major reasons to increase the wastage in construction industry, is not giving a high priority to proper waste minimization methods. Lean concept has made a significant contribution in this area by identifying the mostly expected seven types of waste during the construction (Lean Construction Institute, 2015). The proper implementation of ERP solutions can help to reduce waste while providing all the functionality required (Cunha, 2018). Hence this research aims to study the possibility of integrating the Enterprise Resource Planning system with Lean principles in order to enhance the performance by eliminating waste generation in the Sri Lankan construction industry.

2. Research method

Research is a process of critically examine solutions for a problem by thorough study or analysing situational factors or else implementing new thing which is not addressed by any others up to now (Bodla, n.d). Thereby the research methodology was developed as a systematic approach to examine these problems. A research method is developed with a properly organised research design, research approach, research techniques and research process. Every research needs to have an advanced design or structure in order to achieve the aim of a study (Walliman, 2011). The research approach is a systematic procedure which is used to organize the research activities within the developed research design framework. Qualitative, quantitative and mixed method are the most common approaches used to analyse the findings from the data collection. Among those approaches qualitative research method was used with critical documental review.

3. Literature Findings

3.1 DIFFERENT TYPES OF CONSTRUCTION WASTE

The construction sector plays an important role in every developing country (Foo, et al., 2013). Increasing the rapid growth of construction activities will escalate arising of construction waste problems all around the world (Nagapan, Rahman, & Asmi, 2011). Shankari et al. (2017) found that such increment of construction waste will increase the overall project cost, reduce the excepted profitability and gives a negative impact for environment also.

Koskela (1992) described waste is a combination of material losses and execution of unnecessary work which significantly generates additional costs without adding any value to the final product. Thus, Emuze and Smallwood (2011) emphasized from the client's point of view, waste can be defined as non-value adding activities since it directly or indirectly generates some costs from the activities which does not add any value to the final output.

Further to that, Formoso, Soibelman, Cesare, and Isatto (2002) described that any inefficiency that results in the use of labour, material, equipment, and money can be considered as non-physical waste in construction processes. Nevertheless, Formoso et al. (1999) stated that waste in the construction

industry is not limited to the quantity of excess material remain on site. It comprises many other facts such as inventories, material handling, unnecessary movement of workers, waiting time and overproduction which are invisibly occurred throughout the construction process.

3.2 LEAN CONCEPT AS A WASTE MINIMISATION PHILOSOPHY

The lean concept was implemented by Shigeo Shingo and Taiichi Ohno based on Toyota Production System in mid-1940's (Namrouty & AbuShaaban, 2013). Lean manufacturing is one of the most precious tools which is used to eliminate waste in different industrial sectors (Chahal & Narwal, 2017). Ballard (1990) defined "Lean production is a concept that aims to systematically eliminate wastes, simplify production procedures, and speed up production". Harish & Selvam (2015) expressed "Lean is a way of achieving more with less resources, creating an organization that responds to greater flexibility with shorter lead time and where the focus is on the customer, both external and internal". According to these definitions, lean concept can be seen as a methodology introduced to use the resources efficiently and effectively by eliminating waste and develop the final output.

3.2.1 Lean Tools & Techniques

The main goal of lean production is to produce products with minimal waste and to continuously improve all activities and processes involved in every type of work (Modi & Thakkar, 2014). Therefore, many researchers, Chahal and Narwal (2017); Sumant and Patel (2014); Rewers, Trojanowska, and Chabowski (2016) have highlighted lean production paradigm can be accomplished by applying a wide variety of lean manufacturing tools such as Value Stream Mapping, 5S, Just –In-Time (JIT), Single Minute Exchange of Die, Kanban, Kaizen, Jidoka, Heijunka, Standardized Work, Poka-Yoke and Kamishibai in their researches.

3.2.2 Classification of Lean's Waste

Waste can be classified based on the source of its origin. Osmani , Glass, and Price (2008) emphasized that even though generally waste is visible during the production or construction stage, it can be originated at initial stages such as planning, designing, material supply and material manufacturing processes. Ohno (as cited in Formoso et al., 2002) presented seven categories of waste which was identified in Toyota Production System. They are;

- Unneccessary movement of people - including waste of human energy
- Waiting by employees for process equipment to finish its work or an upstream activity
- Defects in products
- Overproduction of goods not needed
- Inventories of goods awaiting further processing or consumption
- Unnecessary processing
- Unnecessary transport of goods

Table 2.1 shows the lean waste types. Among these seven categories, first two refer to waste related to operations and works performed by people. Other categories have been identified as waste related to flow of material process.

Table 1 : Lean's waste types

Waste type	Description	Reference
Overproduction	Making more than that is required by the next process, making earlier than that is required by the next process, or making faster than required by the next process.	Arunagiri and Gnanavelbabu (2014)
Defects/ Rework	Failure of any work can be called as a defective work. Rework may require once the defect is occurred.	Rawabdeh (2005)
Inventory	Inventory waste can be identified as having level of raw material unnecessarily, works in progress and	Capital (2004)

	finished products.	
Transportation	Any movement of material without adding a value to the final product.	Hines and Rich (1997)
Waiting	Waiting generally comes up with the idleness. Waste of waiting is occurred when the time is being used ineffectively.	Formoso et al., (1999); Hines and Rich (2007)
Movement/ Motion	Any excess movement of either machines or employees that adds no value to the final product.	McGee-Abe (2015)
Over processing	Over processing generally occurs when processing a work more that it requires to obtain its quality or any other feature.	Capital (2004)

3.2.3 Causes for lean waste generation

Table 2.2 presents the causes for generation of lean waste types as identified by Domingo (2013).

Table 2 : Causes for lean waste generation

Waste Type	**Waste causes**
Overproduction	High capacity equipment Poor production planning Volume incentives Engineering changes Fails to forecast producing Poor scheduling Unclear requirements Long set-up times
Over Processing	Unclear customer specifications Unclear work instructions Poor communication Frequent engineering changes Overdesigned equipment Inadequate value analysis/ value engineering Excessive reports Excessive quality Re-entering data and duplicated data
Inventory	Overproduction and buffers Line imbalance Big batch sizes Poor monitoring systems Mismatched production speeds High rework rate Long set-up times Misunderstood customer needs Unreliable suppliers/ JIT-incapable suppliers Lack of material requisition and issuance standards
Transportation	Unnecessary or excessive steps in the process Complex material flows Poor plant/office layout (Disorganised workplace) Misaligned process flow Line imbalance
Waiting	Inflexible work force Insufficient staffing/ over-staffing Unplanned/ unscheduled machine downtime Long set-up times Material/ manpower shortage or delay Unbalanced workloads

	Work absences Poor communication Unsynchronized Processes (Line imbalance)
Motion	Poor process design and controls Poor workstation/shop layout Disorganized work place and storage locations Shared tools and machines Workstation congestion Unclear, non-standardized work instructions Unclear process and materials flow Lack of standards
Organizational	Poor design and specification Unclear customer specifications Incapable processes Lack of planning and control Poor qualification of the team work Lack of integration between design and production Poor quality controls Poor documentation Lack of standards Weak or missing processes Misunderstanding customer needs Uncontrolled inventory levels Poor design and undocumented design changes or repair

Source: (Domingo, 2013)

3.3 IMPLEMENTATION OF LEAN CONCEPT TO THE CONSTRUCTION INDUSTRY

Mao and Zhang (2008) identified the manufacturing industry and construction industry has similar characteristics in terms of delivering a constructed facility or manufactured product to the customers. Howell (1999) explained that lean construction is designed to maximize customer satisfaction concurrently through the design of a constructed facility and the construction process while providing the consequent control during each phase of the construction project.

The principles of Lean Manufacturing applied in the construction industry could achieve many positive results in many areas of the construction industry, with enhanced value, lower cost and better customer satisfaction (Mao & Zhang, 2008). Figure 1 shows the categorization of waste in the construction industry considering the lean thinking approach.

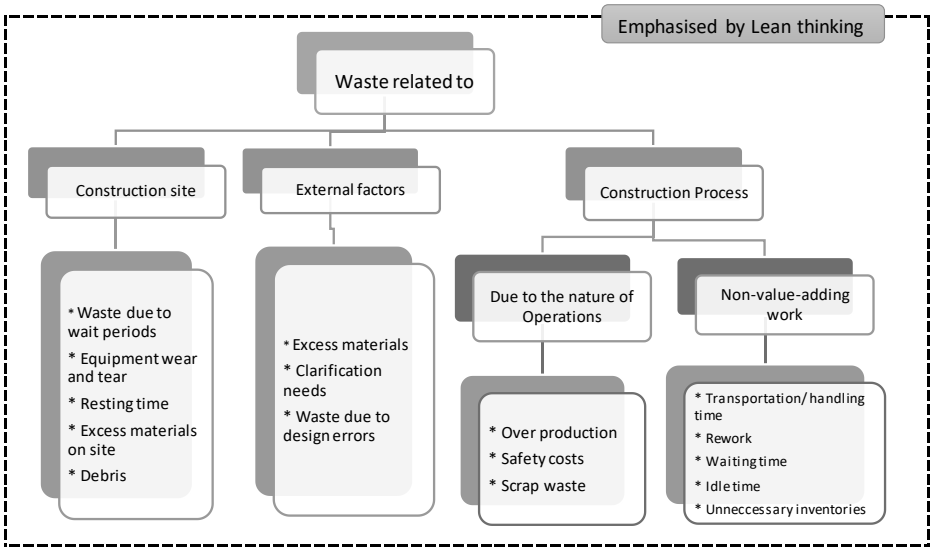

Figure 1 : Waste categorisation in construction industry considering the lean thinking approach
Source: (Nikakhtar et al., 2015)

3.3.1 Benefits of lean implementation

To remain competitive and profitable, the construction team must find ways to maximize value and efficiency, or reduce waste, or do less (Ayala, 2018). Applying the principles of Lean principles to a project is a way of challenging old consolidated processes and constantly evaluating ways to eliminate waste and obtain the following benefits.

- Higher quality construction
- Greater productivity
- Greater customer satisfaction
- Smoother operation - improved continuous flows
- Greater profitability
- Reduced operating costs
- Increases Employee Collaboration and Accountability

3.3.2 Drawbacks of lean implementation

The application of some lean principles derived from manufacturing industry to construction sector has encountered varying degrees of difficulties (Mao & Zhang, 2008). They have further highlighted that main reason for this as the unique and complex nature of the construction process and high level of risks and uncertainties are engaged throughout the construction process.

However, Garbie (2010) emphasised that despite the benefits of lean, more efforts are needed to explore ways to overcome lean-related shortcomings. Furthermore, findings of (Issa, 2013) confirms that lean construction does not address the risk factors such as change in material prices or price escalation, delay in running bill payments to the contractor, design errors and suitability to the nature, and poor quality of local materials. Therefore, Ward and Zhou (2006) identified there is a need of leveraging another technique with Lean to overcome the drawbacks associated with it.

3.4 ENTERPRISE RESOURCE PLANNING SYSTEM

Today every industry is turning into more complicated because of the requirement of continuous data flow among each department for decision making and resource allocation within the organization (Madanhire & Mbohwa, 2016). Therefore, efficient and effective data frameworks would improve intensity by reducing costs and better coordination (Holland & Light, 1999).

Nah, Lau, and Kuang (2001) defined ERP system is “a packaged business software system that enables a company to manage the efficient and effective use of resources (materials, human resources, finance, etc.) by providing a total, integrated solution for the organization's information processing needs” (p.285).

Tenkorang and Helo (2011) have also undertaken a critical review on an ERP system. According to their findings, ERP system has been identified as an approach that integrates all the business functions into a single process to increase the efficiency of all the activities by supporting to that organization to maintain the competitiveness within the industry. Moreover, it was identified that successful implementation will ensure achieving project benefits by improving productivity and competitive advantage.

By considering the different definitions provided by the authors, ERP can be identified as an enterprise wide information system which integrates all the business functions in order to manage and control all the resources within the organization.

3.5 IMPLEMENTATION OF ERP SYSTEM

ERP implementing will require major changes to employees and work practices. Therefore, in order to improve cost effectiveness, it is recommended to use external consultants who have the ability to provide specific training for ERP implementation (Madanhire & Mbohwa, 2016).

Gefen and Ragowsky (2005) identified the consultant is responsible for the initial phase, staff training, workflow research, custom interface, troubleshooting and ERP problem assistance. Further, they discovered that it is important to involve all the employees in the particular project because many changes will affect almost everyone in the organization and ultimately it leads to make the ERP system successful and useable.

3.5.1 Implementing ERP system to Sri Lankan Construction Industry

The acquisition and implementation of ERP systems often improve productivity and quality of the work with standardisation and simplifying the multiple, complex operating procedures throughout the company (Nah et al., 2001). According to the findings on Gunasekara et al. (2018) there are several reasons to adopt ERP system to the construction organisations.

- Integration of application
- Business process reengineering
- Competition
- Increased demand for real time information
- Integration of information system
- Cost reduction
- Better customer interaction and improve on-time deliveries
- Information generation for decision making
- Supportive for planning and budgeting activities
- More user friendly reports
- Improved security applications

Among the above mentioned reasons, competition, better customer reaction, information generation for decision making and providing more user friendly reports were identified as mostly influenced reasons to implement ERP system to the Sri Lankan construction industry.

3.5.2 Benefits of ERP Implementation

Organizations invest in ERP systems in order to achieve significant benefits. These benefits can occur in the form of increased business productivity, such as reduced lead times, reduced cost and increased communication efficiency between functional limits (Nwankpa & Roumani, 2014). Further, Davenport (2000) explained the benefits of ERP may vary from industry to industry and in many cases, it may depend on the firm in which it is implemented.

Shang and Seddon (2002) clustered ERP benefits into five categories namely, operational, managerial, strategic, IT infrastructure and organizational. Table 2.3 illustrates the key benefits which derive under each category.

Table 3 :Key Benefits of ERP system

Dimensions	Subdimensions
Operational	Cost reduction Cycle time reduction Productivity improvement Quality improvement Customer service improvement
Managerial	Better resource management Improved decision making and planning Performance improvement
Strategic	Support for business growth

	Support for business alliance Building business innovations Building cost leadership Generating product differentiation Building external linkages
IT infrastructure	Building business flexibility for current and future changes IT cost reduction Increased IT infrastructure capability
Organizational	Changing work patterns Facilitating organizational learning Empowerment Building common vision

Source: (Shang & Seddon, 2002)

3.5.3 Drawbacks of ERP Implementation

Even though there are numerous benefits that can be achieved through the implementation of ERP system to the organisations, Gunasekara, et al. (2018) identified some of the drawbacks of ERP implementation through a critical review undertaken by them. Following are the drawbacks they have identified.

- Higher initial investment
- Higher maintenance and development cost
- Misfit with the business requirement
- Lack of skilled employees to work on
- Users' resistance to change
- Poor knowledge transfer
- Poor top management support
- Poor quality of testing
- High turnover rate of project team members
- Lack of strong infrastructure for the system
- Lack of support services from the system supplier
- Lack of storage services (in-house / cloud)

3.6 CHALLENGES FOR ERP IMPLEMENTATION

Successful ERP implementation can be achieved by identifying the challenges engaged with its implementation in local companies (Otieno, 2010). There are several challenges identified by different researchers throughout their studies.

3.6.1 Interconnections/ Integration problems

Previously all the information were maintained by different departments. With the implementation of ERP system all of them were integrated and perform as a single system (Otieno, 2010). Since the change of the whole process is a challenge for the employees because they may not be prepared for these new procedures and rules (Rishi & Goyal, 2008).

3.6.2 Technological complexity

According to Lowe & Locke (2008), ERP systems are perhaps the most complex and comprehensive of business information systems. Managers found that it is very challenging to manage the technological complexity of different platforms and to harness the power of new business technologies.

3.6.3 Lack of proper ERP management

Enterprise systems require managers to have a greater understanding of their actions, including other products, departments and even external business companies (Bingi, et al., 2002). Therefore, ERP systems must be developed and implemented step by step under the guidance of a common vision of the

goals. Laudon & Laudon (as cited in Otieno, (2010)) highlighted that many organizations face difficulties to develop a shared corporate-level vision to guide the implementation of the system.

3.6.4 Staff turnover

Once the selected employees have been trained and invested heavily, it is a challenge to hold them back, especially in markets that require qualified consultants. Employees can double their salaries by accepting other positions (Skok & Legge, 2002). Loyalty plans, company benefits, salary increases, ongoing training and loyalty strategies for company loyalty can be effective (Skok & Doeringer, 2001).

3.6.5 Cost of technology

Monk & Wagner (2006) found that the total cost of implementation could be three to five times the purchase price of the software. This is because ERP is a semi-finished product and that must be configured and customized according to the needs of the consultant's organization.

3.6.6 Organisational change

Umble, Haft, & Umble (2003) stated that ERP implementation may have an impact for the change of overall organization process. By the time Wagner, Scott, & Galliers (2006) also discussed that successful implementaion of ERP system is not an easy task because it changes the business process and it requires adequate attention by the senior management with co-operation and good teamwork background.

3.7 ERP AND LEAN SYNCHRONISATION

Implementation of Lean and ERP together shows commonalities in different terms of cost, time and effort required for implementation (Djuric, 2008). Implementation of ERP system emphasises accurate and real time reporting of an organisation. This is exactly what lean needs for its continuous improvement principle. Adam, Keckei, Kostenzer, and Klepzig (2013) stated that accurate data of current performance with high visibility is essential to fulfill lean principles.

Adam et al. (2013) further eloborated that, if there is no single database, dedicated data entry points and analysis and visualization features provided by ERP and business intelligence systems, it can be time consuming and erroneous. ERP reduces labor-intensive processes and facilitates performance visibility, error management, work status and inventory. So it is recognised as Lean ERP or ERP systems that support lean principles (Nakashima, 2000).

3.7.1 ERP support for Lean production

Organisations are basically focused on increase the productivity, eliminate the time and resource wastage, reduce the cost of production and ultimately achieve the streamlined business process through it (Powell, et al., 2011). They have identified such achievements can be fulfilled by using ERP system and lean methodologies, tools and techniques. They have further elaborated that complementing these techniques may overcome the deficiencies of each method and companies can achieve business excellences. Thus, it can be elaborated as the following way.

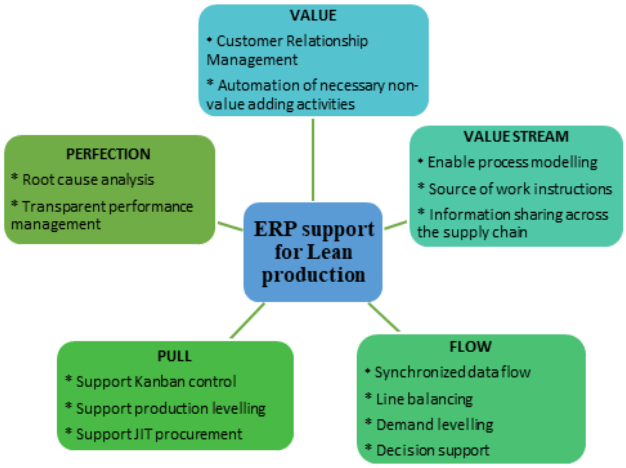

Figure 2: ERP support for Lean production
Source: (Powell et al., 2011)

Figure 2 presents how ERP system supports for the lean production principles. As the first principle value of the product can be determined by using the customer relationship management feature in the ERP system. Then, mapping the value stream by eliminating non-value-added tasks with the use of information sharing across supply chain of ERP system. Remaining value-added tasks will be taken into the flow with the decision support. Pull and perfection is enhanced by the support of better management ERP system.

3.7.2 ERP for waste minimisation

At the beginning, ERP systems were implemented in order to integrate business functions and to support the management for decision making processes (Powell, Riezebos, & Strandhagen, 2013). Riezebos (2010) identified that many of the lean practices depend on the high-quality data and it is essential for problem solving process and effective production control. As a result of that, companies have created hybrid environments in which they use both methods and facilitate by the development of information technology. Furthermore, Ward and Zhou (2006) identified that even companies that have experienced success through implementing lean practices may benefit from IT integration practices that are available through ERP system implementation.

4. Conclusion

Today, waste generation in the construction industry is becoming a severe issue to both the economy and environment. Lean concept is introduced as a waste elimination concept to the manufacturing industry. Though it originated from the manufacturing industry, later on many of the researchers identified those lean principles can provide benefits for construction industry also. With the time being the researchers could categorize the waste that occurred throughout the construction projects, into seven basic types namely overproduction, over processing, inventory, transportation, motion, waiting, motion and defects. Even though there are many tools and techniques introduced to eliminate those wastes, some researchers identified there are certain drawbacks on those tools which drive the waste elimination unsuccessful. Thus, the ERP system was merged as one of the best options to overcome these issues.
This paper represents the basic idea about how the lean concept affects to the construction industry by examining the lean concept, lean waste types, lean tools and techniques with the support of ERP system and the way of synchronizing lean concept and ERP system together to minimize construction waste in Sri Lanka.

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REVIEW OF SUITABLE PARAMETERS AND METHODOLOGIES TO DELINEATE THE TRAFFIC IMPACT AREA FROM A PROPOSED DEVELOPMENT IN SRI LANKAN CONTEXT

PATHIRAJA A.L.A.C.[1], DE SILVA P.C.P.[2] & JAYASINGHE A.B.[3]
[1, 2, 3]Department of Town and Country Planning, University of Moratuwa, Moratuwa, Sri Lanka
[1]*amapathirajauom2018@gmail.com,* [2]*chameera.chameera.desilva@gmail.com,* [3]*amilabjayasinghe@gmail.com*

Abstract
An upcoming development usually generates both vehicles in and out to the accessible and adjacent roads and junctions. Therefore, most countries have adopted different planning and building regulations and guidelines to manage them in advance. Although, there is a vast positive movement in guidelines in Sri Lanka as well, still doubtful areas could be observed in delineating the traffic impact area properly. A 500m buffer area from the proposed site is currently taken as the minimum study area at developing the traffic impact assessments which is mentioned under the Term of Reference (TOR) in Sri Lanka. The geographical extent of the traffic impact area is not a fixed boundary, which could be changed especially based on varieties of parameters. Therefore, a fixed boundary may misdirect the developers, consultants and planning authorities at the decision making in transport planning circumstances. Thus, many studies have gone wrong due this very subjective selection. Therefore, many scholars in the transportation field and its allied disciplines argue the importance of developing suitable parameters and methods to delineate the traffic impact area for each development uniquely. Only a few number of models, techniques, and algorithms would be observed on this subject from present assessments. Hence, the objective of this research is to review relevant methods and parameters from past studies and to select the most suitable parameters and methods for delineating the traffic impact areas for proposed developments in the Sri Lankan context. Most suitable parameters and methodologies were identified through the Snowballing technique and multi-criteria analysis for delineating the extent of the traffic impact area from a new development.

Keywords: *Delineate, Methodologies, Parameters, Proposed Developments, Traffic Impact Area*

1. Introduction

A proposed development automatically generates the vehicle demand to the main accessible and adjacent roads and connected nearby junctions (Weerasekera, 2011). Therefore, a new development or expansion of existing development or redevelopment influences on the extent of the traffic to the external environment (Land Transport Authority, 2011). If it is not properly managed, problems would be more and worse (Ponnurangama & Umadevib, 2014). Therefore, the traffic generation from an upcoming development should be properly identified and managed.

Once identifying this, different countries have adopted different planning and building regulations and guidelines in order to identify negative effects and avoid them in advance (Cooley, Gruyter, & Delbosc, 2016). A Traffic Impact Assessment (TIA) is a study that is required to conduct as per the guidelines to obtain the development permit for a new development. It determines the possible traffic impacts to the surrounding transport network from the proposed development and it acknowledges the developer by recommending the remedial measures to erase them (Teodoro & Regidor, 2005).

In Sri Lanka as well, mega-developments should be accompanied by Traffic Impact Assessments as stipulated in parking & traffic control (Regulation 34, Schedule III) under the City of Colombo Development Plan (Amendment, 2008) in order to obtain the development permits. Although there is a vast positive movement, doubtful areas still could be visible in some subject areas mentioned under the Term of Reference (TOR) (Director, Enforcement Division of Urban Development Authority, 2019). One of them is the delineating the traffic impact area properly, where it is currently taken as the 500m buffer area from the proposed site. Moreover, a fixed impact area is adapted by many countries (Ponnurangama & Umadevib, 2014) like Malaysia (Ministry of Public Infrastructure & Land Transport, 2015), Singapore (Land Transport Authority, 2017), Australia (Department of Planning, 2016), Mauritius (Ministry of Public Infrastructure & Land Transport, 2015), New Zealand (Abley, Durdin, &

Douglass, 2010), and United Kingdom (Department for Regional Development (DRD) & Department of the Environment (DOE), 2006) as the study area under own their TIA guidelines and Term of References (TOR). However, extent of the traffic impact area is not a fixed boundary, which varies in their range of parameters depending on the development types, size (Abley, Durdin, & Douglass, 2010), location of the development (Ponnurangama & Umadevib, 2014), surrounding land uses (Weller, 2007), road network, vehicle flow concentration (Wen T., Chin W., & Lai P., 2017), intersection performance (Cooley, Gruyter, & Delbosc, 2016), surrounding developments and considerable distance from the site (Land Transport Authority, 2017) etc. Therefore, a fixed boundary may misdirect the developers, consultants and planning authorities at the decision making in transport planning circumstances.

Although various national and regional TIA guidelines are available in most countries regarding the study area limits, there is a little understanding of the flexible extent of impact area in their guidelines and the practices for the traffic impact analysis (Cooley, Gruyter, & Delbosc, 2016). Moreover, a minimum study area is included in the guidelines based on the size and land use of the development in few cases such State of Utah (Utah Department of Transportation, 2015), Indiana (Indiana Department of Transportation, 2015), Arizona (Town Council Of Buckeye, 2012), Minnesota (New Prague City Council, 2010) and City of Visalia (Community Development Department, 2019) etc. in United States.
A minimum impact area or study area limit should be recommended in the TIA guidelines and TORs as a major component (Weller, 2007). Thus, it should be clearly defined the flexible study area limit for understanding how far a proposed development will impact (Cooley, Gruyter, & Delbosc, 2016). Otherwise, many studies will be gone wrong due to this very subjective selection. Hence, many scholars in the transportation field and its allied disciplines argue the importance of having a new method to identify the traffic impact area for each development uniquely.

Only few models, techniques and algorithms would be observed for identifying and delineating the impact areas from present assessments such as Flow-based PageRank (FBPR) and network modularity algorithms (Wen T., Chin W., & Lai P., 2017), V2V-based method (Wang R., Xu Z., Zhao X. & Hu J, 2019), GIS techniques, spatial multi-criteria analysis and fuzzy logic (Rashed & Weeks , 2003), GIS, GPS and Accelerometry (Yin , et al., 2011), GIS software, trajectory model, Multivariate cluster analysis model and Oil Spill Risk Analysis Model (OSRAM) (Guillen, Rainey, & Morin, 2001), GIS technology with GFLOW software, U.S. EPA's WhAEM software and Analytic Element Models (Raymond, et al., 2006) etc. But, all these studies were based on specific and subjective criteria, unique geographical locations and no general models or algorithms could be observed especially for developing countries. Hence, the objective of this study is to review the available methods and parameters from past studies and select the most suitable parameters and methods for delineating traffic impact areas for proposed developments in the Sri Lankan context.

2. Literature Review

Unplanned development is a serious issue, due to the unbalanced traffic congestion in most countries (Azra & Hoque, 2014). Therefore, TIA has become a necessity to implement in the most developed and developing countries. Vehicle attraction is habitually increased to the surrounding road network from each new construction activity (Khade, Khode, & Bhakhtyapuri, 2017). Therefore, traffic impact levels from every new development effect on the adjacent roads and intersections. Although a TIA is a proper tool for the decision-makers to make decisions on new developments, it is difficult to delineate the direct impact area from a new development in both developing and developed countries like Bangladesh (Azra & Hoque, 2014), Philippine (Teodoro & Regidor, 2005), Canada (Engineering and Capital Infrastructure Services Infrastructure, Development & Enterprise, April 2016), China (Weller, 2007) and United Arab Emirates (Department of Transport, November 2009) etc., as most them are adopted the TIA "recently or yet to be institutionalized" (Azra & Hoque, 2014).

Few cases have been adopted the fixed standards for delineating the direct impact area from the proposed development. The Land Transport Division of Ministry of Public Infrastructure & Land Transport in Malaysia under the Traffic Impact Assessment Guideline (2015) explains that the study area should be a 1km radius adjacent to the site (Ministry of Public Infrastructure & Land Transport,

2015). All the access roads, nearby roads and junctions within a 1km radius from the edge of the site should be studied as the direct traffic impact area under the guidelines in Mauritius (Ministry of Public Infrastructure & Land Transport, 2015). Although having a fixed impact area under the regulations, the consultants should discuss the extent of the study area with the approval agency.

The size of an impact area will vary on each development (Weller, 2007) and it is not a fixed boundary for each proposal (Abley, Durdin, & Douglass, 2010). The scale of the new development effects on the amount of traffic volume (Khade, Khode, & Bhakhtyapuri, 2017). Azra & Hoque (2014) explain that all new development generate adverse impacts such as traffic congestion, air pollution, and safety issues, etc. to the surrounding area and scope of the impact level depend on the size of the development. Thus, the Division of the Town of Caledon (2017) argues that the extent of the study area will depend on the size and nature of the proposed development. Accordingly, in some states of the United States, specific standards were defined clearly to demarcate the study area in their TIA guidelines based on the size and type of the development (Azra & Hoque, 2014). State of Utah (Utah Department of Transportation, 2015), Indiana (Table 1) (Indiana Department of Transportation, 2015), Arizona (Town Council Of Buckeye, 2012), Minnesota (Table 2) (New Prague City Council, 2010) and City of Visalia (Community Development Department, 2019) are real examples for it.

Table 1, Study Area Limits for Transportation Impact Analysis in Indiana, United State *(Source: Indiana Department of Transportation, 2015)*

Development	Study Area
Fast – Food restaurant Service station with or without fast-food counter Mini-mart or convenience grocery with or without gas pumps Other development with fewer than 200 trips during any peak hour	Adjacent intersection if corner location Adjacent intersection if corner location 600 ft. from access drive 1,000 ft. from access drive
Shopping center less than 70,000 sq.ft. Or Development w/peak-hour trips between 200 and 500 during peak hour	All signalized intersections and access drives within 0.5 miles from a property line of the site and all major un-signalized intersections and access drives within 0.25 miles
Shopping center between 70,000 and 100,000 sq.ft. GLA Or Office or industrial park with between 300 and 500 employees Or Well balanced mixed-use development with more than 500 peak-hour trips	All signalized and major un-signalized intersections and freeway ramps within 1 mile of a property line of the site
Shopping center greater 100,000 sq.ft. GLA Or Office or industrial park with more than 500 employees Or All other developments with more than 500 peak-hour trips	All signalized intersections and freeway ramps within 2 miles of a property line and all major un-signalized access (street and driveways) within 1 mile of a property line of the site
Transit Station	0.5 mile radius
ft = feet, sq.ft.= square feet, GLA=Gross Leasable Area	

Table 2, Minimum Study Area Guidelines in Minnesota, United State *(Source: New Prague City Council, 2010)*

Development Characteristics	Minimum Study Area
Small Development (100-499 peak trips)	Site Access Drives, Adjacent signal controlled intersections within ¼ mile and/or major street intersections without signal control and driveways within 500 feet.
Moderate Development (500-999 peak trips)	Site Access Drives, All signal controlled intersections within ½ mile and/or major street intersections without signal control and major driveways within ½ mile.
Large Development (1,000-1,500 peak trips)	Site Access Drives, All signal controlled intersections within 1 mile and/or major street intersections without signal control and major driveways within 1 mile.
Regional Development (>1,500 peak trips)	Site Access Drives, Key signal controlled intersections and major street intersections without signal control within 3 miles.

In case of Singapore, still within 400m & 800m walk radius and 2km cycling radius are used for the study area delineation of TIAs (Land Transport Authority, 2017). Further, the Land Transport Authority also is to revise the standard based on the use and scale of the development. However, the same standards in other contexts are unable to apply as it is, due to the differences in travel characteristics, locational and geographic characteristics, socio-economic conditions, and cultures, etc (Azra & Hoque, 2014). The below table shows the traffic impact area standards of TIA guidelines.

Table 3, Case Studies of Standards and Methods for Traffic impact area delineation

ID	Country	Suggested Minimum Study Area / Impact Area	Classification on Development Characteristics	Source
01	Sri Lanka	Yes	No	(Urban Development Authority, Sri Lanka , 2018)
02	United Arab Emirates	No	No	(Department of Transport, November 2009)
03	Canada	No	No	(Engineering and Capital Infrastructure Services Infrastructure, Development & Enterprise, April 2016)
04	Malaysia	Yes	No	(Ministry of Public Infrastructure & Land Transport, 2015)
05	Singapore	Yes	No	(Land Transport Authority, 2017)
06	Australia	Yes	No	(ACT Government & Transport Canberra and City Services (TCCS), August 2016) (Department of Planning, 2016)
07	Mauritius	Yes	No	(Ministry of Public Infrastructure & Land Transport, 2015)
08	Bangladesh	No	No	(Azra & Hoque, 2014)
09	State of Utah, United State	Yes	Yes	(Utah Department of Transportation, 2004) (Utah Department of Transportation, 2015)
10	Indiana, United State	Yes	Yes	(Indiana Department of Transportation, 2015)
11	Arizona, United State	Yes	Yes	(Town Council Of Buckeye, 2012)
12	Minnesota, United State	Yes	Yes	(New Prague City Council, 2010)
13	Wisconsin, United State	No	No	(Bureau of Traffic Operations, 2019)
14	City of Norwalk, California, United State	Yes	No	(Norwalk Transportation Management Plan)
15	City of Visalia, California, United State	Yes	Yes	(Community Development Department, 2019)
16	City of Aspen, Colorado, United State	Yes	No	(City of Aspen)
17	Hong Kong, China	No	No	(Weller, 2007)
18	New Zealand	Yes	No	(Abley, Durdin, & Douglass, 2010)
19	Philippine	No	No	(Teodoro & Regidor, 2005)
20	London, United Kingdom	No	No	(Department of Transport, March 2007) (IBI Group and City of London, 2012) (Weller, 2007)
21	Northern Ireland, United Kingdom	Yes	No	(Department for Regional Development (DRD) & Department of the Environment (DOE), 2006)

It is vital to review and amend the TIA guidelines by understanding the operational requirements in a city (Cooley, Gruyter, & Delbosc, 2016). Without a proper standard or method, the consultants are unbaled to develop a proper TIA study (Azra & Hoque, 2014). Hence, this research purpose to identify the suitable parameters, existing standards, models and techniques to assess the direct traffic impact area from a proposed development.

3. Methodology

The first step of this research was the identification of the parameters to change the extent of the impact area, due to a new development by reviewing the past studies. The second step identified the available models/algorithms/methods/techniques/ standards for delineating the traffic impact area from a proposed development by considering the present planning and building regulation guidelines and the published past studies and evaluated them by case studies. The final step identified the most appropriate methods and parameters by using the snowballing technique and multi-criteria analysis. Here, the proposed study area is the Western Province of Sri Lanka, which presents a high correlation between land-use change and existing transportation issues in Sri Lanka as the commercial capital of Sri Lanka. Hence, this paper will support decision makers to use it easily and effectively for generating accurate decisions in the planning process further.

4. Analysis and Results

New traffic will be generated due to construction around it. Thus, Yayat K.D., Kombaitan B., Pradono & Purboyo H.P.H. (2015) explain that the size of the building also affects the road network and intersections around the development. The high number of development could be generated huge traffic (Yayat K.D., Kombaitan B., Pradono, Purboyo H.P.H., 2015). The size of the catchment area from a proposed development will depend on the surrounding transport network, modes of transport facilities, intersections and road link performance and scale of the activity and trip generation of the new development (Cooley, Gruyter, & Delbosc, 2016). Thus, Sarkar, Maitri, & Joshi (2015) illuminate that topographical barriers, connectivity of road network, nearby trip attraction points and population density around vary on the traffic impact area limits.

Trip generation from a new development, existing traffic condition on the nearby roads and junctions (Ministry of Public Infrastructure & Land Transport, 2015), access points to the site (Indiana Department of Transportation, 2015) and distances from the site (Land Transport Authority, 2017) also may depend on extent of the traffic to delineate the study boundary. The availability of bare land or vacant land and its changes can be used as an indicator to change the traffic impact area (Chen Y. & Liu A., 2019). Further, road classification, width, and the number of lanes of the access road effect on the extent of the traffic generation (PMK Associates, Inc., July 2006). Thus, walking distances to public transport connections may determine the extent of the traffic impact area from a new development (National Roads Authority, 2014). Transport related infrastructure developments such new developments or alterations or improvement of roads and intersections, shared paths, crossovers, pedestrian routes, cycle routes, public transport routes, bus routes or bus stop locations (Department of Planning, 2016) and intersection control type which means signalized or un-signalized (Department of Transport, March 2007) would be affected to enlarge or reduce the boundary of the traffic impact area of a new development.

Partition of traffic zones is an important indicator to analyze and predict the traffic flow on the surround road network in a city (Zheng, Zhao, & Liu, 2015). Accordingly, a traffic distribution model with simulation have been developed by the Yang, Wang, & Chen (2007) to analyze and predict the micro and macro traffic flow on the road network for TIAs by using Geography Information System (GIS) and Voronoi diagrams for detecting the traffic analysis zone (TAZ) and the Multiplicative Competitive Interaction (MCI) model for estimation of new OD matrix.

Cluster methods are used as the traditional method for the division of traffic zones through the location points in past studies. Zheng, Zhao, & Liu (2015) have developed a Novel grid-based K-Means cluster method to identify the clear and accurate traffic zones based on the simple cluster analysis. However, Taxi GPS data is the only parameter taken for this research for traffic zone divisions. Although the four-step forecasting and sketch-level forecasting are common two delineating methods of Transit Traffic Analysis Zone (TTAZ), Wang, Sun, Rong, & Yang (2014) have proposed the Thiessen Polygon to divide the study area into TTAZs. Thus, Shen, Liu, & Chen (2017) used geospatial statistical methods to analyze location-based data through the Thiessen Polygon, Moran's I index, Hot spot analysis and Global Positioning System (GPS). The Thiessen Polygon has been used to divide the study area into small plots to detect the spatial distribution of vehicle pickup and drop-off points. The Moran's I index was to identify the spatial correlation of the distribution of vehicle pickup and drop-off points. Hot spot analysis was used to find the spatial clusters of pickup and drop-off location points. And, pickup and drop-off locations were recorded by the GPS. But, this research has been adopted only taxi-based Floating Car Data (FCD) and ignored the holidays and positional error of vehicle pickup or drop-off plots to identify the human spatial pattern in the city. Thus, land uses such as rivers, lakes, and mountains in the study area were not considered to build the Thiessen polygon. However, GIS can be used to demarcate the traffic impact area by adapting the location-specific characters (Shen, Liu, & Chen, 2017).

The Regression Model (Khade, Khode, & Bhakhtyapuri, 2017) and the scorecard approach (Cooley, Gruyter, & Delbosc, 2016) are applied to evaluate the traffic growth rates at present and future scenarios. Analogy Method, Gravity Model Method, Market Area Analysis and Origin-Destination Method (Bureau of Traffic Operations, 2019) estimate the trip distribution based on land use and locational characteristics to delineate the traffic influence area of the surround transport network.

Different impact delineation models and techniques could be observed in not only the transport-related but also in other subject areas. Meanwhile, as same the TIA studies, the boundary of the study area for an Environment Impact Assessments (EIA) have been delineated through the different methodologies under own their Terms Of Reference (TOR). The legal requirement in India is based on the Environment (Protection) Act, 1986, the Environmental Impact Assessment Notification, 2006 (amended 2009), and it has clearly mentioned the 10km radius from the site is the catchment area to be studied by the consultants (Government of India Ministry of Environment & Forests, New Delhi, India). Accordingly, an EIA study for a proposed bridge in Bihar, India has been taken a 2 km buffer area as the direct impact area and up to 10km buffer area as the indirect impact area (Bihar State Road Development Corporation Limited, Government of Bihar for the Asian Development Bank, 2016). Thus, the minimum study area has been delineated within 3 km radius from the proposed site under the TOR of the EIA for the proposed resort development at Big and Little Pelican Cay Portland Bight, St. Catherine in Jamaica (Terms Of Reference for an Environmental Impact Assessment for a Proposed Resort Development at Big and Little Pelican Cay Portland Bight, St. Catherine, Jamaica, 2011).

Flow-based PageRank (FBPR) and network modularity algorithms (Wen T., Chin W., & Lai P., 2017), V2V-based method (Wang R., Xu Z., Zhao X. & Hu J, 2019), GIS techniques, spatial multi-criteria analysis and fuzzy logic (Rashed & Weeks , 2003), GIS, GPS and Accelerometry (Yin , et al., 2011), GIS software, trajectory model, Multivariate cluster analysis model and Oil Spill Risk Analysis Model (OSRAM) (Guillen, Rainey, & Morin, 2001), GIS technology with GFLOW software, U.S. EPA's WhAEM software and Analytic Element Models (Raymond, et al., Using Analytic Element Models to Delineate Drinking Water Source Protection Areas, 2006) etc.

A GIS methodology has been developed by Rashed & Weeks (2003) using spatial multi-criteria analysis and fuzzy logic to assess the spatial vulnerability to the earthquake hazards in urban areas. Raymond et al (2006) used the GIS technology with GFLOW software, U.S. EPA's WhAEM software and Analytic Element Models to delineate the size and shape of the drinking water source protection areas. Guillen, Rainey, & Morin (2001) have used the GIS software, trajectory model, Multivariate cluster analysis

model and Oil Spill Risk Analysis Model to delineate the common oil spill risk area. GPS, GIS, and Accelerometry are used to identify the physically active land areas within the neighborhoods in Erie County, New York (Yin, et al., 2011). Nelsona, Long, Laberee, & Stewart (2015) used GIS and GPS technologies to detect the slow-moving areas of grizzly bears in Alberta, Canada. Pelot & Plummer (2009) applied to delineate the marine protected area by using the GIS technique.

5. Conclusion

The objective of this study was to recognize the most suitable parameters and methods for delineating the traffic impact areas from a new development. The findings of the study indicated that the Geography Information System (GIS), Global Positioning System (GPS), Thiessen Polygons, Regression Models, Multivariate cluster analysis model, Hot spot analysis and Spatial Multi-Criteria Analysis could be identified as the most adopted spatial distribution methodologies to delineate the extent of the traffic impact area from a new development. Further, the findings emphasized the development type and the scale, location, lands use pattern around, modes of transport facilities, nearby trip production points, population density, and prevailing traffic conditions on the road network have a high correlation with the extent of the traffic impact area from a new development. However, the reliance on the results and assumptions and the homogeneous of parameters are the problems associated with available models and techniques in past studies, when directly adapting them to the local context. Thus, many researchers in the transportation filed argue the importance of having a new technique to delineate the traffic impact area for each development uniquely. Hence, this study direct to develop a spatial and dynamic model to demarcate the traffic impact area from a new development at the decision making in transport planning circumstances.

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MENTAL MAPPING OF DIVERSIFIED URBAN INTERACTION SPACES AT RESIDENTIAL AREAS IN DHAKA

N. ISLAM[1], S. AFROZ[2] & F.F. HUQ[3]
[1]Urban Resilience Project: RAJUK Part, Dhaka, Bangladesh
[2]Pabna University of Science and Technology, Pabna, Bangladesh
[1]nidaliaislam@gmail.com, [2]Saoishi_arch@yahoo.com

Abstract
The Community spaces fulfils "anthropological needs" of human beings. Dhaka is a living city with diverse lifestyle and people from all strata of society with different motivation. The city has different type of land use both planned and organic development which has grown from the need of dwellers. The primary human interaction space for the People living in planned residential areas are community parks and playfields. The organically developed areas of the city lack required number of parks, playfield yet found to be livelier and spontaneous in terms of human interactions and spatial relationships. The narrow alleyways, community kitchen and grocery shop become effective interaction space for the dweller, which has grown in terms of their need. This study attempts to compare the quality of the 'interaction spaces' of both planned residential areas and informal settlement area of Dhaka city by generating 'Mental Map' of the areas. The study uses Lynchian method in analysing city image and producing mental map of study areas. Geographical Information Systems (GIS) has been used as a tool for visualizing spatially oriented qualitative data to produce 'Mental Map' of the areas. The study bestows an idea about the differences between the users' satisfaction from provided public spaces and spontaneously growing path-space community interaction spaces.

Keywords: *Urban interaction Spaces, Lynchian method, Mental Mapping, Path-space relationship.*

1. Introduction

Community space creates a cohesive environment for human being, it creates a "belongingness", a sense of association for them. In urban scale community, space plays an important role in both spatial term and environmental psychology. Urban public spaces enhance human happiness and empathy, as they are the focus of human interaction. Lynchian elements are the unique elements of urban environment (natural or manmade) described by Kevin Lynch, which can create a mental map that constitutes a mental representation of what the city contains. Five elements of the urban environment are paths, edges, districts, nodes, landmarks (Lynch, 1960). Jonathan Raban (1998) has divided the city in two parts soft city and the hard city. Hard city is the concrete part of the city such as alleyways, architecture, and soft city is more connected with the mental side of the dwellers, an image created in the inhabitant's mind. The mental map of a city contains many elements (Lynchian elements), when physical environment coheres with the mental image the city creates more associative for dwellers. Organic developments encourage this sense as Aldo Rossi has put a city is a man-made object, a work of architecture and engineering which grows through time.

Dhaka being one of the densest cities of the world displays a diverse lifestyle of people from all strata of society. Urban interaction space has become a complex term for Dhaka as it is the third most populated city in the world with 47,400 people per square mile (Amin, 2019). Open spaces in urban areas are categorized as 'Utility Open Spaces', 'Green Open Spaces' and 'Corridor Open Spaces'. The public actively uses the green open spaces and the corridors thereby, termed as the 'Public Open Spaces' in urban areas (Nilufar, 1999). The primary human interaction space for the People living in planned residential areas are community parks and playfields (RAJUK, 2015). On the other hand, the organically developed areas of the city critically lack required number of parks, playfield but these areas are found to be livelier characteristics of own created from human interactions and relationships as they lack planned open spaces (d'Cruz et al, 2014). The visual perception of cities is very important rather than the spatial organization. The term mental mapping or the "imageability of city" of city comes in the visual perception of a city in terms of form and space comes. The term imageability was introduced by Kevin Lynch (1960) which gives us insight of a sensory mental image we built in our mind with the stimuli of our surroundings. This study identifies and examines public interactive spaces in three different settings (informal settlement, gridiron pattern and organic residential areas) of densely populated metropolis - Dhaka city in physical and social terms. This study also explores Lynchian elements (paths, nodes and landmarks) and "meaning" (cultural, social factors) in terms of people's anthropological needs and association.

2 The concept of Psychogeography and Lynchian elements

Psychogeography defined in 1955 by Guy Debord is an exploration of urban environments that emphasizes playfulness and "drifting" consciously organized or not, on the emotions and behavior of individuals (Debord, 2008).According to Lynch “Nodes are the strategic foci into which the observer can enter, typically either junctions of paths, or concentrations of some characteristic” (Lynch, 1960: 72). They are the gathering points such as squares, railroad stations, plazas and junctions even ordinary street intersections are nodes. Pathways are the channels of movement within which the city can be conceived such as alleys, streets, railroads, motorways, canals and the like. Any path has three characteristics that enhance its prominence; they are identity, continuity and directional quality. Spatial qualities of width or narrowness can attract attention and strengthen the image of particular paths (chapter two, Lynch, 1950). The concurrent significance of these kinds of spaces for perception, memory, and playful action indicates their key importance in physical, perceptual, and psychological terms. Norberg-Schulz (1971; 1980) suggests that these elements of spatial structure are `existential': they organize human dwelling in the landscape at all scales. They are for Norberg-Schulz the fundamental topological structure of space in relation to movement and visibility, and they define continuity, choice, and enclosure respectively (Stevens, 2006). Kevin Lynch focused on the legibility factors of urban design but later it was extended in three significant points **Identity, Structure and meaning** to include people’s experience and memory as a city should be analyzed with the result of interaction between the observer and environment (Baseer, n.d).

3.Methods

A Systematic Field Reconnaissance

It starts by finding out the existing potential by the site and its surroundings. It is made on foot and automobile by mapping the area and explores the visibility of defining its elements and recording any existing activities and forms which could be used to make the place more legible. The researchers’ analyses the area in terms of three elements- Nodes, Paths and Landmarks in respective area. The spatial analysis was done in field survey to identify “Structure” and “identity” in urban morphology.

Observation and interview method

The observatory survey of researchers among the users were done with a motive to understand “meaning” in association with peoples experience and observation. Hence, identifying the structure and urban form in their daily life.

4. Case study Area

The study has been conducted in Uttara and Abdullah Beribadh area. The case study area A- sector 11 of Uttara model town is a grid iron patterned planned residential area. The ‘Abdullahpur Beribadh’ settlement is an organic settlement adjacent to Uttara model town.

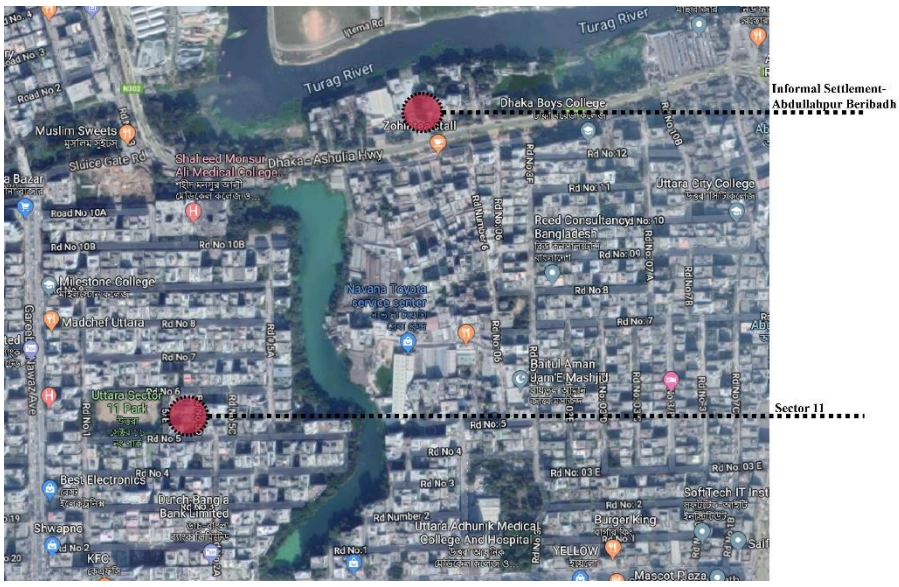


Figure 1, Site plan of the case study area (*Source: satellite image*)

4.1. CASE STUDY AREA A

4.1.1 Site and surroundings:
The study area is approximate 1235 km. the sector 11 park and its surroundings area adjacent to a 25m main road, 265m away from a lake, although no strong visual connectivity.

Figure 2, case study area A (*Source: Google Earth,2019*)

4.1.2 Social and physical context of site:
Mostly high income and higher middle-income people live in this Planned residential area with urban necessary infrastructure (park, mosque etc).

4.2.3 What kind of a place is it:
The residential area is designed and perceived as gridiron pattern modern housing for middle income or higher middle-income people. The grid iron network gives a thoroughfare connectivity to the residential area but it lacks hierarchy.
No pocket space was created. As a result, the site elevation seems blunt.

4.2. CASE STUDY AREA B

4.2.1 Site and surroundings:
This organically developed settlement near Beribadh near Uttara model town is known as “beribadh basteei(slum)”. This place is situated on the north side of Dhaka-ashulia highway or beribadh road. Uttara sector 9 is situated just opposite of it (south side of Dhaka-ashulia highway)

Figure 3, case study area B (*Source: satellite image*)

4.2.2 Social and physical context of site:
The slum is adjacent to an industrial zone nearby and a planned residential area which act as a dominant factor in the lifestyle and profession of the people living in that slum. The dweller of slum is lower income people and adjacent high middle-income area has created scope of employment for them. The growth of small industries in that area ensures a scope of employment for slum dweller. A fish market, bus stand and the highway also encourage the spontaneous growth of slum as these features make a promise of employment to the dweller. Female member works as a part time maid or garments worker. Male members mostly work in rickshaw garages or small industries.

4.2.3 What kind of a place is it:
A very organic and informal settlement located adjacent to a highway which act as an important link to the main city. The planned residential area and highway has acted as catalyst to the growth of this slum. They suffer slightly from environmental hazard and there is a lack of good sanitation. Otherwise it's a very organic layout and there's a sense of place in the nodes and small pocket spaces which faces the river Turag. Children have also made their place to play and the dweller has also made their individual lifestyle and sense of place.

5. Findings of survey

5.1. CASE STUDY AREA A

Uttara sector 11 is a residential area with a park located at almost at mid-point (230m from the main road) along east-west direction and one-third point (130m) along north south direction. This is the only open space for respective case study area (apx 1230 km). The park is open in four sides, it has two entrance gates. It has four nodal points which act as the Lynchian nodes and landmark for the area (Lynch, 195). The space is perceived as community's child play area and jogging track for adults. There are some sitting spaces in park and near the play area. The field survey finds that the sitting spaces at the edge are not as active as the sitting near play area. Children play in afternoon at the mid of the park in cluster of different age group or peer group. The brick tracks at edge is perceived and used as a jogger's track. At the entrance gate of the park some street hawkers and food cart are seen which spontaneously creates another community interaction space. At the northeast node, there are other food carts. As this park is designed within gridiron pattern, it is open in four sides' nevertheless poor visual connection and lack of hierarchy of space is observed in the park area. There are two grocery shops and tea stall from 100m ahead of the park which also act as a community space. Number of park user during different time of day are recorded. The park is found to be more active in afternoon for user of all age groups. The joggers are seen in both morning and afternoon.

Figure 4, Map of the sector 11 park
Source: Authors preparation by using DAP 2004-2015

Entrance of the park, seating near play area, play area and instruments (*Source: field survey*)
Source: Field

Tea stall 01
Source: Field Survey, 2019

Tea stall 02
Source: Field Survey, 2019

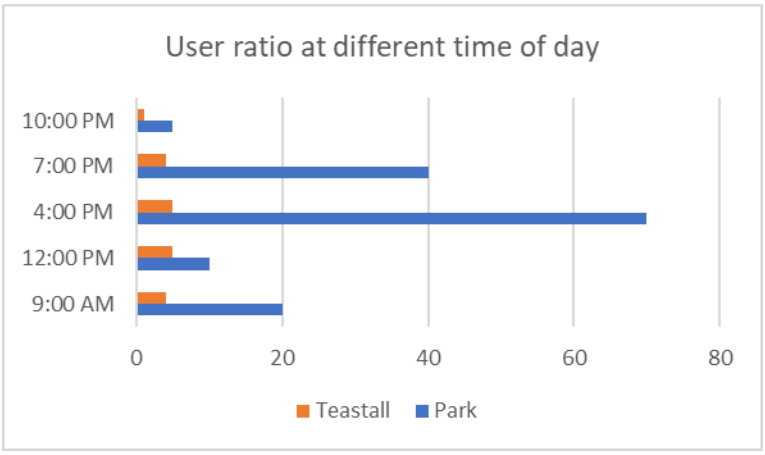


Figure 5, the no of user through-out the day (*Source: field survey,2019*)

5.2. CASE STUDY AREA B

The Abdullahpur beribadh bastee (squatter) is a U-shaped informal settlement along the branch of Turag River. At the entrance a Banyan tree is located just before the slope which acts as a landmark for this settlement. The settlement has started from the slope. Some residential units (made of bamboo, wood and corrugated sheet) are just above the swamp and waterbody, the units are connected by wooden bridge. The pathways have connected the residential units with the main land and it acts as a community space for dwellers. At the entrance 2-3 grocery shop is located just before the residential units, it is one of the liveliest community spaces especially for the male members of community. The grocery shop is a landmark and it situated along the pathway and before a node. After the grocery shop a two-way node is seen where one branch of node is leading to the linear pathways of residential units. The service units (Shared kitchen and shower) are situated along the pathways. The latrines are located far from shanty units facing the lake. The children are playing through the narrow alleyways, pocket spaces are created along the lake/ river. The narrow alleyways are the interactive spaces for dwellers especially for children. The kitchen acts as a community space for women. Most of the women here work as a part time maid in the adjacent residential area Uttara model town. The kitchen using time is early morning (7.00-9.00 am) before going to the work and before dinner time (8.00-9.00 pm). Women of the community gossip and cook simultaneously during aforementioned time period. The shower space is mostly used by woman, the male users are seen less in number. They usually do hurry in a shower but woman interacts with each other while taking bath, washing clothes or collecting water. The male users hardly interact in the shared bathroom. The user number is seen highest in morning (6.00 -8.00 am). During afternoon (12.00-3.00 pm) children are the dominant user of bathroom as other members are busy with their livelihood. The narrow alleyways are also used for children's activity and interaction space for the community people. The children play in the pocket spaces, alleyways or they just visit sometimes the small shops. The security is an issue in lower income group therefore children are not encouraged to go outside of the homestead area. The space and ratio of users are presented in a chart based on field service data.

The shops at entrance (Source: Field Survey)

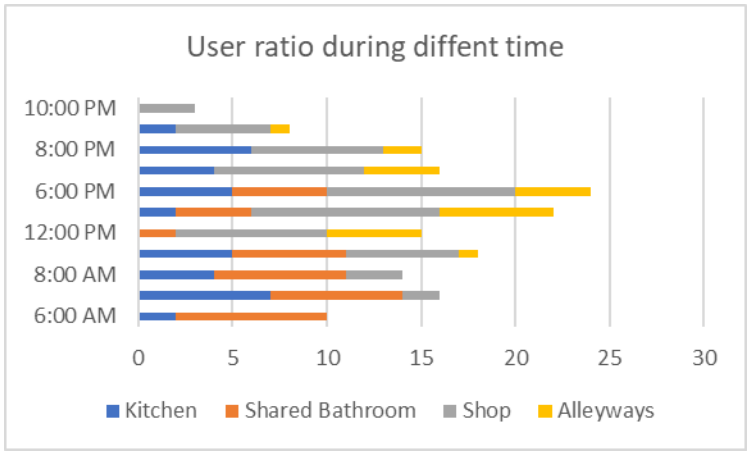
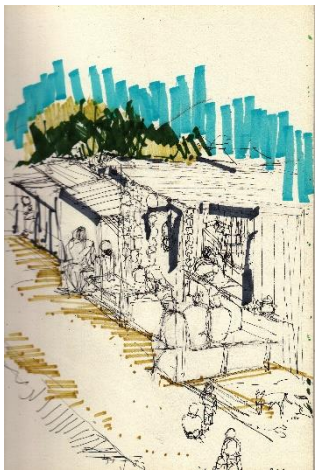


Figure 6, the number of users throughout the day (*Source: field survey)*

Community kitchen Pocket space, child play Shared Service

Organic community space created in between their home along the linear wooden deck



The entrance with grocery shop

Source: Authors' Preparation

6. Results and Discussions

Study area A is a planned residential area following grid iron pattern. The park is designed to fit the grid iron pattern manner with four nodes around the edge, the active node is north and north east corner which is actually close to the main entry of the park. The open area itself is a landmark for the area, it is visibly clear as it is the only open space in the area. The "identity" is clear but the park was not designed to create a strong dialogue or visual connectivity with the physical environment of the community rather it is a "fit". The park is only breathing space for community of sector 11 the users have an affiliation towards the park but it is like an option rather than a choice. Use of space during different times of day show us that in the afternoon it is the most active space. The tea stalls are more or less active during the whole day but in terms of community action, it is not perceived as a place for all age group and genders.

In study area, B there is no designed open space or community space. The functional space i.e. grocery shops, community kitchen and shared services (water collection, shower) act as community interaction space. The shared services are located in nodes or edges of alleyways. They are located regarding their functional need and merged with physical environment, as the main axis of the settlement is linear and organic. The user shares a belongingness to the spaces however in their mind; it is not conceived as an interaction space. The interaction developed in case study area B is not a choice of the residents but "unconsciously" spontaneous as it is directly related to their daily activities. The user number in different time of day indicates that kitchen user is highest in morning, shared bath is also same. The children have their activity during the whole day. Both the case studies have their space-user ratio according to their living pattern.

6. Conclusion

The image of an environment is two-way process, an interaction between the observer and the surrounding environment. A space must have meaningful relationship with its surroundings and the activity of the users. The visual environment should be significant to people's other aspects of life exceeding the daily commute and activity. A built environment become more meaningful to the environment when there is a congruence between physical form and activity. People can filter and built environment based on their choices. Study of two different spatial aspect and different strata of society shows that a designed pre-decided urban facility for inhabitants fulfil their needs but not their mental satisfaction properly. Aside from, in organically developed settlements, space is perceived in peoples mind and they can feel having a sense of kinship. These spontaneously growing spaces can bestow the users' mental satisfaction, as they possess the space.

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COMPARATIVE STUDY OF IMPACTS ON DESIGN THINKING BY USING AUTOCAD AND MANUAL DRAFTING IN THE SCHEMATIC DESIGN STAGE

HETTITHANTHRI U.[1] & MUNASINGHE H.[2]
[1]National School of Business Management, Green University Town, Homagama, Sri Lanka
[2]School of Architectural Studies, George Brown College, Toronto, Ontario , Canada
[1]upeksha@nsbm.lk, [2]hmunasinghe@georgebrown.ca

Abstract
Drafting is a key component in architectural studies. The medium of drafting matters in design thinking. This study was set up to find out if and how drafting media would be effective in stimulating design thinking in the early stages of design ideation. In the architectural learning system, computer aided drafting is not encouraged by lecturers in the early design ideation stage, the reason being that many lecturers believe that computer aided drafting will limit design thinking at this stage. However, drafting is a skill which designers could personalize by adding his/her techniques in order to add aesthetic value to the drawing. This scenario is common in architectural practice. This article aims to find out in what manner the medium of drafting could generate an impact on design thinking of students at the early design stage. For this study, fifty students of an Interior Design degree program were observed, and twenty students were selected based on type of drafting technique: ten students used computer aided drafting and ten students used manual drafting at their schematic design stage. The schematic design stage of the design process has been selected for this study. Qualitative methodology has been adopted in conducting this study and data has been collected through interviews conducted at 2 levels of the process. The collected data has been analysed through a thematic analysis. Furthermore, the results of the project have been analysed parallel to the data gathered from the interviews to measure design thinking capability.

Keywords: *Computer aided drafting, manual drafting, design thinking*

1. Introduction

Architectural learning is unique from other disciplines and has its own teaching culture. Drawing and drafting possess an inseparable interconnection with the architectural study domain (Yee 2012). Prior to the millennium, architectural drawings and sketches were the best design communication mediums in both practice and learning (Pektas & Erkip 2006). It was an era where architects would add personalized skills to their drawings, thereby creating many trends and styles in drawing which made visual communication more effective and graphical (Donald A Schon 1984). Undoubtedly, drafting has been recognised not only as a significant communication medium, it is indeed a skill-based application in design communication (Senyapili & Basa 2006). Project based learning and studio centric education are the main key components in architectural education (Abdullah et al. 2011). Drawing and drafting are applied in nearly all design stages but the medium selected to express design ideation could be affected on stimulating design thinking specially in the stage of early design ideation.

With the development of advanced computer software, architectural education has faced drastic changes in its inherent learning culture (Alkymakchy 2012). Computer aided drafting became significantly popular among young learners due to many reasons (Al-Qawasmi 2005). Undoubtedly, computer aided drafting tools make the drafting procedure easier and save time, however it is important to research on the manner in which these computer aided tools will affect students' design thinking. It is believed by many lecturers that exposure to computer aided drafting medium at the early design stage will impact students' design thinking negatively. Through this article, we present the results of a comparative study on the impacts of computer aided drafting and manual drafting at the schematic design stage.

1.2. RESEARCH QUESTIONS

This is an observational study conducted to compare the impact of the medium of drafting on the design thinking of students. Research was conducted to find answers for following questions.

- Does the medium of drafting impact design thinking at the early design ideation stage?
- Does computer aided drafting limit students' design thinking?

2. Research Methodology

This is a qualitative research conducted via the study of 20 students in an Interior Design degree program. For this study, students in the first semester of their second year were selected, out of which 20 students were selected for the study based on the medium they were using for the given design projects. Mean age of the selected sample was 21 years while 5 girls and 5 boys have been selected for each drafting medium to maintain gender balance. The reason to select these students for this project specifically is that at this academic level they have been exposed to both mediums for drafting. In the second semester of the first year, learning computer aided drafting has been incorporated into the curriculum as a module, therefore when they approach the first semester of their second year they possess a thorough understanding on the software. A duration of 8 weeks has been allocated towards the design project for the first semester of the second year. The researcher has observed the entire design process as a fly on wall observer (Given 2019). The given project was to provide interior design solutions for a hotel lobby and dining space. Students have completed the initial background study including site and client analysis, and brief finalization within the first week. From the first week to seventh week, students' designs were individually tutored by the module leader and allocated tutors. During this period, students worked in a design studio complete with typical design studio facilities such as space to use drawing boards, model making facilities plus electrical and WIFI facilities in order to use individual laptops and obtain internet access.

The researcher was a silent observer throughout the design process, therefore ethical clearance was obtained to observe the students' learning process and glean the results for this study (Charmaz & Henwood 2019). There were 50 students in this class in total, while for this study 20 students were selected with an equal distribution of 10 out of 20 for both digital and manual drafting medias following an observation of the medium used for designing and communication of their schemes within the first week.

Each student got a tutoring sheet to be filled by all the tutors with their comments on each day of tutoring. In this sheet, tutors had to comment on the students' progress, design thinking, approach and any other matters related to their design. The researcher has used these comment sheets as data for the analysis.

The limitations faced by the researcher is mainly on selecting the sample. It is usually benefited if the researcher could increase the sample size from 20 to at least 50. But due to limited student counts in the class and variations on computer aided drafting skills made the selection challenging. Furthermore, it was difficult to say that all the students who used auto cad were having similar skill levels on handling the digital drafting tool which could limits the application in different ways.

2.1. DATA COLLECTION

Data collection was initially carried out via observation and interviews conducted at two stages of the design process. The researcher used a field diary to record observation notes and a special recording sheet has maintained individually for each student for the purpose of data recording (Cohen, Manion & Morrison 2018). The recording sheet had a distribution of columns for data entry by the researcher under following categories: week, drafting medium, and comments of tutors on progress. In the field diary, the researcher has noted all important facts including activities engaged in during studio sessions. Data collection was carried out throughout the 8 weeks but for the analysis, data obtained from the first 6 weeks has been used since the researcher's primary focus is on finding the impacts of the drafting medium at the schematic design stage. Each week, students got 12 studio hours to develop their design schemes. As per the academic semester calendar, each Monday and Thursday has been allocated with the inclusion of 6 hours per day. The module leader and tutors were available throughout the allocated studio hours to provide design tutoring for students. Each student was equally tutored by the facilitators; students got an opportunity to receive one-on-one tutoring at each studio session, and it was mandatory for students to maintain individual tutoring records with the comments of the tutors. The researcher has access to observe and use those tutoring sheets as research materials.

Interviews were conducted during the 3rd week of the process and again in the 6th week of the process. Students were individually interviewed, and each interview has been recorded by the researcher for the purpose of analysis. The questions were based on discovering reasons for the selected medium and how it has supported them in the generation of novel design ideas and solutions for the given project.

Interviews were taken externally and not within the studio hours allocated for students in order to minimize potential disturbances.

Photographs were taken at random throughout the design process as another recording medium and the learning behaviour of each selected student has been captured for further analysis. Photographs were taken during every studio session and categorised under the name of each student.

2.2. DATA ANALYSIS

In the data analysis, firstly, observation notes have been taken into consideration. For each student, a separate folder has been maintained and the data generated by observation sheets has been categorised according to weekly progress. The data was analysed by a thematic analysis (Tracy 2013). Thematic analysis consists of 3 major steps: coding, categorization and generating themes. Recording sheets generate codes such as use of CAD for layout, use of CAD for elevations and sections, CAD for mind mapping, free hand sketching, drawing perspectives, mind mapping using collages, etc. Those codes also generated categories such as CAD for communication, CAD for drafting, free hand drawings for communication, free hand for drafting. These categories have generated two themes: use of CAD in schematic design, use of manual drafting in schematic design.

Interviews were recorded and transcribed by the researcher for analysis. Questions of the first interview which was conducted at the 3rd week of the program focused on discovering reasons behind the selection of the medium of drafting. The following questions were asked by the researcher and answers were fed in to MAXQDA 11 for analysis.

- Why did you select AutoCAD / manual drafting for your drawings?
- How did it help you in developing your design scheme?
- What are the methods you used in communicating your design to your tutors?
- According to your point of view what are the advantages of the selected drafting medium?
- Does the medium of drafting was helpful in generating novel design ideas?

Students who were engaged in those two mediums were individually interviewed and recorded. Interviews conducted among students used AutoCAD generated codes following codes; faster than manual drafting, easy to reproduce drawings, easy maintenance, less paperwork, easy to put materials, time saving. The above codes categorised in to two main categories, such as easiness and less paperwork which generate the theme as efficient tool. Being confident on the skill, hands on practice, an instant medium to record the imagination, self-satisfaction, visible progress were the codes generated by the initial interview conducted among the students who were using manual drafting. Recording medium, satisfaction and improving skills were the categories generated which lead to a theme called satisfactory tool.

The second interview was conducted at the 6th week and following questions were asked.

- Does your design was well understood by your tutors?
- Were you able to apply possible design solutions for the given problem?
- How the selected drafting medium was supportive in communicating your design?
- Does the selected medium was supportive in managing your time?

Tutor's comments were weekly collected, and those comments were again categorised in to three major themes. Positive comments on design approach, negative comments on design approach, average were the three major themes generated by the comments of the tutors.

2.3. RESULTS

The thematic analysis generated two "major themes" such as "efficient tool and "satisfactory tool". In addition, the researcher has notified many reasons behind the selection of a drafting medium for a given project. Selection of AutoCAD was reasoned out by students due to its and user-friendliness and easy usability. Students were able to easily reproduce drawings, based on their previous work, through the use of AutoCAD.

Students who used AutoCAD brought printed drawings for tutoring. Three out of four tutors commented negatively on the design approach of the students (n=6) in the first week. The table below summarises all comments from the tutors.

Table 1, Summary of the tutors' comments at the schematic design stage

Tutor's Comments	Drafting medium	Number of students
Negative	AutoCAD	6/10
Positive	AutoCAD	2/10
Average	AutoCAD	2/10
Negative	Manual Drafting	2/10
Positive	Manual Drafting	7/10
Average	Manual Drafting	1/10

According to tutors' comments 60% of students received negative comments on their design approach. The reason behind this is that the majority have found difficulties in developing novel design solutions for the given project. The use of AutoCAD leads them to reproduce spaces with typical furniture design templates which were freely available from the software. Surprisingly, 70% of students who got very positive comments from tutors due to new furniture design solutions given, and due to new material applications and non-identical special solutions generated to the given space had used manual drafting techniques.

According to the results generated by the observation, 70% of students used typical furniture templates which are available on AutoCAD and have reused the same furniture for many spaces by copy pasting. This caused the students to complete their drawings much quicker than the students who used manual drafting. In addition, 50% of students failed to give innovative material applications other than typical solutions rendered by AutoCAD. This was significantly contrasted within the manual drafting cluster, where sketches, perspectives and sections were given with new material applications.

Notably, 60% of students who used manual drafting have thought of colour and textural effects of the interior. In comparison, none of the students who used AutoCAD thought of these effects of the interior at the schematic design stage which was depicted as 0%. In terms of attention to detailing, 30% of students who used manual drafting gave thought to joinery and fixing details at the initial design ideation stage while 0% from the students who have used AutoCAD gave thought to these details.

3. Discussion

This article aimed at discovering answers to the research questions depicted in section 1.3. Following the analysis of results, the design thinking ability of the students who used manual drafting were significantly higher than the students who used AutoCAD. In the process of procuring the reasons behind this, many interesting factors were identified. It was proven that the use of AutoCAD is faster than manual drafting which makes editing much easier than manual drafting. After a regular tutoring session, students are required to make changes as per comments made by the tutors; students believe that AutoCAD makes this process easier. It is undoubtedly true that manual drafting is more time consuming than AutoCAD, and that students have to trace or copy the exact existing drawing multiple times in order to make changes which is time consuming. But it was notified that during the manual drafting process, students tend to experiment with novel design solutions compared to the others, which allows the creation of rough sketches (as a result of sudden imaginations) as a recording medium. This process is helpful in stimulating design thinking of students in the early design ideation stage (Cross 2011).

Significantly poor design abilities were seen in the students who used AutoCAD while students who used manual drafting produced quality drawings which had more value than a mere printout. In terms of quality, they have tediously thought out and visually displayed the 3D appearance of the designed space by using perspectives which was significantly less visible among students who used AutoCAD. Drawings produced by AutoCAD were rich in intricate details such as tilling, wood finishes and functional specifications, but they were weak in expressing the holistic image of the designed space to the tutor as majority had not thought of using details beyond plans, sections and elevations.

3.1. CONCLUDING REMARKS

It was evident that the use of AutoCAD has made the process easier and faster, but it was significant that the digital medium has generated a lower stimulant on the design thinking of students. Manual drafting

has generated more sensible design solutions than AutoCAD. Therefore, the use of manual drafting can be recognised as a medium which could stimulate design thinking ability particularly at the schematic design stage, whereas AutoCAD could work as a supportive tool in detailing the scheme when students are in the final design development stage, which would require more time and techniques.

Importance of conducting this type of researches is to understand the impacts of computer aided drafting on design thinking. With the rapid development, those tools are getting updated and changing its functions to cater the complicated needs of the design society. This research will be an eye opener on how the medium could be affected in novel design solutions which could be usually generated in design ideation stage. If the digital tool could be modified in a way to cater or empower novel design solutions, the impact could be lesser. However, through this article researcher has taken an initial step on observing the design thinking process of students and how the other factors could make an impact on it.

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IMPACT OF VISUAL LANDSCAPE CHARACTERISTICS OF URBAN WATERSCAPES ON THE CITY IMAGE: *A Study of Sri Jayawardenepura Kotte*

RANATUNGA M.K. [1] & HERATH H.M.K.D. [2]
[1, 2] Department of Architecture, University of Moratuwa, Moratuwa, Sri Lanka
[1]ranatungamk96@gmail.com, [2]kavi_dh@yahoo.com

Abstract
Over many centuries great civilizations are inspired by water and it has contributed to both natural and man-made environments. Water- based urban environments are combining natural scenarios and aesthetic qualities of water in order to create urban spaces. Urban waterscapes are there to celebrate the role of water in a water- based environment. A positive image of a water- based city environment can be identified through a visual landscape character assessment. Objective of the research focused to find visual landscape character indicators of urban waterscapes and those were used to evaluate the dependency of spatial memory recall on the water- based city imageability. Diyatha Uyana water Front Park, Parliament lakeside and Kimbulawala urban paddy field urban spaces were selected as case studies since they are identified as urban waterscapes within Sri Jayawardenepura kotte. Quantitatively collected data used to qualitative data analysis and aquaphilia based hypothetical question were taken into investigate the applicability of water- based imageability in a city landscape. Field study was carried with thirty participants and using a questionnaire survey and a Photo Projective Method place identification. Findings demonstrated that the visual scale parameters of urban waterscapes mostly influence on the identity of water- based city image.

Keywords*: Urban waterscapes; Visual landscape character; City image in water-based environment.*

1. Introduction

Ancient city planning and landscape tradition in Sri Lanka possibly adopted with integrating the aesthetics of nature while creating built environments. During the settlement process, man- made environment was dominated by the 'Wewa' and paddy field landscape since traditional tank-based villages had a specific environmental character with a strong cultural fabric. The "Wewai Dagabai Gamai Pansalai" concept was derived to create a great sense of interrelationship with the natural systems of the environment. Water is an asset for many cultures, and it gives birth to human as well as many civilizations. Water and watery contexts contributed to a considerable level of townscapes by involvement of people's actions, events, memories and myths. The city landscape have an ambience for a sensory quality or character that public can quietly feel (Nasar, 1998).

1.1 BACKGROUND OF THE STUDY

Water resources in an urban context play a vital role for treatment and engaging people with the pleasures of water. People are mostly preferring to the areas where water bodies are presented in their recreational activities (Smardon, 1988). "A water surface with visual quality will be capable of attracting large set of people. The fascinating and impressive visual quality of water landscapes has the ability of attracting people to the water element and the formed surrounding" (Bulut & Yilmaz, 2008). It is believed that the visible landscape affects the human beings, from such ways as aesthetic appreciation, health and well- being (Velarde et al., 2007). Therefore, the visual landscape assessment becomes more important in the designing and planning of landscapes and landscape elements accordingly. Visual data will be also helpful sustainable planning and development in an aesthetic landscape (Krause, 2001).

Current trend of recreational uses in urban spaces with the emergence of cultural and eco-tourism practices can be identified as a positive approach towards the sustainability of urban environments. The issue addressed as the lack of visual amenity in urban environments and how it can be improved with the use of visual landscape characteristics of urban waterscapes and its contribution to the perceived city image by residents and visitors.

1.2 OBJECTIVES AND CONTRIBUTION OF THE STUDY

The use of water resources in land use is an important aspect of urban and rural landscape planning and design (Bulut & Yilmaz 2008). Therefore the main intention of the study is to explore that how to integrate the visual landscape characteristic of urban waterscapes in a water- based environment. People respond to their environment that appears and open before their inferences and derive from visual cues to recall a memory of a place. It seems that places have different memories. The shaping or reshaping of cities should be guided by a "visual plan": which is about a set of recommendations and controls which

would be concerned with visual form on the urban scale (Lynch, 1960). Final objective of such a plan will be an image in the mind from which it reflects the ultimate goal. Accordingly it will be useful to improve an image by training an observer to look at a city.

Hence, the objectives of the research are,

- To identify visual landscape characters of urban waterscapes in a water- based city environment.
- To find out the most influential visual landscape characters of urban waterscapes on the water-based city image

Findings of the research, would be helpful for Landscape Architects and Urban Planners to integrate urban water element in an appropriate manner in the city planning and development. Because it is important to incorporate aesthetic considerations in urban spaces to enhance the sense of belonging in a city context while promoting a visually pleasing built environment with a particular city identity.

1.3 RESEARCH GAP

Pouya & Behbahani (2017) cited that visual landscape assessment is a key factor of decision processes of landscape architecture and landscape planning. The assessment allows the integration of local perception towards the surrounding and creates a sense of belonging and identity of future planning developments (Rosley et al., 2013). Research on environmental preferences mostly focused on natural or rural environments. There were several researches on urban landscape preferences due to the reasons of urban complexity with the structure of the urban form. Because of that, it is a bit difficult to assess the landscape preference factors in urban landscapes (Kaymaz, 2012). This research was conducted to fill the knowledge gap of visual landscape attributes in a city context, to address the requirement to evaluate the impact of visual preferences of urban water bodies on the city identity with a particular city image.

1.4 SCOPE AND LIMITATIONS

Sri Jayawardenepura Kotte city was selected as the major case study area due to its location, availability of natural waterways and the nature of that region with the exist large green belt in Kotte. Built fabric of Kotte city and natural waterways that formed with Diyawanna oya and marsh, functioning symbiotically as a key characteristic of a water- based city environment. It is the current capital of Sri Lanka and it provides administrative services to the country. The combination of built fabric and water provides sufficient urban spaces which combining natural scenarios and aesthetic qualities.

Research scope was finalized to do the assessment by comparing three types of waterscape characteristics in a particular water- based environment. Public open spaces which emerges with dominant waterscapes characteristics were selected to the assessment in Sri Jayawardenpura Kotte city. Then, Diyatha uyana Rectreational Park, Parliament lakeside and Kimbulawala urban paddy field sites selected as the potential urban spaces for the assessment.

2. Theoretical background and theoretical framework

2.1 VISUAL PERCEPTION AND VISUAL LANDSCAPE CHARACTER ASSESSMENT

Bell (1999) described that, “Sight is a particularly important sense for humans to which we have become evolutionarily adapted. It has also become one of the main ways in which we think, and use the ‘mind’s eye’ to picture creative ideas like we use our real eyes to picture our environment”. Porteous (1996) discussed about that the spatial information which we receive through our senses as seeing, hearing, smelling and feeling. Among them sight is the most valued sense because more than 80% of our sensory recognitions happen through the sight. Therefore, to provide necessary guidance for visual landscape designs, theories related to visual perception and landscape aesthetics will be presented (Kaymaz, 2012).

Ode et al. (2008) defined landscape visual character as a visual expression of the spatial elements, structure and pattern in the landscape. Moreover, visual landscape assessment was defined as the process which contribute to analyze the visual landscape character. Pouya & Behbahani (2017) referred, visual landscape assessment is a key factor of decision processes of landscape architecture and landscape planning. Such assessments provide clear data of the landscape structures as land form, color, water surface and green elements (Tveit et al., 2006).

2.2 CITY IMAGE IN A WATER- BASED ENVIRONMENT

Various early human settlements initiated in closeness to surface water bodies (Hampton, 2002;

Hooimeijer, 2011). This desired factor possibly can be extent to symbolize that, water- centric environment as a subset of water- based environments where water is intentionally integrated within urban fabrics as an extensive urban design element. Water as a fundamental landscape element, functionally important aspect for the way finding and as characteristics of water-based spatial anchors to promote the acquired human attachment to water-centric environments (Rising, 2015).

2.2.1 Urban Waterscapes

Rising (2015) mentioned that, historically there are flood prone water cities that adopted to a water-coherent approach such as, Yellow river basin of China (Yu, Lei, & Dihua, 2008) and Angkor Wat in Cambodia (Shannon & Manawadu, 2007). So far most of these water cities have been popular with their original hydrological functions of waterscapes. Systematic integration of waterscapes, including a large body of water within the city limit, a moat or lake along the city perimeters, or an interconnected network of canals, ponds and wetlands for flood retention, conveyance and groundwater recharge are some of the characteristics of such water urbanisms.

Periyasinaki (2010) defines urban waterscapes as ecologically and culturally designed spaces that people embrace in the natural process and aesthetic qualities of water in an urban context. Waterscapes create and develop a consciousness of people through a link between nature and culture of a place. Most of the waterscapes are constructed water features in public open spaces and they have a great impact on an urban landscape by providing experiences of water qualities through touching, sighting and hearing. Peoples' preferences of water as an aesthetic feature, movement patterns of water and its forms correlation with urban waterscapes strengthen people's sense of belonging in urban open spaces.

2.2.2 Water- based imageability

Imageability refers to the ability of a landscape to present a strong visual image in the observer and making landscapes distinguishable and memorable. Tveit et al. (2006) covers a range of synonyms with relates to theories such as spirit of place (Bell, 1999), genius loci (Lynch, 1960), vividness (Liton, 1972) and topophilia (1974) for the concept of imageability. Lynch (1960)'s study focuses on the connection between imageability (the 'identity' of a landscape) and cultural or personal identity. His works acknowledge that, the identity of a landscape can support and develop cultural or personal identity for the people in living area.

Lynch (1960) discussed the cognitive images of cities by using imageable cities like Venice and Dutch polder cities and suggesting that the urban environment is known as a structure of landmarks, nodes, paths, edges and districts. His results explicit that imageability of water- based cities have well-integrated water bodies within the urban fabrics and have more water- based salient spatial anchors with canals or water- based paths or narrower linear water surfaces rather than, rivers or water- based edges (Rising, 2015).

Figure 1, Blue- green network of the Sri Jayawardenepura Kotte city

2.3 RESEARCH HYPOTHESIS

Rising (2015) explicate 'aquaphilia' as a timeless place- making concept, which significantly motivated from the affection for water, from the Latin aqua for water and philia for love from ancient Greek word. Aquaphilia concept is emerged with the eco- centric perception and a potential factor which provides a safer loci of attachment due to the instinctual human affection towards the water or water- based environments.

It is such a foreseeable reaction to specific water- based aesthetics coupled with subsistence-based advantages in an urban environment, where the perceptions of scenes contain clean and safe waters.

Moreover, 'aquaphilia' is based on such a kinship attachment with genetically familiarized notion as human instinctual attachment to survival enabling water" (Rising, 2015).

A research hypothesis was used to assess the applicability of water- based imageability in a city landscape. The study assumes on the aquaphilic aspect of human preferences in the landscape because people develop their mental image/ identity in a water- based landscape due to their innate tendency towards water and water-based environments. Accordingly, approach of the theoretical framework assumes that it would- be applicable in a water- based environment.

2.4 THEORETICAL FRAMEWORK

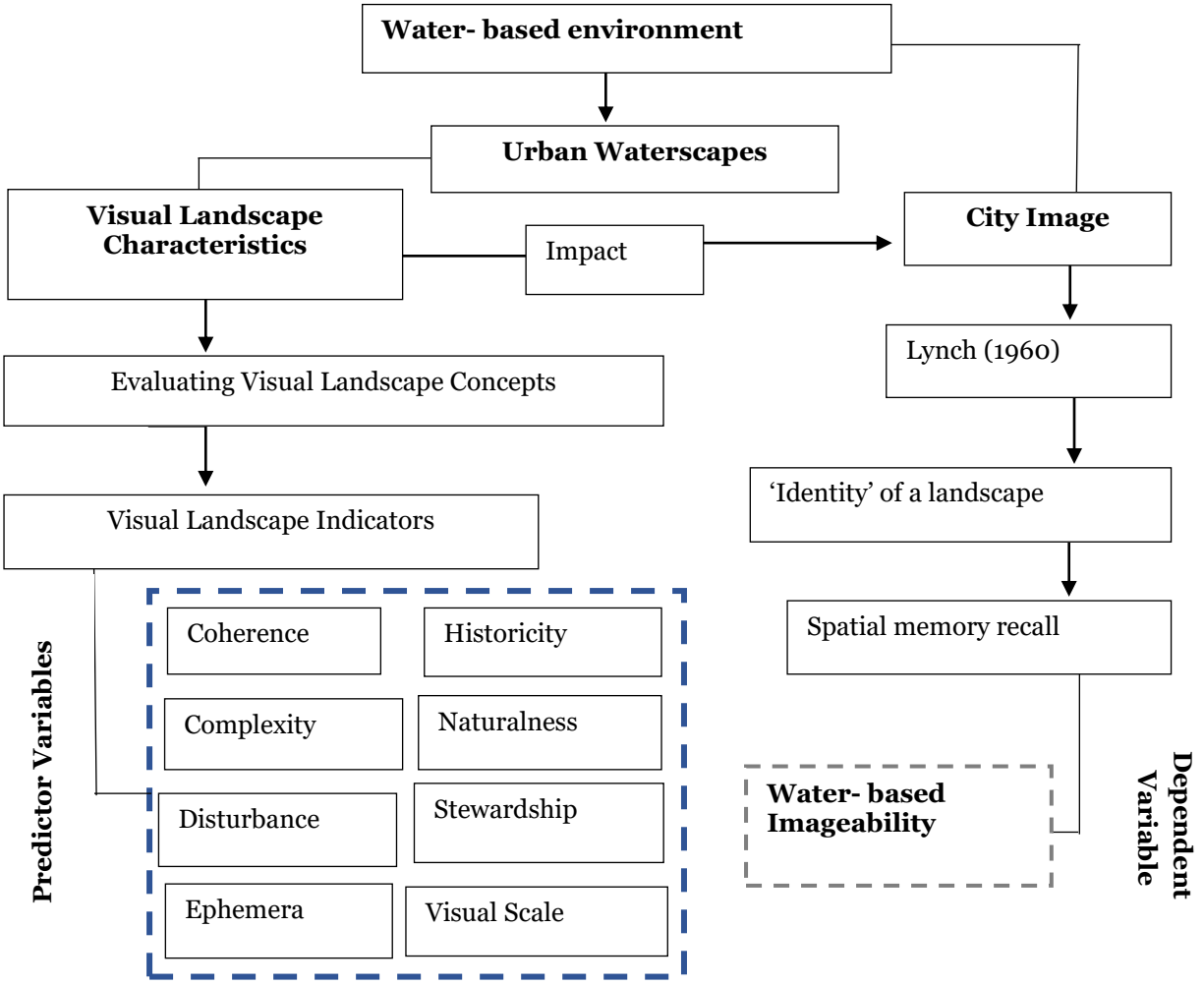

Figure 2, Theoretical Framework (*Source: Ranatunga M*)

3. Research design

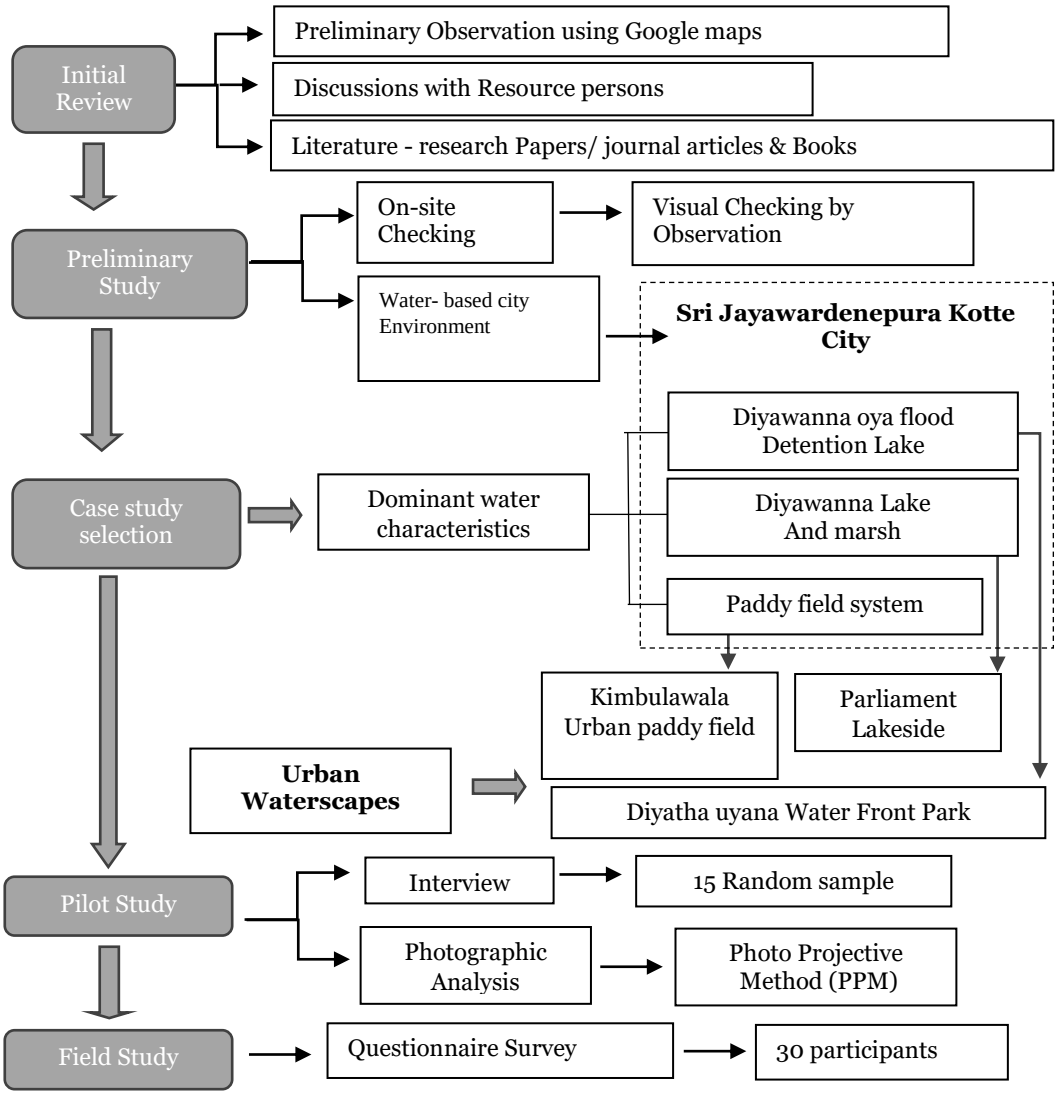

Figure 3, Research Design (*Source: Ranatunga M*)

4. Method of the study

Method of this study based on a public perception based approach conducting a visual landscape quality assessment, focused on visual perception which has been based on a method, because human perception is mainly based on visual simulation.

Research study conducted among inhabitants and visitors of the city to collect quantitative data and qualitatively analyzed that data to figure out the positive and negative outcomes of the study. Field survey was conducted to investigate the applicability of the theoretical framework on the city image of Sri Jayawardenepura Kotte. Thirty participants were selected to the field study in the age group of 20- 29 years. They were from same ethnic group and same region of the country. In this study, age, education level, cultural background and ethnicity were considered constant, while gender base participation was disregarded.

4.1 DATA COLLECTION PROCEDURE

Identified theory based eight visual concepts (coherence, complexity, disturbance, ephemera, historicity, naturalness, stewardship and visual scale) used as predictor variables of the study in order to evaluate the dependency of spatial memory recall (imageability) in a water- based city environment. Visual concepts were converted into 24 measurable visual character indicators for the easy understand of people and used to find most influential factor of urban waterscapes on the city image.

Table 1, Visual concepts converted to identifiable parameters for the easy understand of majority of people (*Source: Ranatunga M*)

Visual Concept	**Dependencies derived from the literature (Ode et al., 2008)**	**Measurable parameters of the visual landscape indicators of urban waterscapes (Predictor variables)**
(from literature)		**(compiled by author)**
Coherence (1)	Presence of water correspondence with the land form, water location and natural condition	Appropriateness of the water body location with the land form and vegetation arrangement in the city (Fact 1)
	Repetition of patterns across the landscape	Water flowing patterns (Fact 2)
		Colors of the water due to the reflection of surrounding environment (Fact 3)
Complexity (2)	Richness of landscape elements	Richness of water- vegetation combination of the city (Fact 1)
	Diversity of elements in the land cover	Varieties of water body find in the city (Fact 2)
	Shape and size variations of landscape elements.	Shape and size variations of water bodies in the city (Fact 3)
Disturbance (3)	Landscape elements classified as disturbing	Visual barriers to the water body scenery (Fact 1)
	Area visually affected by disturbance	Visual disruption occurred due to urban infrastructures (electricity wires/ cables; pipe lines) (Fact 2)
	Visibility of disturbing elements.	Disturbance for the water body scenery due to color contrast of the built environment (Fact3)
Ephemera (4)	Presence of water which projected and reflected environmental images	Color changes of the water (Due to sky reflection on the water or reflecting vegetation colors on the water) (Fact 1)
	Water with seasonal changes	Seasonal changes of the water mass (during flood/ dry periods) (Fact 2)
	Presence of water with weather characteristics.	Water ripples & waves due to wind action (Fact 3)
Historicity (5)	Presence of traditional land use and pattern	Nature transformation of water- based environment (Ancient paddy field lowland green belts convert into urban development) (Fact 1)
	Spatial arrangement of natural elements	Proportion of water features in the city (Such as canals, lakes, river, wetlands/ paddy fields) (Fact 2)
	Density of cultural elements	Cultural value of the water- related places (Fact 3)
Naturalness (6)	Proportion of natural vegetation with the presence of water	Water- vegetation combination (Fact 1)
	Level of succession with the presence of natural features	Integration of the natural character with the city character (Fact 2)
	Shape of edges	Natural arrangement/ shape of the water margins (Fact 3)
Stewardship (7)	Management type and frequency	Clarity of the city landscape (Fact 1)
	Condition/ maintenance of structures	Maintenance of water- related urban places (Fact 2)
	Presence of weed	Proper care of water- related urban places (Proper waste disposal) (Fact 3)
Visual Scale (8)	Proportion of open land	Proportion of water mass as compared to urban elements (Fact 1)
	Depth of view	Visibility of the distant views across the water area (Fact 2)
	View shed size/ shape	Size and shape variations of water bodies as compared to build elements (Fact 3)

5. Data Findings and discussion

Overall findings of three case study spaces considered to generate an overall city image in a water- based city environment. Overall findings of three case study spaces considered to generate an overall city image in a water- based city environment. Figure 4 and 5 shows the influence of the visual landscape indicators related imageability parameters of urban waterscapes on the overall city image.

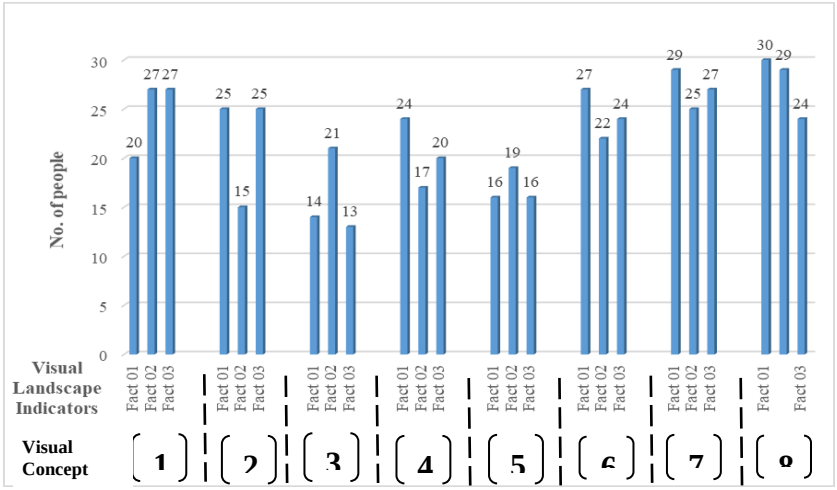

Figure 4, Fluctuation of visual landscape character indicators on the water- based city image (Separated into visual concepts) (Source: Ranatunga M)

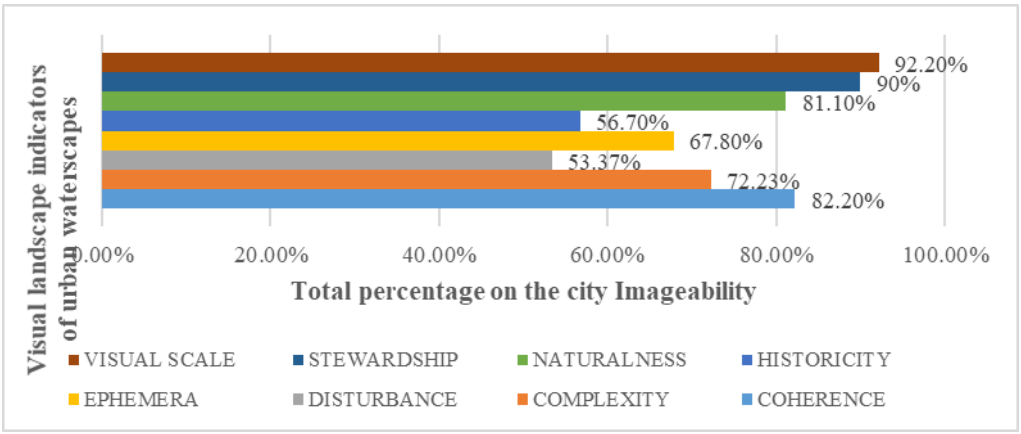

Figure 5, Visual landscape indicator fluctuation on the overall Sri Jayawardenepura Kotte city image (Separated into visual concepts) (Source: Ranatunga M)

According to the results, 92.20% of participants voted for the visual scale, 90% of participants voted for the stewardship, 82.20% participants voted for the coherence, 81.10% of participants voted for the naturalness, 72.23% of participants voted for the complexity, 67.80% of participants voted for the ephemera, 56.70% of participants voted for the historicity, 53.37% of participants voted for the disturbance. Visual concept predictor variables are fluctuating as this way,

Visual scale > Stewardship > Naturalness > Coherence > Complexity > Ephemera > Historicity > Disturbance,

Findings reveal that 'visual scale' related visual landscape indicator parameters have a remarkable influence on the city image of Sri Jayawardenepura Kotte and the city image is dominant with the 'visual scale' related waterscape parameters.

Disturbance is the least impacted visual parameter on the city image because disturbance related visual landscape indicator factors have a least impact on the study.

Overall findings demonstrated that the idea of 08 visual concepts and their indicator predictor variables perform together to bring a particular city identity to the Sri JayawardenepuraKotte. People would

prefer and appreciate the combination of water, vegetation and built fabric of the city and clarity in the overall landscape.

6. Conclusion

Environmental image of a water- based city environment can be identified through a public perception based approach, conducting a visual landscape character assessment. Study objects are focused upon identifying most influential visual landscape characters of urban waterscapes on the city image. Therefore, theory based eight visual concepts, coherence, ephemera, naturalness, complexity, visual scale, disturbance, stewardship and historicity were identified as the predictor variables and converted to the identifiable 24 visual landscape indicator parameters and used to evaluate the dependency of spatial memory recall (imageability) in a water- based environment.

Research hypothesis was used to assess the applicability of water- based imageability in a city landscape. Based on the aquaphilic aspect of human preferences in the landscape, this study assumed that people develop their mental image/ identity in a water- based landscape due to their innate tendency towards water and water- based environments. According to the hypothesis, the study assumed that the approach of theoretical framework and consequential visual landscape character parameters would be applicable in a water- based city environment.

The study presented that 08 visual concepts perform together to bring a particular identity while visual scale has a significant influence on the city image. Visual scale related indicator parameters are emerged with,

- Proportion of open land (Proportion of the water mass in the waterscapes as compared to other urban elements),
- Depth of view (Visibility of distant views across the water surface),
- View shed size/ shape (Size and shape variations of the waterscape (water body) as compared to the built elements).

Analysis of the study adduced that these 03 parameters collaborated to the dominance of visual scale related factors of urban waterscapes on the city imageability.

This research was conducted to fill the knowledge gap of visual landscape attributes in a city context, to address the requirement to evaluate the impact of visual preferences of urban water bodies on the city identity with a particular city image. Then the study was used to prove the influence of the identified visual concepts on the overall city image of Sri Jayawardenepura Kotte. The research study addressed the research problem as the lack of visual amenity in urban environments and how it can be improved with the use of visual landscape characteristics of urban waterscapes and its contribution to the perceived city image by residents and visitors. Findings emphasize the importance of a unique identity of the city image.

This study does not encompass the overall landscape preferences on the city imageability, since the study mainly focus upon the visual landscape preferences of urban waterscapes. Also the study is mainly focused on a perception based approach that depends on respondents' comments and behaviors of the landscape quality interaction. Perception based studies are mainly impacted by age, gender, education level, cultural background and ethnicity etc. In this study, the parameters such as age, education level, cultural background and ethnicity were constant, while gender base participation was disregarded. Therefore it is better to consider the aforementioned parameters for further researches to assure the overall impact on the city imageability by visual landscape preferences of urban waterscapes.

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SEQUENTIAL EXPERIENCE OF SPACES THROUGH MULTI-SENSORY APPROACH IN DESIGN: A CASE STUDY OF AN INDIAN TEMPLE

FATHIMA RISHIN RAZAK[1] & SAMEER I.K.[2]
[1,2]Thejus College of Architecture, KERALA, INDIA
[1]*ar.rishin@gmail.com*, [2]*architectsameerik@gmail.com*

Abstract
The purpose of visiting a temple is to gain the positive energy and feel refreshed, through an exchange of emotions and association with the spaces there, for which, the space needs to be personalized. To understand and experience a space, one must perceive information, from the surrounding and interprete it for a better understanding of the environment. The spaces in a Hindu temple are the best examples with a multi-sensory approach, which can potentially nourish both emotional and spiritual needs, but it has to be experienced with proper sequential perception. The study is trying to understand how to perceive a space in temples sequentially, through multi-sensory approach.

To study the same, the methodology adopted is identification of a temple and visiting and experiencing the same. The temple identified is Brihadeeswarar Temple, Tanjaore, Tamil Nadu, India; as it is a fine example of Dravidian temple architecture during its peak, and the most ambitious structural temple with a very different ambience altogether. The study will be focusing on how a space is perceived, do all senses respond to that one particular space, and why is it so. Contemporary architecture is having an ocular centric paradigm. An architectural work is not to be experienced as a series of isolated retinal pictures, but in its fully integral material, embodied and spiritual essence. This aspect is emphasized through the study, and also the involvement of all senses in space perception was hence purposeful, and an important aspect in temple design. The study may conclude with how senses help in connecting spaces directly between the individual and the surrounding, making it a sanctified approach.

Keywords: *Multi-sensory, Space Perception, Sequential Experience, Indian Temples*

1. Introduction

Architecture communicates through spatial tools, at three levels -sensorial, experiential and associational. Perceiving architecture (art) emotionally, i.e. relating oneself with space and time, needs the support of senses, as senses helps to perceive information from the surroundings. Sight, hearing, smell and touch are the sensory modalities that play a dominating role in spatial perception in humans, i.e. the ability to recognise the geometrical structure of the surrounding environment, awareness of self-location in surrounding space and determining in terms of depth and directions and the location of nearby objects. Touch, smell and taste provides information on the so called 'near space' (termed also haptic space), whereas vision and hearing (sociable senses) are capable of yielding percept, representing objects or events in the so called 'far space'. Occupancy of building is truly felt when designing of a building makes an individual move through a space while experiencing through senses. So, architecture cannot be isolated from its association with senses and results in a wonderful feel of belonging, which creates an affection and movement.

Figure 1, Senses perceiving spaces

Indian aesthetics search for beauty in every creation of nature and every art thus created have some in-depth meaning to disclose through symbolism. Beauty is enjoyed through all five sense organs, which contribute joy to life, as they perceive the impulses from surroundings and carry it to the brain. Hence

multi-sensory approach towards beauty is reflected in all art forms including architecture. The spaces in a Hindu temple are the best examples with a multi-sensory approach, which can potentially nourish emotional and spiritual needs, but it has to be experienced with proper perception. Symbolically, temples are having a multi-sensory approach, in rituals, in the form of offerings - panchopachaaraas to God, the offerings namely *Gandha* (sandal), *Pushpa* (flowers), *Dhoopa* (incense), *Deepa* (lamps) and *Neivadya* (food) which symbolises that our senses and their stimuli are reverentially offered to the Paramatma, and we shall not be inclined to misuse these sense organs[1].

2. Multi-Sensory Perception of Spaces

Juhani Pallasma, in his book 'The Eyes of the Skin' describes, "instead of creating mere objects of visual seduction, architecture like every meaningful art, relates, mediates and projects meanings that directs our consciousness back to the world and towards our own sense of self and being"[5]. The isolation of eye outside its natural interaction with other sense modalities, and elimination and suppression of other senses results in the ocular-centric paradigm forgetting the inner meanings. To avoid such ignorance, a multi-sensory approach to understand the concept of spatial manifestation was prevailing from earlier times in Indian Architecture.

2.1 VISUAL PERCEPTION THROUGH LIGHT AND SHADOW

The eye is the organ of distance and separation, also it surveys, controls and investigates that which it perceives. Eye tries to touch the shapes, contours, profiles, textures and colours of nearby as well as far away objects, to communicate the quality of the surrounding to the brain. Eyes are able to perceive this due to the presence and absence of light.

Light, both natural and artificial, contributes to the character and ambience of a space and manipulates design to identify places. This occurs with varying light intensity as soft even light, strong brightness, sharp shadows, constantly changing intensity and darkness[4]. Deep shadows and darkness are also essential along with light, because they dim the sharpness of vision, make depth and distance ambiguous, and invite unconscious peripheral vision and tactile fantasy[5].

2.2 AUDITORY PERCEPTION THROUGH INTIMACY AND TRANQUILITY

Sound is omni-directional and creates an experience of interiority. When eye reaches and isolates objects, sound tries to receive and incorporate it. Spaces never respond to gaze, but it always refracts sound to connect and bring affinity in us. The space accommodates the perceiver and he can feel the response of a space when being intimate and silent. The most essential auditory experience created by architecture is tranquility[5]. Architecture presents the drama of construction silenced into matter, space and light. An architectural experience silence all external noise, it focuses attention on one's very existence. Architecture, like all art, makes us aware of our fundamental solitude. Architecture detaches us from the present and allows us to experience the slow, firm flow of time and tradition[5].

2.3 OLFACTORY PERCEPTION THROUGH MEMORY & IMAGINATION

The most persistent memory of any space is often its smell[5]. The odour of a space remains the remembering character of it and the perceiver tries to imagine the space from the memory. A particular smell makes us unknowingly re-enter a space completely forgotten by the retinal memory. The retinal images of contemporary architecture certainly appear sterile and lifeless when compared with the emotional and associative power of olfactory imagery. Smell could be the natural result of chance and purpose, but sometimes it may be intentional with the use of materials. It could stimulate emotions, guide or distract the perceiver.

2.4 GUSTATORY PERCEPTION THROUGH INTRICACY AND DETAILING

Vision becomes transferred to taste as well: certain colours and delicate details evoke oral sensations[5]. Tactile and taste experience has a subtle transference being felt through intricacy and detailing. Colour, texture and finishing of those details present themselves to the appreciation of the tongue. The sensuous materials, colours and skillfully drafted details evoke oral experiences in the perceiver. The details are

not to be assessed as mere decorations, but helps in understanding whole of which they are inherent part. Details try to express belonging or separation, tension or lightness, friction, solidity, fragility etc.

2.5 HAPTIC PERCEPTION THROUGH PROFILES AND TEXTURES
Every touching experience of architecture is multi-sensory, qualities of matter, space, scale are measured equally by eye, ear, nose, skin, tongue, skeleton and muscle. Feeling the profile and texture by touch is the unconscious of vision that provides three dimensional information of the materials and spaces. The skin reads the texture, weight, density and temperature of matter.

3. Space as an Entity

The Upanishads describe space as an entity in which creation in its endless variety of forms takes place. Space is conceived as *bindhu* - the fundamental point from which all forms emerge which is complete in its own[2]. Space exist, but is conceived as emptiness, in mind and then physically, thus having a potential to hold infinite things[2], a container and a content. Hence space is not only perceptual, but also experiential i.e., it is not only an object of reasoning or demonstrable knowledge, but a pure experience. Indian architecture has contributed to the creation of sequential experiencing in spaces, where one space merges with another by overlapping uses and interconnections which generate flexibility[2]. To have this sequential experiencing of spaces, multi-sensory perception plays an important role[2]. It offers more than the eye can perceive in one frame and more than the mind can experience in one instant. Sequential experience of space is conceived and perceived on the basis of movement through it. Spatial qualities are observed under various categories as context, construct, realms, threshold, kinesthetic and notions[3].

4. Space perception through senses

- a case study of Brihadeeswarar Temple, Thanjavur, Tamil Nadu, India
The study tries to inculcate the various parameters of space perception with multi-sensory perception, by analysing Brihadeeswarar Temple, Thanjavur.

4.1. THE CONTEXT OF BRIHADEESWARAR TEMPLE:
The temple stands as a testimony to the Chola power in both economic and military stand. This temple admirably reflects the prosperity, indeed opulence and pays a tribute to the victory. Temple complex has been decided to be the focus of the town, and further developments were concentric to it. It is a fine example of Dravidian temple architecture during its peak, and the most ambitious structural temple with massiveness and rigidity being the prominent features. Dedicated to God Shiva, the temple has 4 divisions - enclosure with gopurams, open courts, attached and detached mandapas and sanctum with shikhara. An axial and symmetrical geometry rules the temple layout, with exceptions in the subsidiary shrines.

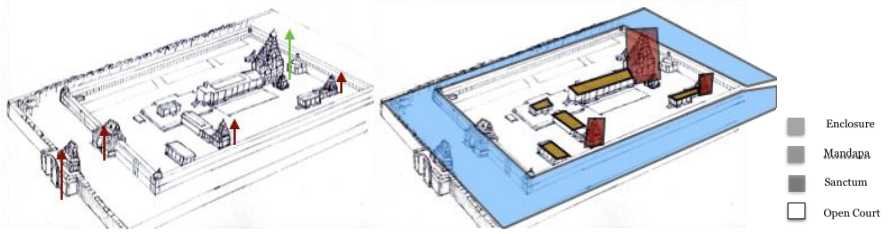

Figure 2, Depicting the hierarchical order and spatial divisions perceived in the temple complex

4.2. THE CONSTRUCT:
Temple construction starts with 'Bhu pariksha', proceed through twelve different stages and ends up with 'Pratistha'-the sanctifying ceremony. Regular geometry and precision falls in the frame from the conception to execution stage of Brihadeeswarar Temple, to comprehend the multi-layered, multi-dimensional aspects in its physical and conceptual form. The pyramid form of shikhara rising to the sky forming a straight line of sight unifies the divine power and the devotee. Articulation of ground levels using variations in plinth height also symbolises the progression of human life. Variations in degree of enclosure, and roof forms bring in, an order and hierarchy, which evokes admiration in the perceiver –

unknowingly with the involvement of senses.

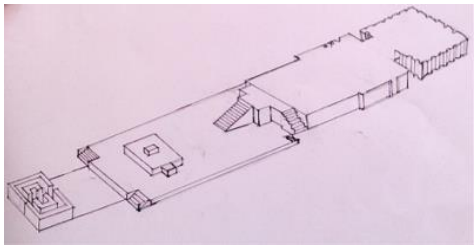

Figure 3(a), Articulation of ground levels

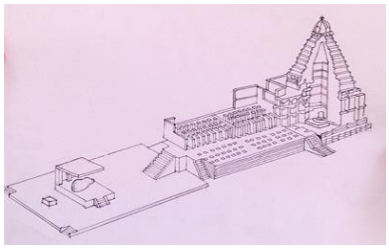

Figure 3(b), Variation in enclosure

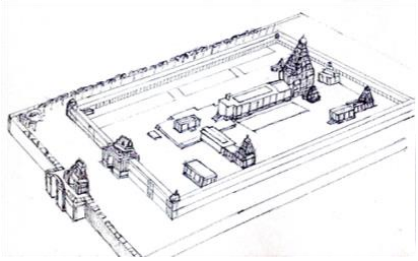

Figure 4(a), progression of Shikhara

Figure 4(b), Line of sight of Shikhara

Temple construction involves deep emotions and devotion, and is a lifetime achievement for those involved. From conception, to manifestation and then to realisation, the essence of the virtue and values are strictly followed. Prayers and rituals form an important part of the process, as it is the 'offering' to ensure protection during the entire process. Mind and body of the devotee is kept undisturbed, with only intention of purity in every sense and every deeds. So the involvement of senses during construction is of great significance.

From the selection of stones for construction, to the minutest detailing and intricacy during execution; visual, auditory, olfactory, gustatory and kinaesthetic perception occurs. A stone is selected for construction or for sculpturing, after experiencing the sound, warmth and texture through touch. During stages of construction, the plan was drawn directly on ground 'to scale', which correlates the 'Sthapati' with the site through all his senses. Each stone was laid in precision, manually, enhancing an emotional attachment and intimacy with them, felt through the sense of touch. The rules of Vastushastra render beauty, structural stability and quality of spaces by virtue of light, sound, massing and volume. This is shown through articulation of ground plane, enclosures and roof forms.

4.3. THE REALMS:

The complex in essence comprises three aspects - the domestic, the religious and the sacred, making the journey from the mortal to the divine world. Even though there is oneness; each part is the comprehensive composition and act as a single unit. Thus, 4 divisions in the complex unifies the whole to part and part to part relationship, the unifying factors being visual juxtaposition, adjacency, organisational axis and implied movement.

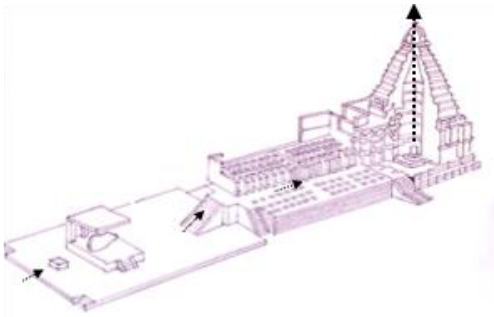

Figure5, Juxtaposing visual axis with path

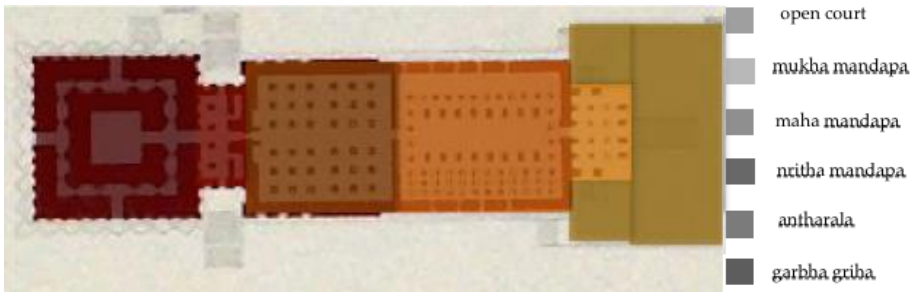

Figure 6, sequential arrangment of spaces showing adjacency

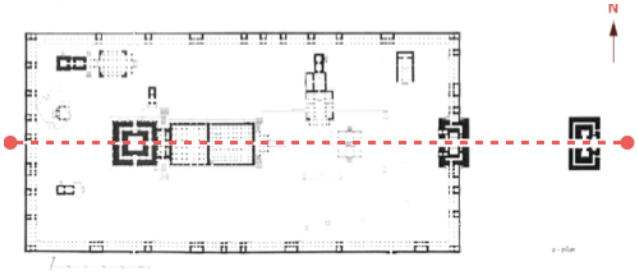

Figure 7, organizing spaces along the axis

As discussed in the initial study, the contribution of Indian architecture in sequential experience of space can very well be seen in Brihadeeswarar Temple. The spaces merge with one another so elegantly that a flow could be experienced to the perceiver. The flow of power field represents the phases of progress in a man's journey towards divine. The sculpturing in the gateways depicts the outward and diverse concerns of man, while proceeding, the inner walls attune his attitude, finally reaching the shrine in tranquility.

Interplay of light and shadow, varying intensity of light from well-lit mandapa to dark sanctum and the dynamic shadows contribute to the visual character and ambience of the spaces. Both presence and absence of light evoke visual perception due to the massiveness of the enclosure. The sequence is maintained in the detailing with the help of same material and aesthetic sensibility, boldness and precision. The haptic perception through the contours, profiles and textures and gustatory perception felt through the sculptors in granite stone, unfinished sometimes, heaviness of the material and treatment given on it, makes an inherent quality to various realms. The auditory perception also varies the level of intimacy according to the spaces, tranquility being prominent near sanctum, chanting prayers in front of it, echoes so produced, murmuring towards perimeter etc.

4.4. THE KINESTHETICS:

The temple complex is perceived as a unified composition along a single axis. Eventhough unified, the ritualistic movement in the complex guides the experience of the precinct. The visual framing of shikhara and the axis behaves prominent, hence the axis of orientation remains unchanged and kinesthetics occurs. Vertical thrust of shikhara is countered by the horizontal spread of long mandapa and plinth, having axis perpendicular to the former.

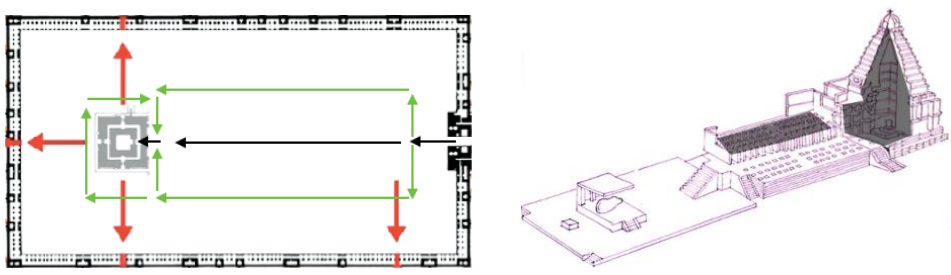

Figure 8, Alternative routes and entrances

The kinaesthetic movement is strongly felt by the haptic perception with bare foot, travelling through the warm brick pavements in Brihadeeswarar temple. The pradakshina path is textured differently, demarcating the path for the perceiver. Circumambulation being a ritual has a symbolic meaning of

encircling the universe. The senses also are stimulated in a sustained rhythm of increasing abstraction - mass, form, elements, material treatment, light and shade, texture and finally notion.

The real experience of built and unbuilt spaces are perceived when one moves through it. All sensory systems co-ordinate, to give a complete imagery of the space and the context. Intensity of light falling into each space varies, allowing well-lit spaces in the mukha mandapa, morning and evening rays into maha mandapa, moderate light into sabha mandapa with very few openings, and single opening with morning sun ray falling on the deity in the garbhagriha. This interplay, along with shadow of columns creates visual dynamism on the ground. The level of solitude increases from the outer zone towards the inner sanctum, where silence communicates with the perceiver. Upon reaching the inner sanctum, the closed eyes in front of deity evokes the fragrance spread around, compelling the perceiver to relax and memorize.

Sculptural detailing also decreases its complexity from the periphery to the inner core. It symbolizes the fact for a human to leave wordily pleasures and behold virtues and values to himself. In Brihadeeswarar temple, 108 dance postures of Bharatanatyam, classical dance of Tamil Nadu, are engraved, which along with haptic perception evoke oral perception. Many inscriptions picturing the story of temple construction is also seen in the plinth of the temple. Proportion and precision of sculptures even to a very large scale can be seen at many places in the complex.

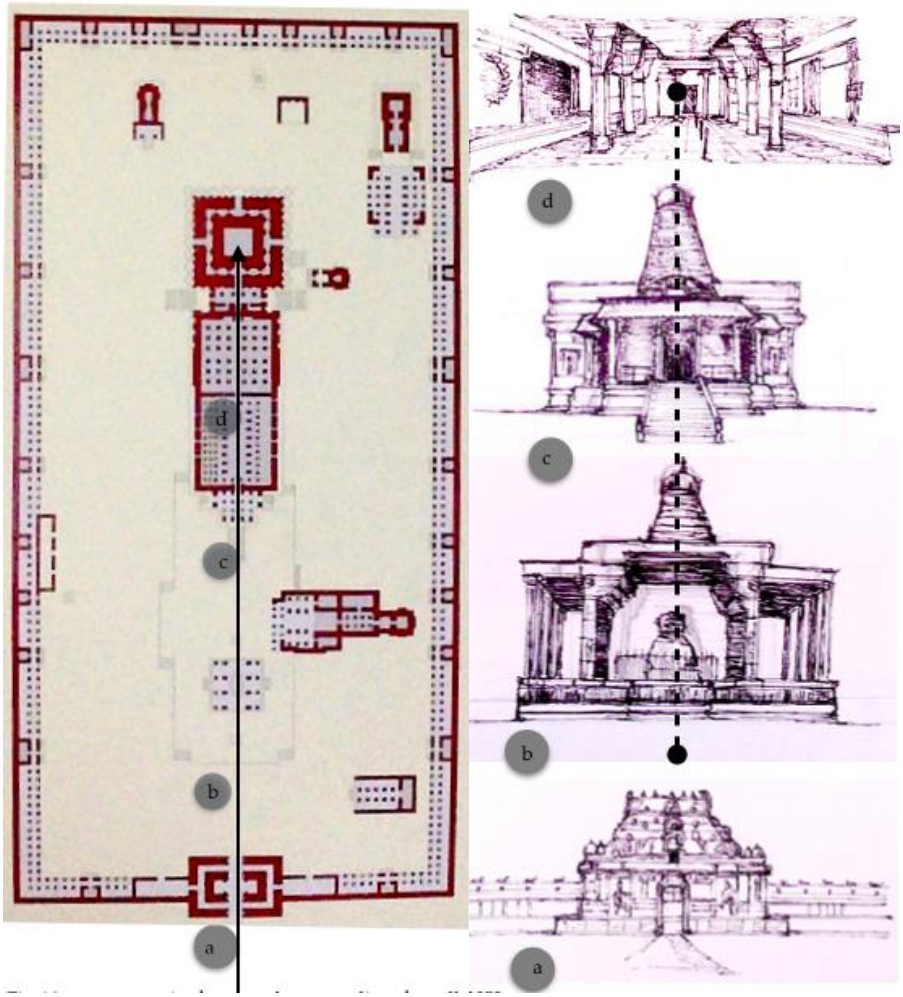

Figure 9, sequential movement along the axis

4.5. THE THRESHOLD:

Threshold talks about the varying degree of enclosure as traversed from the entrance gateway to the mandapa, a semi-enclosed, semi-open pavilion, to open courts with landscape feature, and finally to the walled enclosure of temple. This variation of enclosure gets dynamism due to the varying intensity of light penetrating them. All these are achieved architecturally by using site in terms of placement

orientation and creation of levels. The massing and kind of entablature, the carvings and the overlays of symbols are all bathed with expert sensitivity and knowledge of the quality of light falling on each of these.

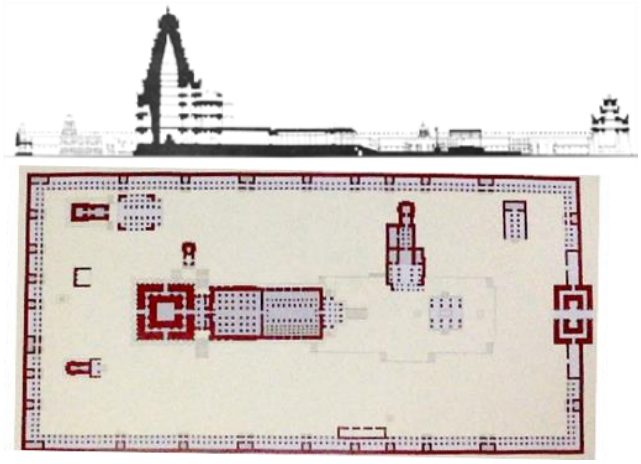

Figure 10, Plan and section showing diversity in structural massing

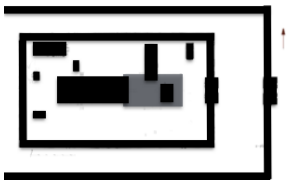

Figure 11, Built & Unbuilt

The temple has comparatively high degree of enclosure. Maha mandapa and nritha mandapa are enclosed on both sides, and only small openings are provided for light penetration. The dark interiors were initially lit up with diyas', that guided the devotee towards the deity. While moving forward, one can easily know the visual transformation from a well-lit open court to the dark massive garbha-griha, which symbolizes the journey of a man towards salvation. The massiveness of the structure is felt due to less fenestration. Externally, horizontal expanse of public spaces transform to vertically extended sacred spaces, and internally it diminishes in size to form intimate and closed cell. The rising plinth detaches the person from the earthly realm and expresses the ascent to the sacred.

4.6. THE NOTIONS:
The Brihadeeswarar temple is an architectural marvel, which stands unaffected by anything even after 1000 years of its construction. The proportions are comparable to the Kailash Temple, Ellora. Usage of granite stone throughout for construction exhibits variation in craftsmanship because of the difficulty in working with it, and this resulted in texture difference. The variations of the same material are a manifestation of variety in duality. The duality is the divine power existing in every creature and is symbolically represented as built -unbuilt, dark and light, finished and raw etc. The various ways of expressing the same is being elaborated above.

Variety in duality is expressed by vertically spread long shikhara to the horizontal stretch of large plinth and open spaces, deep and dark sanctum contrasted with well lit mandapa in front, open - to sky spaces with dim and small sanctum etc.

5. Inferences:

There are numerous approaches to review historic architecture. The approach adopted by historians has been to try and understand the context of which the product has been an outcome[5]. This fails to locate the product beyond a particular time and context and neither does it look at the principles and processes. But a building outlast humans, and hence it becomes imperative that architecture transcends the given time and context, remaining vital and adaptable to changed ones. Correlation between spatial attributes and human behaviour, induced largely through perception of the space construct, helps the space designer interpret, extrapolate and apply the principles of space organisation in a changed time and space. This understanding is possible through the personal evaluation and experience through a sensory perception, which signifies the relevance of the study.

From the study to analyse & perceive the spatial qualities through the structure using senses, kinaesthetic perception seemed to be the most interactive way to perceive a space. All senses where equally prominent in perceiving, while in movement, and hence could be summarised as a phenomenology inherent to any space-making. Kinesthetics is possible through creative juxtapositions of visual and movement axis. Volume, fenestrations and play of light guides the perceiver to move

through spaces and associate with it emotionally.

Sequential unfolding spaces, a schema for Indian Architecture, is clearly visible from the study. The spaces have simultaneous concealment and revelation of information brought about by an element of mystery, inviting exploration by shifting visual and physical axis. This kinesthetics, thus makes architecture experiential, where 'being there' is what matters. So creating spaces which evoke a kinaesthetic perception would involve senses, for better emotional and associational approach and understanding.

6. Conclusion

The study tried to analyse and perceive spaces in temples through various senses, understand the emotions, meanings and purposes it conveys. An architectural work is not to be experienced as a series of isolated retinal pictures, but in its fully integral material, embodied and spiritual essence. This aspect is emphasised through the study, and also the involvement of all senses in space perception was hence purposeful, and an important aspect in temple design. The study concludes with how senses help in connecting spaces directly between the individual and the surrounding making it a sanctified approach. Kinesthetics demonstrates the holistic experience of architecture, involving all senses for perception - an essential transformation of the past, for its relevance to the present and implied potential of the future.

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7.1. ACKNOWLEDGMENT:
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DEVELOPMENT OF CLAY MATERIAL AS AN ANCIENT INSPIRATION FOR COOLING ENCLOSED SPACE FOR CONTEMPORARY SRI LANKA

LIYANARATHNE B.L.S.W.[1] & RANASINGHE W.M.N.D.[2]
[1, 2]University of Moratuwa, Moratuwa, Sri Lanka
[1]*wasana.liyanarathne@gmail.com,* [2]*dilshaniranasinghe80@gmail.com*

Abstract
Huge energy demand can identify in the contemporary world not only in Sri Lanka. Environment cooling is a most considerable aspect in energy consumption. The research discovers the possibility of using ancient techniques with clay material for maintain indoor thermal comfort. Clay is a material which has remote history and numerous qualities. The research is based on the 'clay' material which creates a cooling condition. When concern on the properties of clay, evaporative cooling and low heat conductivity are pair of main important properties. Clay and mud were used in civilizations which were in hot climatic regions. Sri Lanka also used clay material in various methods for traditional houses as wattle, roofing tiles and floor and domestic usage as Guruleththuwa, pinthaliya etc on maintain a cooling condition. The research investigates condition of cooling indoor space in traditional houses. It analyses data from quantitative and qualitative methods based on interviews and observations in traditional houses which were made from clay material under three climatic regions. According to investigation clay material maintain cool space in afternoon comparatively outdoor. It was a positive behaviour of clay material that contradictory adapts in indoor temperature comparatively outdoor temperature. The research investigates how effect clay properties in house envelopes for enhancing cooling effect. It reveals that the clay body can develop as a product for cooling enclosed space with value additions. This study is the initial step of the innovation to identify clay properties in building envelops as a traditional inspiration.

Keywords: *Clay material, Design, Cooling inner space*

1. Introduction

"Sri Lanka is a tropical country with 28-30 °C average temperature. It is quite hot, and some month's temperature goes beyond 33°C. Hence, air-conditioning is desperate need in countries like Sri Lanka." (Wickramasinghe, 2014) According to Sri Lanka Sustainable Energy Authority most of units of energy consumed for cooling the environment. Electric methods like fans, intercoolers and mostly air conditioners obtain highest energy consumption in domestic context. "The inefficiency of existing buildings in tropical countries especially in Sri Lanka means that large amounts of energy would be required to maintain comfortable temperatures especially with future scenarios like global warming. In this context, evaporative cooling could offer many advantages as an effective low energy consuming means for providing thermal comfort." (Arandara, Attalage, & Jayasinghe, 2010) The research investigates the possibility of ancient techniques for contemporary world as a solution for this energy crisis. Design considerations have investigated in research which are inspired by traditional clay usage.

The clay is one of material which can be used for a cooling purpose. Wattle wall, floor and the Sinhala roofing tile are the supportive clay design components used in traditional houses for cooling indoor space. Guruleththuwa, Pintathaliya and water storing clay pots also declare the possibility of cooling in clay material compose with water. The based cooling technique was evaporative cooling. "The principle underlying evaporative cooling is the fact that water must have heat applied to it to change from a liquid to a vapor. When evaporation occurs, this heat is taken from the water that remains in the liquid state, resulting in a cooler liquid" (What is evaporative cooling, 2010). Possibility of using this passive cooling system will investigates in the research as a historic inspiration.

2. Literature Review

Shelter was in the priority of needs in historic human. Though they had practiced using natural caves when they were nomadic people. But with the cultivation the traditional dwellings were made by own in specific area. Clay, wood, straw and coconut brunches were used for houses which were found around the village. Further needs were emerging in order for aught there was the idea of sheltering. They were

used to make their house components according to the respective climate changes. Although heating and natural ventilation have been given attention in the architecture of early civilizations, the visual and structural aspects have been predominated the minds of architects. (Coorme & Roberts, 1981, p. 1) Mostly they were considered on the comfortability of the dwelling they were built. They had experiment with the house form, material usage and many other ways to face their climate changes. According to Oremus, attempts to control indoor temperatures began in ancient Rome, where wealthy citizens took advantage of the remarkable aqueduct system to circulate cool water through the walls of their homes. (Oremus, 2013) Most of the ancient people were consider on keep their houses in cooling condition as well.

Sri Lanka was a country which was situated in close to equator. With the various climates in Sri Lanka they also consider on ventilation of their inner houses. The heat would probably have made such a house unliveable. However, Kandyans have incorporated in their houses certain architectural feature that would mitigate the effects of heat. (Uragoda, 2000, p. 214) Even Kandyan people were consider on the thermal comfort in their houses. Courtyard concept was one of their structural adaptation for more comfortability of indoor environment of the house.

Clay material were used in most traditional houses in Sri Lanka. And in Experience there were cool indoor environment in the traditional houses. Influence of the material of clay for this cool condition will investigate on the research.

2.1. DIVERSITY OF TRADITIONAL HOUSES IN SRI LANKA.

2.1.1 Early settlements in Sri Lanka- cave

There was a nomadic lifestyle were maintained by the earliest human in Sri Lanka. They had settled in a natural dwelling which was like stone caves. Aborigines were in Sri Lanka introduce as 'Vaddas' in here.

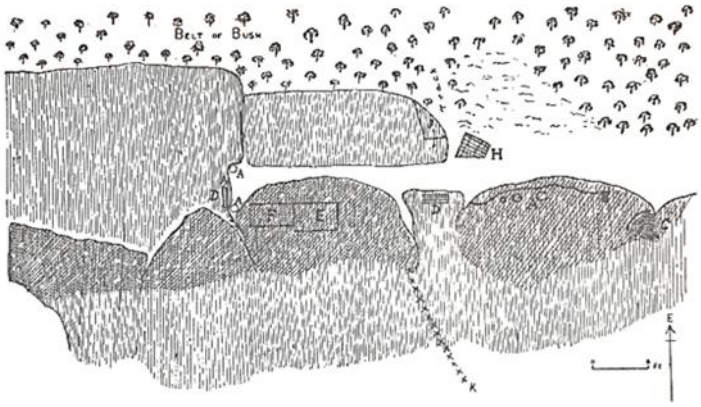


Figure 1, Plan of caves Bandiyangala (Seligman & Brenda, 1993)

The family life of the wilder Veddas centres round the rock-shelters which are truly their homes. And even among those Veddas who practice chena cultivation, but have not formed permanent settlements, these rock shelters play an important part, the movements of the community of family group from shelter to shelter being regulated according to season and available food supply. (Seligman & Brenda, 1993, p. 6) With the cultivation some of human settled as village after several years. The villagers were indeed to make their lifestyle with the farming, hunting and also with honey collecting. Gradually they had become for permanent dwell for live as a family.

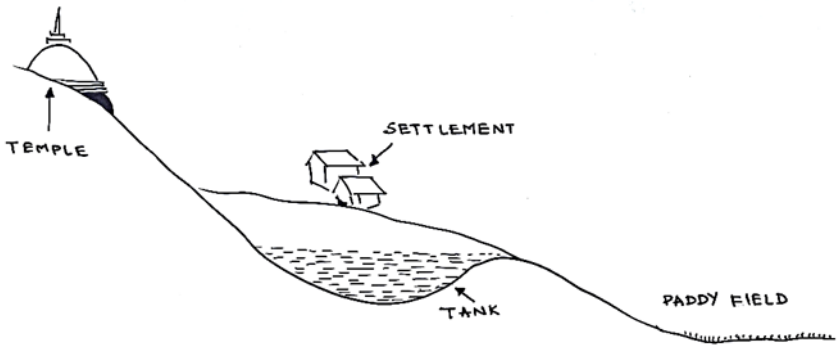


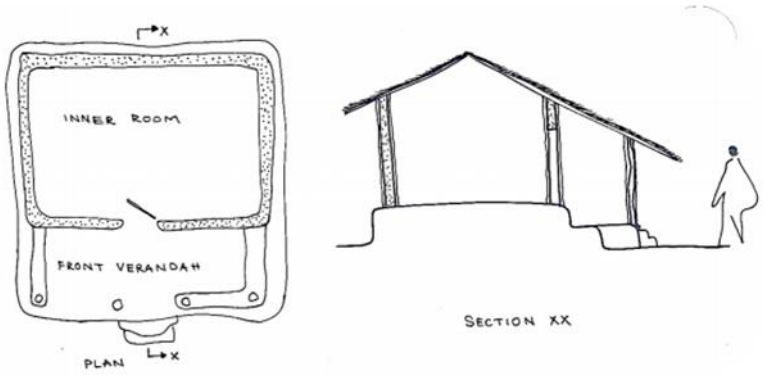
Figure 2, Gamai, Pansalai, Wewai, Dagebai (Village,temple, lake and stupa)

2.1.2 Early traditional house- In lake fed village

In early settlements of the village made as a circular pattern. There was a central square in the village common for the few individual houses named 'Gammedda'. And another open space was on rear side of these individual houses. This is the 'Tisbamba' or communal reserve of the settlement. The 'Tisbamba' is maintained with the two-fold object of sanitating the immediate living surround by compelling the use of the jungle to satisfy the needs of nature, (Brohier, 1973, p. 113)

A simple structure was in these earlier traditional houses. Inner room and the front verandah were the main components in individual house. Front verandah uses as a transition space between public and private space and multi-functional space. The verandah face to the common central square of the village. Raised plinth eaves and enclosed sides with wattle and daub half wall, called Pil kote formed the defined place for such activities. The high plinth is used as a built-in seat or a bed depending on the time of the day and specific activity. It is the workplace during the daytime and men's sleeping place during night. (Abeygunawardena, 1994, p. 40) Natural material was used as constructing material. Smoothly plastered and cow dunged, formed the floor and verandah, and projected out- side the walls as a narrow ledge or outer verandah (pila) used to sleep or sit on. (Coomaraswami, 2011, p. 199) Roofing was done by the thatch. With the help of small door, the pila or front verandah gave access to the main inner room, where they had their private activities such as cooking, sleeping area for females and small children, sexual activities and storage facilities. This place was rather dark and had very small windows or small opening used only for ventilation. (Abeygunawardena, 1994, p. 41) Earlier development of the very first individual clay house is adding a rear verandah. According to undergraduate Dissertation of 'House forms and its evaluation' the rear verandah used for cooking mostly in dry zone. But kitchen was situated separately to the house in wet zone.

Type 1



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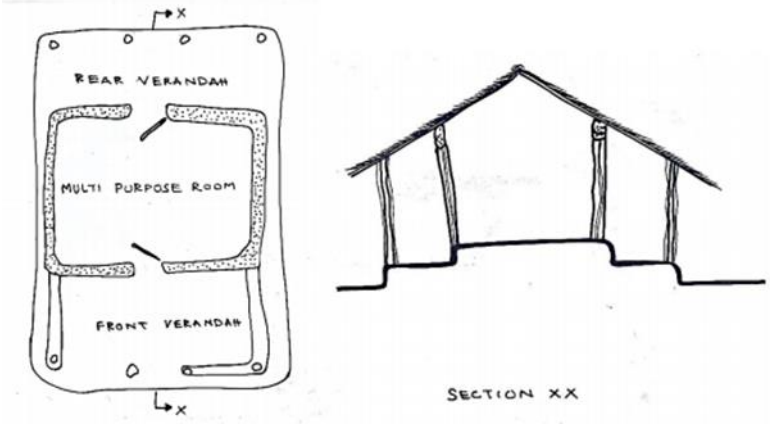


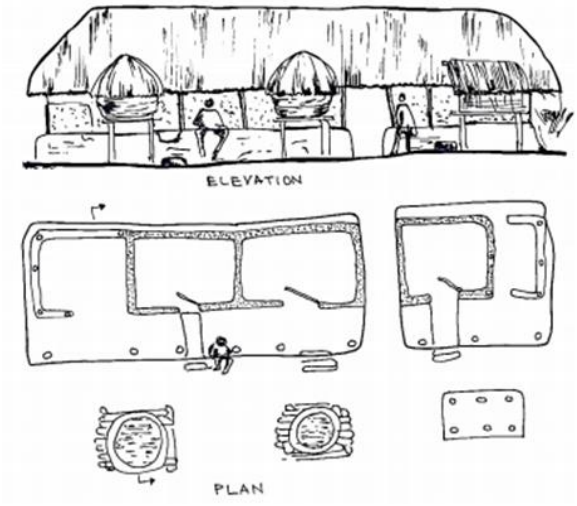
Figure 3, Early traditional house- In lake fed village Type 1,2

2.1.3. Early traditional house- in rain fed village

There was a difference of the traditional houses depend on the climate changes. Sometimes that deference can identify as a feeding fact of the village.The most significant difference of the tank fed village and these two-rain fed and hill country valley villages is the emergence of the individual family unit as the powerful entity of the village at the expense of the cluster of families or the community. It still consists of the front open verandah and the inner room. But sometimes this unit was larger than the genetic form with three rooms per unit. The front verandah faced the footpath. (Abeygunawardena, 1994, p. 46)

The circular pattern of the individual house settlements became to leaner pattern in the rain fed villages. There was a different housing structure in rain fed village housing. Specialty was their kitchen was located separate with the main house structure. The inner space was separate in to two parts. A room and a multi-purpose space were they. 'Wee bissa' was a common part in those all kind of houses as a separate part near the house structure. After the one room and free space structure the house form rise with a pass over the square shape. The main structure became to the 'L' shape.

Type 1



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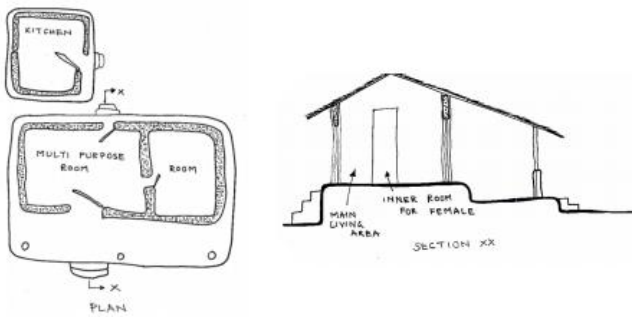

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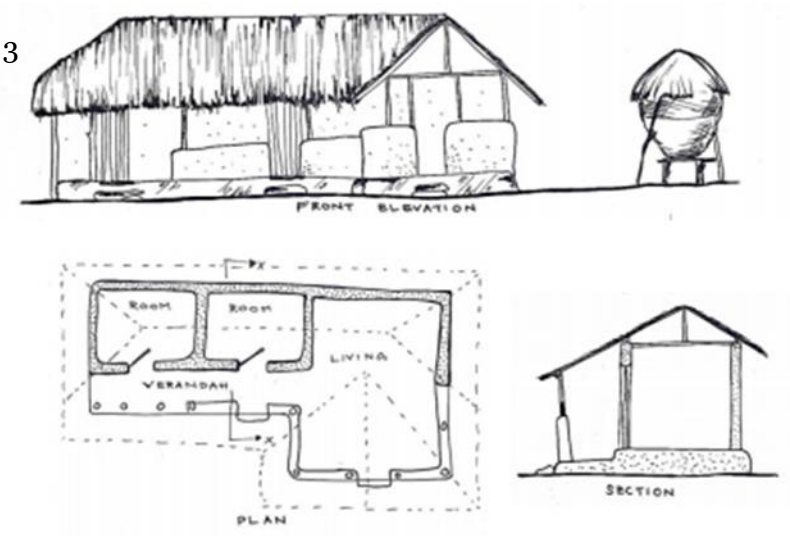

Figure 4, Early traditional house- In rain fed village Type 1,2,3

2.1.4. Kandiyan yeoman's house

The Kandiyan yeoman's house was a direct development of the traditional rural house but taking a different form. (Balachandre, 1990, p. 39) As a considerable change in traditional housing evolution in Sri Lanka was birth of courtyard inside the house. Historic courtyard buildings in warm humid climates have often being adapted for wind-induced cross ventilation other than making use of thermal mass effect. (Rajapakshe, Rajapakshe , & Rajapakshe, 2013) It was a unique characteristic mainly in hill country valley villages. This house form called Kandiyan yeoman's house form.

The kandyan yeoman's house usually consisted of two rooms and a large enclosed space which had an open sunken court in the middle. The both rooms were accessible, from the open court. The rooms were used for storage, sleeping for women and children and for cooking, while internal verandah opening into a courtyard in the middle were the men's domain. This was used for the purpose of sleeping and entertaining friends and relations during the day. The bedrooms rarely contained windows to open to outside, but to the internal courtyard (Balachandre, 1990, pp. 39-40).

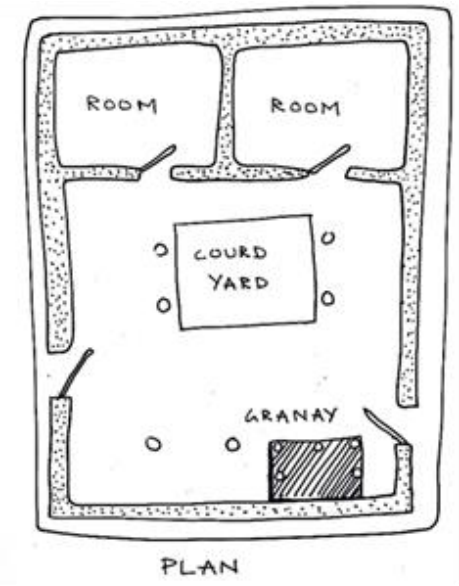

Figure 5, Kandyan Yeomon's house

2.1.5. 'Walawwa

'Walawwa' was another housing structure which was residence of the person who Kandyan feudal landowners or chiefs in ancient society in Sri Lanka. They were allure for somewhat comfortable housing structure. These buildings possess some points of architectural interests. The main living area centred around a courtyard open to the sky, known as meda-midula or central compound. This rectangular or square space is bounded on the four sides by a verandah on to which opened the doors of a series of small rooms that lined the sides of the space. Each room or cubicle was equipped on its exterior wall with a miniature window which served mainly as a look-out post for intruders rather than for ventilation. The absence of a door on the outer wall of the rooms was again a concession to security. (Uragoda, 2000, p. 213) Most 'walawwa' a situated in wet climate. That was the reason for central courtyard with suit with relative climate region. Thicken walls is one of considerable facts in 'walawwa'. The roof in a 'walawwa' was usually covered with what are popularly known as Sinhala tiles, which are essentially gutter-like pieces of baked clay. (Uragoda, 2000, p. 214) Sinhala roofing tile realize better appearance and elegant look for 'Walawwa'.

As the world house form differences based on region, there was a diversity in the housing form in Sri Lanka. Sri Lankan traditional houses enhance chaing of human needs with their lifestyle, social background and the climate condition of region. The material they were used are natural as convenient for find around the village. Flow chart mentioned below expressed that the variation of using materials in Si Lankan Traditional houses.

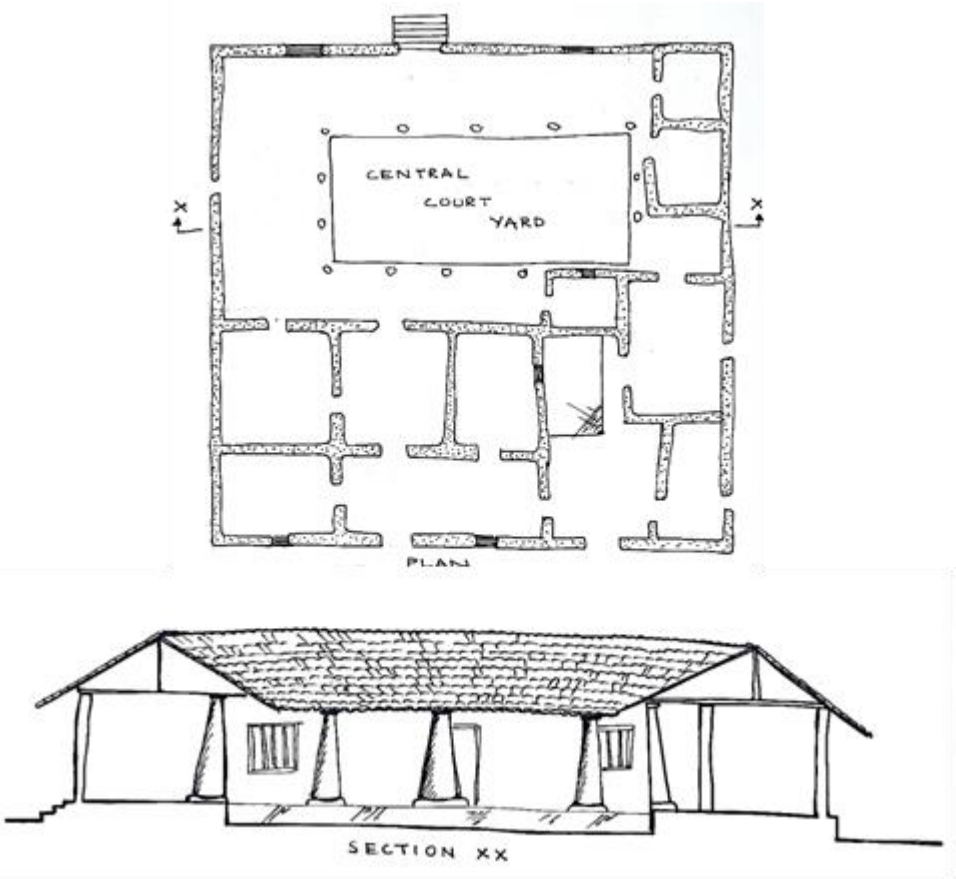

Figure 6, Walawwa

3. Methodology

As the first step research should prove the condition of cooling indoor space in traditional houses. For that the research expect to get data from interviews and observations in traditional houses which were made of clay material under three climatic regions.

The survey main considerations are wattle, Sinhala roofing tile and clay floor which are the most popular usages in Sri Lankan Traditional houses. Those cases were investigating on three climatic regions such as wet, intermediate and dry climatic zones. Material quality is the main consideration in this research. Evaporative cooling and heat conductivity are the methods which are support clay body to create cooling.

4. Results and Discussion

The investigation revealed that there was a cooling condition in inner space of the clay houses. Additionally, ventilation and the sheltering are the supportive factors for cooling indoor environment in traditional houses. Evaporative cooling condition in behave with the porosity of the material. Clay body make indoor temperature cool with this evaporation performance. Indoor humidity level increases because of that process. There can be a more efficient clay category to possible for the product design for creates cooling more than traditional ordinary clay types.

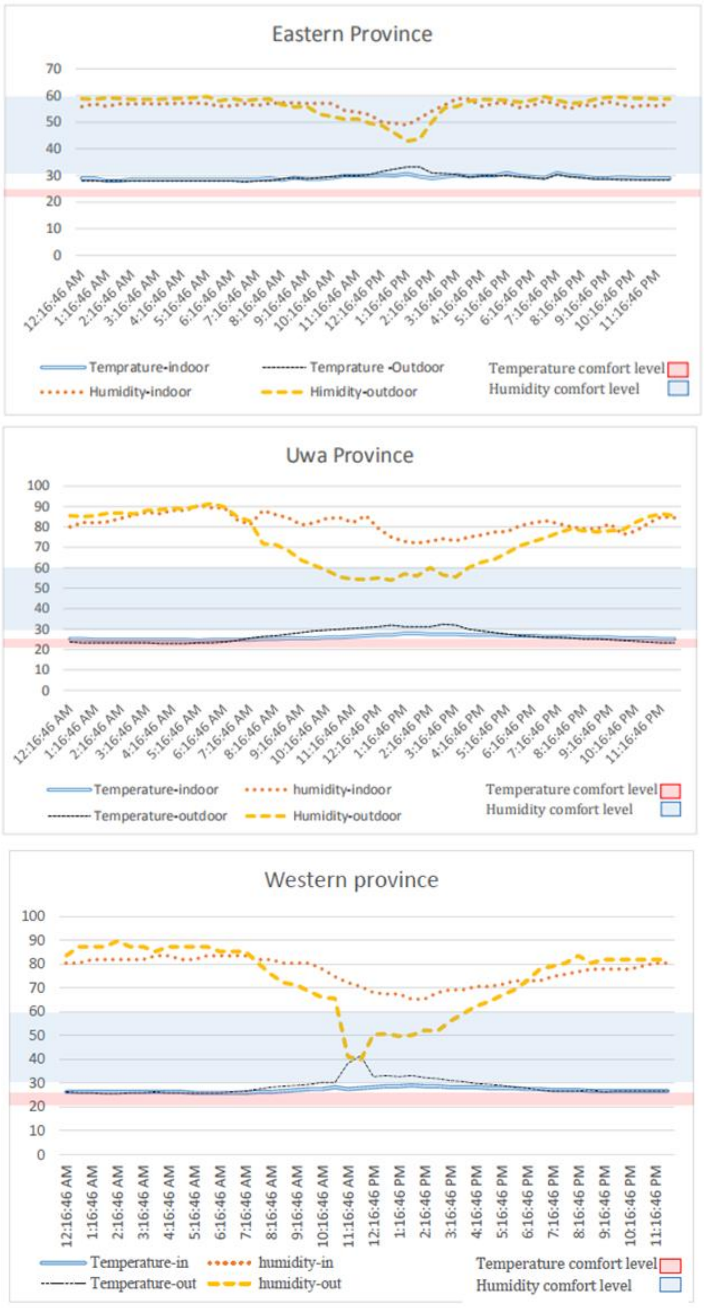

Figure 7, chart of indoor and outdoor air Temperature and Humidity in Uwa, Eastern and Western Provinces

Heat conductivity is one of unique attributes in clay material. At the daytime clay absorb heat and it emits to the indoor in night-time because of this low speed of heat conductivity. Because of that quality

clay material maintain low temperature in daytime and relative high temperature at nighttime. But it can be varying with the thickness of the clay component.

Clay material have a possibility to work as evaporative cooler for indoor cooling in enclosed space. The cooling effect can enhance with various differentiations of the clay body. Thickness, body composition, colour, surface texture, firing temperature and most of the factors can enhance the cooling property of clay body other than the weather condition and structure. The study focused on the house structures and how they affected in the various weather conditions. It is important to consider on value adding and product form for better ventilation in approach to product design.

5. Conclusion

Clay is a material which more qualities. There is a possibility on product design which creates cooling condition. Heat conductivity of the material, evaporation and the additionally ventilation are more significant fact that should concern design applications of the product design on cooling the enclosed space with clay material. The study makes a pathway for innovation in place of an initial step as a inspiration of traditional housing structures and various climatic conditions.

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RE-EVALUATING SPACES WITH ADDITIVE TRANSFORMATIONS ON EXISTING RESETTLEMENT DWELLING UNITS

PUNSISI P.K.A.
KIA Designers (pvt) Ltd, Boralesgamuwa, Sri Lanka.
amapunsisi@gmail.com

Abstract
In many low income resettlements in Sri Lanka, the given design is identified as mismatch solution for the requirements of dwellers according to their "additive transformations". After background studies, it was understood that among various types of resettlements, the horizontally expanded housings in urban context have the full potential of user transformation according to their adaptations since each individual has the touch of land area. Even though the visible issue was the identical and limited area dwelling units to address different family conditions with occupational and other individual basic matters, in reason of identifying the embedded proper causes behind the chaos, the study had been arranged along with horizontally developed resettlement in Matara, and it followed by field visits, altered plans and layout studies, interviews and data collection to get the clear picture of re-evaluation spaces through the usage and human interaction, hence the practical examples are reflecting the parameters of which analysis supports to prevent further complications.

In lieu of repeating the unfitted community solutions, understanding the specific communities, which are to have the opportunity of housing units, is a vital action. Any solution in the future apart from above consideration could be a wasted product which are more to become an abandon dead spaces or dwellers with frustrated mind without having any option for space transformation.

Based on the details, this research paper analyzes the main failure parts of the particular housing procedure and the suggestions to overcome them to be more successful in similar future projects.

Keywords: *Additive transformation, low-income resettlements, dwelling units*

1. Introduction

As a reason of modern life requiring people to live inside or nearby main cities, illegal resettlements by low income communities have been a common scenario over the period of time. After identifying such settlements, government always has to provide most suitable option for them with respect to their already established life patterns without or minimum damage.

Even though the government spends money and funds for budget resettlements, most of such projects are in abandon stage due to user being unsatisfied. Therefore, the "Architecture" comes in to the major consideration, and its supported solutions according to the concepts of responding the particular crowd is best path to satisfy both authority and community.

Had the problem architecturally responded with respect to the culture, economical background, education, occupation, heath and other related basic facilities, the settlement would have uplifted the living being itself by the improved qualities. In present situation, dwellers attempt to either leave the places by renting the house for third party or re-evaluate the spaces to fulfil their needs.

1.1. TYPES OF RESETTLEMENTS IN SRI LANKA

Key types of resettlements can be categorized as below.

- **Rural:** Due to large scale developments, natural disasters, social conflicts such as civil war, etc.
- **Urban:** Due to high population density with poverty in cities
- **Linear:** Due to development projects such as highways, electricity distribution and irrigation.
- **Site-specific:** Due to specific projects such as Hotels, Ports

1.2. BACKUP OF THE POLICIES

Both international and local housing policies have been adapted to support the victims and such guidelines can be seen in the specific authorities (the ministry of resettlements and the Urban Development Authority) and organization notifications. UN and ADB are those kinds of international structures, which conduct researches on housing, including related problem and methods of overcoming them.

With reference to ADB guidelines, below key points should be addressed.

- Free from natural disasters
- Proper facilities with basic requirements
- Close distance between resettlement and previous habitat
- Fulfilling other related requirements
- Political willingness
- Occupation responding

1.3. URBAN RESETTLEMENTS

Urban Resettlement is said to be the most complicated resettlement that needs more concern on design parameters and to be more precise on fulfilling the rules and regulations as it directly effects not only the community but also the economy of the county. Providing houses for those who have illegally settled in valuable lands that can be utilized in commercial aspects, would boost the economy only if the resettled community satisfy with the solution.

2. The Study

This study is based on an urban resettlement project in Matara and how people had transformed given spaces for failures was deeply analysed. Poverty and Natural disaster conditions can be widely identified as main reasons for resettlements in the city. However, the selected resettlement was initiated by the government as a solution for poverty in the particular community. The design of this resettlement had scattered horizontally so that the degree of alterations and additions are much higher than that of vertically developed housing schemes.

Details and data collection for this analysis were extracted from the dissertation of the paper writer for the final year (2014), Department of Architecture, University of Moratuwa.

2.1. STORY OF THE COMMUNITY

Since Matara is a commercial urbanized area, large crowd has been converged to fulfil their needs in the city. The research goes around such a group of gathered people lived near Nupe junction, Matara. It is now termed as “Nupewela Housing scheme”. In a government land near the junction, the particular group had built their squatters and gradually it was increased by joining more families, who did not have a land to build even a temporary shelter. When government identified it as an illegal settlement, there were 209 houses within the selected area. As a less conflict solution, Authorities decided to build houses for them by only using part of the large land (04 acre 02 route and 16 perch).

As they planned, the project was completed by handing over the houses to the community and a method to pay the cost of the structure to the authorities was also introduced. Since each unit was a very basic structure with only external envelope and a toilet, the value of a house quantified as LKR 366, 000.00 and users should pay them within 60 years by following equally weighted monthly payments (LKR 508.33).

2.2. METHODOLOGY

After studying the scenario, the specific group that had been highly impacted was found. Friendly and trustworthy person was selected among the group to join with the field visits, interviews and other data

gatherings, while others had the chance to explain their burden and their difficulties without hesitation. The priority was given for the section where the highest transformation was appeared and each and every house owner joined to the interview in their own house with their unique transformations.

Further, the community comments on the research was a good approach and it was understood that they were happy, despite the project being a research, to see someone hearing their burdens.

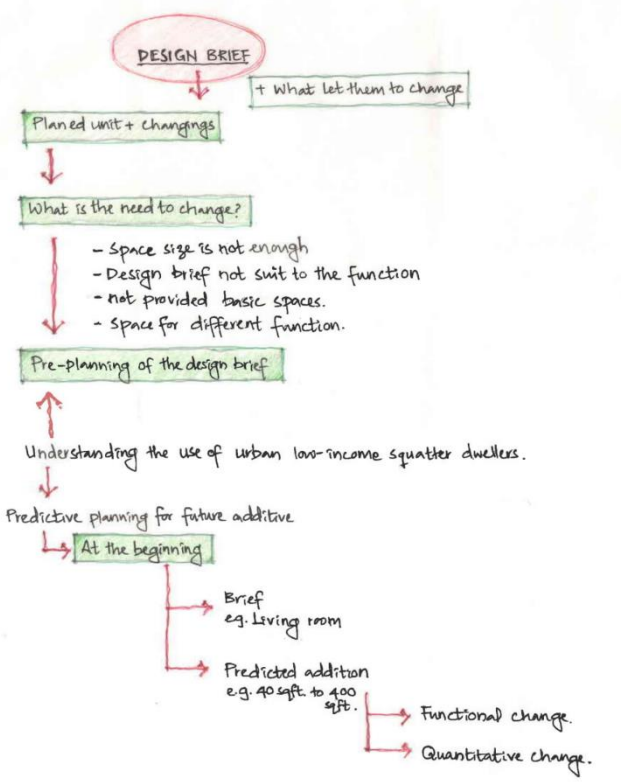

Figure 1, Methodology

Pre-arranged data sheets and drafts, through the surface studies, had been carried to question the people about their life experiences of new settlement with keeping a spare column for newly identified issues. While interviewing each family, the re-evaluated and transformed layout had been sketched on the copy of original plan designed by the authorities.

Once all the data and useful facts were collected, the project analysis had been started to see the depth of the problematic environments. At the first stage to understand the problems, the community was divided to few categories according to their house modifications, since those were made on purpose of improving their own life quality.

- Quantitative additions to failures; for basic needs
- Qualitative additions with different use; special needs
- Changing the use; Re-evaluation
- Cultural additions with related functions
- additions and alteration to respond weather
- Variation of expansions

3. Research Analysis

All the houses were two story blocks and it was, in surface, identified that the insufficient space had been the major reason behind users altering the houses.

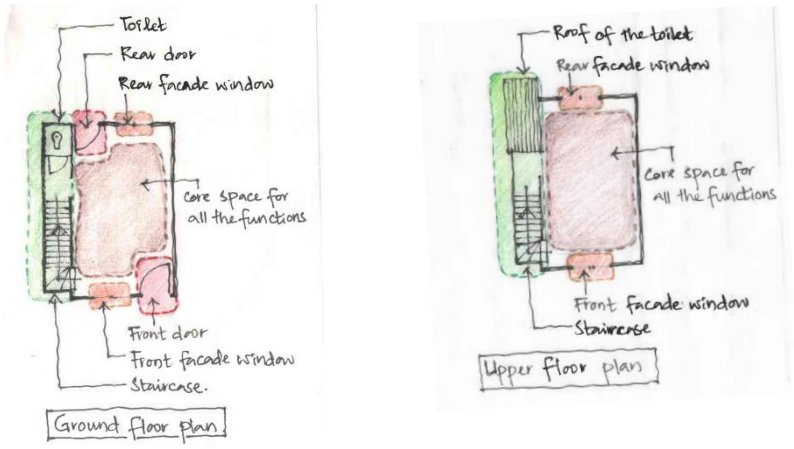

Figure 02, Existing spaces of core house design

The open space in both ground and first floors had been offered allowing user to define their spaces. However, the given space is not enough for a family with more than 4 members and they had to share the spaces with less privacy.

3.1 QUANTITATIVE ADDITIONS FOR FAILURES

By dint of the given space not being enough for all the functions, the ground level had been added with front space for living area and the rear with kitchen and upper floor, with two or three bedrooms following ground floor alternations.

As a reason for the alterations, the number of family members showed much potential. The members were varying to two to twelve persons, while the six members were the most common count. It was observed that the number and gender caused to most interior changes.

3.2 QUALITATIVE ADDITIONS WITH DIFFERENT USE

There had been some changes according to their life pattern and cultural requirements. Majority being Buddhist, they used the open areas beside housing complex for the small temple with a Bo tree and Buddha statue. A small playground for their children was also added for their convenience. Moreover, the privacy basis partitions were visible in most of the units.

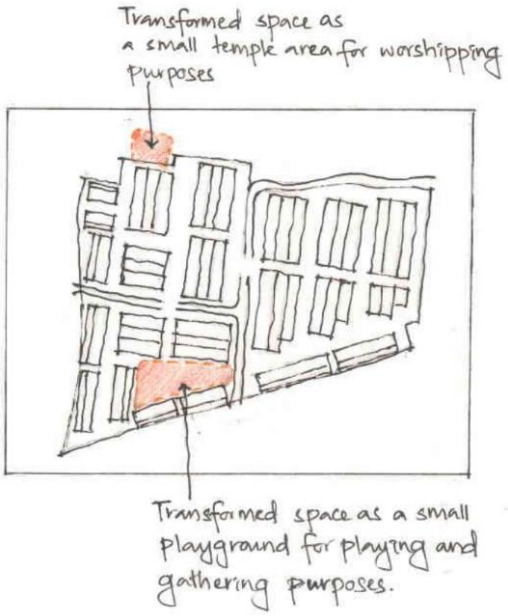

Figure 03, Layout transformation

With respect to the occupation, most of them were labors, who did not need a specific space, but the second heights number with small shop owners, electricians and tailors asked a particular space for their needs. The Auto rickshaw/ three-wheel drivers were also not provided with the parking spaces. Then, the people had added spaces to cover their special needs.

3.3 CHANGING THE USE; RE-EVALUATION

Users had converted some specific spaces for other needs depending on their habits and practices. As example, they had used common bath tank, as they had practiced for long time, instead of own bathroom provide in the house. In such cases, the bathroom had been converted to store room.

3.4 CULTURAL ADDITIONS WITH RELATED FUNCTIONS

It is clear that each culture has unique requirements. As example, the needs and interior such as bright colours for Tamils differ to each religion which relates to the culture as well. Even though the majority was Buddhist, the need of any religious activities had not been addressed, so that people later changed the interior and exterior according to their wish and the Buddhist community had also added a small temple with Boo tree as shown in figure 03.

3.5 ADDITIONS AND ALTERATION TO RESPOND WEATHER

The design given by the government is a common one for all. Same design being incompatible to each site and its orientation variations, users had to alter mainly windows to regulate the sunrays and avoid water sprinkling during rainy season. The draining system had to be redesigned site to site, as the floor angle and water flowing pattern during rainy season was different to each site around the unit.

3.6 VARIATION OF EXPANSIONS

All the changes and alterations had been executed depending on the available space in the site. Since the size and shape of many sites are different to each other, options for alterations have not been common to all, which has created some patterns depending on the site arrangements and orientation.

If the house is closer to the drainage system, they encroach the space by keeping wood or using another light material. The highlighted areas on the figure04 can be transformed, but in rear side of the house, there is a drainage system and also another set of houses. Then their rear expansion is limited with those constructions.

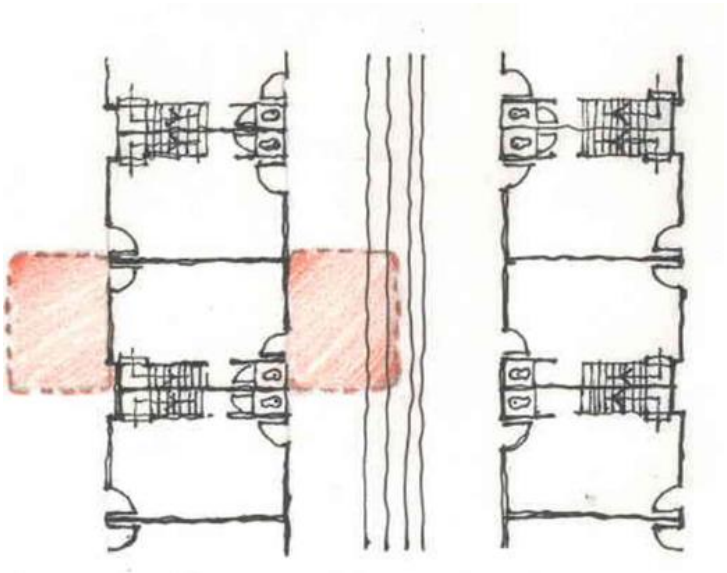

Figure 04, Transformation proceed only two sides

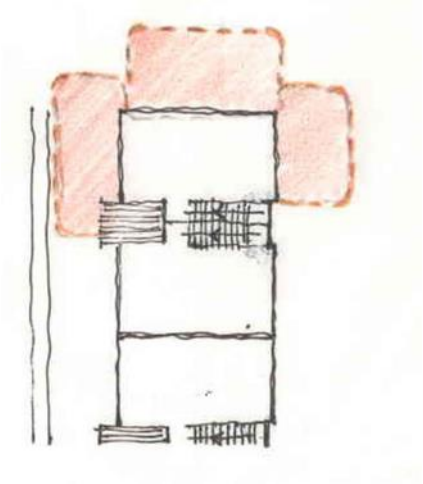

Figure 05, Three sides expansion

There are some houses that have open spaces from all three side with one side being limited with drainage

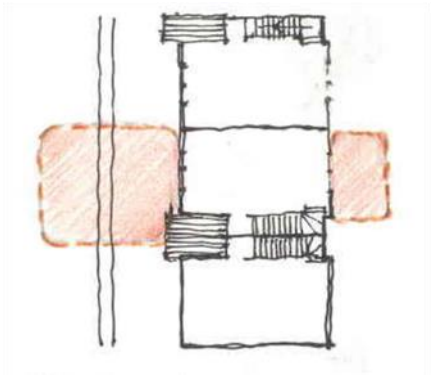

Figure 06, Expansion with one large side

Another set of houses has two sides with one side being large space for expansions passing even the drainage as there is no building thereafter.

4. Suggestions to be successful in such resettlement in future

4.1. STRENGTHENING FEASIBILITY STUDIES

There was a visible failure in feasibility studies on the selected people. It should have been started with the observation of the community and few discussion sessions of the beneficiary's idea about the proposed plans. If the officials identify the needs of people and address them through the design, the both parties will satisfy through the project without further complaints.

4.2. FEW TYPES OF DESIGNS, OWNER DRIVEN DESIGNS OR PROVIDING ENOUGH SPACE FOR THE TRANSFORMATIONS AND EXPANSIONS

All the families were provided with the same model houses for the different family conditions with number of members, occupation types etc.

There should be few types of designs, which have the ability to address the various family and site conditions. The owner driven house designs can also be a good solution, hence the owner supervision directs to their habitual paces. As a last solution, the enough space for transformations would be a best method, as it will have the freedom to re-evaluate, alteration or additive transformation with the provided sufficient volume.

4.3. SPACES FOR COMMUNITY RELATED FUNCTIONS

Tight housing block composition had limited the specific community functions and people have hardly cleared some areas to create playgrounds and cultural needs. Providing the spaces for common functions is a must to be sustain as a community.

4.4. STRENGTHENING THE INITIAL INVESTMENT;

The cost which government spent for one house is LKR 366,000 which is not enough to fulfill at least most of the requirements which need to satisfy the community. Government should focus on to get some value addition through the beneficiaries by satisfying them instead of going forward with low investments.

In this community development project, the government allocated large cost for the drainage system, which was hard to maintain as well as covered and blocked by the additive transformation of the people. With proper studies in initial stages, these type of money wasting can be reduced.

4.5. PROVIDING ALL THE BASIC FACILITIES

This settlement had not defined the most common facilities of Kitchen, bath area and users were given the open house and allowed to decide themselves, nevertheless the space was not enough at all.

To reduce the conflicts, it is important to provide very basic needs of the individual family basis through the design itself.

5. Untenable Views of the Research

As the research starting point was stuck with the already established resettlement, image of their previous houses was a mere composition of descriptions. Those could be an erroneous, since neither authorities nor people had evidences through a plan or any other method to prove.

To observe the reasons of transformations and reduce the quantity of inter-viewers, the high effective area had been chosen as a sample. Had the whole community taken in to the consideration, the result might have changed with the quantity.

6. Conclusion

“In practice, it may be Impossible to specify and estimate a choice model that will always be correct in predicting the chosen alternative by all individuals. In order to overcome this problem we resort to the concept of random utility. In a random utility model the true utilities of any alternative are considered as random variables.”

KamleshMisra, Housing the poor in third world cities, p. 25

Resettlement is one of the areas which need more professional’s attention to uplift the quality. Even though many studies and researches have been carried out, suggestions of those researches have not been able to come into the practical situation properly. This study proves how difficult it is to apply those methods in real world situations. Any way if authorities are brave enough to understand what case studies show and change their practices according to the particular application, a properly designed resettlement, with all the requirements appearing in policies, articles and case studies, will satisfy the community as well as the government.

Considering all the analysis and the observations, any community should have owned a comfortable surrounding even in a low-budget resettlement. Hence the government cannot afford all the requirement that the people are asking, through the understanding the community, it would be more easy to compose than the non-responding building for the community aspirations. In such cases, the idea of additive transformation and re-evaluation theories help to satisfy the community by creating their own spaces following their specific needs. However, for that the adequate space, feasibility studies and enough initial investments are a must.

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EFFECT OF EMOTIONAL FACTORS TO PRODUCT FUNCTIONALITY ON HOT BEVERAGE CONTAINERS.

W. DESHAJA DEWAPRIYA KULATHUNGA[1] & W. M. N. DILSHANI RANASINGHE[2]
[1, 2]Department of Integrated Design Faculty of Architecture, University of Moratuwa, Sri Lanka.
[1]*dewapriya006@gmail.com*, [2]*dilshaniranasinghe80@gmail.com*

Abstract
Every human in the world is born with five sensory organs. Each of them is capable of identifying different sensory perceptions. The combination of these sensory organs makes a path to the most interesting subject in human lives which is human emotions. Each human is different from one to another so as the emotions. Also, it is important to keep our body hydrated. Water is the main beverage used by humans. beverage containers are an intelligent design created by humans. it can be found in different shapes and forms according to the purpose and relevant to the beverage philosophy it contains. This study was carried out to identifying emotional effects on product functionality. This research is focused to study only about hot beverage containers in Sri Lanka. It is based on mix methods and conducts a real product observation to analyze the written data. The results revealed that particular effect of designs and materials which are directly affected by human emotions and functionality of products. It was identified that the emotional effects of metal, ceramic, glass, plastic, and the impact of the surface finishes and forms. Also, by the research, it was identified the emotional levels and the effect of materials and designs on hot beverage containers on each level respectively.

Keywords: *human emotions, emotional levels, product functionality, materials, emotions, the effect of human*

1. Historical Evolution of the Beverage Containers in Sri Lanka

five sensory organs are the most essential parts of the human body. Because of these organ's humans have different sensory perceptions. These organs can be satisfied positively and negatively. This negative and positive connection between humans, products, and services can be identified as emotions. Drinkware is another intelligent design created by humans. It was invented by the ancient people to satisfy their day to day needs as a result of fulfilling their thirst. In the beginning, they use natural containers to full fill their needs such as animal horns, animal skins, plant shells like coconuts *nelum kolaya*, *labbu kataya*, or different shaped clay objects. Today people can find drinkware in different shapes and forms. It was designed according to the purpose and the beverage it contains. Drinkware has different backgrounds to take shapes, forms, colors, sizes, materials its own. And drinkware directly effects on human behaviors and thinking patterns and psychology. This research will try to understand the connection between the consumer and the drinkware as well as its emotional and functional values. Furthermore, this research tries to find out the impacts of designers, to give positive and negative emotions on products.

1.1 THE FUNCTIONALITY OF A PRODUCT

The functionality of a product is the root system for a good product. Designing a product is not just making another art piece. Products are usually specific for a known work task. A good product should be functional and eye-pleasing at the same time. To build a functional product the designer has to understand the best possibilities such as shapes, materials, forms, textures, sizes, etc. (Wong, 1993) Wong explained about 4 elements which are related to the functionality of a product. Conceptual element, Visual element, Relational element, Practical element.

2.Historical Background and Different Approaches in Human Emotions

2.1 WHAT ARE HUMAN EMOTIONS?

Mankind is the most intelligent living being on earth. Their thinking patterns and the behavioral pattern is different from one to another. So, it is very difficult to understand human emotions and functional levels. At the beginning of the studies emotions, mood and personality were identified as different stages in the human mind. Moods take longer time than emotions. Personality is with humans longer than both. After the term of emotion was described by Plato there were certain attempts to explain human

emotions. By the studies done by the Desmet, it was identified that there were four reactions happen in our body as a reaction to the emotions. Physiological reaction, subjective reaction, behavioral reaction, and expressive reaction are them. (Desmet, Pieter, 2005)

Humans are naturally adapted to react to emotions since birth. For that, almost every human being is born with five sensory organs. They are eye, nose, skin, lounge, and ear., these sensory perceptions can be identified by our self-experiences. Humans are naturally adapted to satisfy their sensory organ's perceptions in every possible manner. These organs can satisfy positively and negatively. This connection between humans, product and service can be identified as “emotions.” Humans are naturally used to like these positive emotions. They reject and get uncomfortable when they get negative emotions.

2.2 THE EMOTIONAL CONNECTION BETWEEN PRODUCTS AND CONSUMERS

Miklos states that “as humans, we establish some sort of an emotional connection with all kinds of products that we use. Therefore, we expect some level of human life feedback when we interact with them. Even though we know the products aren’t human and can’t feel emotions, we want to believe that they can” (Miklos,2018). When talking about human emotions and products, both these factors are depending on the consumers. The emotions of products and positive emotions such as attraction, attachment, and happiness are an effect on users

2.3 THE EMOTIONAL RELATIONSHIP BETWEEN THE USER AND THE DESIGNER

It states that people willing to keep their products as long as it remains, and they do care about the products as long as it remains, and they do care about the products which have good emotional values due to behavioral aspects of relationships. (Savas, 2004). Designers are the first perspective of this emotional relationship. They have to consider so many considerations which are depending on different factors like company cost, brand identity, and market analysis. User is the second perspective of emotional relationship and functionality and appearance are the key factors for the user. Users can be love or hate products depending on their emotional effect.

2.4 THE TWO PARALLEL LINES OF THE EMOTIONAL EFFECT ON PRODUCTS.

The emotional effect can be categorized into two different approaches. One approach is the effect of basic emotions to the humans and the other approach is three different emotional design levels. An individual person can experience a random number of emotions by experiencing a product. And at the same time, the above emotions can be in touch with the design levels as well.

2.5 SCALING OF EMOTIONS

The reaction of emotions is happening at different levels and scales and Human reaction of emotion happen in both verbal and nonverbal communication methods. These emotional effects are measured by using different methods like verbal and nonverbal manifestation and observing some physiological reactions. The nonverbal instrument is an objective way of scaling emotions. Ex- Gew, PrEmo, Emo card, Physiological reaction /ASN (autonomic nervous system), Electromyography, Electrodermal activity, Skin temperature, Blood volume pulse (BVP), Electrocardiogram (ECG) are some of the verbal methods of scaling

Verbal instruments are the subjective method of measuring emotions. Self-assessment manikin (SAM) – is one of the most common verbal instruments in emotional scaling. It is a kind of pictorial representation of the scale of emotions.

3. The evolution of the beverage consumption and its usage of beverage containers in Sri Lanka

3.1 ANCIENT BACKGROUND OF SRI LANKAN BEVERAGE CONSUMPTIONS.

As Sri Lanka is a country which is located near the equator the temperature is normally taking a high number throughout the country. In the past, as they were depending on *chena* cultivation and paddy cultivation, people used to drink more water to keep their bodies hydrated. When it considers the

ancient beverage consumption culture it can see that cultural impact was highly affected by the beverage consumption of Sri Lankans. According to "*saddamalankaraya"* in Sri Lanka before the colonial period water, fruit juice and toddy were the main beverages used by the society.

As a Buddhist country for the consumption of the monks there were used certain special beverage types called "*ashtavidapana"*. Their beverage containers were small in size as they were drinking less amount. Alcoholic beverage toddy was the most famous drink among the general people since ancient time. There were *coconut toddy*, *palmyra toddy* and *kittul toddy* as the geographical variation of the country. As farmers work hard on their cultivations, they were used to drink more water than the other people. So, they were used *labu kataya* to take water to their *chena* or paddy field which contains more amount of water. Other than the main beverages, traditional ayurvedic beverages such as *ranawara ,belimal,* and other *kada* types were used by the people as their daily beverages (Dharmakeerthi, 1996). Earlier in Sri Lanka had a very simple culture on beverage consumption. That is *the "eat and drink"* concept. They drink an amount of water right after a big meal.

3.2 CULTURAL, NATURE AND TRADITIONAL EFFECT ON BEVERAGE CONTAINERS IN SRI LANKA.

In Sri Lankan, all the products were based on two approaches like nature and culture. In Sri Lankan culture at an early period, before the colonial influenced were happen people use more flat containers to drink beverages. Coconut shell *(polkatta)* was the main natural container that they use and by the time clay containers were used for daily purposes. It is amazing to see how the designs were changed according to the cultural factors and traditions in Sri Lanka. Ancient Sri Lankans were used to pouring water into the mouth when someone else also using the beverage container. The designs that were used to pouring water came with more narrow ends which makes easy to pour water into the mouth. People used *kendiya* to pour water into the mouths. Other than the *mati koppe* and *polkatta* people use *labu kataya* to contain and drink water, especially when they are on *chena* or paddy fields.

When looking into the cultural side the direct effect of temples and monks can be seen in the product variations. Whatever the temple and monks were used considered as the highest level and later it was spread quickly in the culture. Every temple has *thaliya* to contain water for drinking purposes and later on, it becomes *"panthaliya "*. Our culture has hugely influenced by the Indian culture as the Buddhist arrivals. According to the "*ananadakuarasswami"* in *medieval Sinhalese art,* it says that the different patterns and designs were influenced by the Indian culture. The higher class of the society used materials such as clay, ceramic metal, bronze, copper, silver, gold as their likeness. The famous ancient folk song by the *andare* explains the material variation of the beverage containers according to the social class very well.

"Ridi kale ran kothale beepu mata
Nikam kale pan nethi wiya pipaseta"

According to the song, it says that he used a silver pot and gold *kothale* for his personal use. And now at his bad time, there is not even a clay pot to drink water. This explains how the social class and materials derived in the Sri Lankan culture. Then after the influence of Portuguese, Dutch and English, things get changed in the traditional culture. As they were introduced tea and coffee that when the cup and source came. The beverage consumption also changes as the products. The china porcelain and glassware were highly spread all over the county. Different materials and designs were taken place of the old traditional designs. The foreigners introduced vine and alcohol to the country. in these two different cultural approaches, there was a very identical different in the designs. Our designs were very stable and horizontal in shape but the foreign-influenced make it more vertical in shape.

3.3 THE EMOTIONAL BOND WITH ANCIENT PRODUCTS, CULTURE, AND PEOPLE.

Sri Lankans had two different approaches to experience product emotions. They were by the functionality of products and the aesthetic experience of the product. The emotions of the Sri Lankans were changed according to the age, actual activity and event with the time as well. As Sri Lankans had a family-based society people used to like things based on different approaches. They were mostly used to like, what they have used already, what their parents and grandparents used & The shape they're familiar with nature.

Even that time people had an emotional bond with their beverage containers. According to the *"paliputtaka viaya vinshya"* there was a case filed on a *"polkatta"*. The case was filed based on a complaint by a monk. According to the story, one monk from another temple borrowed a *polkatta* which was not used at that time. But however, after another monk has filed a case complaining that "polkatta was mine". So, the case filed and the *polkatta* was given back to the owner of it. This story shows the strong emotional bond between humans and beverage containers at that time. Even the monks who practice leaving everything had such an emotional bond with their beverage containers.

Another example is the archaeological remain *kotale* which has the *kashyapa* name on it. It has been written on the *kotale* "*kasubu mage kothale"* which means this "kotalke belongs to *kashyapa"*. It shows how strong is the emotional bond in that time with beverage containers. They all had separated beverage containers for themselves. It was the same as today, people were used to attaching to the products that they use, and they had a huge bond with beverage containers.

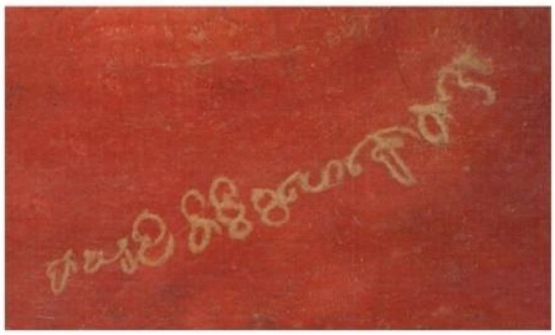

Figure 1/image of king Kashyap's Kotale details.
source: A catalog of ancient pottery from Sri Lanka

3.4 ANCIENT CLASSIFICATION OF BEVERAGE CONTAINERS ACCORDING TO FORM AND FUNCTION

Function - It is proven by the evidence that ancient Sri Lankans were considered about the form and function of a product very effectively. Other than the basic beverage containers from the natural objects such as coconut shells, *labuakataya* or animal horns, the beginning of the forming beverage containers can be taken as the time period which is the clay vessels were made. It can clearly understand that those clay vessels were made by considering the basic form and functional values.

To understand this functional effect on the beverage containers the best example is to study the basics of a clay pot *(kalaya)* which is used to store and take water from the sources. The famous ancient folk song says that,

"kata kadi kale diya ukule thabagena ,Rodi kella koi yanawada udasana"

The *kalaya* was designed by considering the main function of it. Event today also rural women used to carry water from the *kalaya*. The *kalaya* has two main parts which is belly and the neck. The normal way of carrying a *kalaya* is by keeping it to the hip of the women and gripping by the elbow joint. In the design of the *kalaya* the large belly was designed to fit the hip of the women and the neck was strong and

small enough to grip by the elbow joint of the women. Comfort, Range of motion, Strong, Stable, and abrasion-resistant all these properties can be seen in the design of *kalaya*. The consideration of form and functionality to the beverage containers can be clearly seen in these old designs

Figure 2/ Image of Rodi women with a traditional clay pot.

Forms - By studying the remaining archaeological samples furthermore it can be understood that the form of the beverage containers was highly considered by the ancient peoples. Rice said that the function of these vessels can be understood by its form. The form of these containers was based on factors like its capacity, handling, transporting, storing and stability of the product (Rice, 1987). The materials and their thickness also depend on these containers according to their form as well. Rice has categorized these products according to its manufacturing technologies. According to that four characteristics were considered in a product. they are, The thickness of a product, The hardness of a product, Density, Surface treatment (glaze/slip/burnish) (Rice, 1987) pg226.

Shape and the size of the containers were changed by the time with the cultural effect and usage. According to Professor de Silva (2008), these beverage containers can be divided into two parts. They are the upper part and lower part. The lower part was used basically for the containing purpose and the lower part was designed according to its body proportions and by considering the functional factors. (De silva& Bandara R, 2008) . These forms of beverage containers also can be divided into two groups according to their purpose. They are restricted mouth and non-restricted mouth containers. Restricted mouth containers were used for storing purposes and non-restricted mouth containers were usually used for serving purposes. The restricted mouth of the containers allows keeping the beverages without spreading even it carried.

4.Research Methodology

The research is mainly based on primary and secondary data to do as a literature review and as qualitative and quantitative surveys. As a secondary data which is written evidence was used. Books, websites, articles, research papers, murals, paintings and museum artifacts. The quantitative survey was done based on selected target groups by using open-ended and close-ended questionnaires. The questioners were based on available beverage containers in the local market during the last 5 years. The available samples were selected according to four material types, plastic, ceramic, glass and metal which are commonly used by the consumers. And use two types of questionnaires A and B. questioner B was conducted by a real product observation. questioner A was done to identify the most commonly preferred hot beverage containers, and the questioner B was conducted to identify the emotional factors and the general features of the selected cups from survey A.

from the above beverage containers, the most preferred two cups from each category were taken for survey B and through the survey, it was identified the emotional effect on the product functionality. Several emotions were rated through the experience of the participants' and they were able to have a real product experience with a hot beverage in the container before answering the questions. plastic, metal, ceramic and glass cups were rated by using different direct and indirect questions and general functional features and the emotional feeling were taken as answers. The emotional design levels were identified by the end of the survey and it was helping to analyze the data findings as well. Given below are the selected cups from each category with their identification

Figure 3/selected cups from each category

4.1 EMOTIONAL EFFECT VARIATION WITH DIFFERENT CUP DESIGNS

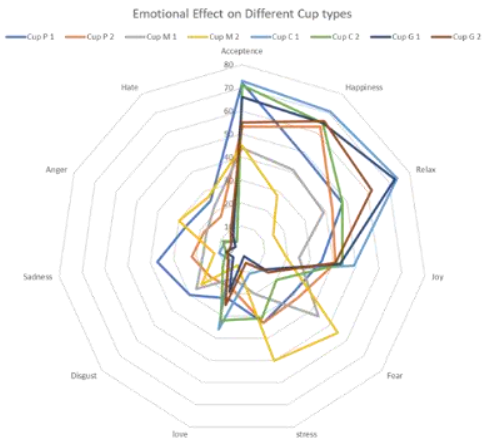

Figure 4/Emotional effect on different cups

As the data findings, it shows the deviation of emotions with the experience of each cup. According to the results, the positive rate cups such as ceramic and glass shows the flow of positive emotions on the chart and the negatively rated cups such as metal and plastic show the negative emotional impacts with the users. Cup M2 and M1 show the highest negative flows of emotions while the glass cup G1 shows the highest positive impacts on results.

4.2 EMOTIONAL EFFECT ON CUPS CONSIDERING THE MATERIALS AND DESIGNS

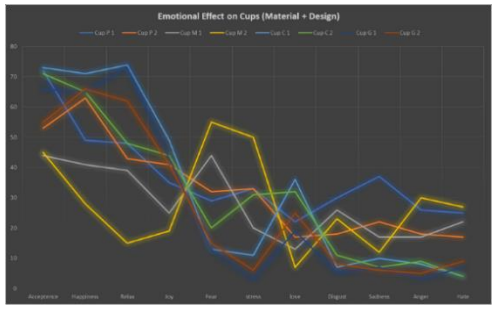

Figure 5/Emotional effect with designs + material

When compares the material and design it shows some kind of relationship with materials as well. Cups in the same material category shows the same kind of emotional flow according to the results. As the results metal cup, 02 shows the highest negative flow and the glass cup G1 shows the highest positive overall result in the chart.

4.3 MATERIAL IMPACT TO HUMAN EMOTIONS.

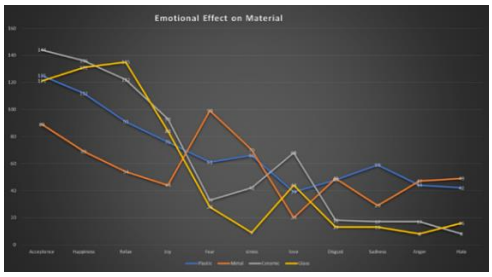

Figure 6/Material impact on human emotion

If the results were analyzed according to the materials it clearly shows the behavior of each emotion with the materials. As data ceramic, glass, are the best materials that are capable of touching the positive emotions and meatal is the material that has the highest capability of touching the negative emotions. Fear is the highest rated negative emotion with the metal and acceptance is the highest rated positive emotion with the ceramic cups.

5. Research Finding and Discussion

As the findings on the research, it shows the general behavior of the Sri Lankan beverage consumption as a tropical country. It shows the same as the past as findings in the literature. Still, people used to consume different beverages at least once a day to keep the body hydrated. As humans are very sensitive to temperature changes, to work with hot beverages people find a solution with a handle. It still moving forward continually from the past as it is the simplest solution for the problem. The aesthetical favors of the peoples become change during the time as well. The results show an idea that is different from the literature findings. Even if the details become more valuable and aesthetical pleasant in the past majority of the millennials from the survey preferred plain surface finished and bodies.

It may be a result of their modern simple lifestyles. Sometimes the new bad design details may be the reason for the trend. Culture and tradition can impact on people's choices when it came to the visual selections. As Sri Lanka is a multi-cultural country the Tamil and Muslim cultural effects can be seen in findings of the cup's selections. Even it hasn't handled, participants have selected the metal cup as it can be seen in every Tamil house and restaurant.

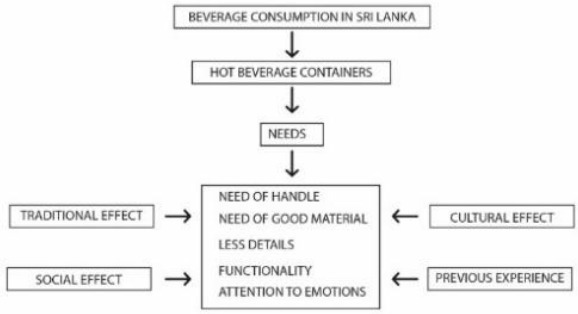

Figure 7/Researchers model on beverage consumption basics in Sri Lanka
source: authors creation

The difference between first impression and the functionality can be Cleary identified by the results of survey B. The aesthetical look should not be the only concern of a product. It proves that the need for attention to the functional details in a product. Even if the selections votes from the survey A is high, according to survey B the overall results of the plastic and metal cups are negative results. It shows how the functional and Aesthetical different ends approach products as well. The results show the less concern of new generations to the esthetical values than the functional factors like comfort, safety, and range of motion. The new generations do care about the functionality of a product than aesthetical deep approaches.

The material behavior of a product also plays a huge role in human emotions and the functionality of a product. Although today people used high heat transferring materials for hot beverages ancient people have used low heat transferring materials like clay to consume hot beverages. It shows how the general market become overruled by mass production techniques than consumer preferences. As mentioned in the literature findings the functional values depend on factors like cultural influence, traditions, visual memories, social impact. As the analysis of the data findings, most people select the functional values by their previous experiences. Most of them have selected ceramic cups for drinking processing and serving purposes as our daily usage. Ceramic cup C2 has the highest votes for serving purposes as it is the usual shape cup that people already used by a term of "our cup" to serve visitors. The cultural impact on the products can be seen by looking at the metal cups' results. The majority of the samples have selected it for the ritualistic purposes as most of the temples and other religious places used metal containers for the common ritualistic uses. According to the data findings even today the millennials have an impact from the culture in Sri Lanka.

Most of the participants have voted for several functional values in the same cup as their previous experiences. As overall results, it shows how the products become multifunctional in the local contexts. When it sees the big picture it all shows how history repeats itself in different forms. The cups which are rated in the survey A shows the best general feature in survey B as well. It shows how nonconscious decisions happen with previous memories. It only provides a single picture in survey A and yet the peoples have voted for the best general featuring products from their first impressions. But in reality, it is not only the aesthetical look that matters for these decisions it happens because of our previous experience with the same kind of products and its emotions. People have a relationship with visual memory and emotions. It can be good or bad emotions, yet they have an unconscious memory with the overall design of a product.

The emotional levels, as described in the literature chapter **Error! Reference source not found.** almost every product, have the capability to touch the three emotional levels. But as result, most of the emotions were an impact on the users at their behavioral level. Reflective level is having less impact on a short time using products than the other levels. The results have proven the researcher model on literature 0 and it shows how each level reacts with different users in different combinations. Not only the form and function of the product but also the material combination playing a huge role in human emotions. It has proven according to the data findings. As shown in figure 6. Human emotions have a unique variation with different materials. Given below *figure 8* shows the researches model on connection with human emotions and products.

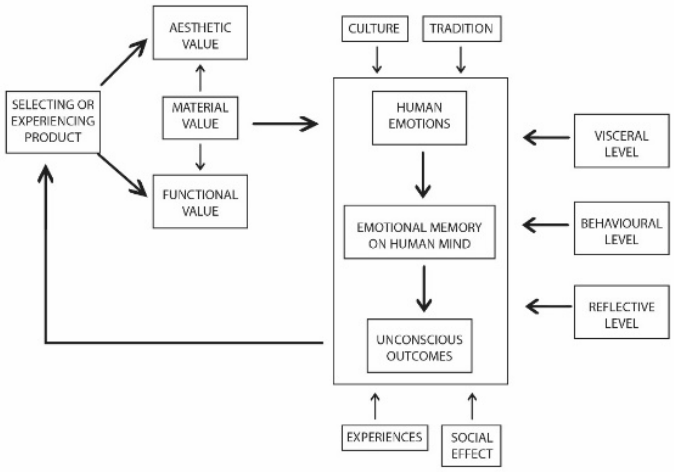

Figure 8/Researcher model on the connection between products and human

The research itself proved some facts and finding on the literature and some facts are changed as a result of a generation gap. And the results have clearly shown the effect of emotional factors on product functionally. Also, as experimental data, the emotional connection with materials has found out by the researcher.

6. Conclusion.

Form the literature and data analysis it was found a path to a better conclusion of the survey. The research was conducted by using physical and phycological features. as literature findings general and functional features were tested from the surveys. The basic emotions are happiness, sadness, acceptance, disgust, fear, love, hate, joy, anger, relax, stress. According to the findings, the researcher had come into some conclusions as below,

The hot beverage containers with a handle are the most suitable design for Sri Lankans. According to the results, almost every Sri Lankans consume hot beverages at least one times day. Because of that, when it comes to the hot beverage container industry it is a huge market to address. According to the general survey majority of 66% prefer ceramic as a material to the hot beverage containers. As the survey is based on the majority of millennials, they prefer more plain and clean design solutions for their lives. further studies can be done to identify their other preferences as well. According to the material and design glass and ceramic cups are the majority choice of the participants. Even though the majority choice of material is ceramic as a results glass cups has taken the highest number of votes from all participant. It shows the influence of the designer's role in a product. As it has the best general functional features people had good experience with the products as well. From the result of 56 % males and 43% of females, the emotional impact was measured. According to the results for the hot beverage containers, the highest concern of functional features was safety, comfort and the range of motion and weight. Enthought we think highly on cleaning easy, surface finishes, color combinations, the majority have minimum concerns on them.

The functional values of the beverage containers have a similar impact on the people as findings in the literature. Traditional, social, cultural impacts play a huge role in fictional values as same as the functionality. However, according to the data summary, the beverage containers in the Sri Lankan context plays a multifunctional role in the function. The effect of emotional factors on products has a direct connection with product functionality. According to the researcher's view, the functionality, materials and aesthetic values are the three primary variables to human emotions. Secondary variables of human emotions are the social impact, cultural values, traditions and the previous experiences of a user. When it comes to hot beverage containers functionality takes the first place among all. By observing the chart figure 4 it can be identifying the direct impact of the functionality to the human emotions. According to the results, it has proved the hypothesis which is **"The design features of the drinkware effected to improve human emotional levels"** as well. Also, materials play a huge role in both functionality and emotions. It was a new experimental result from the research to explore the connection of material and its impact on human emotions. These impacts of material can be happening directly or indirectly. The chart figure 6 shows the emotional variation it each material separately. As found in the literature the researchers build a model of emotional levels and their connection is practically experienced in the reach as well. Those probabilities as mentioned in chapter 02 can differ according to the consumers.

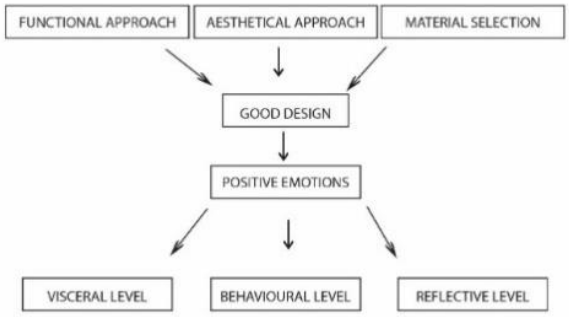

Figure 9/researchers' model on Different approaches and design levels on products
source: Authors creation

According to the analysis of data findings, Designers have a huge role to design eye pleasant products as well as functional. Also, the correct material selection is very important to create a good product. If a designer were able to address these three approaches it will affect the human emotions positively and most probably it will be a design to touch the three emotional levels positively as well. The above figure *09* shows the researcher's model on the connection between different design approaches and design levels.

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EXAMINATION ON METHODS, TECHNIQUES IN STRUCTURAL DESIGNS OF GREEN WALL CONECEPTS: Application to Concrete brick Wall in Sri Lanka

RAHUMAN A.A.[1] & DILSHANI RANASINGHE W. M. N.[2]
[1,2]Department of Integrated Design, Faculty of Architecture, University of Moratuwa, Sri Lanka.
[1]*rahuman0327@gmail.com,* [2]*dilshaniranasinghe80@gmail.com*

Abstract
Green and eco-friendly environment systems are having an evolution within the architecture and design fields. When designing built environments, it is the duty and responsibility of architects and designers to pay attention to environment and ecofriendly factors. With respect to the above, the concept of "green wall" or "vertical garden" reached a rapid development in structural and irrigation systems. Sri Lanka has been home to creative architects and designers for centuries, a fact that the country's ancient irrigation systems, can attest to. This island nation has a monsoon based tropical climate, which is primarily governed by rainfall and humidity, are thoroughly considered when developing irrigation patterns. For plantation purposes, pipelines are often used, and is a major component in vertical garden systems. Considering vertical garden through climatic landscape technology and cost of procedure, this research attempts to explore how different green wall types respond to the Sri Lankan climate, with reference to its basic structural design systems used. The entire process was carried out through the help of RAYMAN software, which was checked by sample testing using a similar type of building within the University of Moratuwa Sri Lanka, University of Wayamba and the University of Jaffna, followed by an analysis of qualitative research methodology, thus based on its simulation, research will conclude that Green facades are more suitable than Living Walls in the Sri Lankan Context.

Keywords: *Green facades, Traditional living wall, Creative structure*

1. Introduction

1.1 RESEARCH BACKGROUND

In a global context, the idea of green and ecofriendly systems is facing an evolution within the fields of architecture and design. As professional of these respective fields, individuals need to think about the environment and eco-friendly design factors when making interventions in the built environment, which has led to the inclusion of green wall or vertical garden into design concepts, causing rapid transformations in structural and irrigation systems. Although blessed with abundant creativity in ancient technology, now lost, is where some of most efficient irrigation systems found in the ancient world are found. Our climatic conditions are also sound for agriculture and plantation, but we seldom find the concept of green walls incorporated into design by architects or designers in Sri Lanka, which leads to the question if issues in irrigation systems and planting material are to cause this lack of incorporation.

Sri Lanka has a tropical climate, which has seasonal monsoon rainfall, so considering irrigation patterns with respect to climatic conditions is a must. For this reason, progress pipelines are often used, and is also a major component in vertical gardens, considering the overall process, climatic landscape technology and cost of procedure.

This research is about what plants grow in green walls in the Sri Lankan context, how irrigation suits for those plants, what are the structures already developed among the world and its availability in the Sri Lankan context. In analysis of structural design, research about types of green wall and which of them are used in Sri Lanka and availability of material and techniques. (Newman, p. & Matan, A. (ed). (2013))

1.2 RESEARCH QUESTIONS

The research revolves around questioning the methods and design elements of a green wall structure or vertical garden structure in high rise buildings, specifically questioning on the used Structural systems, if and whether they are suitable for the climatic conditions of Sri Lanka, or are they yet another system copied with no regard to the climate locale. The research also questions the effects of the surrounding and indoor environments with immediate contact of vertical gardens in high rise buildings. In conclusion, all the questions above should be able to answer the question of which methods are suitable for vertical garden methods and irrigation technology which is compatible with the Sri Lankan context.

2. Identification of Green wall for Energy Saving

This chapter focuses on the important factors to be considered in Green wall construction by analyzing of the structural system, irrigation impotency and planting material influences. It's content will cover, types of facades available, detailing about façade types and therefore, will be discussing theories and rules applied for green wall techniques. Regulation and rules for building wall ratio also will be discussed in this chapter.

2.1 THE IMPORTANT FACTORS TO BE CONSIDERED IN GREEN WALL CONSTRUCTION

2.1.1 Structural system
Basic structural design primarily considers construction method or characterizing. There are two basic categories.
Green Facade
Living Walls

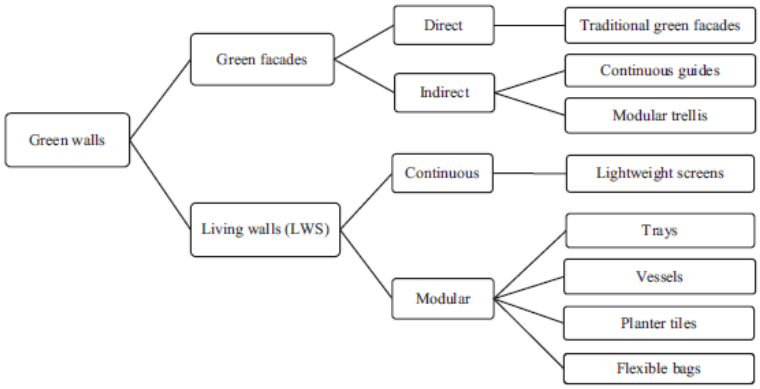

Figure 1 – Classification of Green Walls, in accordance with construction characteristic
(Source: Maria Manso, João Castro-Gomes. (2015).*)*

"Traditional or direct green facades usually have no support structure. They rely on the capacity of climbing plants to attach themselves to the vertical surface. However, when the vegetation fulfils full coverage can become too heavy and the risk of falling is increased."

(Maria Manso, João Castro-Gomes. (2015))

2.2 DIFFERENT TYPES OF FACADES AND THEIR USES FOR GREEN WALL IN SRI LANKA AND THE WORLD

2.1.2 Metal mesh green wall
"A metal Mesh Green wall uses a tightly intertwined grid of aluminum or light weight steel, usually attached to the façade via brackets. Plant typically grow from planters or troughs strategically positioned throughout the Hight of the wall."

(Gabriel Pérez, Julià Coma, Ingrid Martorell, Luisa F. Cabeza. (2014)).

With the above statement, we can identify that a wall partially or completely covered with greenery that includes growing medium like soil, water or other substrate materials, includes an integrated water delivery system.

The metal mesh green wall system provides an eco-friendly living wall system for design and construction professionals. It also has ability to transform space, which changes facades by creating an environment.

2.1.3 Cable Mesh Green Wall
"This type of green façade uses flexible cables that are used to support plants in irregularly shaped and wide span installation."

(Gabriel Pérez, JuliàComa, IngridMartorell, LuisaF.Cabeza. (2014)).

This type is more flexible than the previous, where its basic structure is a cable mesh.

2.1.4 Rigid Green Wall
"This system can utilize two and three dimensioned trellises that can be attached to a wall substrate, build around columns, or can be free – standing".
(Gabriel Pérez, JuliàComa, IngridMartorell, LuisaF.Cabeza. (2014)).

2.1.5 Vegetation mat Living Wall
This has a rigid substratum attached with a fabric layer where the grown plants are interposed into the holes cut, as they can establish their root system in the soil layers which facilitates the growing medium.

2.1.6 Hanging pocket Living Wall
This consists of hanging pockets which bring up the whole structure of this type of green wall. In order to prevent the plants, form oversaturation, the shells are vented to contain excess moisture.

2.1.7 Modular Living Wall
Modular living wall is structured by plants, planting boxes which are built on a vertical surface of a building. The plant box consists of growth medium and supply in a way that's replaceable. Continuous living walls are known as Vertical Gardens. The continuous living walls combine many modular living walls together.

3. Research Design

This research aims to clarify human assisted adaptation towards the hot humid outdoor and with the applicability of the universal thermal climate index, which forecast the thermal comfort votes in urban areas. UTCI (Universal Thermal Climate Index) would be able to reflect the impact on thermal comfort by urban geometry (H/W Ratio, SVF -Sky view factor-) which are outlined by surrounding factors. And the simulating outcome from RAYMAN for selected sites and discussed deviation with manually measured ratio.

3.1 REASEARCH FLOW CHART

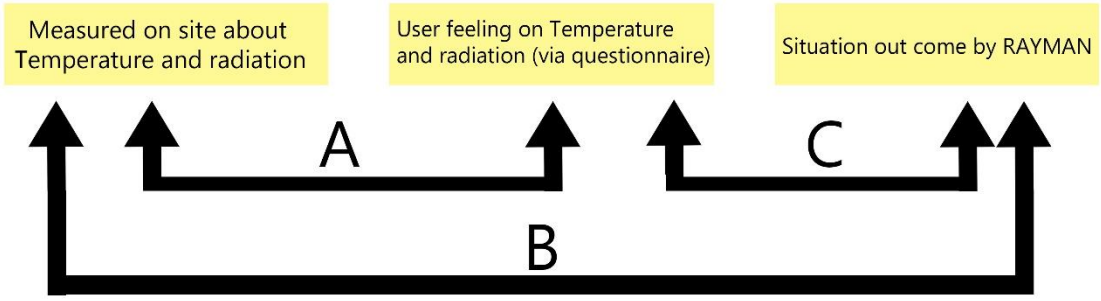

Figure 2 – Research Flow Chart (Source – Authors' Collection)

Research will be conducted in accordance to three major functions.

A – Comparing measured on-site data on temperature and radiation, with user feeling on temperature and radiation (Via – questionnaire),

B- Comparing measured on-site data about temperature and radiation and situation outcome by RAYMAN".

C-The conclusion.

3.2 SELECTING BUILDING DATA FOR COLLECTING
For collecting primary data, three local universities were selected, based on their location, with reference to climatic zones.

3.2.1 Climate Zone

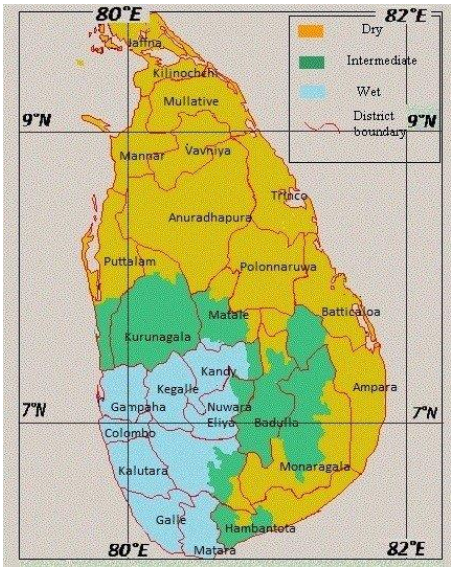

Figure 3 - Map of Sri Lanka, Climatic Zones (dry, intermediate and wet zones) of Sri Lanka, arbitrarily demarcated based on the annual rainfall.
(Source - :https://www.researchgate.net/publication/260252714_On_the_road_to_eliminate_malaria_in_Sri_Lanka_Lessons_from_history_challenges_gaps_in_knowledge_and_research_needs)

3.2.2 Selected universities for data collecting
For this study there are three buildings were selected. Each buildings from each climate zones.

- University of Moratuwa (Wet Zone)
- University of Wayamba (Intermediate Zone)
- University of Jaffna (Dry Zone)

3.3 ONSITE DATA MEARSUREMENTS

Figure 4 - Building Canyon at UoM selected building (Source: Authors' Collection)

Figure 5 - Building Canyon at UoM Selected Building (Source: Authors' Collection)

Figure 6 - Building Canyon at UoW Selected building (Source: Authors' Collection

Figure 7 - Buidling Canyon at UoJ Selected Building (Source: Authors' Collection)

The experimental research was conducted in an open space and a building canyon in the University of Moratuwa, the University of Wayamba, and University of Jaffna, covering areas of outdoor of the building and building canyons of brick buildings, with relevance to the study.

Before commencing experiment, a pilot study was conducted in a open space of the university, the vintage pro 02 weather station was identified and familiarized in order to extract information during this time, as well as how to handle equipment, extract data, setting of equipment, set the environment, and leveling of weather station. Participant questionnaires were also distributed which lead to identifying problems that subsequently effect the final experiment, and thereby avoiding any such behaviors that would tamper ability of conducting a reasonable experiment.

3.4 MODELING: BASE CASE USING RAYMAN SOFTWARE

Many climatic parameters and conditions were affected in their temporal spatial behavior by the natural and artificial morphology on macro and micro levels. These effects are therefore important in different levels of regional and a variety of other applications. (*Matzarakis 2001, Matzarakis et al ,2007 ,2010*).
As an example, the thermal outputs from the human body has a great deal of application in bioclimatology and applied climatology, standard climate data, such as air temperature, humidity and wind speed, and is needed to calculate and quantify thermal bioclimatic conditions. (Hoppe 1999, Matzarakis et al 1999). One of the most important environmental parameters used to derive modern thermal indices, however, are short and long wave radiation (and the derived mean radiant temperature). There can be determined using special techniques that have been developed for urban climate studies, with a broader use in applied climatology. (Matzarakis et al 1999, Matzarakis, 2008).

3.5 SIMULATING OUTCOME BY AUTHOR AND RAYMAN ON UNIVERSITY OF MORATUWA.

Table 1 - Simulating outcome by Author and RAYMAN software on University of Moratuwa (Source: Author's Animation Creation)

Date	15.07.2019			(By Measurement (Indoor)) Gact	(By software (Indoor)) Gact
Place	University of Moratuwa				
Time	Air Temperature	Rel. Humidity	Wind Velocity		
8:00	26	85	12	25	26
9:00	28	76	15	36	34
10:00	29	72	16	43	43
11:00	29	69	17	42	45
12:00	29	70	16	46	46
13:00	29	71	15	45	45
14:00	29	72	15	43	42
15:00	28	72	15	34	36
16:00	28	76	15	25	27

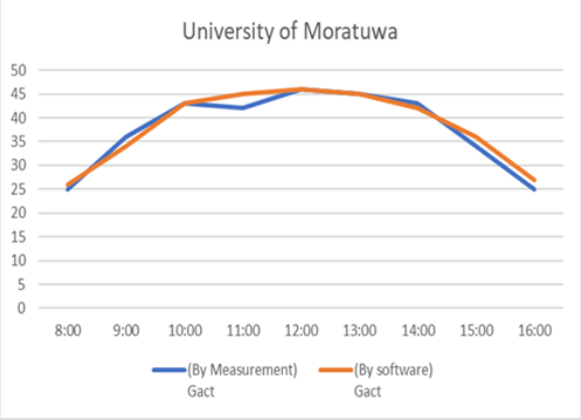

Figure 8 - Simulating outcome by Author and RAYMAN software on University of Moratuwa (Source: Author's Animation Creation)

Table 2 - Simulating outcome by Author and RAYMAN software on University of Wayamba

Date	15.07.2019			(By Measurement (Indoor)) Gact	(By (Software)(Indoor)) Gact
Place	University of Wayamba				
Time	Air Temperature	Rel. Humidity	Wind Velocity		
8:00	26	66	8	25	26
9:00	27	61	10	36	34
10:00	28	56	12	42	43
11:00	30	51	13	44	45
12:00	30	52	13	46	46
13:00	30	52	13	45	45
14:00	30	53	13	45	42
15:00	29	57	122	36	36
16:00	28	57	10	25	27

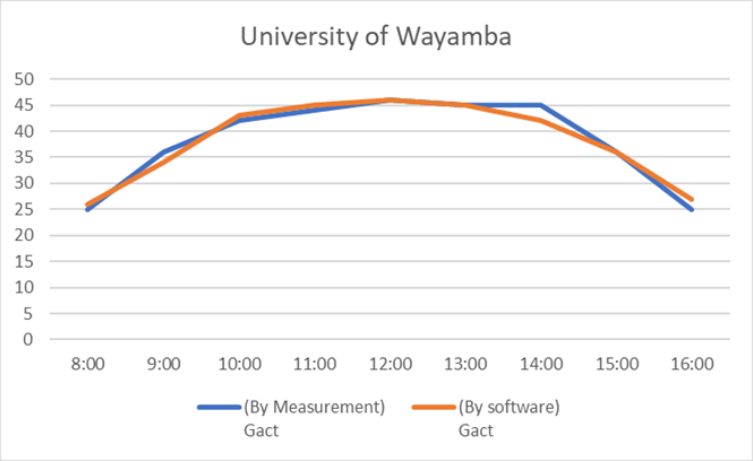

Figure 9 - Simulating outcome by Author and RAYMAN software on University of Wayamba
(Source: Author's Animation Creation)

3.6 SIMULATING OUTCOME BY AUTHOR AND RAYMAN SOFTWARE ON UNIVERISTY OF JAFFNA

Table 3 - Simulating outcome by Author and RAYMAN software on University of Jaffna (Source: Author's Animation Creation)

Date	15.07.2019			(By Measurement (Indoor)) Gact	(By software (Indoor)) Gact
Place	University of Jaffna				
Time	Air Temperature	Rel. Humidity	Wind Velocity		
8:00	26	66	14	25	26
9:00	28	80	28	36	34
10:00	28	56	32	42	43
11:00	30	51	29	44	45
12:00	30	52	26	46	46
13:00	30	52	28	45	45
14:00	30	53	27	42	42
15:00	29	57	28	36	36
16:00	28	57	16	25	27

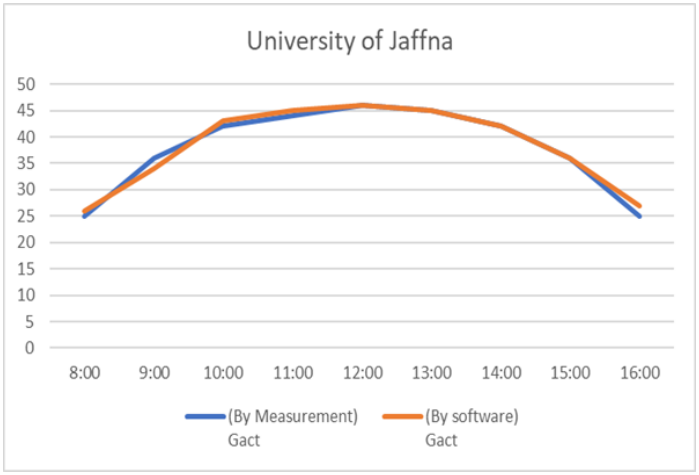

Figure 10 - Simulating outcome by Author and RAYMAN software on University of Jaffna (Source: Author's Animation Creation)

4. Analysis

4.1 INTRODUCTION
According to the data simulation on wet zone based on Green Facades and living walls. Simulations will be presented considering air temperature, relative humidity, and wind velocity during the lapped time. Similar reading will be result of the living wall structures as well. Finally, the results will be analyzed considering both the above-mentioned scenarios.

4.2 SIMULATION ON GREEN FAÇADE AND LIVING WALLS.
According to the discussion on 2.1, Manso M. and Castro-Gomes J. divides green walls into two major parts

- Green Facades
- Living wall

Therefore, this chapter will be mainly based on Green Facades and Living wall.

4.2.1 Simulating on Wet Zone
"As more than half of the world`s population resides in cities, where the neutral environment is being substitute for manmade"

(Woods, A., Bahrami, P., & Safarik, D. (2014))

Green walls are mainly constructed in the most polluted zones of an urban area, therefore, I have based the first simulation on the wet zone of Sri Lanka, with the chosen case study in close proximity to Colombo, the most populated and high in pollution city in the Sri Lankan context

4.2.2 Simulating on Green Façade

Table 4 - Simulation on Green Façade (Source: Authors creation)

Date	15.07.2019			Gact (Green Facades)
Zone	Wet zone			
Time	Air Temperature	Rel. Humidity	Wind Velocity	
8:00	26	85	12	23
9:00	28	76	15	32
10:00	29	72	16	38
11:00	29	69	17	40
12:00	29	70	16	42

13:00	29	71	15	44
14:00	29	72	15	41
15:00	28	72	15	34
16:00	28	76	15	24

4.2.3 Simulating on Living Wall

Table 5 - Simulation on Living wall (Source: Authors creation)

Date	15.07.2019			Gact (Living Wall)
Zone	Wet zone			
Time	Air Temperature	Rel. Humidity	Wind Velocity	
8:00	26	85	12	24
9:00	28	76	15	32
10:00	29	72	16	39
11:00	29	69	17	41
12:00	29	70	16	43
13:00	29	71	15	45
14:00	29	72	15	42
15:00	28	72	15	36
16:00	28	76	15	26

4.2.4 Comparing Green Wall with and without Green Wall building interior radiation

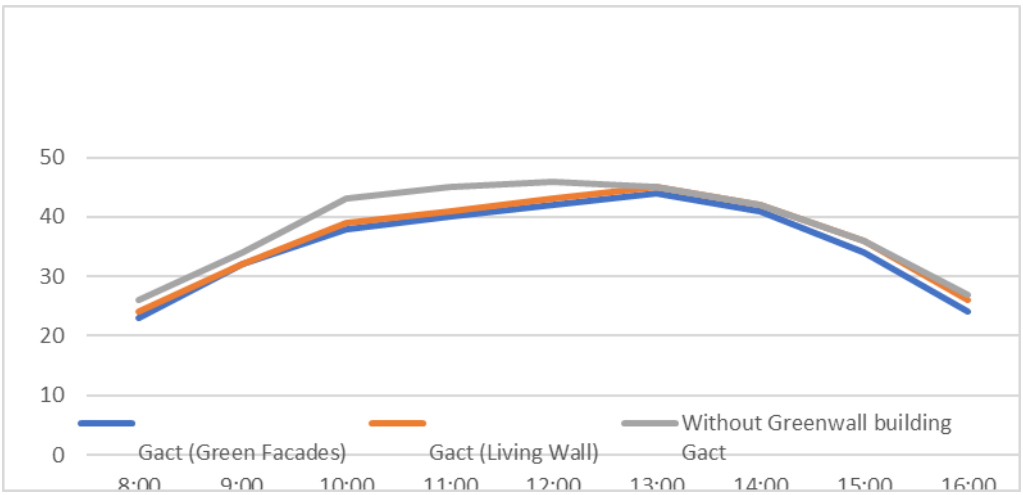

Figure 11 - Comparing Green wall and without Green wall building interior radiation (Source: Authors creation)

5. Conclusion and Recommendation

There are three types of climate zones in the Sri Lanka. The green wall is mainly structured in wet zone. For that this research is mainly based on wet zone. As mentioned above, for this research is took three state universities on three climate zone. There for measured indoor and outdoor temperature and global radiation with user experience how they feel the climate. And computerized simulation also done with those selected sites. Then the outcome of computerizing is manual calculation is mostly similar. Because of that for this research final simulation is done by computerized software.

There are three types of climatic zones in Sri Lanka, where green walls are mainly constructed in the wet zone. For that this research is mainly based on the wet zone. As mentioned above, this research observed three state universities within three climatic zones, measuring indoor, outdoor temperatures and global radiation with user experience, how they felt the climate.

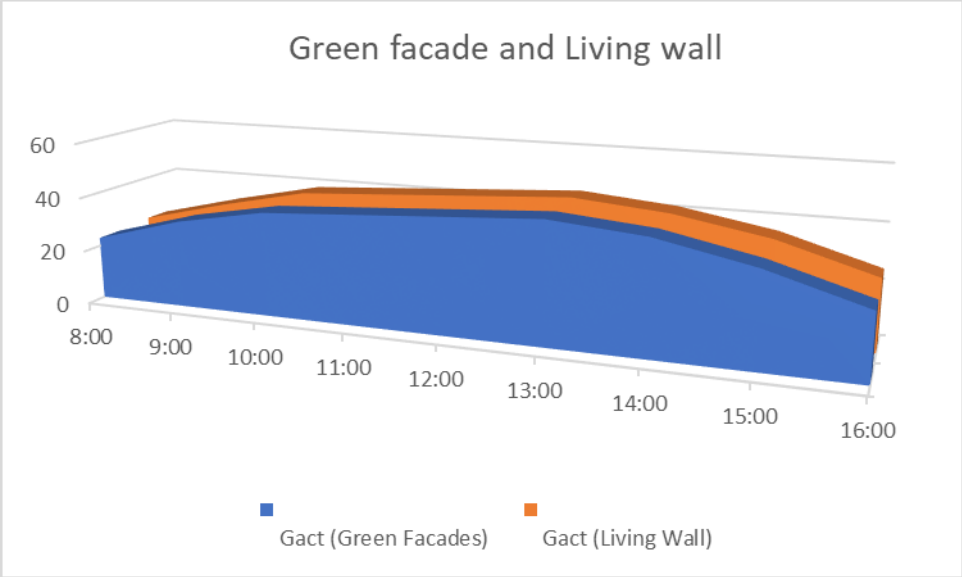

Figure 12 - Comparing Green face building and living wall building interior radiation

computerized simulation was also conducted in the selected areas. selected areas.
As the outcome of the computerized simulation and manual calculations were mostly similar, and for this reason, the final simulation for the research was done only with the aid of computerized software. The readings of the RAYMAN software simulation has been charted in figure 11 shown above. According to the graph, Green façade and living walls give far better results than buildings with no green wall. Therefore, it can be included that reach the conclusion that Green facades are better for the reduction of radiation penetrating brick walls and maintaining better indoor climates.

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EXPLORING GENDER DIFFERENCES IN STUDENTS' SATISFACTION WITH HOSTELS IN HIGHER EDUCATION INSTITUTION CAMPUSES IN INDIA
Are we designing considering students could be girls?

AKSHYA SINGHVI[1] & NEERAJ GUPTA[2]

[1] Team Architects, Jaipur, Rajasthan, India

[2]Central University, Kishangarh, Rajasthan, India

[1]*akshyasinghvi@gmail.com,* [2]*ng@curaj.ac.in*

Abstract

Students' hostels are an essential component of higher education campuses where students come from far off places. The design quality of hostel buildings, public spaces and various amenities play an important role in students' satisfaction with the educational institution. This has a direct and indirect impact on the quality of the teaching-learning process. With the emergence of private sector higher education campuses, there is an emphasis on the quality of hostels to attract the students. However, the design of hostels continues to follow the 'gender-neutral' approach. The only difference in the hostels for boys and girls are the design of wash rooms. This paper presents the results of the assessment of gender differences in student's satisfaction with the hostels in higher education campuses in India. Five educational campuses catering to different disciplines are chosen and data was gathered through the use of questionnaire administered to 176 students selected through random sampling. The study revealed that there are subtle but important differences in the requirements of boys and girls in terms of thermal comfort, privacy, public spaces, wash rooms, and the spatial distribution of facilities, etc. The results of this study provide a possible direction to architects and management of educational institutions to adopt a gender-sensitive approach while planning and designing of hostels and related facilities.

Keywords: *Gender, Hostels, Design, Students' satisfaction*

1. Introduction

Hostels are very important component of higher educational campuses and greatly impact student's liveability, academic performance and overall development. However, students who are the real users are not involved in the design and development process. All decisions are based on perceptions of the top management, campus development team, architects and other consultants. With men dominating the decision-making process, the so-called gender-neutral designs are often biased towards men. Thus, girls end up compromising with the buildings and facilities designed for boys. As proper facilities sensitive to women's needs are missing in most of the public buildings in India, the girls have become conditioned to accept the design anomalies as normal. At times, such situation may lead to dissatisfaction that may hamper their studies. Thus, there is a felt need to understand the subtle but important differences in men's and women's physical, psychological and cultural requirements and develop truly gender sensitive designs. This paper explores gender differences in the level of satisfaction with the design of hostels in higher educational campuses in India and suggests a few parameters which could be considered by the designers, campus developers and decision-making authorities while designing and developing the hostels.

Authors' experience of designing and managing educational campuses, backed with literature studies and semi structured interviews with women architects helped in developing a list of functional requirements specific to girl students. This was used to develop a survey questionnaire that was administered to girl students of five higher educational institutes of different disciplines. These covered institutes of Management, Architecture, Science, Liberal Arts and Law. The sample included girl students ranging from an age group of 18 to 28 and spread in educational profile ranging from under-graduate to post-graduate level.

The questions were designed to understand the usage pattern of girl students of spaces in an academic institute. The spaces of varied uses like academic classrooms, hostel rooms, mess, toilets, outdoor spillouts etc. were considered. The survey was done both in the form of written documented

questionnaires and spoken interviews. We also spoke with a few college administrators to understand the concerns further.

Need for Gender Sensitive Designs

The need for gender sensitive approach to design is best reflected by the in the initial designs of seat belts for cars in 1960s. The vehicular test crash protocols used dummies modelled on male anthropometrics. This resulted in creating seat belts that made women more vulnerable. In case of car crash female drivers were 47 per cent more likely to be seriously injured. (Reiley, 2016)

In order to capture larger consumer base, designs of web pages and products are moving towards gender neutral approach. In case of planning and design of public buildings, neighbourhoods and infrastructure also, a gender-neutral approach is adopted. (IGNOU, 2018) For women specific products there are a conscious effort by designers to create designs that would serve women's needs. However, when it comes to design of buildings like hostels specifically meant for women, there is little effort to understand women's functional and psychological needs. One of the evident reasons for such lack of sensitivity is the dominance of men in the world of architecture and planning. (Friedman, 2010)

The sensitivity to women's needs is missing even in the most developed nations. A survey conducted in Stockholm in 2019, by Tryggare Sverige Foundation shows that the public toilets are not designed to meet women's needs. (Reiley, 2016)

In Indian context the requirements of women are quite different from that of western culture. Most obvious and visible difference is the dress. These differences become more noticeable in tier two cities and towns. During informal conversation while researching for this paper, head of an institution expressed anguish that even the modern airport lounges are not designed to cater to women wearing Indian dresses. (Rohemtera, 2019) During interview with women architects, all agreed that when designing and detailing the buildings scant attention is paid to subtle details that are important for women.

A study by the City University of New York has established that men and women see the world differently and have distinct design preferences. (Striking Gender Differences in Modern Interior Design and Decorating for Guys and Girls 2015) Speaking of the design preferences, Men like solid design, functional furniture, strong contrasts and comfortable colours, deep tones, like rich red wine colours burgundy and Beaujolais, forest green, navy, black and brown. Leather, wood and heavy fabrics are their favourite materials that manifest strength and comfort which is quite in contrast with the preferences of women.

It has been observed that females prefer the use both natural & industrial ventilation More than males who prefer natural ventilation. That may be associated to larger size of Hypothalamus which is 2.5 times bigger in males than females. (Fuster, 1998) The scientists have found that in most cases women demonstrate higher sensitivity to smell, sound and colour than men. (Ibrahimagic, et al., 2006). They found that boys needed a little long wavelength colours to see the same colours as the girls. It means that women enjoy monochromatic colour schemes and interior decorating ideas for women should include rich colour palette with more than one colour. Men are unable to describe the small differences in colour shades. (Feingold, 1994)

In terms of physiological systems, since the centre of gravity is lower in women than in men, women have lower balancing strength than the men. (Stander n.d.) Differences in intake and delivery of oxygen translate into some aspects of performance besides Female lung capacity is about 30 percent less than in males: when a man is jogging at about 50% of his capacity, a woman will need to work at over 70% of her capacity to keep up with him. (Ritchie, 2017)

The points stated above clearly establishes the difference between the requirements of men and women, but still we continue to design gender neutral designs. Wherein, the "average male" is used for design

prototyping although there are biological differences between men and women that result in different ergonomic needs and comforts. (Friedman, 2010)

Therefore, making design for male's room has to definitely differ from room design for female in all elements of interior design, and in colours, forms and lightening and the interior designer should achieve the gender specific requirements. taking into account anatomical, physiological and psychological differences between the two genders. (Nimako & Bondinuba, 2012)

Importance of hostels in academic life

Almost every parent feels that a hostel life will be safe and more protective for their child. The supervised atmosphere combined with the strict regimen almost resembles the way parents perceive their kids at home. (FLORES Ğ GONZALEZ, 2005) Apart from this, many colleges make it mandatory for students to live on campus in their hostel. There is a general notion that students who live in decent housing units within or around their university have a better chance of exceling academically. (Garland, 2017)

Numerous studies as conducted by Clinical and Counselling Psychology Department, Kinnaird College have also indicated that instead of having a positive impact on a student, a hostel like could adversely affect their overall development, if hostels are not properly aligned to meet the requirements of habitants. (Iftikhar & Ajmal, 2016) It is important to note that girl students are forced to live in an environment which is not designed considering them but their male counterparts. (Mindoiola, 2010) (Nimako & Bondinuba, 2012) In order to establish our hypothesis that girl students are forced to adapt to male centric spaces against their level of comfort and satisfaction, we did a survey with randomly selected 176 students from 5 different educational institutes and results were revealing.

The selection of institutes was done to include students from different background, courses and age groups. The background factor was ensured by selecting institutes from different regional locations in the country which includes Rajasthan, Uttar Pradesh, Maharashtra and Kerala. Colleges selected included affiliated University, Architecture College, Government Undergraduate College, Management College and a Law University. Among the selected institutes, there were Post-graduate college, Undergraduate college and also an all-encompassing University. This helped us in ensuring a varied group of students consisting of different locations, courses and age-groups.

Importance of students' hostel in academia

Based on our interviews and survey with students and academic administration teams of different institutes, it was established that quality and facilities at hostels do impact the selection of institute; to the tune that students while selecting their management college did give preferences to institutes having air-conditioned hostel. (NIUA-CIDCO Smart City Lab, 2019) The students believe that comfort conditions help them study and prepare better for their classes and tests. Therefore, it becomes pertinent to establish that if hostels are duly designed considering the due importance to gender specific design, it will result in spaces which are more conducive and would help them perform better in academics which will have a direct impact on their placements.

As per the findings of Mansoor and Ali, there is statistical evidence to claim that there is a relationship between Hostel Students' Satisfaction and its Academic Performance and the level of Hostel Students' Satisfaction in the universities is moderate implying that its greater degree of improvements is needed to reach the level of very high. (Mansoor & Ali, 2015)

Thus, if one group of students is put in more stressful conditions than the other in an academic institute, it could lead to an underperformance of that group. ***It is important to realize that we constantly put our girl students under such pressure in all the gender-insensitive designs.*** (Daniel, 2013)

2. Gender Neutral Design

Design of hostels

As designers of the built environment, we are invested in the idea that our design interventions will help to positively shape and link relationships to one another and its importance reaches to an altogether different level when we deal with designs of academic institutes wherein hostels are the home that the students have for their 3-5 years in institutes.

Architects are known to design hostels which are generic in nature, and could easily accommodate male or female students and it has now led to a gender-neutral building typology design system for hostels. (Rohemtera, 2019) (Feingold, 1994) The prime criteria considered for hostel design are:

a) Occupancy to be considered in each room
b) Attached or clustered toilets
c) Air-conditioning to be provided in the room
d) Clustered facilities
e) Leisure activities

All these points, consider the standard proportions of male bodies thereby skewing the design against the requirement and needs of the girls. As established earlier, the requirements and abilities of men and women is inherently different and things comfortable and experienced by men cannot be generalized for women as well. (Student Accommod8, 2018)

Gender inequality in design parameters is a universally accepted challenge wherein we still lack in having appropriate standards which consider women as prototype. (Kalms & Korsmeyer, 2017) Addressing gender inequality is ranked universally high on the global agenda. (Pothukuchi, n.d.)

Differences between gender hostels

As recorded, the major difference in the design of boys and girls' hostels was the absence of urinals in the girl's toilet, apart from skewed entrance-exit timings for girls' students. (Oluwaseyi, 2015) (Stander, 2017)

3. Research Results

The research was conducted using multiple surveys and was based to understand the level of satisfaction that the students had with the prime requirements of their hostel life and it had a quite insightful result which is as shared below:

- The architects give no importance to the requirements of girls even while designing exclusive toilets for girls. Around 72% of the girls felt that there is no appropriate space in the toilets to meet their mandatory requirements, things as important as dustbins are not suitably placed in the toilets forcing them to carry undesirable items with them to their rooms. Also, the space is small and not appropriately planned to let them carry their set of clothing.

- Similar to the boys, girls were expected to carry their luggage to the upper floors. There is no design provision made in the girls' hostel to let them carry their luggage conveniently. More than 60% of the girls expressed their helplessness in being able to move their luggage, they told either they had to request the sweepers or the boys of their class, establishing a prior dominance over them and leading to a constant sense of helplessness.

- 95% of the girls expressed that there is a mandatory need of a full-length mirror in the hostels considering the numerous conferences, placement sessions, feast or cultural events taking place in colleges and more than 60% of them recorded an absence of it. They also said, they see no space available in the hostel where it could be easily installed. It leaves them with an unwanted

consciousness in spite of them being dressed for the occasion. Things like this, unwantedly impact the girl students and give the boys an unseen upper hand in their level of confidence.

- 2 of every 5 students surveyed, told that the design of storage cupboards is poor and they were high unsatisfied with the organizers provided in the students' hostel.
- The centralised air-conditioned spaces have a temperature adjusted wherein the girls don't feel comfortable, as recorded by more than 70% of the students. They said that there was no option for them to change the temperature and were forced to feel comfortable in the uncomfortable surroundings.
- As per the survey, around half of the girls cannot comfortably close the latch of their room or washroom doors. Also, to add to it 1 out of every 5 girls surveyed cannot even access the top latch of the door comfortably, every three out of 5 girls cannot adjust the shower head. They also said that they couldn't use their hair-dryers and other accessories in the washrooms owing to the absence of the plug-points in the toilets.
- Sometimes, because of the design negligence of the hostel, workers can easily peep inside the hostel room and washroom block, creating an unsafe environment for the girls. This problem was felt by every 2 of 5 girls as per the survey.
- Due to the insecure environment, the university campus girls are often forced to stay inside their rooms from late evening onwards which is different than the timings allowed for their male counterparts, as told to us by more than 65% of the grils. (Kneeshaw, 2018)
- There are absolutely very few high heel friendly spaces in campus. The presence of cow catchers etc make it absolutely impossible for them to wear a footwear of their choice. It was put forth by more than half the girls surveyed.
- Around 80% of the girls surveyed, expressed that they found spaces boring, depressing or dominating, a few of them expressed that it is owing to the colours and materials used in the design.

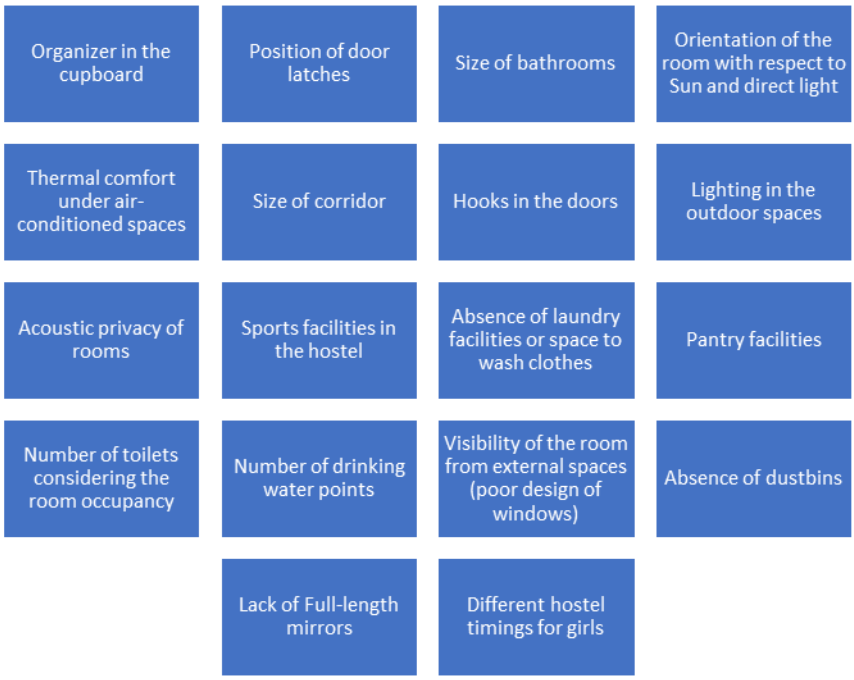
We would like to bring it to the notice of our readers that the survey findings were found to be consistent among different institutes. It was also noted that the students in post-graduate courses had started to accept the findings as the reality of life, wherein they suspect they would have to adjust with male-centric spaces throughout their life and they should accept the fact without any protest whereas the younger students were more vocal with their discomfort and unbalanced design.

Architects

Students of architecture are made to look at issues like climate, orientation, universal design etc. however, the aspects of gender are missed while discussing the design principles, resulting in insensitive architects. When we spoke to 5 design firms of national repute who participated in an academic college design competition (a national level competition for design of one of the most reputed brands of academic institute), all the five firms admitted that there has been no special consideration made for gender sensitive architecture. Their designs didn't pay any form of attention to the requirement of the girls, in fact none of them even initially realized that this is any form of a negligence from their side. They expressed that they were never made to realize that there could be different form of requirement of the girl students. (Mansoor & Ali, 2015)

4. Analysis of Results

The girls have found discomfort in the following parameters:



From the analysis of the survey it is found that till now no special consideration are taken into practice for designing Girls Hostel. However, it is very clear that the housing requirement for a female Is quite different than that of male's and as here we are talking about Girls

Difference in requirements of boys and girls
Gender based designs is about creating spaces that respond equally to men and women. However, women experience spaces differently, and meeting women's needs also are equally important while promoting sustainable development.

The most widely adopted model of personality is the Five Factor Model (FFM), whose five domains are known as the Big Five: neuroticism (negative emotionality and emotional instability), agreeableness (altruism and cooperation), conscientiousness (self-control, self-discipline, and organization), extraversion (sociability, assertiveness, and positive emotionality), and openness (imagination, intellectual curiosity, and aesthetic appreciation). If these five points are considered while attempting the design for girls' exclusive spaces, the resulting designs would be more sensitive to the requirements of the girls. (Karlqvist & Gard, 2012)

5. Conclusion

In order for architects, educational administrator and policy makers to understand the differences in the way girls and boys experience the built environment and public spaces of educational campuses there is need for more awareness and training. This requires back up of well researched evidence of specific challenges that a girl student faces.

Direction for architects

While doing the research, we came across a set of interventions that had taken place in Vienna over a period of 25 years and it has set the city as an exemplar city for gender sensitive urban planning. The environment for women is safer in the city and facilities are more accessible. (URBACT, 2019)
Our survey also concluded that the requirement of girls is different than boys, therefore after the study of different interventions and our research, we have come up with the following considerations:

- As discussed earlier the difference in Anthropometric standards should be taken into consideration. The cabinets or cupboards should be designed in such a fashion so that each corner of it can be easily accessible.

- The interior design of space should be aligned with colours and materials which improve the satisfaction and performance of women. (Hallock, 2003) The standard practice of the choice of texture is aligned with male sex and is still quite insensitive to the requirements of women.
- As the average height of the female is recorded as 5' 4" so the door latch should be placed accordingly. If it is undesirable to decrease the height of the door the door latch can be placed at a suitable height on the side stile. (Mindoiola, 2010)
- Washrooms / toilets can be furnished with small lockers to meet the storage requirements or appropriate hooks or niches could be provided within the spaces in the toilets.
- To match the thermal comfort level of the occupant, a regulator should be provided in each room so that the occupants can easily regulator adjust the temperature or the temperature should be adjusted to match the requirements of girls which is 2 degrees higher than men.
- As safety is a big consideration in girls' hostel, the building should be design keeping in mind that the privacy of the girls should not be hampered due to the presence of any male worker inside the hostel.
- The pathways towards all the public gathering space must kept lit up all the time or all the public gathering spaces should be design to ensure the safety of students. (Velarde, 2018)
- The public gathering spaces must be design in such a fashion that the area is visible from all the security points. All the gathering points should be lit up by ample amount of lights.
- The electrical sockets should be provided in the toilets for the use of hair-dryers and other cosmetic accessories that they might want to use them. Also, there should be space for the placement of such items.
- Study of Anthropometrics should incorporate differential spatial behaviours and needs by men and women in a particular area and community. (West, 2018)

Requirement of Gender sensitive approach

It was the lack of emotion and lack of intimacy that Eileen Gray decried in modernism is 1929, 'Modern designers have exaggerated the technological side… Intimacy is gone, Atmosphere is gone… Formulas are nothing, Life is everything, and life is mind and heart at the same time. (Mahimkar & Gokhale, 2014) (Mansoor & Ali, 2015)

The insensitive designs impact both the mind and heart of one of the genders, thereby impacting performance of half of our population thus causing massive underperformance as a society.

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USE OF ARCHITECTURE IN DEMONSTRATING POLITICAL POWER IN POST-CONFICT COLOMBO

KATUGAHA B.H.M.R.I.[1] & BOTEJUE W.P.S.[2]
[1,2]University of Moratuwa, Colombo, Sri Lanka
[1]*rik.2062@gmail.com*

Abstract
Architecture and political power have associated each other throughout the history. Architecture has the ability to 'frame' space and thereby structure actions and construct meaning. The study intended to research upon the nexus between architecture and political power by investigating 'how' architecture demonstrate political power and 'what' they intend to mean, thereby influence and frame the usage of space by people. A theoretical framework was established at the beginning. Studying the context and international examples were studied. The case study was is post-conflict Colombo (2009-2015) which was analysed with evidences gathered through interviews, reports, newspapers, magazines and many more. The study was broad and multi-disciplinary by its' nature. Hence, the research was carefully narrowing down without compromising its' very nature. Since the research was investigating into social-physical phenomena, the analysis was conducted in a narrative format, with the intention of describing it in holistic form. The study identifying key factors such as identities, symbolic representation of identities, change of context, projected imagery of public space and political ideology, aspirations were significant factors contributing subconscious of the public. These were achieved by means of building processes and built form either by design or by default are not deterministic or complete.

Keywords: *Power, Built form, Representation, Urban meaning, Identity*

1. Introduction

The study was on the use of architecture as to demonstrate political power in post-conflict Colombo. Architecture has always associated power and it has been used as tool in many ways to demonstrate political power throughout history in an attempt legitimise.

The research was similar to Interpretive Research where typically evidence is drawn from archival and artifactual sources. This was due to the fact that these types of research are primarily focuses on a setting or circumstance from the past. Imperative Researches are specifically investigating into social-physical phenomena within complex contexts. With a view toward describing and explaining those phenomena in a holistic narrative form (Groat & Wang, 2002).

Under third heading, Architecture and its power relations in the world are discussed first. Under architecture and political power in the world, international examples from different parts of the world representing different political ideologies belonging to different time periods in the recent history.

The data/evidences on case studies was collected, organized, evaluated and narrated in a circular process in the final part. The analysis was done under, Power in building process and Power in built form. It is very important to understand such clear distinction cannot be made between built form and process of building. It was done only with intention to conduct and elaborate the analysis in scientific manner. Data was collected through newspaper articles, journal articles, interviews with scholars, books, exhibition catalogues, photographs, drawings, websites, observations and etc. Interviews were conducted with Architects, Artists, Sociologists, Journalists and other scholars as a part of not only gathering information, yet as form of validating the gathered information. Reports published by Centre for Policy Alternatives and Centre for Poverty Analysis during the post-conflict period, are incorporated since they are published in public, debated publicly and covers a large number of people.

Short Term

(1) To demonstrate political power and what they mean in deeper sense in terms of cultural, psychological, social.
(2) Thereby, create a foundation in understanding nexus between architecture and urban design and

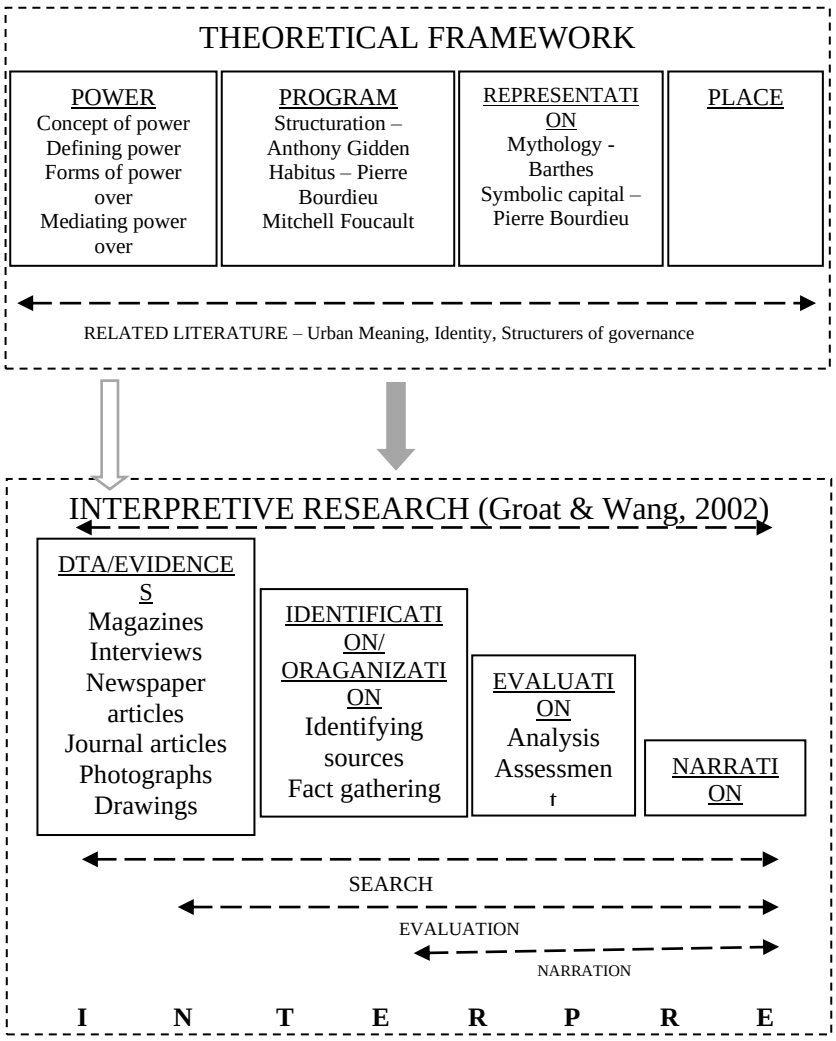
power by analysing a selected case study (Colombo).

Long Term

(1) It is important that as designers have an understanding on these, since it is the architects and urban designers themselves are the ones who has the capacity and academic training in creating the built environment. Therefore, this understanding is vital certain that in order for an architect to fulfil their role and responsibilities in the society.

(2) Setting up a foundation for further research on this field of study

(3) Thereby, contributing to the architectural discourse



2. Theoretical Framework

2.1. POWER

The word power is used and rather misused widely. It refers to a variety of different capacities. The potential danger in using this term word is that it can mean anything therefore nothing. The term 'power' derives from the Latin word potere, which means 'to be able' or the capacity to meet an end. Generally, in human affairs, power is control 'over' others. Isaac (1992) states that the distinction between 'power to' and 'power over' or in other words between power as capacity and as a relationship between people, is fundamental (Dovey, 2008). According to Rorty (as cited in Dovey, 2008, p.11) "Power is the ability…to define and control circumstances and events so that on can influence things to go in the direction of one's interest".

Everyday life experiences have seemingly given awareness of 'power over' while 'power to' is taken to granted. Therefore, this could be identified as an illusion which creates an opposition between power and emancipation.

The distinction between power over and power to is important. Power over is the power of one agent (an individual or a group) has over another. Power to ensure the compliance of the other with one's will. The distinctions between terms such as coercion, manipulation, force, authority and seduction are important. These forms rarely appear in isolation. In fact, often in a complex mix of them in architecture and urban design (Dovey, 2008).

There is a question whether exercise of power over is mostly transparent to its agent. Nietzsche says that civilized life is really a cover for an all-consuming 'will to power'. Machiavelli had said that all forms of legitimation are masks for the individual 'will'. Either self-deceit or hypocrisy is necessary to the effective pursuit of power, since naked 'will to power' cannot be legitimized as an end itself. Self-deceit is what Orwell terms as 'double think', where two contradictory beliefs are held within and thereby deliberately service one agenda while justifying it with the use of another. Self-deceit is important to the discourse of aesthetics (Dovey, 2008).

Powerful symbolic use of physical environment which is a form of political power (Vale, 1992) has a strong say in the political space. This is due to the capacity it poses to stabilize identity and symbolize a 'grounding' of authority in the landscape, nature and 'timeless' imagery. It is clear that architecture is called regularly to legitimate power in a crisis (Dovey, 2008).

2.2. PROGRAMME

There are three main social theories which would help to understand how the power is mediated through spatial planning and spatial practices. They are Theory of Structuration by Anthony Gidden, Habitus by Pierre Bourdieu and literature by Mitchell Foucault. Yet, at this point, the study will only touch upon only on certain parts which can be related to understand this nexus between architecture and political power, since these theories are vast bodies of knowledge which addresses a broad range of social phenomenon.

2.3. REPRESENTATION

This part of theoretical study is on representation will help to understand the ways in which ways the meanings of places are constructed in text. These theory systems are largely from social theory. The language is not a transparent medium and it is through the language that we view the world, rather the language is what construct the experiences (Dovey, 2008). The city is a discourse which is a language. The city would speaks to its citizens, we peak our city simply by living in it (Barthes, 1997). Concepts such as culture, identity, nature and community are social constructions. Therefore, the central role of agency is questioned. Human being as an agent is replaced by the 'subject' who is constructed and enmeshed in the discourse, through which meanings are communicated. The built environment is a major form of discourse just as speech, food or fashion. In this sense, power relations are naturally entangled with the discourse since the subjects are constructed with certain interests. It includes the interest of the state in maintaining social order and power; private interests in stimulating consumption; and dominant cultures, classes and groups interests in maintaining privileges. Desire, identity, fear and joy are created from representation and discourse., which would create oppositions between the normal and the deviant (Dovey, 2008). As Dovey (2008) say, the real becomes a social construction.

2.4. PLACE

'Place' can be viewed as an experiential phenomenon as opposed to 'space'. It is a location which is experienced as meaningful in a larger spatial context. The concept of 'place' is linked with terms such as identity, community, character, home which play major roles in everyday life. However, these are the terms which resonate in different scales from local to global; neighbourhood, city, region, nation and

global. Places construct and frame programs and representational narratives (Dovey, 2008).

3. Architecture and Political Power in The World

Architecture can be understood in different ways. When trying to understand transformation of cities and particular work of architecture created by the direct and indirect involvement of the state, it is vital to understand them in different dimensions of political point of views. One needs to understand them in terms of the political and cultural context that helped to bring these factions into power. Transformation of built environment needs to be studied and analysed parallel to the political structure of the state and its' evolution.

The built space is what we perceive, conceive and live (Lefebvre, 2003). Aristotle once said that man is a political creature. Therefore, the built environment or space is created and lived by the man is essentially political. The buildings and their contexts are symbols of political presence and economic power.

Having stated that, it is clear why political idols have closely associated architects and have been conscious on built environment throughout the history across the globe. Unlike any other forms of art Architecture is can be identified as the single most dominant instrument of demonstrating political power (Jameson, 1997)

The study of political power and architecture, there are quite a number of cities, monuments and contexts. The City Beautification Movement in Chicago, New Delhi, Berlin and Moscow during 1900-1945, is one such. The City Beautification movement had its origins in the nineteenth century which was on the promenades and boulevards in Europe. The two classic examples were the construction of Paris by Haussmann under Napoleon III and the construction of Vienna Ring Strasse. However, the twentieth century manifestation were seen in other parts of the world and cultures. One such was in western and middle America, where civic leaders wanted to overcome collective inferiority complex and boost business by building (verb). The other fine example was in British colonies, where British civil servants were commissioned to plan the newly designated capitals of the Empire, which were meant to express and showcase the imperial dominance and racial exclusiveness. Then again in 1930s, the city beautification came to its spiritual and geographic location; Europe. The totalitarian dictators who were largely interested in the powerful use symbolic use of physical environment (Vale, 1992), wanted to impose their megalomaniac vision of glory on their capital cities (Hall, 2001). As Hall (2001) suggests, there are strange similarities in the outcomes with disquieting implication, despite the superficially different contexts.

Figure 1, From L to R – Model of Germania, Cathedral of Light, Painting of Palace of Soviets, Painting of Chicago Center *(Sources: http://germanhistorydocs.ghi-dc.org , https://rarehistoricalphotos.com https://www.heritage-images.com, www.architecture.org)*

4. Conflict

The conflict had its' roots since the beginning of independence in 1948. The Ceylonese nationalism which led towards gaining independence from the colonial rule, took a form of ethno-nationalism especially after independence (it was evident from colonial rule). The three major ethnicities, the Sinhalese, Tamils and Muslims clinched on to their ethnic identities in the attempt build a national identity. Ethnic conflicts are much more powerful than other social conflicts such as on class and elite.

The ethnicity in the modern world is therefore a powerful source of conflict. Therefore, all communities are prone to social conflict. The political authority finds its legitimacy by the inherent ethnic composition of the country (Balasuriya, 2011).

The successive governments continue the British policy of divide and rule and the political leaderships on both ends kept on acting on ethnic lines since it was an effective method to win votes. Tamil politicians campaigned to racially unite their people while the Sinhalese politicians nursed the grievance bared by their people against the Tamils. The quest for national identity further deteriorated the relationship between the two ethnicities. Subsequently ethnic riots clashes and riots took place in 1956, 1961, 1977, 1979, 1981 and 1983. Constitution reformations too had a major impact to the conflict (Balasuriya, 2011). The conflict turned to an armed struggle between the state forces and the Tamil militant group, Liberation Tigers of Tamil Elam (LTTE) for three decades and was finally over in 2009 after the LTTE was militarily defeated.

5. Demonstration of Political Power in Post-Conflict Colombo-Case Study Analysis

"City is really about consolidation of power (Kostov, 1991), by a ruler, a political regime or the expression of economic power." (Powell, 2016, p.95)

Architecture has long roots in the broader quest for identity, power and legitimacy. Therefore, as Dovey (2008) writes, the question is never about whether these particular works of architecture and urban design partook symbolism, but the scale at which they did. Yet to determine that it is important to investigate on how it was done and what they intended to mean/ signify.

According to Lawrence Vale (1992), there forms of power by which power is evinced. They are a charismatic leadership, an indomitable military presence, and entrenched bureaucracy, imposing network of laws and status and the powerful symbolic use physical environment. The analysis will elaborate on the powerful symbolic use of the physical environment in post-conflict Colombo. In fact, it will make you aware that, these forms are intertwined.

5.1 CASE STUDY SELECTION

Key reasons to select post-conflict Colombo as the case study are,

1. Colombo has been the capital city Commercial Capital at present) since British Imperial Rule and post-independence Ceylon and it continues to be the center of attraction.
2. Governments over the years have shown keen interest in developing Colombo.
3. Post-conflict Colombo development was the most recently witnessed out of the different eras in Colombo development such as immediate post-independence (1948) phase, introduction of Republican constitution (1972) and the phase after the introduction of Executive Presidency and open economy (1978).

It is an extension of the post-conflict Colombo is still what we perceive, conceive and continue to live in this very instant.

According to the UDA, the transformation of Colombo had few phases under the Urban Regeneration Project (UPR), which accelerated both beautification and regeneration of the city (Rodrigo, 2014).

1. Waste management.
2. Beautifying Colombo, which in fact is kind of the larger picture behind all other phases.
3. Urban parks such as Viharamahadevi Park, Diyatha Uyana, Independence Square and Fort and roadside development (paving).
4. Renovation projects noticeably focused only on colonial architecture. The three main renovation projects were Dutch Hospital, Racecourse and Arcade-Independence Square.

5. Turning markets into an eye-candy state.
6. Relocation of informal settlements in the city (slums and shanties according them) which according to the UDA were on illegal and unauthorized land.

This research was mainly focused on (2) Beautifying Colombo, which was focused on public spaces. Yet, it touched upon other phases as well as mentioned before, since they are essential to understand this transformation as whole rather than picking individual works of architecture (buildings), or else if not the study will not reach the intended depth. As Jameson (1997) notes, "None of the individual projects that makes up politics has the supreme value of the whole collective activity".

5.2. MODES OF VALIDATION

The validation was based on three factors;

1. The theoretical framework and other literature
2. International case studies discussed in heading 3 (Architecture and political power in the world).
3. Evidences – interviews, magazine articles, newspaper articles, video documentaries, web articles, public surveys and reports, photographs, advertisements, research papers etc.

5.3. RESEARCH FINDINGS

There is no denial on the fact that architecture and political power has been closely related throughout the globe ever since human society was formed. Political leaders and architects have always been keen on this nexus. Hence, the study was not trying to raise the question whether architectural space is political or not, or should it be political or not, but how and what architectural spaces have become political. When posing such questions, one needs to be clear that the study itself is multi-disciplinary, therefore can be interpreted in multiple ways which might even contradict each other. The study was very much qualitative and is based on different social and political theoretical interpretations. Therefore, it is open for debate, by all means.

Post-conflict Colombo as public space witnessed a variety of architectural and urban design projects. Having stated that, the study was focused only on projects initiated by the state and its' institutions, in this instance mostly by the UDA. Especially public spaces, while not degrading the other projects such as social housing projects.

One of the first things to be noted is that, the military defeat of the LTTE in 2009, after three decades of conflict has naturally created new social and economic aspiration. Moreover, it became a milestone demanding interpretation for long standing issues, some which had been the root causes for the armed conflict, such as national identity. Hence, it can be said that there was a strong incident or a context which has given and raised a great deal of significance to the nexus between political power and architecture.

When trying to understand 'how' political power has been demonstrated by the use of architecture and urban design, or the powerful symbolic use of physical environment suggested by Vale (1992) to be precise, which would evince power. It is evident that itis achieved by means of architecture/ building as an object and then building as a process. When by means of an object, or in other words through the built form, power is demonstrated either by design or by default. Nevertheless, they can be attributed to the location, architectural language, architectural semiotics, orientation, access (physical or psychological), scale, geometry, aesthetics and so forth as seen in places such as Arcade-Independence Square, Racecourse and even in and parks such as Diyatha Uyana. It is vital to understand that they are not only determining ways of expression and that they used and operated in collectively. Hence, it proves the fact suggested by Krier (as cited in Dovey, 2008, p.74), "that architecture is not political; it is only an instrument of politics".

Next to touch upon the process of building expressing political power. This is evident by means of militarization (force and authority), forced evictions as witnessed in incidents such as Mews Street and ceremonies and parades (seduction) in Colombo public spaces. These processes create a 'spectacle' in the eye of the society and moreover acts as a symbol of different forms of power as well.

Figure 2, Cultural shows and light shows at Arcade-Independence Square *(Source: http://www.colombopage.com/archive)*

Figure 3, Arcade Independence Square illuminated at night *(Source :http://www.sundaytimes.lk)*

Figure 4, Forced eviction at Mews street *(Source: https://mffcoexist.wordpress.com)*

Irrespective of whether power was demonstrated by built form or by process, one could say that both these create a spectacle or an image, by which the political power is legitimized. At the same time, they become important parts of the day to day space we dwell in; space is in this case is not only physical yet a complex mixture of social, cultural, political and psychological dimensions.

Hence, the powerful symbolic use of physical environment both as objects and as processes, in fact contribute to a greater extend to the other forms which Vale (1992) had suggested, from which power is evinced.

In attempt to state 'what' they mean, it yet again a complex mixture of identities; individual identity, national identity, class identity and ethnic identity, political ideologies and cultural and economic phenomena. Yet, by all means they undoubtedly establish power and help those in power to locate them in time and space.

The very nature of the study enables many other interpretations to be brought into the discourse, while raising questions such what degree these architectural spaces are political and how effective they were in demonstrating political power than to another.

It is understood that there is nothing wrong in the nexus between political power and architecture (place) or that there is an ideal way to design. In fact, place and power are strongly linked to each other, which suggest that designers should not design with a blind eye towards this nexus.

This study touched upon some of the practices of political power in the built form. But they are not complete nor discrete. Power has many faces. The its' practice and mediation are slippery and hidden. These cannot be severed completely, since "we are always already engaged in its practice" (as cited in Dovey, 2008, 18).

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APPRAISING THE INFLUENCE OF PAVING MATERIALS ON PEDESTRIAN THERMAL STRESS IN TROPICS: *Evaluating the effects of tree shading on surface thermal performance*

I. RAJAPAKSHA[1] & M. EKANAYAKE[2]
[1,2]University of Moratuwa, Moratuwa, Sri Lanka
[1]*indrika_rajapaksha@ymail.com*

Abstract
Escalating trend in the formation of urban heat island (UHI) in the cities of tropical Asia contributes to warming microclimates and imposes a greater challenge on human health and well-being. Rapid urbanization and declining green plot ratio has contributed to the formation of an UHI in the city of Colombo. Consequences of UHI on urban green spaces exaggerate with the increasing use of paved surfaces. As surface heat inflation causes thermal discomfort for dwellers, it is vital to understand the thermal performance of different artificial and natural paving materials with a particular focus on tree shade variation.

This study experimentally investigated parks of Independence Square and the Water's edge in Colombo. Onsite field investigation was performed on a typical hot season identifying most users perceive settings inside the park. The Mean Paving Surface Temperature (MPST) and predicted Physiological Equivalent Temperature (PET) values were obtained in relation to Crown Volume Coverage (CVC) of trees. Results explicitly confirm PET values inside the parks correspond to high discomfort range. Exposed concrete paving is evident for high PET levels and the shaded surfaces are apparent for a reduction of 10°C of mean MPST. The Lowest PET of 30 °C was evident over the shaded grass paving with 31°C mean MPST. Reduction of the MPST significantly correlated (p=0.00) with increasing tree CVC. Thus, the findings of the study inform natural paving design implications with improved shading composition can promote less heated urban green spaces in developing cities of tropics.

Keywords: *Urban Heat Island, Surface Temperature, Thermal comfort, Tree canopy coverage.*

1. Introduction

Accelerating urbanization trend prioritize 66% of the population growth in urban areas by 2050. According to the UN projections the highest urbanization evident in Asia, which will respectively increase to 64% by 2050 (United Nations, 2004). Simultaneously rapid densification of structural mass in cities triggered the urban heat island effect (UHI) by generating heat trapped environments. Current urban settings are recording 4.0°C to 10°C temperature difference compared to the peri-urban surroundings (Gartland, 2008) leading to thermal discomfort in city dwellers inducing greater risk in terms of increased morbidity and mortality (Shahmohamadi et al., 2011).

UHI effect is not an exception for the megacities of Sri Lanka. Exaggeration of impervious ground surfaces is one of the major drivers of UHI effect in local context (Ranagalage et al.,2017). The development trends in past decade have imposed sever ground modifications by reduction of green plot ratio in cities. This intense application of heat-absorbing surfaces and paving materials contribute to generate Surface UHI (SUHI) intensity in microclimates of Urban Green Spaces (UGS) (Sharifi et al. 2015). Thus, it is paramount important to understand the thermal performance of different artificial and natural paving materials on human thermal comfort in green precincts.

1.1 THERMAL BEHAVIOR OF URBAN PAVED SURFACES

The thermal performance of paved surfaces directly integrated with SUHI phenomenon altogether with environmental aspects of heat stress and air pollution (Chudnovskym et al., 2004). In urbanized areas paving materials differentiated with various energy absorption rates and albedo indexes (Ghazanfari et al., 2009). However, urban paving materials of higher heat capacity tend to absorb and re-emit solar radiation increasing the microclimatic temperature profile. When UGS are replaced by high thermal admittance materials, it's a worst-case scenario triggering thermal dis-comfortability for park users.

1.2 HUMAN THERMAL COMFORT

Thermal comfort interpret as the physiological interval where the human can operate or tolerate the thermal environment with a state of satisfaction (ASHRAE Standard 55P, 2003). The comfortability of thermal environment of human are best determined with aid of the thermal indices based on energy balance of human body , interpreted as PMV (Predicted Mean Vote) (Fanger 1972), PET (Physiologically Equivalent Temperature) (Höppe 1999), SET (Standard Effective Temperature) (Gagge et al. 1986).

Exposed to high heat in micro settings contributes to heat exhaustion, heat cramps, heat-related rash and heat stroke (OSHA, 1999). Thus, it is crucial to identify mitigation measures to reduce the SUHI phenomenon in urban public spaces.

1.3 URBAN TREES ON SURFACE URBAN HEAT ISLAND (SUHI) EFFECT

Urban tree canopies can enhance the local radiation balance through shading effect, regulating both of the person's body itself and of the surrounding ground or built surfaces (Holst and Mayer 2011). These surfaces maintain a lower radiant temperature when shaded than when exposed by intercepting solar radiation and preventing the heating of the surface under their canopy (Brandani et al. 2016). Thus, the application of canopy interventions with maintaining a standard surface energy budget is a crucial scenario to mitigate SUHI.

1.4 CRITICAL CASE ON URBAN HEAT ISLAND IN TROPICS

Research on the thermal performance of paving applications in tropics is yet to be explored. The limited research explored, SUHI phenomena in Colombo Sri Lanka (Ranagalage et al. 2017); Land surface characteristics in Heat mitigation (Chowdhury et al. 2017) in India ; Urban morphology on thermal conditions of street canyons in Thailand (Takkanon et al.2018) and Cooling effect of tree canopies Malaysia (Tukiran et al. 2016).

Field studies on thermal comfort are less represented in Sri Lanka and no studies to address the synergies between paving SUHI and thermal comfort. Thus, this study explored the thermal performance of the differed paving materials in the UGS of Colombo, with special reference to tree canopy coverage to configure landscape interventions to establish outdoor thermal comfort indices for tropics.

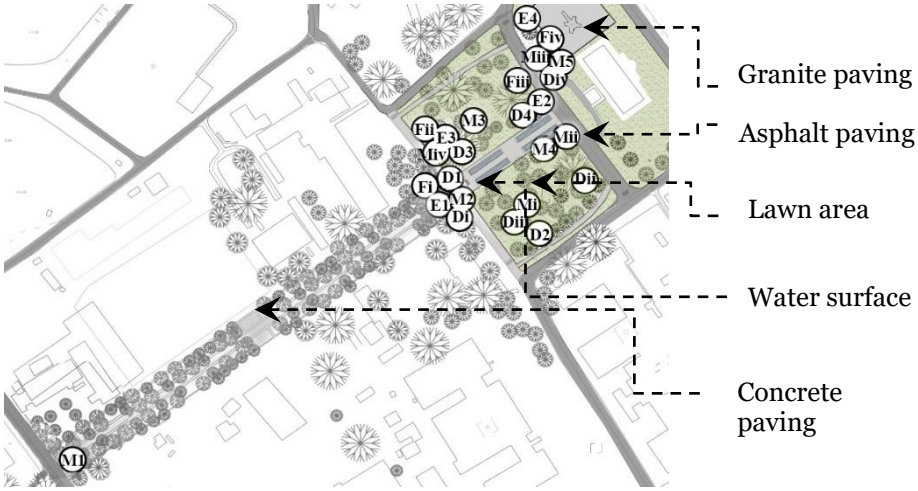
2. Experimented Urban Parks

This study was performed in two highly popular urban parks situated in the city of Colombo (6.9° N, 79.8° E) in Western province, Sri Lanka. The City of Colombo represents the highest population density of the country with 3438 persons/Km^2 and it is the most congested city due to rapid urban sprawl for economic and employment activities (Dept. census & Statistics, 2012).

According to World Health Organisation (WHO), 9.5 m^2 of green area per capita is the minimum requirement for healthy living. Urban development in Colombo precincts has altered the urban landscape by decreasing green areas, resulting in an uneven spatial green area distribution. Due to this scenario 34 out of 55 administrative divisions were not complying with the WHO standards for the city (Senanayake, 2013). Thus, its paramount importance to re-establish healthy green areas within the city limits.

Location of the urban parks and its landscape characteristics are shown in figure 1. Independence square (ISP) is a historical commemoration park positioned in a highly urbanized area of Colombo. The façade landscape design of this park spreads in 2 Hectares with dense vegetation.

a. ISP: Independent Square Park



b. WEP: Water's Edge Park

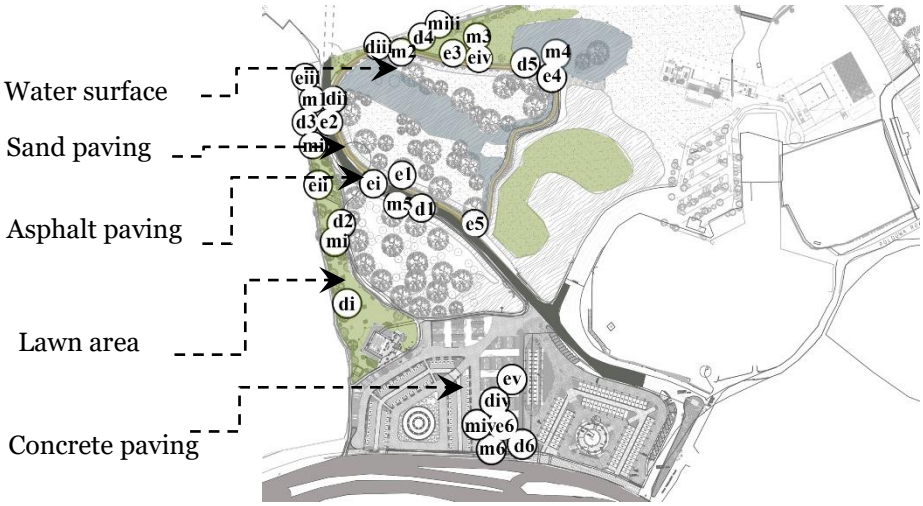


Figure 1, Landscape paving design including weekday and weekend peak usage profiles of experimental urban parks; (a) ISP *(microclimatic settings of M1 to E4 and Mi to Eiv and paving characteristics)* and (b) WEP *(microclimatic settings of m1 to e6 and mi to ev and paving characteristics)*

Water's Edge Park (WEP) is a suburban wetland in Sri Jayawardhanapura, Kotte. This park contains 12 Hectares of land amalgamated with watershed environment and averagely dense vegetation. Both parks provide facilities for active and passive modes of exercises such as relaxing, walking and jogging.

2.1 EXPERIMENTAL METHODOLOGY

The experimental methodology of this study is consists of a walk through survey, formulation of a tree inventory and onsite thermal recordings to quantify the park users' exposure to SUHI levels in the investigated parks.

2.1.1 Walkthrough survey: Mapping of the peak usage profiles

A walkthrough survey was performed on a typical weekday and weekend during three peak usage time slots such as Morning (M), Daytime (D) and Evening (E). Time periods for morning, daytime and evening are from 8 to 11 am, 12 to 3 pm and 4 to 6 pm respectively. These sampling locations represent 25 and 31 peak usage settings of ISP and WEP.

2.1.2 Recording of Landscaping characteristics

Landscaping characteristics of 56 places were recorded by developing tree inventories. This inventory is consists of four main variables of trees such as Species, quantity, height, and diameter of the crown (Nowak, 2008). A three-dimensional green quantity model was used as an indicator to characterize urban vegetation structure and which is represented as Crown Volume Coverage (CVC).

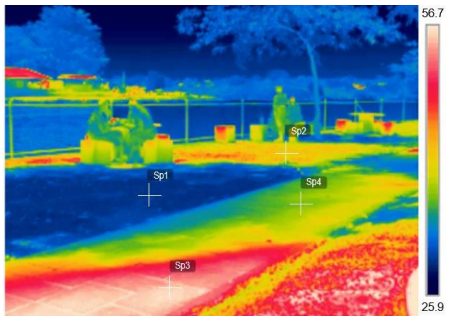
$$CVC = \text{Total Crown volume } (m^3)/ \text{ Surface area } (m^2) \qquad (1)$$

This model considers the geometrical difference of the crown of tree species and combines the diameter (x), height (y) and coverage of the crown to calculate its CVC per unit area (Zhou, 2001). Crown volumes of all inventoried live trees were calculated using equation 1 and the common growth of each tree species were recorded by calculating the mean of diameter Xp and height Yp of the crown.

In addition, the normalized crown volume (Vn) and CVC of the tree species were calculated. Total crown volume coverage (CVC) of identified microclimatic settings represents tree species located within 100m^2 coverage.

2.1.3 Onsite experimental Investigation: Measurements of Mean Paving Surface Temperature (MPST) of peak usage settings

MPST was measured by thermal imagery recorded in each micro climatic setting by FLIR T530 Thermal Imaging Camera. FLIR tools processed thermal imaging plus software to acquire the surface temperature measurements and parameters (emissivity and Reflective temperature) as shown in figure 2.



Surface Material		Spot	MPST °C
Lawn	Shade	Sp1	30.2
	Unshade	Sp2	42.9
Concrete paving	Shade	Sp3	55.1
	Unshade	Sp4	37.7
Emissivity		0.81	
Refl. temperature.		20 °C	

Figure 2, Spot measurements of the different paving surface temperatures in a selected microclimatic setting of WEP.

2.1.4 Measuring Human Thermal Comfort via PET

To measure the thermal comfort of the park user, microclimatic parameters such as air temperature (Ta), relative humidity (RH), and wind velocity (v) were measured in 56 places of investigated two parks. Sampling protocol was established to collect data for 10 minutes in each microclimatic setting with an acquisition time of 10 seconds. Adopting the measured data PET values were calculated using the RayMan1.2 for each microclimatic setting.

Table1, Ranges of the PET for different grades of thermal perception by human beings and physiological stress on human beings; internal heat production: 80 W, heat transfer resistance of the clothing: 0.5 clo (Matzarakis and Mayer 1996)

4°C	Very cold Extreme cold stress	PET Thermal perception (Grade of physiological stress)
8°C	Cold Strong cold stress	
13°C	Cool Moderate cold stress	
18°C	Slightly cool Slight cold stress	
23°C	Comfortable No thermal stress	
29°C	Slightly warm Slight heat stress	
35°C	Warm Moderate heat stress	
41°C	Hot Strong heat stress	
	Very hot Extreme heat stress	

3. Results and Discussion

3.1 SURFACE HEAT ISLAND EFFECT AND THERMAL STRESS

Park user's thermal stress index was calculated for the microclimatic settings of ISP and WEP and was appraised based on hourly meteorological Ambient Temperature (AT) and microclimatic Air temperatures (MAT).

3.1.1 Independence Square Park (ISP) Surface Heat Island effect

Figure 3, shows the SUHI effect in peak usage profiles in ISP during typical two sampling days. Two sampling days consists of 25 places (M1 to Eiv). Results explicitly prove that the MAT (min, max, avg) of the particular microclimate is higher than the meteorological AT.

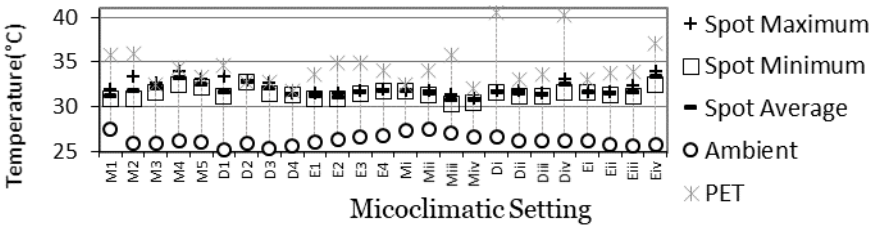


Figure 3, SUHI effect on ISP in selected microclimatic settings

In two sampling days of ISP evident a MAT ranges from 32.3°C to 31.4°C, whereas AT represents 26.3°C. Respectively the mean SUHI intensity (UHII) on the ISP evident 3.94 °C difference. Thermal Sensation profile of the park ranges from PET, 40.5°C - 31.7°C to average 34.4°C, which indicate warm moderate heat stress. The paving surface temperatures measured by thermal imaginary in ISP indicated by figure 4.

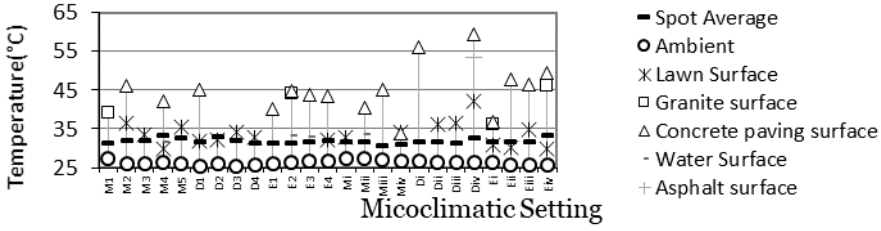


Figure 4, MPST of different natural and artificial paving types in ISP.

The SUHI has created in the specific settings due to ground MPST. PET and MPST evident p=0.00 significant strong positive relationship with R2=0.919. In ISP concrete pavings represent 68% from paved surfaces evident PET range 32.1°C - 40.5°C average PET of 35.2°C respectively. Lawn surfaces 32% PET ranges from 33.6°C - 31.7°C average PET of 32.8°C. Thus, the concrete paving dominated spaces create moderately "Hot Strong heat stress" while natural lawn paving evident spaces maintain "warm Moderate heat stress" for park users.

3.1.2 Waters Edge Park (WEP) Surface Heat Island effect

SUHI effect of the microclimatic settings of the peak usage profiles of WEP during a typical weekend and weekday is shown in figure 5. All the sampling areas are consists of 31 Places (mi to e6).

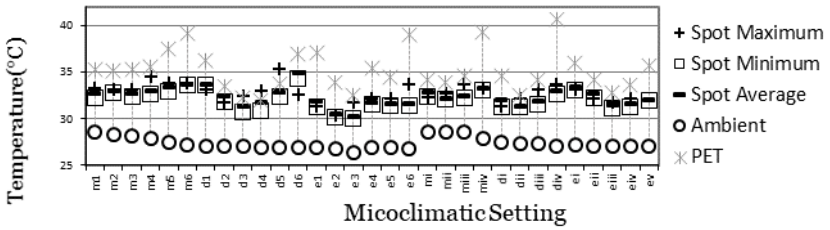


Figure 5, SUHI effect on WEP in selected microclimatic settings

WEP microclimatic settings prioritize MAT ranges from 32.8 °C to 31.9°C while mean ambient temperature represent 27.3°C. The SUHI effect indicates a mean temperature difference of 5 °C for WEP, which is high comparing the ISP. The mean PET values in WEP ranges from max 40.7 °C to min 32°C to average 35.1°C which indicates a "hot Strong heat stress" thermal sensation for the park users.

Figure 6 indicates the surface temperature in different sampling sites due to different paving heat storage capacities.

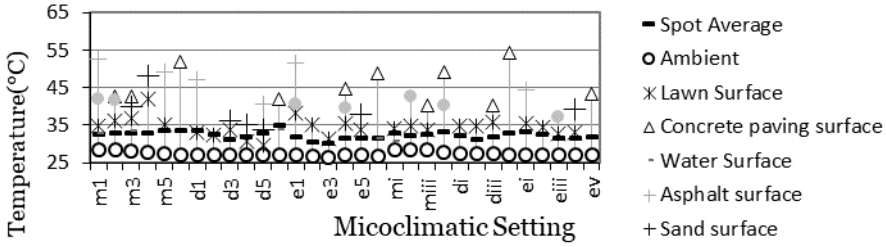


Figure 6, MPST of different natural and artificial paving types in WEP.

In WEP, high surface temperature is evident on concrete paving and asphalt paving. Dominates 55% from the chosen paving settings, concrete evident a PET range of 40.7°C - 34.2 °C to mean PET of 36.8. Whereas 16% Asphalt paving, represents PET range of 37.5°C-33.7°C average PET of 36.06°C. Both Asphalt and Concrete dominated spaces created "Hot Strong heat stress" sensation for the park users. 35% Natural Lawn prioritize PET ranges from 35.5°C-32°C to mean PET of 33.6°C perceiving "Warm Moderate heat stress".

Table 2, MPST acquired by thermal imaginary for different paving types in ISP and WEP

ISP	Maximum°C	Minimum°C	WEP	Maximum°C	Minimum°C
Lawn	42	29.8	Lawn	41.8	29.2
Concrete	63.8	33.9	Concrete	58.7	32.5
Water	34.7	31	Water	33.8	30.8
Asphalt	60.2	46.6	Asphalt	59.8	38.5
Granite	47	33.9	Sand	48	33.2

The heat storage capacity of the different ground materials according to the study is shown in table 2. The evident results for the MPST emphasis a very high temperature in Asphalt and Concrete Paving. Moderate surface temperature shown by the Granite and Sand. Very low surface temperature is evident by Lawn and Water surfaces.

3.2 INFLUENCE OF SHADE VARIATIONS ON SURFACE HEAT

Normalized crown volume (Vn) was measured by applying the three-dimensional green quantity model in respective to the tree composition of the identified 56 places of both parks. The values were accumulated by previous research (Rajapaksha et al., 2018) carried out on 17 common tree species of investigated parks.

Figure 7 shows the impact of CVCs on MPST levels in ISP and WEP respectively. Results demonstrate a negative relationship between MPST and CVC for both parks.

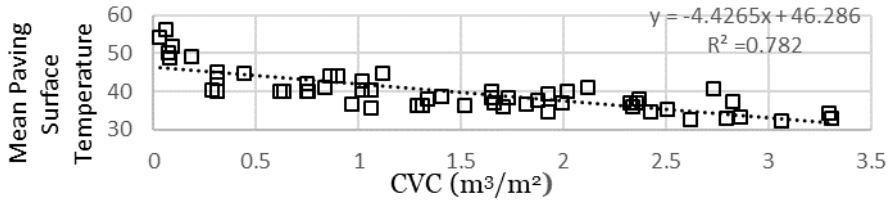


Figure 7, Relationship of CVC and MPST levels for ISP and WEP

Analysis informs the significant relationship between CVC and MPST. The person co-relation analysis reveals p=0.00 with negative regression of 0.782 (m^3/m^2). The CVC varied from 3.30(m^3/m^2) to 0.03(m^3/m^2) whereas, high CVC (<2.5(m^3/m^2)) evident low MPST (>35°C) and low CVC (>2.5(m^3/m^2)) resulted in high MPST (<35°C) correspondence with shading effect.

Moreover, the shading effect is an important criterion in regulating MPST. The calculated MSPT from shaded and non-shaded paving environments are shown in figure 8.

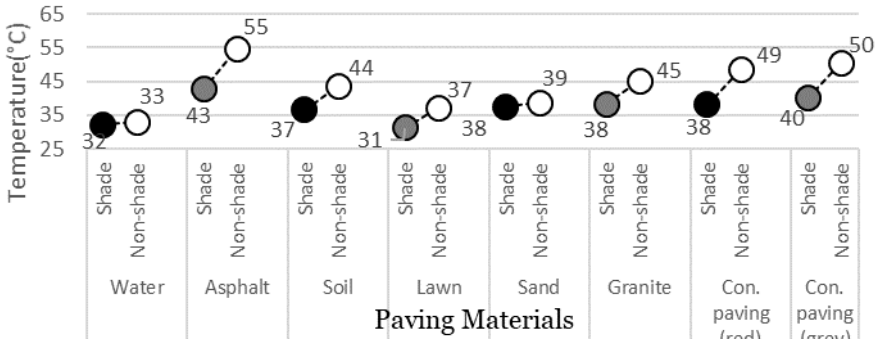


Figure 8, Measured MPST for shaded and non-shaded paving settings

Figure 8, indicate the effect of tree shade on the MPST to reduce SUHI in urban green spaces. The shaded Concrete and Asphalt paving evident 21% reduction of surface heat than non-shaded. The Natural paving typologies of Lawn, Soil, and Granite evident 16 - 15 % surface heat reduction in the shaded environment. The natural paving typologies such as water and sand prioritize the lowest gradient 2% of temperature reduction in shaded conditions.

4. Conclusion

Influence of paving surfaces on thermal stress of UGS of Independence Square (ISP) and Water's Edge (WEP) were explored in this study. As peak usage profiles, 56 microclimatic settings were identified for both parks. An onsite thermal imagery recording was conducted to measure different surface temperatures alone side with microclimatic measurements. Moreover, characteristics of vegetation were recorded to evaluate the effect of shading on the paving heat reduction. The conclusions derived from the detailed analyses and discussions are as follows;

- ISP mean air temperature (MAT) is 31.8°C whereas Ambient Temperature (AT) is 3.98°C, with a recorded SUHI intensity of 3.98°C.
- In WEP MAT recorded as 32.3°C while AT 27.3°C with SUHII of 5°C.
- Thus, the mean PET for most of the settings of ISP is 34.4°C, highlighting "warm moderate sensation" for users.
- In WEP, PET is comparatively high which stimulated as 35.1°C, scaled as "hot strong heat stress".
- PET and MPST significantly correlated (p=0.00) with each other emphasizing positive regression (R^2) of 0.919.
- The highest PET evident for concrete and asphalt paving ranged from 36°C to 36.6°C respectively. Likewise MPST of 44.95°C and 47.68°C for concrete and asphalt.
- The Lowest PET value measured paving material was lawn with 33.2°C PET and MPST of 34.1°C
- The CVC has a pronounced effect over the MPST with strong significant co-relationship (p=0.00).
- The shading effect of trees resulted in percentage surface temperature reduction. Concrete and Asphalt from 21%, and 16 to 15% from Lawn, Soil, and Granite. Shading effect has a very low impact on water and sand.

The study reveals that the local UGS are in an uncomfortable PET range of 40-30 °C due to SUHI effect. Thus, the finding of the study informs that the natural paving design implications with improved shading composition can promote comfortable thermal performing green spaces for the city dwellers.

5. Acknowledgment

This research was funded by the SRC/ST/2019/19 grant of the Senate Research Council, University of Moratuwa.

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ESTABLISHING RISK INDICATORS IMPACTING THE FUNCTIONALITY OF CRITICAL INFRASTRUCTURE IN EXTREME WEATHER EVENTS

NIYATI GUPTA[1] & VIRENDRA KUMAR PAUL[2]
[1, 2]School of Planning and Architecture, New Delhi, India
[1]niyatigupta101@gmail.com, [2]vk.paul@spa.ac.in

Abstract
Urban infrastructure and services are critical to functioning of society, economy and well being, especially in case of disaster, hazard or an extreme weather event. This paper focuses on the Extreme Weather Events and their impact on functionality of the Critical Infrastructure in India. It establishes the need to identify risk indicators that Critical Infrastructure are exposed to, in case of Extreme Weather Events. The study undertaken outlines the methodological approach towards identification of risk indicators. The data for establishing risk indicators is ascribed through comprehensive literature review of post-disaster assessment reports, case studies and Disaster Risk Reduction frameworks in the Indian Context. The final outcome of this paper establishes the risk indicators under the umbrella of the physical, social and economic attributes of the critical infrastructure. The comprehensive list of indicators are sub-categorized and clustered in groups based on critical infrastructure vulnerability, susceptibility and adaptive capacity.

Keywords: *Critical Infrastructure (CI), Indicators, Risk Assessment, Extreme Weather Events (EWE)*

1. Introduction

Climate Change is a global phenomenon which has lead to altering of the weather and climatic events (IPCC, 2001). The effects of these events are witnessed in the form of extreme temperature, humidity, prolonged precipitation for example rain, fog, snow etc. The uncertainty of these weather conditions leads to severe conditions like flooding, drought, avalanche, cyclones, landslides etc. The impact caused by these events are dependent on severity, vulnerability and exposure to the Critical Infrastructure (CI) and services such as transportation, healthcare, energy, telecommunication, water supply etc. (Tagg et. al. 2016)

Risks of Extreme Weather Events (EWE) on the Critical Infrastructure are felt through geographically differentiated locations in India. The Intergovernmental Panel on Climate Change (IPCC) framework, 2011,14 considers the multifaceted impacts on the functionality of the CI upon society, economy and environment. their impact and consequences have often proved inadequate. The probability of occurrence of the EWE is expected to increase (figure 1), thereby measuring the impact on the CI is vital. Hence, there is a need to build climate resilient CI for well functioning of the society and cities in general.

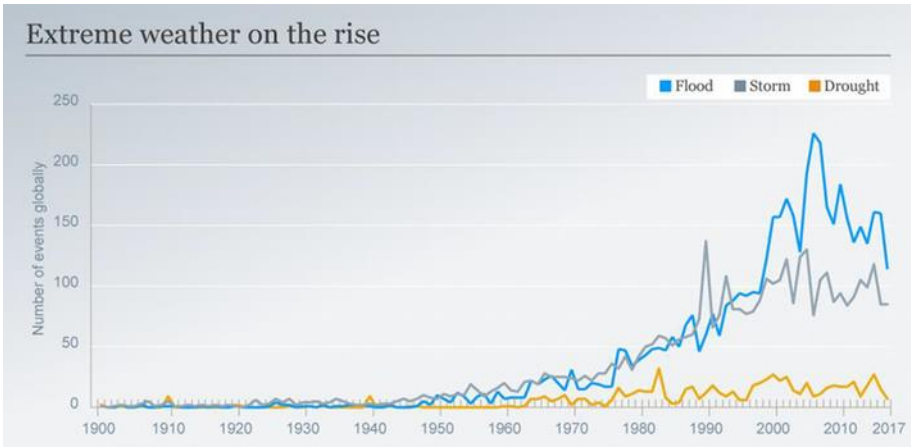

Figure 1 Global Trends of Extreme Weather Events, EM-DAT

In order to measure the impacts on functionality of CI, identification and clustering of risk indicators is essential (Molarius et. al. 2016).

1.1 DEVELOPMENT OF PROBLEM STATEMENT

With the adequate literature it is established that identification of the risk indicators is a pre-requisite to the development of the quantification framework for risk assessment.

This paper reviews various research projects taken up by the European Union, which has contributed vastly in establishing risk assessment methodologies and matrices.

Based on the literature review of the projects, this paper is developed and is broadly divided into 3 sections. The first section is focused on the purpose and need of the identifying risk indicators and risk assessment frameworks adopted for the protection of the critical infrastructure against extreme weather events. The second section describes methodology and literature review of the assessment framework adopted for the identification of risk indicators.

Based on the ascribed methodology in the second section, the final section of the paper outlines the cause-consequence diagram method to strategically identify the components of risk indicators.
Indicators are selected based on their relevance and measurability, under the umbrella of social, physical and economic indicators.

The scope of the study is limited to establishment of cause-effect relation with Extreme Weather Events and critical Infrastructure. It does not take natural disaster or man-made hazard into account. In order to measure the vulnerability and risk of critical infrastructure, indicators are identified through literature review. The risk indicators are thereby categorized as per exposure, susceptibility and adaptive capacity of the critical infrastructure when exposed to extreme weather condition.

The outcome of the paper forms a basis for carrying out risk assessment studies for infrastructure projects in case of EWEs. In addition, this paper will help CI operators and Policy makers to re-evaluate the functional aspects of CI in case of EWEs.

2.1 DEFINITIONS

2.1.1 Critical Infrastructure

Critical Infrastructure (CI) definition differs amongst countries, depending upon the officially recognized infrastructure components and regional differentiation. (Claudia Bach et. al. 2013). Few of the definitions are enlisted below for reference.

UNIDSR, 2017 defines Critical Infrastructure as *'The physical structures, facilities, networks and other assets which provide services that are essential to the social and economic functioning of a community or society'.*

Council Directive-European Union defines Critical infrastructure as *"an asset, system or part thereof located in Member States which is essential for the maintenance of vital societal functions, health, safety, security, economic or social wellbeing of people, and the disruption or destruction of which would have a significant impact in a Member State as a result of the failure to maintain those functions."*

CPNI, UK defines Critical National Infrastructure as *"those facilities, systems, sites, information, people, networks and processes, necessary for a country to function and upon which daily life depends."*

CI including power, transportation, telecommunications, financial services, information and communications technology (ICT), etc needs to be protected from cyber or other attacks along with Extreme Weather events or natural disasters (Singh et. al, 2014).

Table 1 indicates the global scenario for recognition of the CIs by different countries. It is established that the categories of CI varies from country to country.

Table 1 Country wise list of differentiated Critical Infrastructure
Source: Author

	Transport	Energy	ICT	Food and Agriculture	Health	Financial Services	Public Safety	Industry/manufacturing	Environment	Defense Base	Water Supply and Sanitation	Public Buildings	Government	Social Infrastructure	Emergency services	Chemical industries	Dams	commercial facilities	nuclear	monuments	Telecommunication	Space
India	✔	✔	✔	✔	✔	✔					✔	✔	✔	✔								
Canada	✔	✔	✔	✔	✔	✔	✔	✔			✔		✔									
USA	✔	✔	✔	✔	✔	✔		✔		✔	✔	✔			✔	✔	✔	✔	✔			
UK	✔	✔		✔	✔	✔				✔	✔		✔		✔	✔			✔		✔	✔
Australia	✔	✔	✔	✔	✔	✔																
EU	✔	✔	✔	✔	✔	✔			✔													
China	✔	✔	✔		✔	✔																

As suggested in the table, UK enlists 13 type of CI whereas USA enlists 16 type of CI. Based on the Critical Infrastructure protection priority list actions are thereby taken by both government and other agencies. Refer to table 1 for country wise listing of CI. The CI are divided into 22 categories based on the literature review of the critical infrastructure list and components. The countries from where the literature has been referred to area India, Canada, USA, UK, European Union, Australia and China.

Singh et. al, 2012 identifies 9 types of CI for India, as reflected in table 1. The selection is based on evaluation of all the CI definitions and 22 categories of the CIs.

2.1.2 Extreme Weather Events

IPCC, 2011 report defines Extreme Events as *'the occurrence of a value of a weather variable above or below a threshold value near the upper or lower ends of the range of its observed values in a specific region'.*

In other words, unforeseen weather events which has occurred in a specific region affecting the society, economy and physical infrastructure of the city. As defined by the oxford dictionary; Extreme: Reaching a high or the highest degree; Not usual and Event: a thing that happens or takes place, especially one of importance.

David B. Stephenson in 2008 gives various other terms similar to extreme events such as severe events, high-impact events, rare events etc. He also marks the attributes associated with EWEs such as probability of occurrence, magnitude, spatial-temporal duration, multi-variate dependencies etc.

Understanding the patters of the EWEs in order to identify risk indicators is vital to this study. With the increase in occurrence of the EWEs, the impact on CI also increases. The first step towards risk

assessment of the CI is to identify the hazards caused by the extreme weather events (EWENT, 2012). Hence understanding of the EWEs and its attributes is vital in order to conduct the risk assessment studies.

2.1.3 Concept of Risk

Estimating the severity of the event, expected long term loss is calculated in terms of risks, in order to measure the impact on any infrastructure facility.

For risk quantification probability of occurrence of EWEs is taken into account, until recently product of hazard and vulnerability was identified for optimal calculation of the risks. EWENT, 2012 defines vulnerability of a particular mode in a particular country is a function of exposure (indicated by transport or freight volumes and population density), susceptibility (infrastructure quality index, indicating overall resilience) and coping capacity (measured by GDP per capita). Hence, we define the extreme weather risk as

$$\text{Risk} = \text{hazard} \times \text{vulnerability}$$
$$= P(\text{negative consequences}) \times V[f(\text{exposure, susceptibility, coping capacity})]$$

In order to quantify the vulnerability and thereby risks, indicators for the same is identified for regionally differentiated EWEs.

3. Impact on CI due to EWEs

Various studies and projects have been conducted on measuring the impact on CI in case of natural hazard or extreme weather events. Few of the studies are enlisted in the table 2 below for reference.

Table 2 Research Projects measuring the impact of EWE on CI

Name of Project	Title	Year	Description
Impact of extreme weather on critical infrastructure – Capability Project	INTACT	2014-2017	• Offers a Decision Support to CI operators & policy makers regarding Critical Infrastructure Protection (CIP) against changing EWE risks caused by climate change. • The decision support will enhance the aspect of business continuity, or, sustained resilience, in order to allow societies and economies to function unimpaired.
Risk Analysis of Infrastructure Networks in response to extreme weather	RAIN	2015-2018	• The principal objective of the RAIN (Risk Analysis of Infrastructure Networks in response to extreme weather) projectis to provide an operational analysis framework to minimize the impact of major weather events on land based transportation and energy and telecommunication (E&TC) CI in the EU. • RAIN aims to quantify the complex interaction of existing infrastructure systems and their interrelated damage potential in the event of specific EWE's.
Critical Infrastructure Preparedness and Resilience Research Network	CIPRNET	2013-2017	• The CIPR Net Joint Programme of Activities (JPA) integrates and makes complementary use of CIP and related knowledge, expertise, and resources (e.g., tools, methods, top experts and other staff) of the partners.
Extreme Weather Risk Indicators	EWRI	2012	• The methodological approach of EWENT is based on the generic risk management standard (IEC 60300-3-9) and starts with the identification of hazardous extreme weather phenomena, followed by an impact assessment

Name of Project	Title	Year	Description
			and concluded by mitigation and risk control measures.
Extreme Weather Impacts on European Network of Transport	EWENT	2010-2012	• The framework is specific to the transport systems in the EU framework. It gives a methodological approach towards risk assessment. A probabilistic approach is adopted in the assessment methods.

The framework adopted for most of the projects mentioned in the table 2 reflects risk assessment methodology used in the INTACT project under the 7th European Framework for boosting resilience of the CI against EWEs.

The assessment is performed with a focus on post-construction performance of the CI along with the recommendation of alternative measures adopted on ad-hoc basis for the CI.

In India, National Disaster Management Authority, Government of India sets the rules, regulations and policy guidelines for the regionally differentiated natural disasters, hazards and extreme events across India. In the Asian Ministerial Conference on Disaster Risk Reduction (AMCDRR), 2016 the measurement of impact on CI in case of EWE was recommended. The impact on the CI can be either direct, indirect or intermediate when exposed to an extreme event.

Direct impact is set to have a causal linkage of the complete or partial destruction of the immovable assets whereas indirect impact is referred to as hindered flow of goods and services and social loss. The intermediate or wider impact is on the macro level wherein the long term impact on production is to be measured.

Based on the post-disaster reports and case studies of the occurrence of extreme events in past 10 years in India, physical,
impact on the CI was cross analyzed as represented in table 3.

Table 3 Impact on the CI due to EWE
Source: Author

Extreme Weather Event	Cause/ Impact	Types of Critical Infrastructure										
		Transport	Water Supply	Emergency	Financial Services	Hospitals	Agriculture and Food	Defense Base	Government	ICT	Public Safety	Electricity
Extreme Precipitation	Floods											
	Flash Floods											
	Landslides											
Wind	Cyclone											
	Dust Storm											
	Tornado											
Lack of Precipitation	Drought											

High temperature	Heat Waves											
Low temperature	Snow/Blizzards											

Indirect Impact
Intermediate Impact
Direct Impact

From the cross-matrix formed for measuring the impact on the CI, it can be concluded that sectors like healthcare and agriculture and food suffers from the maximum direct loss when exposed to the events like floods, landslides, cyclones, drought etc.

In addition, sectors like defence, government, ICT, safety etc. endures the maximum indirect impact. Utility and services type of supportive infrastructure, which is set to be most vital for the functioning of the infrastructure like healthcare, public buildings etc. encounters the most wide range of impact. The wider or intermediate range of the impact abides by the adaptive and coping capacity under the umbrella of the risk assessment framework ascribed the EU framework, referred in the following chapters.

4. Methodology to establish risk indicators

Risk indicators varies with the category of infrastructure and The concept of risk indicators for CI against the EWEs is derived from the World Risk Report (WRR), 2016 where in UNISDR, 2004; Wisner et al., 2004; Birkmann, 2006; IDEA, 2005; IPCC, 2012 has also been referred to be using the same Risk measurement index (Refer figure2).

The indicators for the risk has been categorized as per their exposure, susceptibility, coping capacity and adaptability against the EWEs.

In this paper, the broad level methodology is adopted from the WRR, 2016 however the indicators are established under the umbrella of the physical, social and economic attributes of the CI.

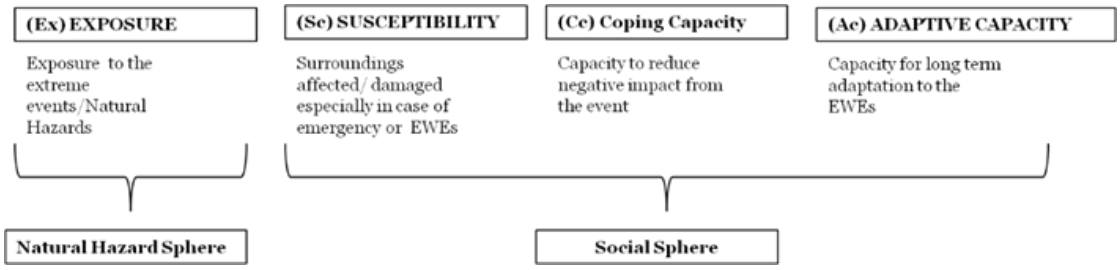

Figure 2 Disaster Risk Indicators
Source: World Risk Index, 2016

5. Risk Indicators and its components

In accordance to identification of the risk indicators, understanding of the CI interdependencies is vital (BOARU et.al 2008). Identification of the physical, social and economic impacts on the CI when exposed to a EWEs is illustrated through a fish bone diagram in the figure 3.

Various literature reveals that the impact assessment of the CI can also be taken into account by the attributes like Infrastructure characteristics, types of CI failure in order to measure the resilience, operational scenario and response mechanism of the infrastructure type. The components describing the

interdependencies of the CI is established through the case studies presented by the report on Disaster Risk Reduction by the National Institute of Disaster Management (NIDM), 2013.

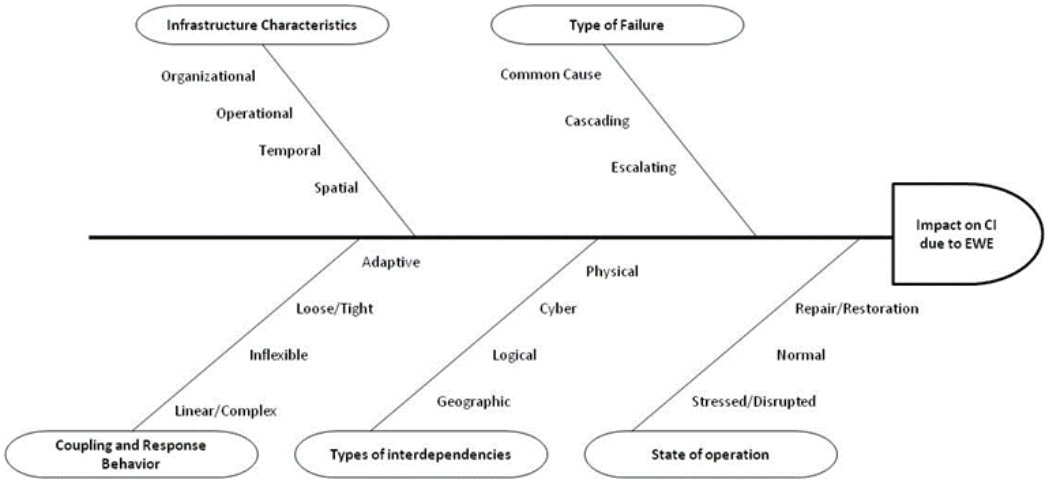

Figure 3 CI Interdependencies and Impact on CI due to EWE
Source: Author

These above mentioned attributes have sub-attributes responding to the typology of the infrastructure. For instance, according to nature of CI interdependencies varies with the geographical locations, physical networks and linear relationships with the other infrastructure (Aaron Clark-Ginsberg et.al, 2018).

5.1 CAUSE-CONSEQUENCE ANALYSIS OF THE RISK INDICATORS

Andrews et. al., 2018 describes cause consequence analysis methods as an extension to the fish bone diagram for system risks. The methods outlines the logic behind the system failure by identification and branching out the indicators established.

A fault tree tool is used to follow up on the cause and consequence analysis. It takes into account the event that has occurred and cause of the incident in order to establish risks.

The author in the figure 4 has adopted this method to initiate the 27 indicators under the umbrella of the physical, social and economic indicators as per their individualistic exposure, susceptibility and adaptive capacity as discussed in the section 3 of the paper.

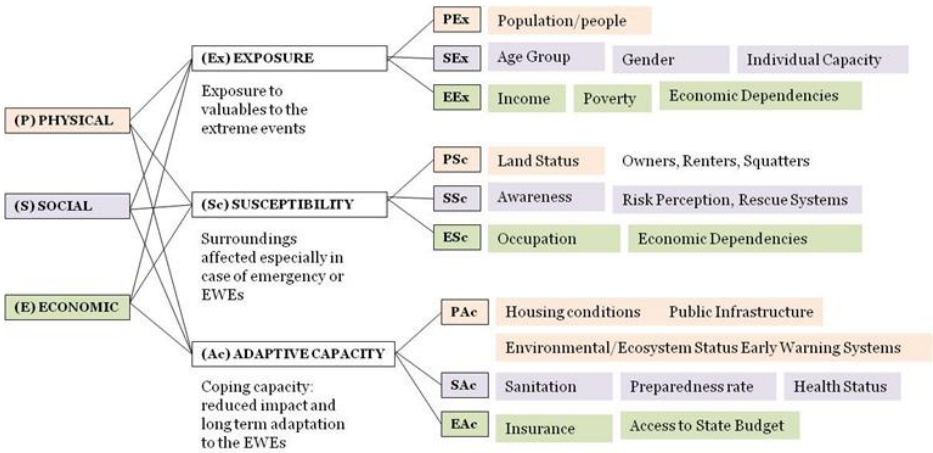

Figure 4 cause- Consequence Diagram for identification of risk indicators
Source: Author

5. Conclusion

With the increased facets of the development activities interdependencies of the utility and services have also increased. A holistic approach towards measuring resilience of CI is adopted through this paper.

As with the first section, defining the CI in the global scenarios and importance of CI protection is highlighted. As a result of variations in the climatic events, measuring the impact on the CI has become vital. The impact assessment carried out in the paper showcases the direct, indirect and intermediate impact on the CI when exposed to extreme weather conditions. Projected increase in the EWEs has also set an impact on educed life expectancy with the increased exposure to the individual capacity and population.

The study also exhibits projects and academic studies across global especially by the Government of the UK, US and European Union for CI protection and risk assessment methodologies adopted by the specific countries.

Hence, significant risk assessment studies are proved to be a vital asset in increasing the coping capacity of the large scale infrastructure projects. While understanding of the risk is vital to the society with the current government engagements in India, assessment and management of the CI and its impact due to EWEs are to be promoted. Hence outlining the future area of work.

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HIERARCHICAL IDENTITY AND SPACE; A STUDY ON LONG SURVIVING RAILWAY STATION INTERIOR IN SRI LANKA.

SAMARASINGHE A.M[1] & JAYASINGHE S.[2]
[1,2]University of Moratuwa, Maratuwa, Sri Lanka
[1]*ajanisamarasinghe@gmail.com*

Abstract
The visual interpretations of railway interior in Sri Lanka continue to maintain its timeworn fashion only with minor changes while infrastructure and furniture design in the rest of the world, experience rapid transformation. This study has investigated interior of twenty railway stations located on the Main Line (Colombo - Badulla) and also has been interviewed with the staff who use this furniture. Moreover, these studies argue the design particulars of the furniture extremely connected to the hierarchy of the staff, within the station.

Keywords: *"SLR : Sri Lanka Railway", "Interior", "Railway Furniture", "Hierarchy", "Hierarchy"*

Introduction

Despite the fact that Sri Lanka had limited freedom of moment during British rule, the railway system was a magnificent gift from them. Rail transportation system was established in 1864, mainly as an agricultural transportation method, subsequently it was appointed as a vehicle for high-income rich class. Later, it became as a public transportation. (Railway, 1964) Even though many railways have been using electrification systems since the early 20th century, Sri Lanka has been using only diesel traction since steam locomotives were retired. (Carratt, 2002)

Over and the above, the railway system in Sri Lanka, has a massive collection of wooden furniture that has survived for long period is still being use. Therefore, this research emphasizes characteristics of interior that have the ability to continue for a long period. In this study, characteristics of interior are introduced as tangible qualities and emotions of the user create a unique identity of furniture through characteristics.

In the British period, the colonies used to take Sri Lankans under their power. Therefore, they had maintained their crown identity among their employees to make a hierarchical structure in the society. Curiously, Railway stations had hierarchical based on the administration system. It was the westernized elite that adapted from the official regalia of the native component of the colonial administration. However, this administration has impacted on survival of the Railway interior for a long period. (Mills, 1933)

Methods and Methodology

This research employs multiple research methods such as observation, field research, and archival research techniques. To understand the contextual background of the railway stations, the study focuses on the railway stations on the Main Line and observation techniques used to examine the existing railway stations. In addition archival research used to find the origin and the historical facts. Similarly, these two techniques were used to define the hierarchical identity through the characteristics of station furniture. In field research, each selected stationmaster on Main Line had interviewed to identify the perception of railway employees on furniture in the establishment.

Origin and Background of Railway Stations in Sri Lanka

Contemporary use of Interior space in the SLR has a long history and unique identity, which survived a long period. "In the lack of an obvious model or precedent for its form, railway station furniture was

similar to railway architecture" (David Jones, 2000) Therefore this chapter will focus on background studies of SLR in addition to the railway station space.

Evolution

The social and cultural status of Sri Lanka changed exclusively during the 19th and 20th centuries. By destroying Muslim power in the Indian Ocean the Portuguese colonized the country in 16th century. Thereafter the Dutch reached Sri Lankan by invitation from the Sri Lankan king to reduce the Portuguese power. The Dutch they got the power of the coastal area by fighting the Portuguese. During the 16-century the Dutch had became masters in the trade and economy arena among the Europeans, but later the British proved superior among all of them. The Dutch empire gradually ceded to the British. The British got possession of the Dutch colonies through the treaty of 1788. Thereafter the British caught power in the costal area of Sri Lanka. (.M, 1907)

However British colonization really affected rapid growth of the economy of Sri Lanka. Tea, coffee, rubber, and coconut were the main profitable export products after a price hike in the United Kingdom in 1880. As a result of agriculture based economy, demand for the development of infrastructure in the estate sector increased. The governor in 1824 showed a massive commitment to develop coffee cultivation in the Kandyan highlands. The problem that they faced was to transport coffee from plantations. Therefore, the British made an extensive transportation network around the country. (Mills, 1933) Railway transport was introduced from 1864 onward as an agricultural transportation system from the hill country to the port city of Colombo. After been established, high-income families used the railway by paying a large sum of money. Trains were arranged for passengers with comfortable dining saloons and seating areas (figure 2) Train interiors and the environment of railway stations were arranged according to the needs of travellers, with more expectation, rail transportation arranged with great comfort to passengers and efficient for good delivery. Somehow in the early 20th century, mortor cars were introduced to Sri Lanka, as vehicles for the high-income society. Therefore passenger transportation by train was minimized. However that situation created to the general public to travel by train. Since then, railway in Sri Lanka has been formed as a service oriented organization. (Perera G.)

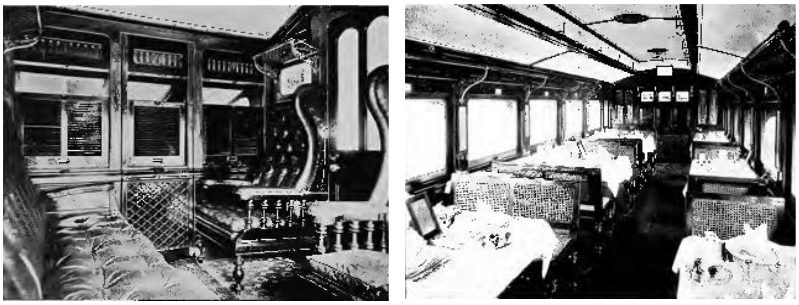


Figure 1, First class compartment in the train and refreshment car (source : Cave,1910)

Distribution of railway lines in Sri Lanka

The railway was established to transport export products from plantation and distributed to meet the different needs of the British. These main railway lines are Main line (Colombo to Abepussa), Matale line (Kandy to Matale), Coastal line (Colobo to Galle), Nothern line (Anuradapura to Kankasanturai), Kelani-valley line (Colombo to avissawella), Puttlam line (Ragama to Puttalama), Tincomalee and Batticaloa Line. Such a reserch needs a thorough observation of all railway stations and employees' perception value of Railway furniture, but due to time constrains this study is limited to observe the Main Line railway stations.

Background Structure of the Railway Station

Building sphere of the railway station

Railway stations built in the 1820s and 1830s were makeshift structures that were sometimes adapted from existing buildings such as small houses, wayside inns, or even timber huts. At the smaller, intermediate-stopping places there was often no station building at all; passengers had to buy their tickets from a local inn, as stagecoach passengers had done since the beginning of the eighteenth century. Later on the single storey, twin pavilion format with central booking hall and decorative barge boards was a formula that was employed in other areas as in the figure 2. (David Jones, 2000)

Sri Lankan railway history goes beyond 150 years. Therefore most railway stations built in the British colonial period still functioning. Even though stations are exposed to unique characters of railway culture, the design of the building was changed in order of the social background. As an example, buildings in the up-country railway line are much more enclosed than the costal line buildings, considering weather conditions. The British created buildings through the Construction Department, and railway stations were designed by architects who worked there, but some station designs came from Europe. Those architectural drawings still exist in railway department. Therefore Sri Lanka railway stations are visually similar to the architecture used in the European stations as in figure 2.

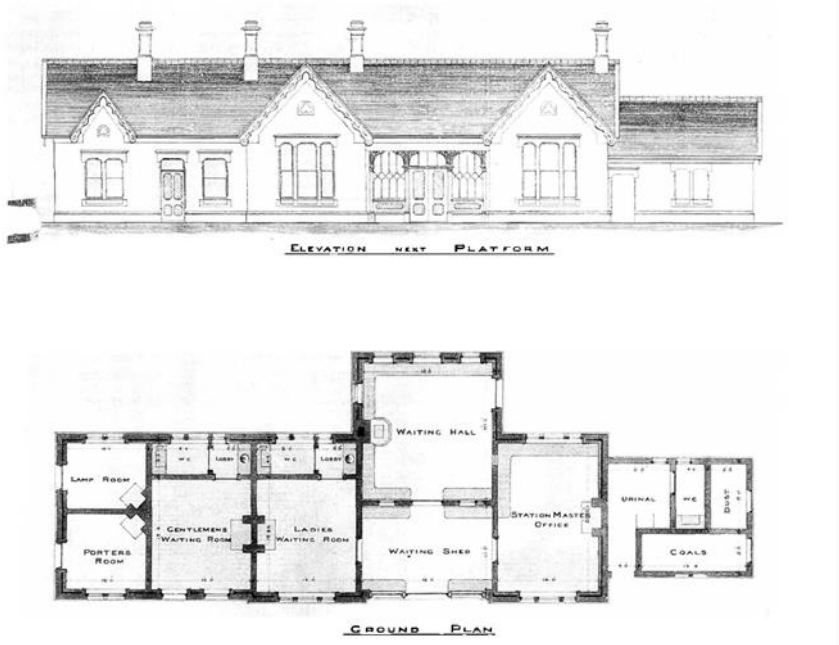


Figure 2, Station built for the market towns of Appleby, Midland, UK
(source: (David Jones, 2000)

When considering the Main line railway stations, most of them were made of stone or thick kabook enclosed because of the cold weather. Common features could be seen in the hill-country railway line, which were built in the colonial period. Bandarawela (UP) to Badulla (UP) railway station buildings are visually same with pointed and high angled shed roof. Those are single storied buildings with verandahs and metal or timber columns. At this period some station buildings were expanded due to lack of space and some had extended the platforms.

Most of the other Railway station roofs are gable-roofed buildings (figure 9,10,11) with a canopy for the platform. Metal brackets, metal truss, arch pillars, and arch grilles, British iron columns are the common feature that takes the eye on the grand monarch architecture in the colonial era.(Figure 3)

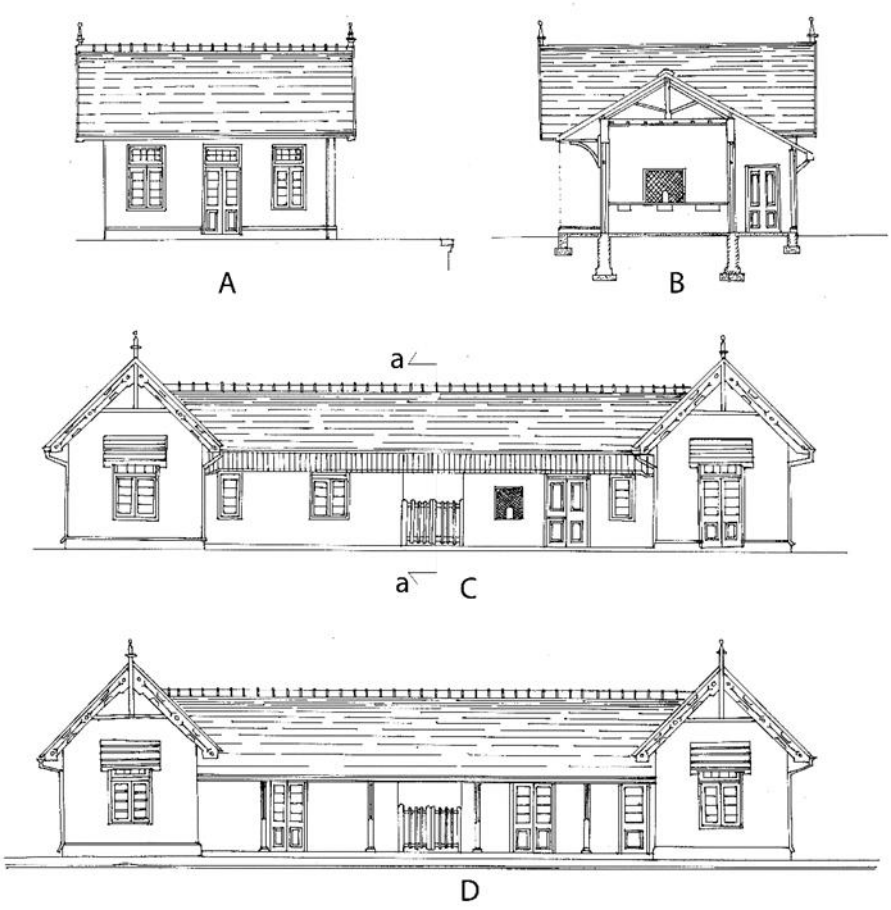


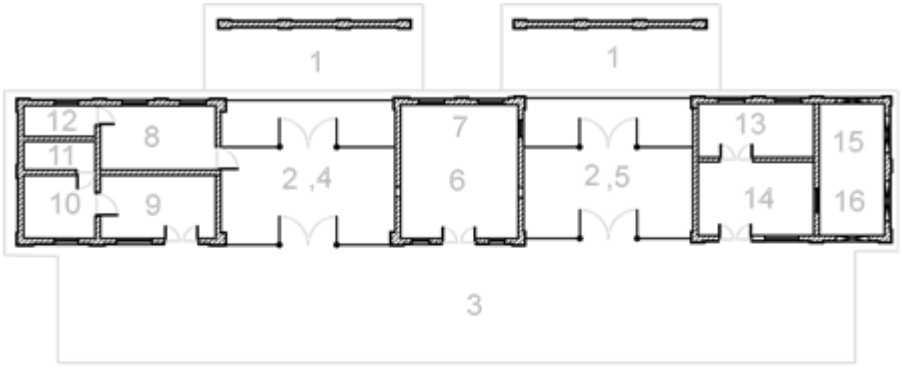
Figure 3, Ella railway station, A; side view, B; sectional view, C; road side view, D; Platform side view (source: Redrawn, survey department, plan no 06997, SLR)

Typical layout of the railway station

Railway track, platform, and roof area is the main three parts in the railway station. Dissanayaka, R. (2010) By providing more priority to railway tracks, the stations obtained linear architecture style. In earlier days, essential building areas were ticketing room (Booking halls), parcel rooms, and lamp rooms. Thereafter with passenger transportation, railway station environment was developed with rain canopies, verandahs, refreshment areas, rest rooms, and sanitary facilities.

Most commonly, every railway station has verandahs in the entrance of the railway station / opposite to the platform and in front of the ticket booking counter. This space would be purposely created to make circulation at the booking office.

For administration convenience, station roof space is separated in to the 3 main parts. Ticketing room, storerooms and stationmaster's room are the three of them. In addition, some stations have office rest room, foreigners rest rooms etc. In most of the stations ticketing room and the stationmaster's room are the prominent spaces even though rests of other rooms are inessential, but in some sub stations the ticketing room and stationmaster's room is placed in the same space. Usually the stationmaster's room is located next to the booking office or near it. However, this administration area was extending with the space availability.



Carriage
Foyer
Platform
1st and 2nd class hall
3rd class hall
Ticketing room
Parcels room
Gents lavatory
9. Ladies waiting room
10. Ladies lavatory
11. Ladies closet
12. Gents closet
13. Store room
14. Stationmasters office
15. Cooler
16. Shelter

Figure 4, plan view of the Badulla railway station (source: Survey department, architectural drawing no 06342)

Human sphere of the Railway station

The station superintendent is the highest position at the railway station but most commonly station superintendents are only appointed at few stations. In other stations, the stationmaster is the head of the station and they are categorized in order of their grades (SM1, SM2, SM3). SM1 is the one who communicate to higher administration. SM2 and SM3 normally communicated with the people and worked in the ticketing counters. Minor staff sarayer is the next position that directs miner staff. Checkers, ticket collectors, policemen's and DKS are the staff that direct by him. When the passenger collects their ticket from the stationmaster, they have to produce it to the ticket checkers, before enter the platform. The ticket collector is in every station to collect tickets when the passenger enters or exits from the platform.

Class according to the train ticket could divide passengers who enter the platform. In the early days first class night berth carriages were maintained for the benefit of the Members of Parliament, during the period motor vehicles were not available. Then the first class, second and third classes were introduced in order of the economical situations of travellers. (Thibbotumunuwe, 2014) This class system has been continuing since the earlier days of railway travel. There were rest rooms for the first class passengers and that signage were still remains. Even if there is a class system, every passenger space irrespective of class by the contemporary.

Characteristics of Railway Interior Style

"Railway furniture, though by the 1870s a widespread synthesis of influences had been accepted as 'railway style'." (Jones, 2000) The focal point is to do an analytical study about furniture based on characteristics. This research primarily introduced tangible qualities of furniture as main characteristics. These characteristics, emotions of usage, create an identity of the furniture. This introduces tangible qualities of railway furniture of Sri Lankan and the United Kingdom.

The long wall of ticket window, ticket drawers, pigeonholes and cupboards are introduced as usual features in railway stations. Figure 5 shows a wooden counter, circular centred table, and rectangular table at Settle railway station, United Kingdom with it drawers, which has been used for a long period

Figure 5, Counter, circular centred table, rectangular table, Settle station, UK (source: Jones,2000)

Railway Station Furniture in Sri Lanka

The railway of Sri Lanka has an illustrious history of 150 years. Most of the unique style of railway stations has exquisite furniture. It is said that, some of these furniture had been imported from the United Kingdom; some of them were manufactured in Sri Lanka. However all of this furniture has colonial identity with ornamented Victorian middle class style.

'At the end of the eighteenth century many references are made to calamander, nedun, satinwood and jak.' (Joseph Pearson, 1928, p. 83) As a result of that most of the railway furniture made locally was constructed in hardwood mentioned earlier. Some furniture was made in the United Kingdom from oak or rosewood. Apart from wooden furniture metal was used as structures in some platform benches.

In this research interior within this large space is divided in to two main categories; furniture used by the administration and furniture used by the public.

Characteristics of furniture

In this field research, the administrative space in railway stations can be defined as the working space of station employees. Ticketing room, storeroom and stationmaster's room could be introduced as common space of the office environment. According to administrative work some furniture was arranged for a specific purpose and it is common in most railway stations on the Main Line. Plan-view of Badulla railway station (figure 5) is symbolically used to give a better illustration about the furniture layout in railway stations on the Main Line. To analyse the Hierarchical representation through furniture in station interior, is mainly describe about the table tops, and seating facilities.

Due to some reasons, the railway station administration maintains hierarchy within the station environment. The uniforms are one way of expressing their hierarchical order and another way is the furniture tradition they maintain. Rather surprisingly, the new generation of the railway staffs also

maintain certain hierarchical order by their uniform and by the usage of furniture. In the closing years that furniture was being in the same position.

Even the larger space of the stationmaster's room, could contain little more than a larger table, and a chair to use. The table at the master room is has well maintained unique qualities which are highly present its' hierarchy as in the table 1. Mostly common master table (table 1- image 2) is large enough to accommodate necessary documents. When comparing to the other working surfaces in the administration space, tabletop facilities at stationmasters' room have highly ornamented legs, surface moldings, cornices, drawers, and some have rotatable access.

The ticketing room consists of a wide space in order to maximize working capacity. Furniture in this area mainly focuses on working capability. Tabletop facilities also allocated according to the usability of the staff. Therefore those tables have a height that goes with the counter level. Especially these do not have any motifs.

Tables in storerooms and used by other staffs are less in motifs, those are small in size, and it has simple wooden frames. But in sometimes there are some highly ornamented discarded tables used by minor staff.

In addition to the furniture in administration staff rooms, ladies and gents' waiting rooms have been over done with motifs of furniture. Those waiting rooms were certainly made for first and second-class passengers. It is separately marked on the station layout drawing that was drawn in the station plan. In the large space in the public area, worktop facilities are only located at the waiting rooms. That might because of the hierarchy that passengers maintain in the station space. Compare to the gents washrooms, ladies washrooms have more railed and carved dressing tables. It could possibly seen in the dressing tables in table 1.

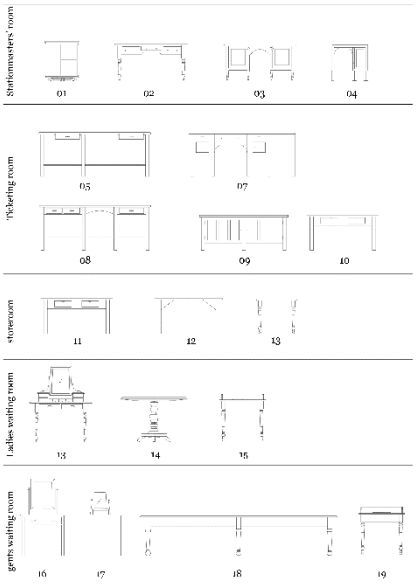


Table 1, seating facilities in station interior

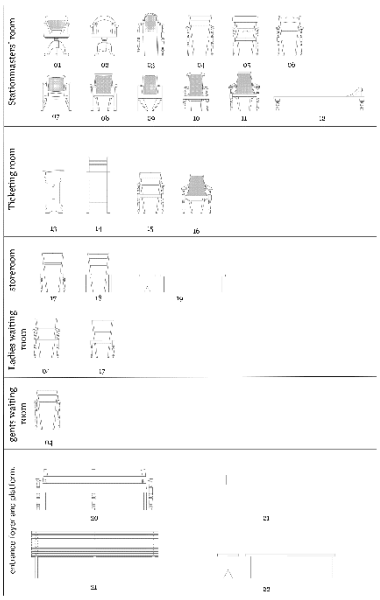


Table 2, Tabletop facilities in station interior

The master chair, other visitor's chairs, and easy chairs are the main types of chairs in the room. In every station, the stationmaster has a visually higher positioned chair, which indicates his position. Decades ago the stationmaster had a revolving chair made out of wood (table 1- image 1,2) but now there are only a few chairs remaining. Even though those chairs were replaced with new ones, most of stationmasters

placed them in their room. They always maintain certain hierarchy among the chairs beside the master table. Normally the master chair has bit more motives than the visitors' chairs. Those visitors' chairs have some specialty, than the chairs how used by the other staff. Commonly minor staff members discouraged to sit on the visitors' chairs without any acceptance. In addition to the stationmasters' common chairs, the easy chair is an essential item in the resting area in the room. The purposes of those chairs are more to extended the general purpose of sitting. Considering the job profile, the stationmaster has to stay day and night in the station, therefore this might be a welcome place for resting. Visually most of those chairs are rattaned woven on the top of the timber structure. Backward angled seats and backrests are common feature of it. (table 2, image 7-11) It is said that, armless chairs were come to placed in the ladies rest rooms for the reason of huge farthingale dress made it impossible the use of armchairs. In time passed those armless chairs were used by the minor staff at the stations. (table 2, image 15) There are two types of seating facilities that is placed in the public spaces. One is the individual seating spaces and the other is the usual seating accommodation for the majority of the passengers. Single seating facilities are only at waiting rooms. That furniture was quite similar to the armchairs (table 2, image 4,17) in the stationmaster's room. As mentioned earlier, armless chairs (table 2, image 17-18) came to be placed in the ladies rest rooms by the reason of huge farthingale dress made impossible the use of the armchairs. However furniture at waiting rooms, which have raised features more than the furniture in administration spaces.

It might be the reason that the Sri Lanka railway used to provide more comfort to passengers who travel by train. On the other hand, there are benches that contribute as usual seating accommodation at platforms for the majority of people. Those seating arrangements are commonly made out of wood strips and basic wood structures but those are not in the same hierarchical level of furniture in resting rooms. Corollary, the platform furniture and the rest room furniture might be designed for the two different communities when the railway was constructed. Those two communities could be divided though the wealth or the caste in the society. However time been, those timber furniture was used as in the earlier without any hierarchical order in the society.

Conclusion

When considering the style of railway interior in Sri Lanka, there is a hierarchical order, in their placements. Comparing with the furniture in the administrative space, high quality ornamented furniture could be seen in the stationmaster's room. Those are comfortable compared to the furniture in other station interior. Ticketing room furniture was mainly focused on the functionality than the comfortability. Storeroom and furniture used by minor staff are mostly made out of unpolished wood and no motifs. In the public spaces are having different types of furniture, which represent the hierarchical order but has less furniture, compared with office space. Public area furniture could divide to, two main parts such as furniture in platform and furniture in waiting rooms. From these two types of furniture, waiting rooms have high quality and more detailed. Those furniture motifs are represent the hierarchy more than the furniture in the stationmaster's room. That might because; the passengers who were wealthy enough to buy 1st class or 2nd class tickets only used restrooms.

Compare with the United Kingdom railway furniture in the 19th and 20th centuries, they have similarities to the style of SLR furniture, but those do not reflect any hierarchical order. In the British colonial period, they used to established classes of administration to attract the general public to work under them. It might be the reason for hierarchical representation in furniture. Therefore, this research was initiated to study the affection of hierarchical order as a reason of furniture surviving for long periods, in order to the qualitative research among station administration, they avoided expressing about the hierarchical order as a reasons of the long survival of furniture. Conversely, station administration adores by using those old dated wooden furniture as high comfort. On the other hand they represent this furniture as a native interpretation. Therefore the survival of furniture was created through the perception of the administration. Those perceptions create identity; manipulate hidden aspirations of the hierarchical order in colonial administration.

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BIOGAS AS A SUSTAINABLE ENERGY MANAGEMENT AND SOLID WASTE MANAGEMENT SOLUTION FOR RESIDENTIAL APARTMENTS

E.R.G.E.M. DHANAPALA[1], K.G.A.S. WAIDYASEKARA[2] & K.L.A.K.T. LIYANAGE[3]
[1, 2, 3]Department of Building Economics ,University of Moratuwa, SriLanka
[1]*erangadhanapalauom2@gmail.com,* [2]*anulk15@yahoo.com,* [3]*kushiliyanage23@gmail.com*

Abstract
In the current global context, attention is being paid towards the sustainability. Moreover, there are many energy sector challenges, which are getting more critical day by day. In order to overcome from such critical energy issues, different strategies are identified by several researchers in the built environment. One such strategy is use of biogas, which advances waste management and it also helps to reduce the solid waste management issues pertaining in the current society due to lack of waste dumping yards. Hence, this paper aims to present the potential of implementing biogas for the apartment buildings as a sustainable energy and waste management solution. Qualitative approach was followed along with the case study strategy. Seven cases were selected for the study purpose. Solid waste types, source of solid waste, waste management procedure of the apartment buildings were identified. Further, under biogas implementation in apartment buildings, benefits, barriers and strategies to overcome from the identified barriers were discussed. The results suggest that effective implementation of biogas system for apartment buildings is a precise solution not only for waste management issue but also for non-renewable energy issues faced by Sri Lanka.

Keywords: *Apartment Buildings; Biogas; Energy Management; Sustainability; Waste Management.*

1. Introduction

As a result of sustainability's potential for solving current global problems and providing for future generations by integrating environmental, economic, and social considerations, it has attracted a great amount of attention in recent years (Mihelcic, Crittenden, Small, Shonnard, & Hokanson, 2003). Sustainability can be defined as a development, which should fit the needs of the present without adding up to the ability of future generations to satisfy their own needs (Brundtland, 1987). Moreover, International Organisation for Standardization 92016) stated that energy management is the procedure of adapting and optimizing energy, with the use of various acts so as to reduce total energy demands per unit of yield while keeping uniform or diminishing total costs of producing the yield from these systems.

There are many energy sector challenges, which are getting more critical day by day such as global fuel-food crisis, overdependence on fossil fuels, and excessive emission of greenhouse gases, global warming, and climate change (Mohanty, 2012). The author has stated that there is a very high demand for energy than ever before due to the growth of population and these conditions arouse the need for efficient renewable energy sources. Further, Mohanty (2012) mentioned that, renewable energy sources are much more needed these days and consequently 'green growth' and 'green economy' can be accomplished via green energy initiatives and development of green energy technologies. As per the findings of World Bank (2013), countries like Sri Lanka, Bangladesh, Pakistan and Nepal, this situation has become much more critical. In many countries in the world, it has become an important objective to utilize renewable energy as it will provide for a clean and sustainable approach to energy production (Lund, Duic, Krajac, & Carvalho, 2007).

There are many sustainable energy sources such as hydroelectricity, wind energy, solar energy, geothermal energy, wave power, biomass, tidal power, and artificial photosynthesis (Stritih, Paksoy, Turgut, Oste, Evliya, & Butala, 2015). Biomass is a basis in the cornerstone in renewable energy projections of the European Union, and biomass will be accounted for 56% of the renewable energy supply in the EU27a by 2020 (Bentsen , & Felby, 2012). Further, authors have stated that biodegradable matter is the highest proportion of the Municipal Solid Waste (MSW), which is when disposed to landfills, form different gases and leachate. Efforts to identify alternative management options for MSW is being a result of concerns over the effects on the environment of the landfill (Facchini, Gronow, Voulvoulis, & Ohandja, 2011). In Sri Lanka, great amounts of MSW are generated pioneering for many

social and environmental issues (Ameen, 2017). In Sri Lanka, great amounts of MSW are generated pioneering for many social and environmental issues. It is noted that 0.40-0.85 kg of waste is generated by one person per year in Sri Lanka and 6400 tons per day is generated whereas the collection of waste is only about 3740 tons per day (Waste Management Authority, 2016).

Biogases can be recognized as an ecological solution, which remarks to constituent like methane and carbon dioxide that are formed by the anaerobic fermentation of biological materials. Biogases are mostly formed from agronomic and biological waste (GE Energy, 2009). As per the finding of Ndzibah (2009), to yield a significant quantity of energy; the waste input should be large enough. The populations of apartment buildings, student hostels, and big companies could be large enough for a rational amount of waste to be produced to fuel the scheme. Biogas generation is an intelligent way of arraying waste. Biogases, advance the waste management and have given biogas-fuelled engines an opportunity to increase the quality of waste management through exploiting the usage of a cost-effective energy source (Ketola, & Salmi, 2010). Thus this paper focuses to discuss the potential of implementing biogas system for apartment buildings as a sustainable energy solution and waste management solution.

2. Literature Review

2.1. CONCEPTS OF ENERGY, AND ENERGY MANAGEMENT

With the increasing population, demand for the energy keeps increasing and it has resulted in energy crisis (Coyle, Simmons, Eugene, & Richard,2014) Energy crisis can be defined as the inability to provide the required amount of energy to the users (Ozturk, Sozdemir, & Ulger,2013). Mainly energy can be categorised into two sources as primary source and the secondary source whereas primary energy is taken directly from the environment while the secondary energy is the change form of the primary energy (Demirel, 2016).

In any organisation, energy cost is considered as one of the key costs, which needs to be saved in order to achieve profits for the organisation (Krishna, & Anuradha, 2016). Thus, energy management is vital for an organisation. Energy management means the process of monitoring, controlling, and conserving energy in a building structure or an organization (Ellsworth-Krebs, & Reid, 2016).

2.2. INTEGRATION OF WASTE MANAGEMENT AND ENERGY

Solid Waste (SW) is defined as the portable objects that have been abandoned by the owners (Bilitewski, Hardtle, & Marek, 1997). In the modern context, priority is given to sustainability due to the resource scarcity (United Nations Environment Programme, 2005 Thus, attention is being paid for strategies like recycling, waste quantity minimization, and conversion of waste into energy (Galante , Aiello, Enea, & Panascia, 2010). Waste is considered as a key issue, which needs to be addressed as it concerns the public health and environment (Wilson, & Rogero, 2015). According to Abouzied, and Chen (2014), waste management in developing countries needs significant improvements.

2.3. WASTE IN RESIDENTIAL APARTMENTS

According to Aiello, Enea, and Panascia, (2010), due to the positive relationship between population and waste generation, waste generation get increased with the population growth. Moreover, authors have stated that it is a critical issue to identify the most suitable method for solid waste disposal. However, with the waste disposal, number of issues like Green House Gas (GHG) emission, leachate generation and different environmental issues get generated (Angelidak, & Batstone, 2010)

According to Yatima, and Arshad (2010), residential solid waste comprises of organic waste, food waste, paper, glass, plastics, metal, aluminium, and textile waste. Further, authors have stated that, organic waste is the most generated waste type in residential buildings while plastic is the second largest waste type generated in residential buildings. For the waste collection in apartment buildings, there are solid waste collection points like allocation of wet and dry bins, and waste collection yard (Waste Management

Authority, 2016). In addition to that, in the report National Building Code (2005), for the waste transportation from different storeys to the collection area in the ground floor, there should be two separate garbage chutes as wet and dry waste. According to Consonni and Vigano (2012), when waste is managed properly in residential buildings, economic benefits can be achieved by implementing strategies like use of biogas system instead of LP gas system.

2.4. BIOGAS SYSTEM

Depending on social, economic and environmental criteria, integration among energy and waste management may vary and by using waste to energy technologies, environmental friendly energy production can be achieved (World Energy Council, 2013). In the current context, most common waste handling methods are identified as recycling, mechanical-biological treatment, landfilling, composting and waste to energy methods (Psomopoulos, Bourka, & Themelis, 2009). Moreover, authors have stated that, through waste to energy technologies, different types of waste are converted into valuable energy sources. Authors have also said that, through organic waste, biofuels can be produced. Furthermore, in the modern world, research projects are being conducted to identify the technologies, which can be used to convert waste into energy (Consonni & Viganò, 2012).

According to Al Seadi, Rutz, Prassl, Köttner, Finsterwalder,and Volk, (2008), in many countries sustainable waste management have become a key political priority, representing a vital share of the common efforts to reduce greenhouse gas emissions and pollution and to mitigate global climate changes. Further, authors have identified biogas as a solution to the organic waste generation. Moreover, Angelidak, and Batstone, (2010) stated that, biogas can be produced through Anaerobic Digestion (AD) of slurries and animal manure as well. In addition to that, Preibler, (2007) has explained AD is a microbiological procedure that use to decompose organic matters. When it comes to the benefits of biogas system through the conversion of waste, there are benefits like use of biogas an energy source, environmental management, efficient and flexible biogas usage, and use as a fertilizer (Al Seadi et al., 2008; Sri Lanka Standards Institution,2017).

3. Research Methodology

In order to check the feasibility of implementing biogas system to the residential apartments as a sustainable energy solution and solid waste management solution, qualitative approach was followed in the study. Case studies were selected as the research strategy and seven cases were selected for the study and Table 1 shows the profile of the cases. Semi structured interviews, documentary review and non-participatory observation methods were used as the data collection techniques. Respondent details of the seven selected cases are provided in Table 2.

Table 1 : Profile of the Cases

Case	Description
A	• The apartment is a 31 storeyed building and has 122 apartment units. • Apartment has roof top, swimming pool, kiddie's pool, banquet hall recreation areas, gymnasium, lounge, building management office, drivers lounge, and a heliport.
B	• The apartment is a twin building and one tower has 23 floors. • The apartment has swimming pool, club house, gymnasium, kiddie's pool, and a car park.
C	• The apartment is a twin building and one tower has 37 floors • The apartment has swimming pool, gymnasium, kiddie's pool, and a car park.
D	• The apartment is a 45 storeyed building and has 160 apartment units. • Apartment has swimming pool, kiddie's pool, banquet hall recreation areas, gymnasium, building management office.
E	• The Apartment has three tower and each tower has 38 floors.

	• The apartment has swimming pool, gymnasium, kiddie's pool, and a car park.
F	• The apartment is a 10 storeyed building and has 61 apartment units. • Apartment has swimming pool, gymnasium, building management office
G	• The apartment is a 32 storeyed building and has 120 Apartment units. • Apartment has car park, swimming pool, gymnasium, and function hall.

Table 2 : Details of the respondents

Case	Respondent	Respondent Profile	Experience
A	A1	Executive Engineer	15 Years
	A2	Executive Facility Manager	5 Years
B	B1	Property Manager	40 Years
	B2	Facilities Executive	3 Years
C	C1	Executive Engineer	30 Years
	C2	Property Manager	22 Years
D	D1	Facility Manager	5 Years
	D2	Executive Engineer	16 Years
E	E1	Property Manager	25 Years
F	F1	Property Manager	10 Years
	F2	Facility Engineer	6 Years
G	G1	Facility Engineer	15 Years

For the analysis of the collected data through the semi structured interviews, content analysis was used along with the N-Vivo computer software. Section 4 presents the analysed data from the semi structured interviews.

4. Results and Discussion

In order to identify the importance of integrating energy management and waste management, current waste generation, existing waste management methods and current waste management procedures were investigated and presented in this section.

4.1. SOLID WASTE GENERATION AND WASTE MANAGEMENT PROCEDURE IN SRI LANKAN APARTMENT BUILDINGS

For the implementation of biogas system in an apartment buildings, it is necessary to identify the waste generation methods in the building. When it comes to the case study findings, it was evident that in all the cases, similar types of solid waste get generated and presented in Table 3 with the source of waste generation of the selected cases.

Table 3: Waste Types and Source of Waste Generation

Waste Type	Source
Food waste	Apartment kitchen, Cafes, Function halls
Paper waste	Apartment units, Condominium offices and Cafes
Plastic waste	Apartment units
Glass waste	Apartment units
Sewage	Apartment units, Condominium offices, Cafes and function halls
Garden waste	Gardens
Others	Maintenance waste form the maintenance division, Waste water from all the apartment units and car washing bays

As per the literature findings, it was identified that biogas can be produced in apartments only through biodegradable waste. The case study findings show that biodegradable solid waste types as food waste, sewage, and garden waste. While analysing Table 3, it could observe, apartment units are the main

source of waste generation. Furthermore, from the findings it was evident that within a week, out of the generated solid waste, food waste is the highest waste type generated in all seven cases while the less amount of waste is generated through garden waste due to the limited garden space in apartment buildings. Figure 1 illustrates main waste type generate in the apartment.

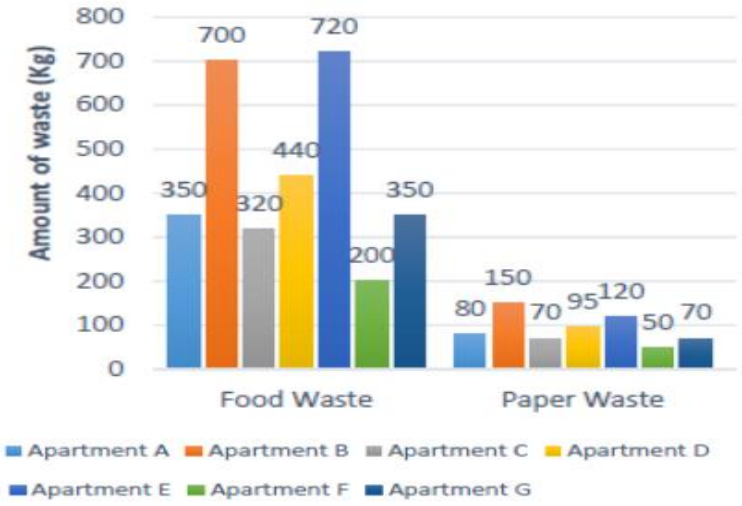

Figure 1 : Main types of waste generation in apartments

Moreover, the study revealed that for the production of bio gas, as the inputs food waste and garden waste can be used. Although sewage waste can be used for the production of bio gas, in the current context of the waste quantification, sewer waste is not taken into consideration. In addition, it was identified that there is a positive relationship between waste generation and the average occupancy of the building based on case study findings. Thus, when the occupancy gets increased waste generation too get increased.

When considering about the waste management procedure in the selected seven cases, except one, all other cases follow the same method. As the initial stage of the waste management procedure, apartment unit owners do the point wise waste segregation in their own apartment units and by using the garbage chute waste is transferred to the ground floor from each storey of the building. Moreover, it was identified that once the waste is collected in their own apartments, they are brought into the shaft room where waste is segregated as for a bin arrangement of paper, plastic and glass waste. Similarly, food waste is also collected in each and every apartment unit and brought to the shaft area and transferred from the garbage chute to the ground floor garbage room. However, in Case C, separate waste bins have been allocated for each storey of the apartment and they are being transferred to the ground floor garbage collecting area by the janitors. Further, in all seven cases, after collecting them to the ground floor, waste is given to the Municipal Council for the disposal.

4.2. POTENTIAL OF IMPLEMENTING BIO GAS SYSTEM FOR APARTMENT BUILDINGS

To implement biogas system for the apartment buildings, possibilities, benefits, barriers and ways of overcoming the identified barriers are discussed in the following sections.

4.2.1 Possibilities and Benefits of Implementing Biogas System

From the collected data through the semi structured interviews, all the twelve (12) respondents of the seven (07) cases believed that there is a possibility of implementing a bio gas plant in the building. Out of the twelve respondents, respondents of B1, C2, and D2 of the Cases B, C and D stated that it is a good decision, if the biogas plant is designed at the initial stage of the building as it needs to look into some technical and safety aspects in the installation.

By implementing a bio gas system in an apartment building, the study identified that there are benefits like environmental, economic and social. When it comes to the economic benefits, as per the respondent A1 stated that, current cost of LP gas usage in Case A on average basis is Rs. 35,000.00 in every two months and if bio gas is implemented in the apartment building, then this cost can reduced dramatically. All most all the respondents of the seven cases stated that, use of bio gas in their apartment buildings, economic benefits can be enjoyed by the savings through the shifting of LP gas usage to bio gas. Moreover, respondents A1, and F2 of Case A and Case F, highlighted that waste transportation cost savings also can be gained through the use of bio gas system. Furthermore, in the process of bio gas production, there are by products like compost. By selling these compost as fertilizer for the farmers, economic benefits can be gained.

When it comes to the social aspect, in order to use bio gas in the apartments, recycling needs to be carried out. Thus, biogas contributes more towards sustainability aspects such as environmental, economic and social. Furthermore, almost all the respondents have agreed that through the waste recycling, sustainability is achieved by the buildings and with the minimization of non-renewable energy usage, solutions can be provided to the world energy crisis.

4.2.2. Challenges and Barriers for Implementing Biogas System

For the successful implementation of the bio gas system, some barriers were identified as, difficulties in applying new system to an existing design, space limitation, unawareness about the biogas system, safety issues, inconsistency of the waste generation, difficulties in finding the capital cost for the instalment of the biogas system, and difficulties in finding new resources and presented in Figure 2.

Name	Files	References
Implementing Challenges and barriers of biogas system in the Apartment Buildings	12	39
To applying a new system to the current design	9	9
Space limitation	8	8
Unawareness of about biogas system	8	8
Safty issues	4	4
Insufficient waste generation	4	4
Finding the initial cost for implementing	4	4
Finding new resources	2	2

Figure 2: Challenges and barriers

Respondents A1, and D1 of Case A and Case D stated that, if implementation of bio gas system was not in the initial plan of the apartment, it will cause issues in implementing service lines for the bio gas system. Further, respondent B1 explained that, as the space is limited in an apartment building, construction of biogas plant is a difficult task and need to be considered during the planning stage.

4.2.3. Strategies to Overcome the Barriers when Implementing Biogas System for Apartments

As per the findings, to implement a biogas system in an apartment building, awareness needs to be provided to emphasis the benefits of using the biogas system. In order to implement biogas plant in the apartment awareness program should be conducted. By doing that attitudes of the condominium occupants can be changed in a positive way to implement the bio gas plant in the apartment. Further to that, to change the negative attitudes of the condominium council it is necessary to aware them regarding the economic benefits as well as the environmental benefits that could be gained from installing a biogas plant in the apartment. Moreover, respondents highlighted that as the initial stage, awareness needs to be given to the apartment unit owners.

Furthermore, in order to overcome from the limited space issue, respondents D1 and F1 stated that, use of an open area in the garden or else to construct biogas reactors in the underground. To overcome from the safety issue, existing safety methods needs to be upgraded with the modern technologies. Further, respondent D1 highlighted that with the use of modern technological safety system as a method for detection and protection system and to establish ventilated area in the apartment.Moreover, through a feasibility study, capabilities and in-capabilities of biogas plant operation can be identified and through that inconsistency of the waste generation can be overcome. To overcome from the issues related to the installation of service lines, existing LP gas lines can be used to distribute the biogas to the building.

5. Conclusions

Potential of implementing biogas system through solid waste management in an apartment buildings was the main focus of this paper. The study adopted case study strategy to investigate current waste management systems, type and sources of waste generated in the apartment buildings. The study revealed that food waste identified as main key solid waste type and chute and bins are used to collect waste from each unit and finally collected them by the municipal council and dispose.

Main benefits of implementing biogas system were identified in terms of economic, social and environmental while there were barriers like difficulties in applying new system to an existing design, space limitation, unawareness about the biogas system, safety issues, inconsistency of the waste generation, and difficulties in finding the capital cost for the instalment of the biogas system. Further, the study revealed that those barriers can be overcome through awareness programs, space management, and conducting feasibility studies on capabilities and in-capabilities of the biogas plant.

All the respondents believed that there is a potential of implementing biogas system for the apartment buildings and identified it is a sustainable solution for current waste and energy crisis faced by the country.

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ENHANCING THE PRACTICES OF SPARE PART MANAGEMENT IN MANUFACTURING INDUSTRY

ABEYRATNA S.M.D.N.[1], THAYAPARAN M.[2] & FAYASA A.F.C.
[1, 2]Department of Building Economics, University of Moratuwa, Sri Lanka
[1]*dabeyrathna3@gmail.com*

Abstract
Spare parts (SPs) are set of extra items that are used for emergency replacements of worn out and defective parts. Maintenance and provision of SPs are the two activities which need to be performed together. Maintenance policy is based on inspection where identified defective items need to be either repaired or replaced. Maintenance activities generate the demand for spare parts. Spare part management (SPM) is an essential concept to be applied in any type of industry, especially in manufacturing industry due to the heavy usage of various types of machineries. Hence, spare part management causes significant impact, positively and negatively on the operations of manufacturing industry. Nevertheless, the applicability of SPM for maintenance in Sri Lanka is comparatively limited and the awareness about SPM is considerably low. There is a dearth of research conducted to identify the impact and to draw the awareness of SPM in Sri Lankan context. Therefore, this study aims to enhance the practice of spare part management for maintenance purposes in manufacturing industry in Sri Lanka. A comprehensive literature analysis was conducted on currently available scientific knowledge through reliable sources in order to realize the current practices of spare part management in other countries and any frameworks used in such countries to enhance the practices. Five case studies covering 5 main types of manufacturing industries in Sri Lanka have been conducted to identify the current practice and impact of SPM. Specially SPM directly related with the maintenance activities and also have the ability to cause direct impact for the production. Priority given for managing SPM is in lover condition. The major reason to have a lacking consideration is the lack of awareness. It increases the cause of negative impact for the organisation. Main six steps to be followed under SPM and the factors to be considered under each step have explained within the study.

Keywords: *Spare parts management, Maintenance, Manufacturing industry*

1. Introduction

Manufacturing industry is the industry which produces different types of products with the help of machineries. Maintenance is a strategy which is carried out by following a set of activities need to restore a system to its required performance state or maintain the equipment to accomplish its designated task towards to each organisation by minimising the failures (Driessen, Arts, Rustenburg, Huisman, & Van Houtum, 2010). Gopalakrishnan and Banergi (1997), stated that, main function of maintenance is to ensure the manufacturing plant and its equipment, to use productively at a minimum cost for scheduled hours with minimum wastages. Satyendra (2014) initiated that, spare parts (SP) are the lifeblood of operational reliability and plant capacity. Plants cannot be operated efficiently without having reliable supply of functional SPs for maintenance. Inefficient management of SPs cause excessive inventory of SPs, non-availability of SPs in case of an emergency breakdown, cause high holding costs and maintenance delay. As per the case studies conducted by Wagner and Lindermann (2008), SP inventory planning for maintenance is not practiced in manufacturing organisations. The applicability of SPM for maintenance in Sri Lanka is limited and the awareness about SPM is considerably low. The aim of the study is to investigate the SPM practices followed in Sri Lanka and identify the impact of SPM for the manufacturing organisation. This paper reviews the concept of SPM for maintenance, its significance, current practices and impact in manufacturing industry based on both primary and secondary data.

2. Literature review

Manufacturing industry is transforming raw materials into a marketable finished product and provide consumable goods to the customers or end users (Levinson, 2018). After identifying the need of low-cost production, industry looked into ways of reducing cost by optimising the maintenance of the organisation by reducing the wastage of costs (Levitt, 2005).

2.1. MAINTENANCE MANAGEMENT IN MANUFACTURING INDUSTRY

Maintenance is one of the major contributors for the cost in manufacturing industry (Porras & Dekker, 2008). Unexpected breakdown of equipment is caused by excessive temperature, faults on electricity supply, excessive force, speed overloading, excessive vibration, defective usage, poor lubrication and contamination (Folger, 2015). Unexpected failures on machines result in reducing the quality and number of outputs which lead to cause tremendous losses on profit (Yang, Zhao, Peng, & Ma, 2018).

Preventive maintenance (PM) and corrective maintenance (CM) are the two main categories of maintenance. (Wang, 2011). PM, which is carried out to keep the equipment in continuous operation condition without breakdown and CM is followed to restore the equipment to its operational state after the failure of the equipment (Doyen & Gaudoin, 2011). ISO/TS 16949:2002(E) standard explains that a manufacturing organisation needs to develop a proper maintenance plan. As the minimum requirement, plan shall include activities of PM on equipment with availability of SPs for key manufacturing equipment to evaluate. The requirement of SPs can be decided with the type of maintenance activities scheduled in ahead of the time period and make them available within the stock. Wang (2011) proved that, PM and provision of SPs are related activities that need to achieve together.

2.2. SPARE PARTS MANAGEMENT

Patterson and Fredendall (2002) defined that the main function of SPs is to assist the maintenance staff to keep the equipment in operational condition. SPM is one of the actions that follows to reduce the risk of uncertainty caused by machine failures (Kang & Subramaniam, 2018). Effective SPM should able to place right parts at the right place in the right time. SPM helps to reduce the downtime of failed equipment (Cavalieri et al., 2008). According to Dyess (2017), the main objective of SPM is to minimise the requirement of inventory while ensuring the timely availability of SPs in case of a failure. But over stocking of SPs cause high overall cost for the organisation (Lanza et al.,2009). Availability of suppliers for some types of SPs are rare and are limited (Cavalieri et al.,2008).

SP planning and controlling is based on the factors like criticality, redundancy, repairability (Driessen et al., 2010), demand pattern, cost of purchase, stock out cost, suppliers (Cavalieri et al., 2008), availability (Kolinska et al., 2017) and specificity (Huiskonen, 2001). Among them Wagner and Lindemann (2008) suggested criticality as the most important component which leads planning and controlling measures. Clear identification of the criticality level of the equipment is the initial level of SPM. To fulfil the requirements of SPM, factors influencing demand forecasting, cost, and the inventory level must be considered. These three factors are further discussed below.

According to Bousdekis et al. (2018), demand for the SPs depends on the type of maintenance action followed by the organisation. Demand forecasting refers for deciding the future requirement of SPs by studying the past demand patterns of SPs. Driessen et al. (2010) mentioned that demand forecasting is conducted based on maintenance policy, price of parts, mean time between failure, data from sensors, historical data, and degradation level.

There are various types of costs incurred on SPM. Initial cost on SP is the acquisition cost or the purchasing cost (Marseguerra, Podofillini, & Zio, 2005). Deviations on SP costs directly or indirectly depend on purchase cost, down time cost, labour cost, inspection cost, replacement cost and breakage cost (Horenbeek et al., 2013). Diallo et al. (2009) mentioned that there are three main types of inventory costs such as, inventory holding cost, stock out cost and ordering cost associated with SPM. Stock out cost occurs due to insufficient inventory levels of SPs. Stock out cost includes cost due to loss of customers, compensation paid for the customers and cost of production loss (Jianfeng et al., 2011). Repairable SPs can save the cost by approximately about 80% than purchasing a new SP (Karsten et al.,2012). But Fleischmann et al. (2003) (as cited in Karsten et al.,2012) argued that the reliability of a used SP is lower than a new one. Therefore, SPM plan or system will help to manage the total costs on SPs effectively.

Managing relevant stocks of SPs in required level fulfils the demand for inventory (Karsten et al.,2012). Poor predictions and poor recommendations of SP inventory cause unexpected failures while low SP inventory and unnecessary ordering cause cost to organisation. Inventory controls for the SPs need to be designed by considering lead time, demand fluctuations, shortage risks and obsolescence (Diallo et al., 2009). Kennedy et al. (2002) mentioned that, SP inventory depends on the maintenance policies and failure rate of machineries. Kyriakidis and Dimitrakos (2006) suggested that impacts caused due to the unexpected breakdowns can minimise by establishing safety stock to fulfil the demands of the PM activities which is called as a buffer stock. Silva (2012) said that the materials must exist closer to the point of usage to reduce the wastages cause from waiting to use. The brief literature review discusses the key features of SPM, which has been analysed primarily in the context of manufacturing industry.

3. Methodology

Due to dearth of research on SPM for the manufacturing industry in Sri Lanka, this research intends to analyse the current practices of SPM in manufacturing industry and its benefits and challenges. Hence, a qualitative approach was considered due to the subjective nature of the research where researcher's judgement played a part as well. In this regard, an in-depth multiple holistic case study approach has been selected to conduct this study where the case study boundary was manufacturing industry in Sri Lanka and the unit of analysis was Spare Part Management (SPM). 5 large scale manufacturing organisations in western province of Sri Lanka with more than 500 employees have been selected for the case study, as the heavy usage of machineries are evident to analyse SPM in such organisations. The details of case studies along with the respondent's profile are shown in Table 1.

Table 1: Overview of case study firms

Case	**Type of industry**	**Number of workers**	**Years of experience of respondents**		
			Maintenance engineer	**Maintenance engineer**	**Maintenance engineer**
A	Garment	560	12	15	5
B	Paint	520	8	16	11
C	Polythene/ plastic	615	17	13	6
D	Food processing	2250	18	12	10
E	Pharmaceutical	535	20	6	8

Fifteen (15) qualitative semi structured interviews with maintenance engineers, supervisors and storekeepers from each case study were used to collect data. Qualitative content analysis that involved data reduction, display and conclusion drawings (Miles and Huberman, 1994) was adopted to analyse the case study interviews. The key findings from the case studies are presented below.

4. Research findings and discussion

4.1 CURRENT SPARE PART MANAGEMENT PRACTICES IN SRI LANKAN MANUFACTURING INDUSTRY

Identifying the current practices of spare part management (SPM) in manufacturing industry is one of the objectives to be fulfilled. One key finding is that, none of the case study organisations have any specific framework for SPM. When considering general overview of the cases, common set of steps are being followed by the factories to address SPM. SP identification, SP planning and controlling, demand forecasting, purchasing, classification and, stock management were the common steps followed under SPM in all the studied cases. Each step described within paragraphs.

According to the view of the respondents, SP identifications leads the SPM process. Two main types of SPs as critical and normal SPs have been identified by them. Critical SPs determine based on parameters such as, parts of critical machines, machine parts that are capable of causing direct shut downs, SPs consumes highest lead time and parts that could cause health and safety issues. Other SPs are non-critical. Identification of criticality has given the priority based on subjective assumptions. All cases used PM schedule, historical data, catalogues, instructions from Original equipment manufacturer (OEM) and experience of technical staff in SP identification. But in addition, case C and D identify SPs required for modification of existing equipment.

Planning and controlling was identified as the second step of SPM process. The factors identified through literature are primarily confirmed with the 5 case study organisations in order to find out their level of considerations as shown in Table 2. The results were based on the experience shared by all 15 interviewees across the 5 case studies.

Table 2, factors for Spare parts planning and controlling

Case / Factors	**Case A**	**Case B**	**Case C**	**Case D**	**Case E**
Criticality	√	√	√	√	√
Repair ability	√				
Redundancy			√		√
Supplier availability	√	√	√	√	√
Availability of SPs in local market	√	√	√	√	√
Brand of SPs	√	√	√	√	√

Based on Table 2, special consideration was given to criticality, supplier availability, market availability and the brand. Quantity to be stored and the quantity to be ordered have decided based on the critical SPs as controlling action. Factories have decided to store identified critical SPs and frequently using SPs as a cost-effective option. With respect to the ideas of the respondents, supplier availability and market availability have considered as one factor. Under planning and controlling, best supplier selection, supplier register preparation and evaluating the supplier are performed within the factories. Reparability of the parts have given low attention in all the cases. Parts which consumes higher cost are repaired and reused, though some of the respondents stated that some repaired SPs have to be replaced for a short period of time. Repair might lead to even higher costs than simply replacing them. The service of the repaired SPs cannot ensure. Redundant items have been considered as a cost for the organisations. As a planning and controlling mechanism, storage of redundant items was reduced by having supplier agreements. Brand of SPs have considered as another major factor in planning and controlling. With respect to the suggestions of the respondents, brand concern only on the identified critical items as a cost-effective mechanism.

Based on the planning and controlling SP demand and forecasting done. All fifteen respondents of the cases have acknowledged, maintenance policy, price of SPs, historical SP consumption records have direct influence on demand forecasting. Case B had separate maintenance history card for each important machine. SPs ordering quantity escalates with the age of machine. Therefore, history cards specify the quantity to be purchased. Demand for the SPs from local suppliers made by considering the price. It is a control measure for the maintenance budget. All cases have highlighted that, regardless of the price, some parts required for machineries have to purchase. Most of them were from OEM. Based on the forecasted demand, purchase was done.

All the factories use similar purchasing and issuing procedure. Interviews revealed that, all factories had two main parties as OEM suppliers and general suppliers for purchases. After handing over the requirement of the SPs, 3 quotations were called to select the most feasible supplier for general supplier

selection. Direct purchases have been conducted from OEM suppliers without supplier comparison. For issuing, factories use a combination of manual or electronic procedure. For example, Case A conducts a '5 why analysis' to identify the root cause for the breakdown as manual procedure. Practical application of '5 why analysis" was not seen as a successful method, due to the frequent requisition of the parts. Case E used computerised system for SP issue process. MS excel tool have been used by case A and B to issue SPs. After purchase, SP classification and inventory management has been performed.

Classification of SPs based on their criticality, usage, importance, characteristics and machine based. However, the factories haven't followed any specific classification mechanism for all types of SPs due to different characteristics. Case A and D have considered important items(A), less important items(B) and common items(C) which is known as ABC method, as well as vital(V), essential(E) and desirable(D) method for the classification. All factories classify some of the SPs based on the type of machine specific for the production. But E1 introduced a new classification type as identical, equivalent and substitutional.

Stock management was the last step. Case B, C and E maintains bin card system to determine the existing stock level, record issue and new arrivals. Each stock item was allocated a bin card. Reorder level was decided based on the experience and the past consumption records. It is impossible to classify all SPs based on one classification due to different characteristics.

Above mentioned were the main steps have by the factories as the process of SPM. The method of practice and factors considered have been different from organisation to organisation based on the product.

4.2 BENEFITS AND CHALLENGES OF SPM FOR THE ORGANISATION

SPM affects for the continuity of production and inventory management. Other objective to be discussed is, benefits and challenges of SPM followed by the maintenance in manufacturing industry. Cost reduction is one major challenge of effective SPM. The major costs components associated with SPs are purchase cost, labour cost, inventory maintenance cost, inventory holding cost and downtime costs. Respondents confirmed that, SPM can use for effective costs management. However, the problem is, none of the factories have mechanisms to calculate or monitor the costs associated with SPs. Case B, C and D have agreed that SPM has direct influence for the downtime fluctuations and directly impact for the production continuity. Quality improvement is another impact to be achieved by using SPM. Quality of the product is associated with the fault in production machinery. Low quality products lead to loss of orders, customers, money and reputation. With respect to case D and E, SPs replaced for the machine parts that touches the final product has a possibility to cause defective products. Minimising the time wastage is another impact made by effective SPM. Time consumed for searching relevant SPs on stores, duration of downtime, operation time wastages and waste of effective working time of workers can save by effective SPM. Accuracy of the reorder level and reorder quantity minimises the inventory holding cost and able to get advantages from bulk purchasing. Efficient storage utilization is another benefit of proper SPM. In all 5 cases, it has been identified that enough space for the storage was not allocated. Therefore, it is essential for them to use the available limited space to manage the SPs without affecting the smooth operation and production activities of the organisation. Effective SPM utilizes the limited space allocated for stores effectively to store necessary SPs for the timely use. Space utilisation have not been paid much attention by the factories analysed by the case study.

4.3 DISCUSSION

Based on the findings from the data collection, SPM could define as, "a set of actions followed, to identify, purchase, issue and store extra set of machine parts, that need to reduce the risk of uncertainties cause from machine failures, by balancing the losses cause from over stocking and unavailability of SPs in case of need". SPM directly affect for the maintenance of the factories.

Regardless with the type of product and the size of the organisation, SPs are essential for maintenance activities.

The findings also identified the key areas such as cost, quality, time and space where an effective SPM can make an impact. However, it was clearly evident through the primary data that the factories do not pay much of attention on SPM in order to effectively manage these key areas. Factories mostly focused on the downtime and the quality of products. There were instances where the factories felt negative impacts due to poor SPM, even though they were not quantified or documented. For example, production delays due to delays in SP purchasing and mismatches of purchased SPs. By using different alternatives and replacement of machineries and SPs, factories have managed to provide quality products and complete the targets with some delays. Wastage of products have been reported to be increased, due to malfunctioning of the machines. In such case, the organisations borne the cost of wastage risking their profits rather than risking the customer relations.

The one positive finding is that all the factories have good level consideration to the concept of SPM, despite they fear the barriers such as high initial cost, lack of expertise, lack of awareness, lack of mechanism to reduce cost, time and wastage. If these barriers are addressed, then the concept of SPM can be easily introduced in these large-scale factories. As such how to minimise the barriers in introducing SPM process in large-scale organisations in Sri Lankan manufacturing industry is proposed for further research.

5. Conclusion

This research paper investigated the current practices of SPM practices and their impact on the organisations. Selected factories were large scale well reputed factories in the manufacturing industry of Sri Lanka. The key finding is, the factories in Sri Lanka do not have awareness, knowledge and expertise on the concept of SPM. Hence the discussion on this paper can be related to large-scale factories of manufacturing industry in Sri Lanka despite their types of products produced. As the SPM process, main six steps have identified. They are SP identification, planning and controlling, demand forecasting, purchasing, classification and stock management. Factors to be considered in each step was explained within the content. In conclusion there is a high level of desirability for using SPM in manufacturing organisation whereas there is a low level of readiness to invest on such as new concept of SPM due to the drawbacks and challenges identified in the paper. Further research on how to minimise the barriers is proposed as once the barriers are addressed there is a good chance of benefiting from the concept of SPM.

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CONSTRUCTIONAL DETAIL VS. AUTONOMOUS DETAIL: EVALUATING THE NOTION OF ARCHITECTURAL DETAIL WITH RESPECT TO SPATIAL CONSTRUCTION

SAJITH S.[1] & PATHIRAJA M.[2]
[1]University of Moratuwa, Moratuwa, Sri Lanka
[2]University of Moratuwa, Moratuwa, Sri Lanka, Swiss Federal Institute of Technology, Lausanne, Switzerland
[1]142138H@uom.lk, [2]m_pathiraja@yahoo.com.au

Abstract
Very significant to the production of architecture is the notion of 'space', which injects a quality that creates meaning and expression to the final product. But an architectural product is also a collection of parts; joining these parts together becomes a critical aspect of materializing an architectural outcome, both in terms of its structural and environmental performance as well as with respect to its spatial performance. Jointing of parts, in turn, require the application of 'details' to make sure that the expected performances of the final product are achieved without possible failures.

Architectural detail can generally be understood as a small-scale architectural design, which itself is a part of a whole architectural outcome. Some scholars say that a minute architectural detail can convey the entire design concept of the building; others claim architectural detail as an ornamental component of a building. Regardless of these different viewpoints, architectural details provide a critical constructional component to the final architectural product. Architectural detail joins each layer of building elements, parts and systems together, thereby acting as a connecting device. However, the hypothesis that this research is based on argues that, other than being a constructional connector, architectural details signify the meanings and qualities of the 'spaces', which the final architectural product is supposed to accommodate and celebrate.

Judging by the building stock that has been produced in Sri Lanka in recent times, the emphasis given to the act of detailing in architecture is apparently minimal, both in the practice as well as in the discourse. Particularly in the practice, it has become a habit to use a library of commonly used details, irrespective of the typology or context of architecture. On one hand, climatic, cultural and economic factors are forgotten in the process of detailing, thereby compromising the expected performances of buildings and, on the other hand, there is very little regard on understanding details in the construction of architectural languages, and the subsequent formation of spatial meanings and expressions.

In evaluating the aforementioned position with respect to architectural detailing, this paper explores two types of intellectual and pragmatic standpoints: (1) Details as constructional representatives, and (2) Details as autonomous interventions. By assessing these two standpoints on 'architectural detail' through case study investigations, the research explores the role that a detail could play in the construction of spatial meanings and expressions, as much as they are responsible to the construction of the building as a whole. At the conclusion of this empirical study, verifications will be offered to prove how architectural details could bring up a language and a spatial identity in terms of both construction and experience of buildings.

Keywords: *Architectural detail; Design process; Constructional representation; Autonomous representation; Spatial detailing.*

1. Introduction

Architecture – through its elements - is expected to inject a quality or spirit that articulate the space, provide a meaning, and compose a language in a larger scale. In this process, "Architectural Detail" can play an important role, providing a subtle yet powerful meaning to the building. Ford (2011), for example, identifies "Architectural detail" as a small-scale architectural design, where the detail translates the entire building vocabulary to the reader in a coherent manner. Linguistically, Ford (2011) identifies "Architectural detail" as a part of the whole building; constructional-wise, he calls it the fundamental technical component of an architectural design.

The research that formed the intellectual basis for this paper targeted three main objectives. The first objective was to understand, within the confines of the contemporary Sri Lankan architecture, what constitutes the idea of an "Architectural Detail". It was found out that, with respect to the idea of "Architecture" in general and "Architectural detail" in particular, the local meanings and interpretations have often changed with historical sentiments. As Dayartane (2000) states, Sri Lankan traditional architecture had an organic background where the social cultural traits contributing to the architectural form were tied up with the subsequent constructional language of buildings. However, the idea of

“detail” remained to be considered as a function of ornamenting the building canvas. It is useful to explore whether such an outlook to “architectural detail” is still valid within the contemporary Sri Lankan architecture.

The second objective was to understand to what extent an “Architectural Detail” could represent the overall “constructional language” of the building. In general, architectural/constructional language evolves as a coherent composition of signs, structures, phonetics and grammar to create a meaningful expression. The building is a form of language where its form and detail can express the structure/meaning of the architecture. Radford (1985) affirms that the tectonic components act as grammatical components that structure the building system. In such context, it is useful to investigate how – and to what extent – can an architectural detail convey the language in the form of expression, and to what extent can it play a role independent to the language of construction.

The third objective was to evaluate the role “architectural detailing” can play in defining our understanding and experience of an architectural space. In architecture, Unarguably, the habitable space is the important part of an architectural outcome where it dwells around the personal who experience the space.

The analytical hypothesis upon which this research is framed looks at how “architectural details” can form the grammar to the construction language, and how this grammar can in-turn have a strong impact on the way a space is perceived and experienced. In other words, details provide the structural framework for the construction process, where the binary relationship – or lack of it - between “Architectural detail” and “Construction language” can define one’s experience of space and building.

Edward.R.Ford (2011) has defined architectural detail as a part of a whole building, and refers to it as a technical component of an architectural process. In doing so, he has identified five typologies of details:

1. Detail as abstraction
2. Detail as Motifs
3. Detail as Structural representation
4. Detail as articulation of constructions / Joints.
5. Detail as an autonomous or subversive element.

This research was built upon Ford’s above definitions of “Architectural detail” to construct a broader discourse on how detailing has been applied in contemporary Sri Lankan architecture.

As mentioned above, the research’s primary focus was on the binary agreement and/or contradiction between the notions of “Architectural detail” and “Constructional language”. Subsequently, its primary analytical focus impinged on the following two types of details:

1. Detail as a constructional representation
2. Detail as an autonomous or subversive element.

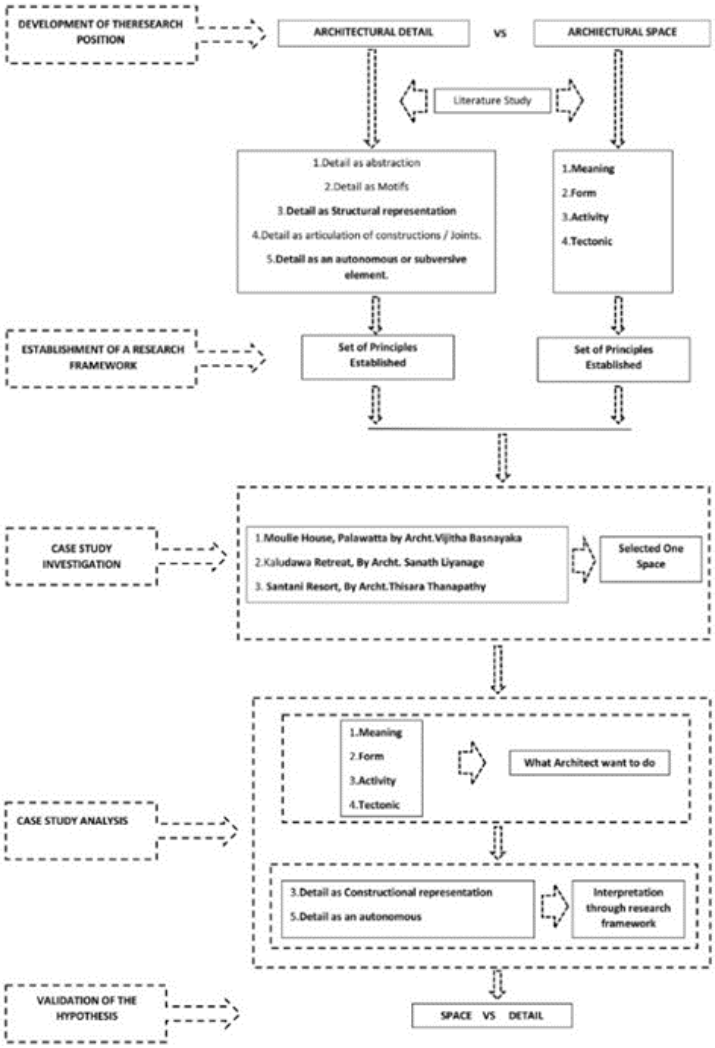

Figure 1: Research Methodology

2. Architectural Detail; Detail as a product

In order to arrive at the aforementioned discursive position on architectural detailing, it is important to first investigate the function of 'detail' as an architectural 'product' via a broader inquiry on its underlying objectives, applications and meanings. The question of 'what is an architectural detail?' is indeed a broader philosophical inquiry, but one may also bring in a rather pragmatic interpretation to the discussion: detail is a strategy that helps putting together various parts of a building in such manner that the building's overall structural, environmental and aesthetic performances are not compromised.

Edward Ford, on the other hand, claims that 'architectural detail' is a term that has been popularized within the modernist discourse of architecture. Though buildings were 'detailed' – or ornamented - before modernism, detailing as a theoretical exercise has not entertained the pre-modernist architectural thinkers.

"Detailing is not a word one often finds in pre-modernism writings on architecture. Words like trim, moulding and ornament were more precise and more useful. No doubt detailing, in its technical sense, is of greater consequence in the modern era simply because of the complexity of the modern building, but recent deluge of architectural theory has seen only occasional forays into the question of detailing. There are a variety of types of detail in modernism, more often found in buildings than describes in text …" (Ford E. R., 2011, p. 18).

2.1 OBJECTIVE OF AN ARCHITECTURAL DETAIL

In general, an architectural detail is both rational and conceptual; pragmatic and theoretical. As Ford (2011) explicitly claimed: a 'detail' extends the larger concept of the design across whole architecture, thereby defining the relevant architectural understanding – and experience - of the building. According to Radford, architectural experience of a building can be established in two ways:

1. By abstraction: Details are used to create an 'abstract' experience of the building by manipulating compositional strategies. It is about understanding a building and external observation.
2. By animation: Details are used to 'animate' an experience as one moves through building.

According to Radford, architectural details can establish the meaning - and experience - of a building in the form of abstraction, animation or both. The above interpretation of architectural detail more or less complies with Ford's assertion (2011) that a "detail" can be a small scale design representing a larger scale architectural ambition.

2.2 DETAIL AS A CONSTRUCTIONAL REPRESENTATION

A review of Ford's generic types of architectural details would reveal that their definitions are largely based on the extent on which they represent the underlying constructional logic of the building.

It is plausible then to suggest that representing the logics, candor and authenticity of construction is dear to a particular school of thought concerning the process of architectural detailing. When comes to architecture, construction is an inevitable phenomenon. There is a universal metaphor between skin and skeleton or clothing and body. Skeleton is known as the structural form of the building. To give a correct form, there must be a correct skeleton to the design. The cladding, on the other hand, is the reflection of the inner skeleton, presenting the overall form through an applied skin. For a building to be 'architecture', the tectonic resolution – and expression – between the skin and skeleton – or the cladding and structure – must be deemed as a key prerogative. This is where the criticality of detail as 'representation of construction' becomes so apparent for most architectural thinkers and practitioners. Following the aforementioned two lines of arguments, there are two modes to define - or express - the construction of an architectural object:

1. Concealment
2. Expression of the real mode of construction.

It must be mentioned that, expressing construction may sometimes lead to the destruction of materiality. In other words, elaborating the true material quality may be compromised in the architect's desire to express the construction. Within post-structuralism, expression of construction became a movement, which evoked mechanical as well as decorative functions

Regardless of the approach of particular architects, the notion of construction detail plays a vital role in expressing/concealing the overall experience of a building artifact. Here, an architect must play a decisive role in determining what function a detail should perform within the overall conception of his architecture.

Within the contemporary practice of architecture, there seems to be greater relevance to detailing as constructional representation, almost by default than by design. This is due to the fact that most of today's constructional processes privilege layered construction as opposed to solid/monolithic/un-layered constructions of the past. Layering the building in terms of structure, skin, fenestration and roof is the favored method of construction at present times. From a detailing point of view, however, relationship between these layers become a critical function that determines the overall performance of the building.

This duality of layering versus monolithic construction will no doubt define the future directions of how buildings are detailed, even in less industrialized economies such as Sri Lanka. In terms of constructional expression, modern architects are left with three choices.

1. To build a new aesthetic in reflective of layering.
2. To build a layered building to be appeared to be monolithic.
3. To simplify as possible and construct using the old way – solid, unlayered construction.

It is however tragic to see how the exterior layer has started to dominate the building expression, with little or no symbolic association between the exterior and the interior layers of buildings. This is an outcome of poor conception of buildings from detailing point of view. In the process, detailing as a true representative of the overall construction has been ignored and overlooked.
Indeed, the function of detailing requires an informed approach to celebrate and reveal the true logics of construction. As mentioned previously, if contemporary buildings are increasingly built in the form of layering, where systems of buildings are layered and constructed separately, then new strategies – and interpretations – of detailing must be spawned.

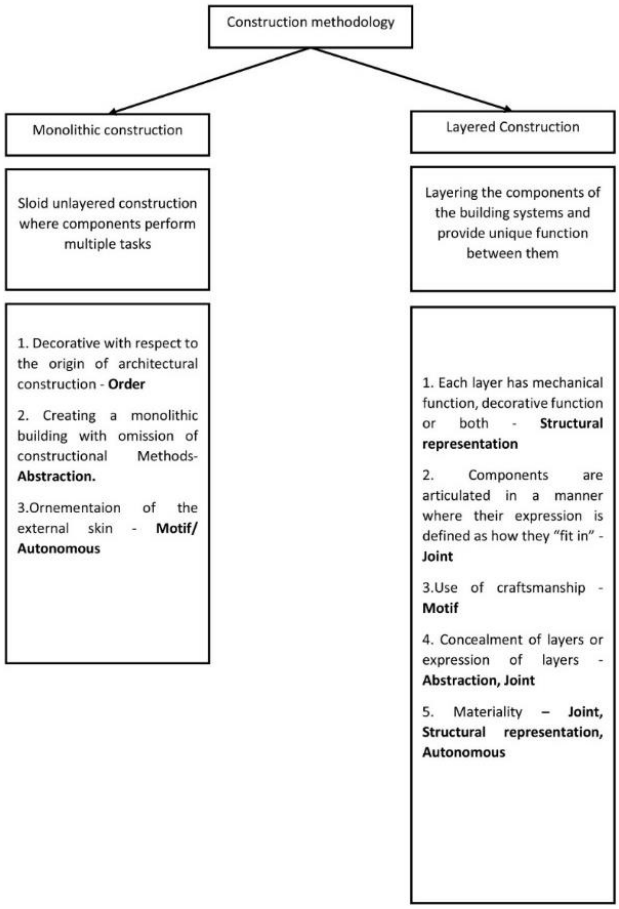

Figure 2: Detail as Construction Representation

Mainly in modern architecture, the relationship between the external layer (commonly known as the skin) and the structural layer (skeleton) defies the overall meaning of the building. Regardless of the particular approaches – i.e., layered or monolithic - the role that an 'architecture detail' can play in triggering a proper representation of construction must be recognized and valued. The following diagram depicts how layered and monolithic duality can define different types – and meanings - of architectural details.

2.3 DETAIL AS AN AUTONOMOUS INTERVENTION

The second type of intervention – the opposite of constructional representation – is the autonomous detail. Here, the detail does not to complement the building concept or the overall constructional vocabulary. As such, the detail is an isolated realization that departs from the overall construction language.

More specifically, the autonomous detail can be identified as an articulated detail forming a striking and contrasted representation to the architecture as a whole. These kinds of details are more representative of a smaller scale with respect to the building's functional program - e.g. a handrail detail. But there certainly can be deviations to this norm. Ford (2011) argues that these types of details are more independent / semi-independent from the overall building construction. But Ford (2011) has also stated that these kinds of details too can have a functional origin, even though they tend to be more ornamental in character and objective.

In general, autonomous details can be found in four elements or situations (Ford, 2011):

1. By program / function – i.e., how the spectator engages with the building's function with respect to the specific piece of detail, such as simple function like eating, sleeping, opening of a door, etc.
2. By joinery/construction – i.e., how the building is assembled; the assembling process of the building elements.
3. By structural resolution – i.e., how the lateral and live loads work along with the structural elements.
4. By the building's response to its elements/performance – i.e., how the building functions with the lateral forces like climate, energy, etc.

Ford has also identified two characteristics of the autonomous detail:

1. Positive/Literal
2. Negative/Abstract

Accordingly, the positive aspect takes place when the detail accommodates the above four factors (construction, structure, program, performance). On the other hand, the negative aspect triggers when above factors are found to be missing or absent from an autonomous detail.

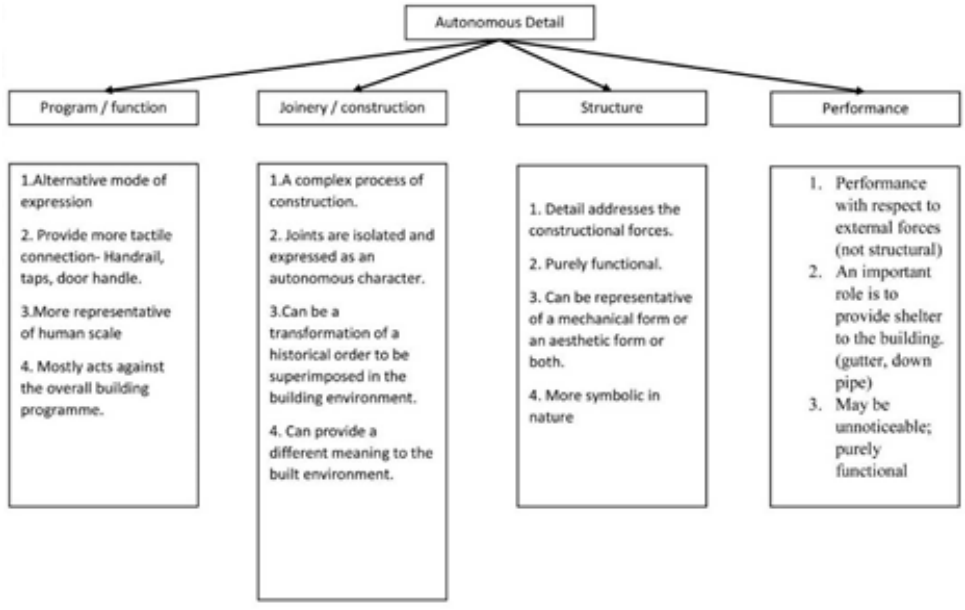

Figure 3: Detail as an Autonomous

On the whole, architectural details are expected to comply with the overall concept of the design. But certain details can oppose the overall concept, the geometric abstraction, and/or the symbolic representation of the building. Such details are called autonomous representations. They can be primary or secondary elements of the buildings – structural or non-structural; architectural or furniture. Some details can even be totally disconnected from its container (i.e., building), and work against the expression of the building, contradicting its role as a part of whole. Some of these details can still weave a positive experience of the building. But buildings are seemingly much better off without them, especially if they are conceived badly. Following is a diagrammatic summary outlining the notion of an autonomous detail as explained above.

3. Space Vs Detailing

The discussion so far in this paper brings us to the critical investigation upon which the research was intended for: the relationship between spatial construction and the art of detailing. In other words, to reflect on how various types and representations of 'architectural detail' contribute to the construction of 'architectural space', both in terms of the architect's ambitions (meaning and activity) as well as the perceiver's experience (form and tectonics).

If as scholars say details are the tools to understand the definition of an architectural language, how can various forms and representations of 'details' pay a part in the construction of particular spatial forms, meanings and tectonics? How have local architects manipulated the function of detailing to celebrate the desired architectural intents while eliminating – or concealing - necessary and unnecessary components of building. Can spatial delight be achieved merely by a process of abstraction where the weight of components is removed and the impacts of elements are resisted? Or is it by an act of suppressing information that spatial meanings and order can be generated? What is the spatial impact of a constructional detail as opposed to an autonomous detail? Where does a motif become relevant as opposed to simply celebrating the joint? These were among the key inquiries that formed the basis for an ensuing case study review.

4. Findings and Discussion

In evaluating the aforementioned theoretical inquiry, the works of three Sri Lankan architects were assessed: Vijitha Basnayake, Thisara Thanapathy and Sanath Liyanage. This selection was based on the impetus that these architects generally lent for architectural detailing, as well as to represent a generational mix from the local profession of architecture. For clarity of the study, architectural detailing applied for three buildings by the aforementioned architects were explored under a list of common themes (or architectural expectations).

With respect to inside/outside relationship of spatial volumes, for example, Basnayake has used the organic forms of material and detailing to achieve an architectural expression of breaching the spatial difference between inside and outside, and bringing the exterior inside while extending the interior outside. His autonomous details arise in the spaces where specific ornamental and functional objectives are met. The other two architects, on the other hand, have been keen on eliminating the complexity of the structure and the built forms, focusing on horizontal proportions and using the internal space as a platform to view outside. Even here, Liyanage, while making distinctive internal spaces that contrasts with the outside, uses his detailing to bring the experience of the exterior to inside space. In contrast, Thanapathy is not too obsessive with bringing the nature in; rather, his focus is more in creating a distinctive, meditative, internal space to be used as an emotive platform to view and experience the nature outside.

As such, it was noted that, by a particular use and manipulation of details, three equally wonderful architectural interventions have generated three different spatial meanings with respect to the idea of inside/outside experience. In other words, a particular language of detailing has lent to the

establishment of specific spatial meanings, which in turn has contributed to a distinctive user experience of architecture and the space beyond.

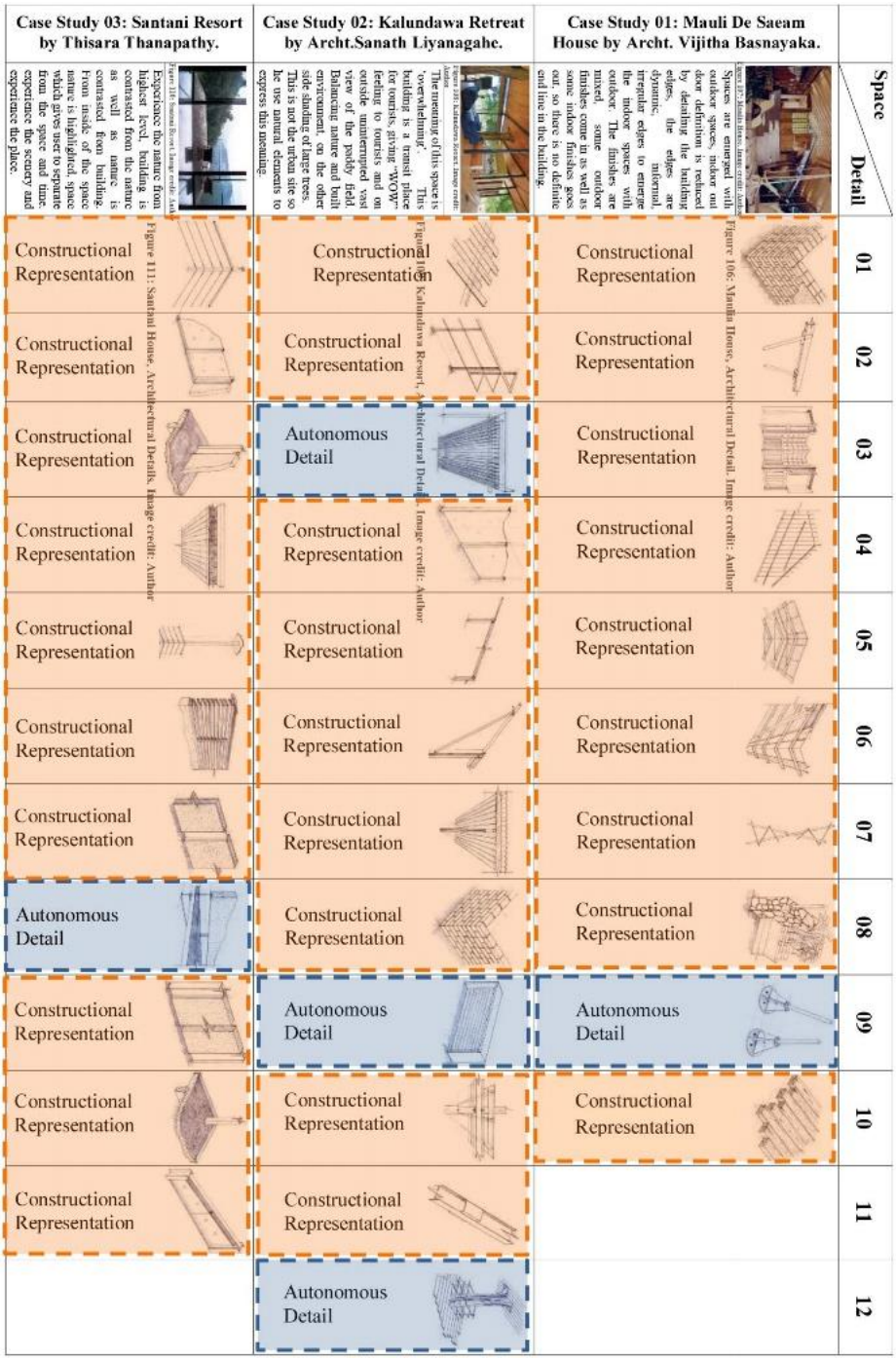

Figure 4: Findings and Discussion

5. Conclusions

Principal challenges for architects nowadays are to construct meaningful spaces which hold a quality and meaning to both the user and discourse. Spatial construction and detailing can certainly inject a quality or sprit that articulate a meaning to the space. In such light, architectural detail is a small-scale architectural design that becomes part of the whole building. This study theoretically summarized those five aspects of architectural details in to two types of representations – autonomous and constructional – as how they influence on spatial creation in a particular regional context.

Spatial construction is undoubtedly a primary objective of architectural production. Architectural space must be habitable, but also be powerful enough to infiltrate the spectator through sensorial mediums.

Spatial languages, concepts and meanings, therefore, is are important for an architect who seeks to generate quality through his or her work. As this study has argued, however, detailing is a process of transferring these larger architectural ambitions into the individual user/spectator experiences. While an architectural idea reflects an overall spatial quality, which in turn defines a path - or a lead - for the detail to follow.

However, architecture is also a process of construction, where the construction elements are layered through architectural details. Thus, the art of manipulating construction details are required to establish spatial meanings and architectural languages. The articulation of such connections – and techniques - will result in various spatial meanings and expressions. Hence, details that are meant to represent construction can define varied meanings and experiences of spaces, depending on how they have been used – and detailed.

Autonomous details, on the other hand, function independently. They have their own configuration and they do not necessarily *"fit in"* in to the building concept. However, the existence of the detail may or may not affect a particular experience of a space.

Today in Sri Lanka, contemporary architecture is inundated with material palettes and building systems of diverse quality, character and performance. In connecting these various materials and subsequent building systems, the usual trend is to follow common, repetitive details burrowed from catalogues and past uses, regardless of what the type, function and meaning that the subsequent architectural spaces are meant to express. This has affected the spatial, technical and environmental performance of contemporary architectural products.

In above context, this study has attempted to define a theoretical framework to understand the notion of architectural detail with respect to how they represent spatial meanings. The study concludes with five important observations. Firstly, buildings with high spatial value use details that represent constructional objectives than those that present an autonomous existence. Secondly, the constructional details can be manipulated – in terms of their choice of material, texture of surfaces and arrangement in the system – to express specific spatial meanings. In other words, constructional details can carry meanings other than its constructional function. Thirdly, when detailing, a similar set of material components can be arranged to different set of configurations, in order to convey different spatial expressions. Fourthly, using autonomous details for ornamentation is not a crime; and if done well, can add to the richness of the space, even though it may not entirely agree with the overall spatial concept. However, the use of autonomous details for the sake of autonomy – or carelessness - may ruin an intended spatial expression. Finally, a proper detailing of an architectural space – one that embraces both quality and meaning – is a task that relies on a careful handling of construction and autonomous representation.

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COLOUR AND VISUAL PERCEPTION: EXPLOITING VISUAL PERCEPTION OF COLOUR, IN TRADITIONAL *'LAKSHA'* PRODUCTS IN SRI LANKA.

DINUKA AMARAKOON A.M.[1] & DILSHANI RANASINGHE W.M.N.[2]
[1, 2]Department of Integrated Design, Faculty of Architecture, University of Moratuwa, Sri Lanka.
[1] *dinukaca@gmail.com*, [2] *dilshaniranasinghe80@gmail.com*

Abstract.
Design decisions behind colour compositions of a product, play a major role in communicating an identity, purpose and functionality of a product. Also, how this particular product would fit in with what's around it. When considering a multicoloured object; change in colour choice and compositions has a great potential to impact the visual perception an object. The Visual perception of a product is the main factor considered in this research; functionality, usability and socio-cultural factors are omitted. The exploration limits only to five case studies of Kandyan era *'Laksha'* products found at Colombo and Kandy National museums. The methodology of research is based on qualitative methods. In order to evaluate "how multi-coloured objects are visually perceived with regard to *'Laksha'* products", a common ground was established on how humans visually perceive. For this purpose, secondary sources of biological, psychological and physical aspects of visual perception and theories related were used to build up the theoretical background for the research. With this background, images of *'Laksha'* products were made in to primary graphics and then dissected into different graphics (Secondary graphics); which are analysed to understand how they are perceived visually. The dissected graphics are used as tools in the study. These graphics of the visual perception of multi coloured *'Laksha'* products will be used as a stepping stone to discover the fossilized contextual creative knowledge regarding the use of colour in design. Moreover, the methodology of the study implies many future studies and possibilities.

Keywords: *Visual Perception, Colour, 'Laksha', Evaluation*

1. Introduction

"Colour is often treated as an afterthought in the design process and colour specifications are rarely mentioned in the briefing stage when it comes to industrial practice of product design. But it is obvious that use of colour is as important part of design alongside form, functionality, technology and finance." (Russell, 1991) Colour and all other elements of design are intertwined and when it comes to their impact towards a product visually and semantically, colour is as important as any other element of design. For colour to be a part of the process in designing and to understand how one could use colour impactfully much research and experimentation is yet to be done. This study sparks with these observations in mind. Considering traditional products in Sri Lanka, *'Laksha'* products are quite noticeable. Also composes a verity of multi-coloured patterns mesmerizing a play between the colours and the shape, form of the objects. In order to understand this impact of colour, the focus question of the study arose; "How multi-coloured objects are visually perceived with regard to Kandyan era *'Laksha'* products?". When considering the *'Laksha'* crafts and products in Sri Lanka from centuries back, they seem to have an originality and attention to detail in use of colour, which seems to be lost along the way. The study of visual perception of *'Laksha'* products is an initial stepping stone to revision use of colour in traditional *'Laksha'* crafts and to capture the thinking behind use of colour. This has the potential to be integrated with modern-day industrial design and as well to uplift a decaying craft sector.

2. Perception, Visual Perception and Gestalt Psychology

2.1. IDENTIFICATION ON BASIS OF VISUAL PERCEPTION

"Visual processing happens in many areas of the brain. Our visual perceptions appear to be produced by cells which fire on a hierarchical basis, coding from simple to more complex features." (Morin, 2016)

2.1.1. Constructive Perception

The Constructive Perception explains; visual perception is created primarily by capturing, comparing and analysing the stimuli with already encoded information in memory and this process is operated below our level of consciousness. As a result, it is commonly referred to as a bottom-up perspective as

well. (Morin, 2016) Prototype theory is a concept that suggests our brain does not need a perfect match, but rather it will search for the closest match to a prototype (i.e. abstraction of templates) before it produces a complete percept. (Neumann, 1977)

2.1.2. The Direct Perception

This view states that all perceptions are produced by the directly obtaining information from the environment at any given time. Direct perception is regarded to be more primal or instinctual. (Morin, 2016)

2.1.3. Integrative view of visual perception

Through neuro-scientific research states; information is rather organized as a distributed system. (Morin, 2016) Also these recent studies suggest that visual percept is not necessarily produced via constructive or direct perception theories, but the brain may be able to handle and process information both ways through specific areas of the brain. (Warrington & Shallice, 1984)

2.2. GESTALT PSYCHOLOGY

Gestalt psychology affirms that there is a simplification happening in the mind in order to understand the visual environment and the mind tends to reduce the subject matter in the visual field to the simplest regular shapes. (Ching, 2014) Emergence, Reification, Mulistability, and Invariance are the key aspects of Gestalt psychology and they are mostly regarded as different aspects of a single unified system and not necessarily as separate modules (Lehar, 2003)

2.3. GESTALT PRINCIPLES

The fundamental idea of the Gestalt perception is the "Law of Pragnanz" (in German language, pithiness). Core idea of Pragnanz is that the mind tending to order the experiences in a regular, orderly, symmetrical and simple manner. (Sternberg, 2003)

Gestalt principles include Closure, Common fate, Constancy, The Figure-Ground Relationship, Good Continuation, Law of Pragnanz, Proximity, Similarity and Symmetry. (Lidwell et al., 2010)

3. *'Laksha'* Crafts in Sri Lanka

Lacquer is a material that produced in South and East Asian countries. It considers as a durable, glossy, water and heat resistant material. This natural material is produced from the sap of a specific type of lacquer trees. *Laksha'* crafts were practiced in Sri Lanka with great heritage with native methods of *'Laksha'* preparation and finishing (Coomaraswamy, 1979). *'Laksha'* products mostly include wooden appliances such as food containers, ornaments, ceremonial accessories such as *"Sesath"*, etc. Lac industry was given a higher position by the ancient Sinhalese kings to uplift the industry. *'Laksha'* workers and painters were named as *'Lokuruwan'* and artists at this time (Vithana, 2010).

3.1. PRODUCTION PROCESS OF *'LAKSHA'*

The cut pieces of hale wood which are seasoned, then turned into curved shapes from the lathe machine, chisels and other tools. Before the introduction of motorized lathe machine, Sri Lankan craftsmen used a device called *"Sakaporuwa"* where two people are involved in. Lathe machines, defines the form of the object to be radially symmetrical. There are two basic methods of application in *'Laksha'*. In "Working with nails (*Niyapothu Weda*)", initially lacquer is applied with use of a Talpiot; a Lacquer string made by pulling of heated Lac, the process includes placing and pushing by the index finger and the nail of the thumb; hence the name. Later it is polished with Talpiot. In "Works in Lathes (*Pattal Weda*)", a hand operated lathe machine is used which rotates the object back and forth. On the rotating object, Lac is rubbed and patterns are added by scratching on the precise layers of colour. When adding colour, prepared *'Laksha'* is heated and then mixed with the colour pigments (Traditionally; Red: *Sadilingam* Powder, Yellow: *Gal Hiriyal*, Black: smut).

4. Visual perception of multi-coloured '*Laksha*' Products from Kandy and Colombo Museums

4.1. SELECTION OF CASE STUDIES

Products that are in the National Museums of Colombo and Kandy were selected to avoid the present-day colour compositions; but to get products with natural pigments of colour and genuine native thinking in application of colours. Following limitations were also considered when selecting the Case Studies.

- Only the wooden products were selected – to avoid different shades in colour and different textures.
- Many of the products were avoided due to discoloration and damages.
- Products with decorative motifs and engravings were also avoided to make sure the products selected remain much similar.
- Only the products that were crafted with the use of *"Pattal Wada"* were selected, in order to limit any variations in form and to focus on similar group of forms.

4.2. INITIAL GRAPHICS AND COLOR SELECTION FOR GRAPHICS

Figure 1 : selected case studies from kandy and colombo museums. (Source : Author)

Since the human mind tend to perceive and understand simpler, more regular forms in any given composition, the photographs of the case studies selected were made in to 2D (flat) graphics. Only the side elevations of the graphics were selected as it was the most suited view to capture the colour patterns. Also, since all the case studies are made from *"Pattal wada"* method, the objects are radially symmetrical; producing a symmetrical side elevation with horizontal line patterns. Gestalt psychology discribes lines and colour lines on three dimensional *'Laksha'* products to be perceived same as the lines and colour lines on 2D graphics. As Invariance explains, that it is possible to identify objects despite any change that happen as elastic deformations and change in scale. When three-dimensional object made in to 2D graphic, the changes that will appear are mostly the change of brightness, value of colour and the shape of the coloured lines towards the edge of the silhouette; which would be perceived as unchanged due to constancy.

4.2.1. Colour selection

For the developments in Graphics, colours were selected from the photographs of the products that were selected. These products, being made in the Kandyan era (18th century and prior), have been damaged

and discoloured over time and hence the shade of the colour will differ from one product to another. Considering freshly lacquer applied products and antiques, colours were selected and final colour selection was done. These selected colours are the colours that are used for the development in graphics for the study and they will be referred to as Black, Red and Yellow respectively.

Figure 2 :Colour selection of Case studies (source: author)

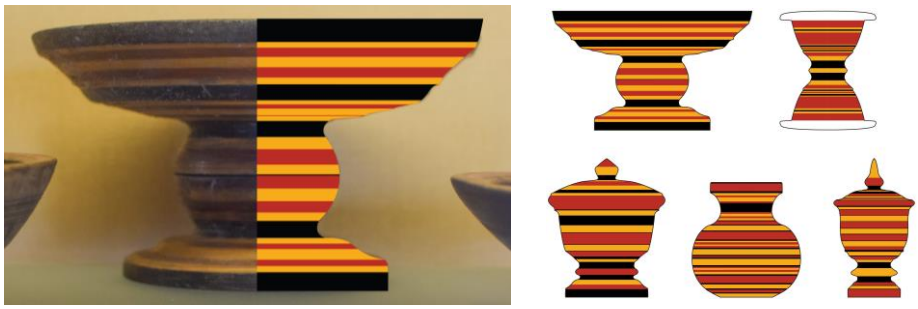

Figure 3: 2D Primary graphics of the case studies; illustration (source: author)

Since the graphics in different backgrounds are perceived differently background is regarded constant (white colour) for this study.

5. Secondary Graphics based on visual perception of colour

Considering that the perception is a constructive process, the graphics represents the possibility of smallest building blocks when perceiving a multicoloured '*Laksha'* product. Multistability (the tendency of ambiguous perceptual experiences to pop back and forth between two or more alternate interpretations unstably) and Figure Ground Relationship with in gestalt psychology breaks down, each and every element with in the perception. Hence when considering the perception of colour with in the simplified graphics. Graphics are dissected as bellow based on visual perception of colour. It could be also stated that; the rest of the Gestalt Principles (e.g.- closure, similarity, proximity, good continuation) are the ones that enable us to construct the complete perception.

5.1 FOREGROUND GRAPHICS

After making up the illustrations from the images, considering all the gestalt principles (mainly figure ground relationship and similarity) the graphics were converted in to separate set of graphics as they will be perceived separately depending on the colour (perception of yellow, red and black separately).

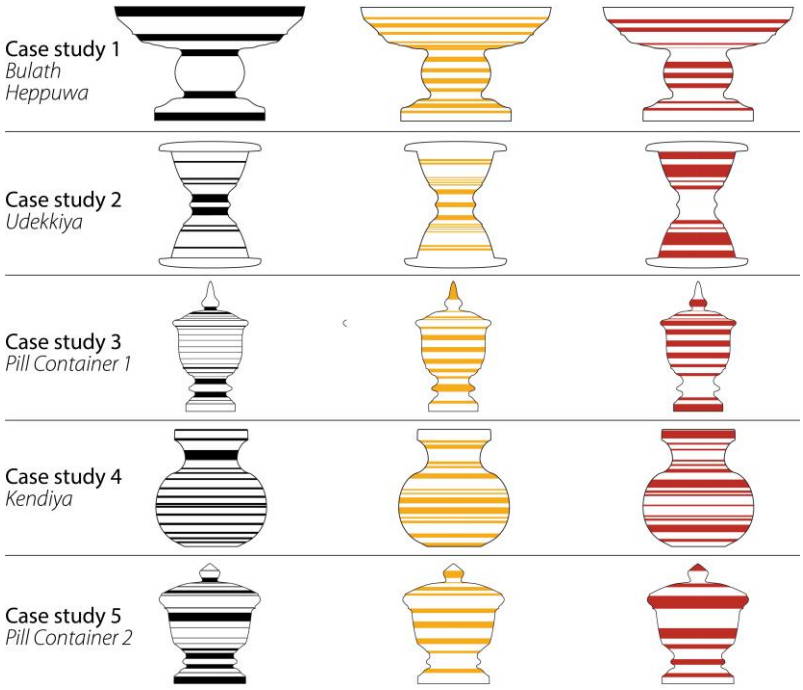

Figure 5: Analysis of Foreground Graphics (Source: Author)

The single colour graphics isolates the colour and in the process of visual perception understood by constructive framework these singular elements of colour are responsible for the mesmerizing effect of the whole composition.

5.2. BACKGROUND GRAPHICS

Similarly, when any colour becomes the fore ground the other two becomes the background.

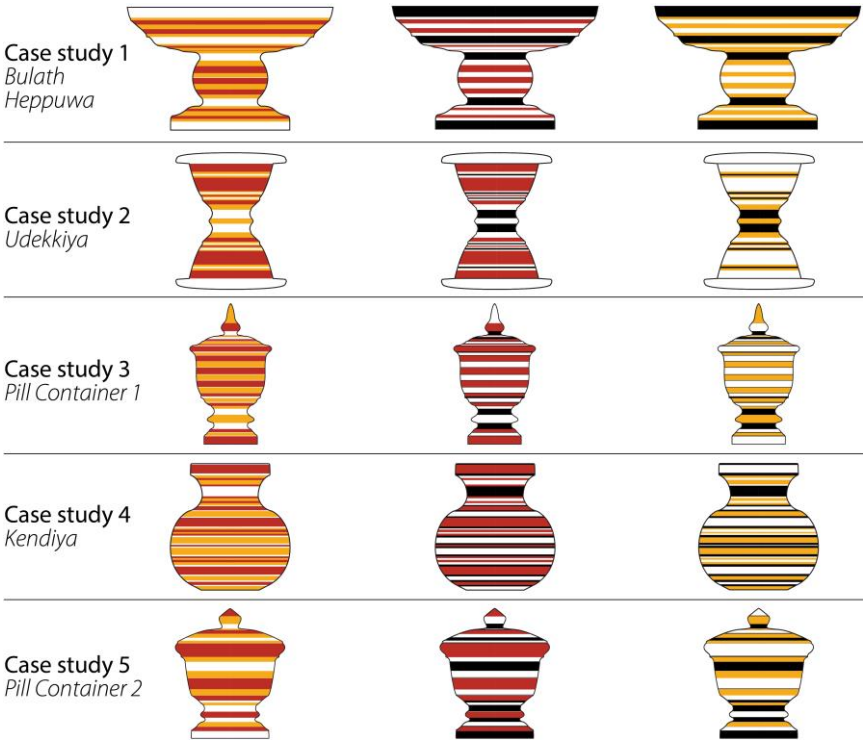

Figure 6: Analysis of Background Graphics (Source: Author)

These graphics are a result of the fore ground selecting in process of perception. But as constructive perception states humans simplify in to the simplest elements and hence these graphics are yet to be simplified creating again the fore ground graphics above. Therefore, it is evident that these graphics are not actually perceived in the most bottom level of perception. But when moving up in the constructive frame, these graphics will appear with the continuous switching back and forth due to simplification and disections of the whole composition.

5.3. GRAPHICS WITHOUT OUTLINE

Considering above mentioned aspects of gestalt principles, perception of colours separately also enables closure to create form through coloured lines. In order to identify how coloured lines impact Closure of the object's form, the available graphics were further developed by eliminating the outline of the graphics.

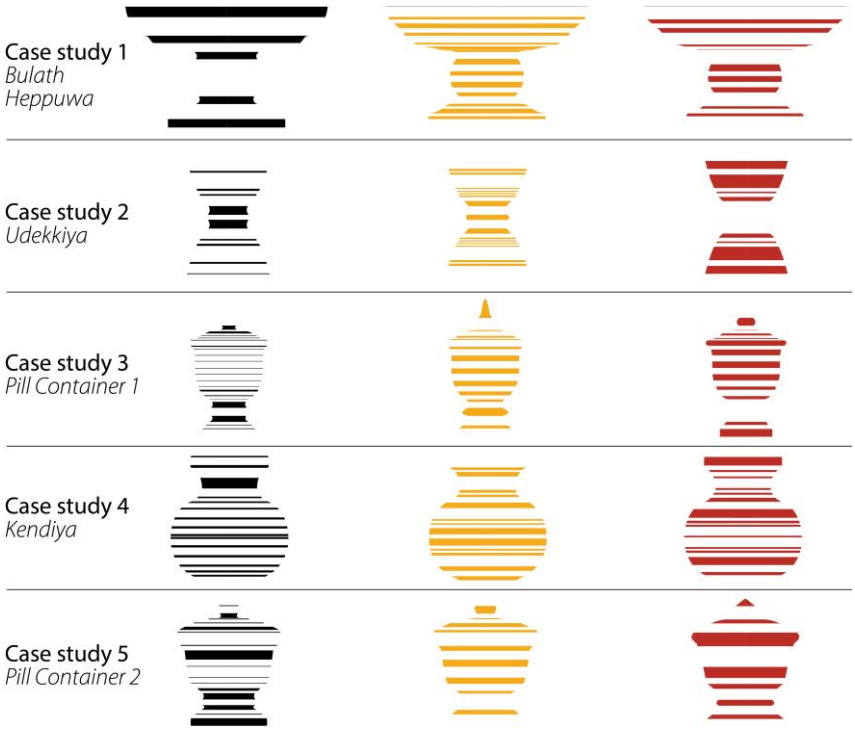

Figure 7: Analysis of Graphics without outline (Source: Author)

Regarding the original form of the case studies, it is observed that most of the time there is a single colour which supports perception of an accurate form; compared to other two. This effect is clearly visible in *"Bulath Heppuwa"*; where yellow contributes mostly towards continuation of form. Similarly, it is seen that red colour does very little towards maintaining form in *"Udekkiya"*. Comparison of background graphics and these it is seen that the black rarely has any impact on maintaining form through closure. Thin lines of black are merely to highlight the yellow and red and takes less prominence in the whole composition.

5.4. MONO COLOUR GRAPHICS OUT OF COLOUR SEPARATED GRAPHICS

In order to capture how line patterns are distributed without considering them as coloured compositions; the coloured graphics of yellow and red are turned into black.

Mono colour enables the understanding of each colours' distribution without and disorientation caused by colour. '*Udekkiya*' clearly has an equal horizontal symmetrical distribution in colour while on '*Kendiya*' the line of symmetry is dragged towards the bottom of the object. Also, this distribution of the pattern sometimes changes from colour to colour in the same object often.

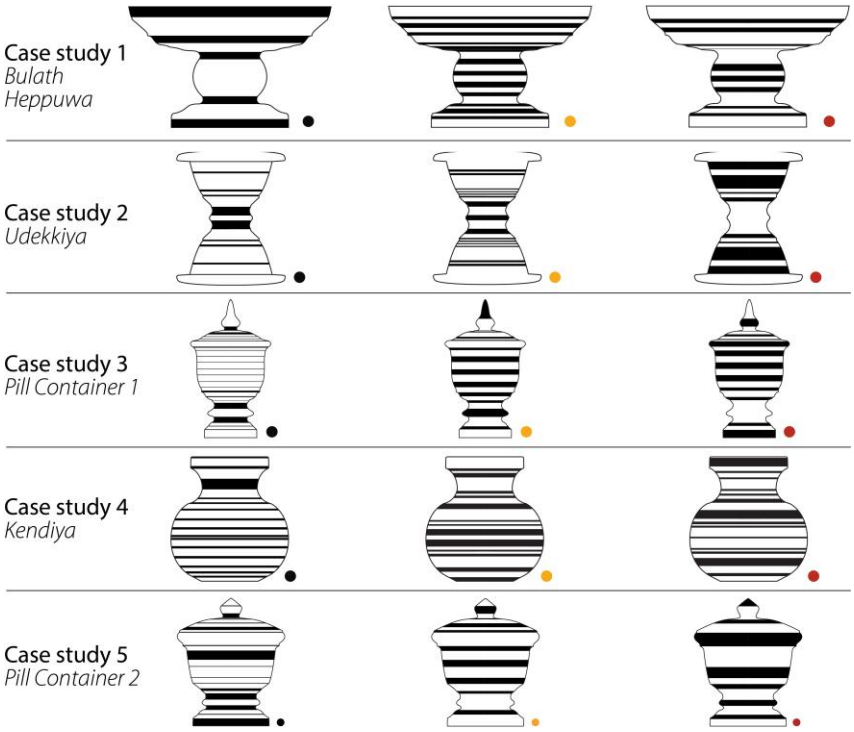

Figure 8: Analysis of black and white Graphics (Source: Author)

5.5. GRAPHICS WITH RELATION TO FORM

Furthermore, with principles; good continuation, similarity and proximity enabled dissecting the initial graphic with regard to form. The nature of the form of the product (as it's manufactured in the lathe machine) results forms which extrudes; outwards from the centre axis (extruding forms) and the forms which narrows down towards the centre axis of the object (narrowing forms). Other than these the top most form and the bottom most form was considered separately. On some occasions the top form or the bottom form could also be an extruding form or a narrowing form as well.

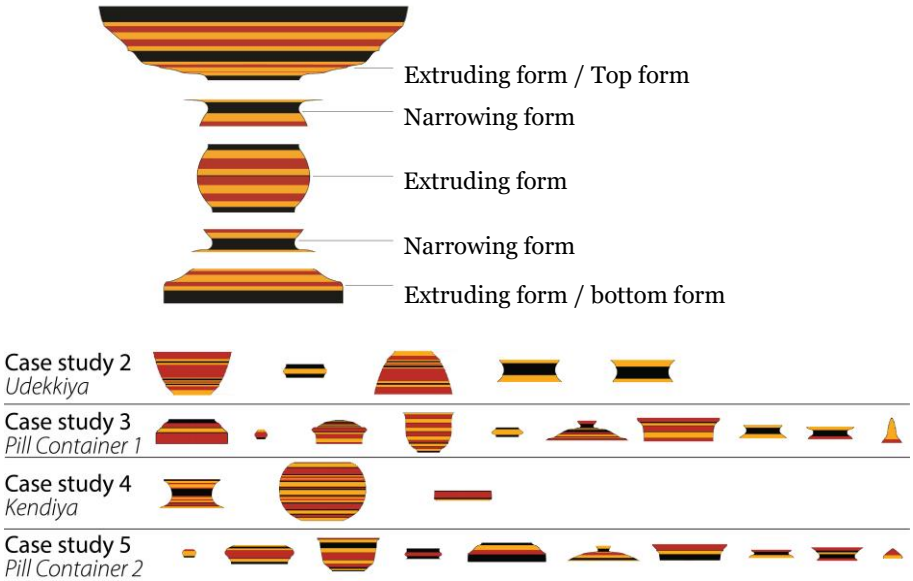

Figure 9: Analysis of Graphics with relation to form (Source: Author)

Colour distribution and usage with regard to form; could be identified in here. Considering the whole object, extruding forms are with more space and also with multiple lines where as compared to narrowing forms with most of the time thick black line. Distribution of colour and also pattern and thicknesses of the lines dramatically change with the form they are applied on.

5.6. OVERVIEW OF THE OBSERVATIONS AND DISCUSSION

Dissected graphics of the selected case studies express basic identification of the simplest units and their combinations. Is the first step to impact the whole aspect of the aesthetics; and, to identify the potential motives behind these created compositions. Hence the thinking behind 'use of colour' and also the impact created with colour is an exploration of 'Native identity in colour use'. But in order to capture the whole idea, use of colour should be thoroughly studied considering the emotional cultural and social aspects as well. Studying the shades of grey and corresponding tones, yellow is the highlight among the three colours that are used. Black being the shadow and the red being median grey. Adding a black frame or an outline on a hue will constrain its visual presence, as if black is compressing the hue and white will swell the hue. (Bleicher, 2012), the black and the highlight (yellow) impact the red and each other to appear differently. These effects are much more exaggerated by the saturation and brightness of these colours. With the narrowing forms (on Graphics with relation to form) most of the time black is used at the narrowest point in form between two stripes of the highlight; creating an even narrower percept of the narrowing form. This is done similarly with the extruding forms as well; using yellow at the most extruded point in between two black stripes. Also, minimum use of thick black lines on the extruding forms supports the same effect.

Use of a simple analogous colour harmony (warm colours) makes the differentiation or switching back-and-forth between the colours (single colour graphics) much intense due to low contrast between the colours and familiarity of the harmony. Use of black and white or more contrasting colours would make the differentiation between the colours much easier and hence not an intense switching of precepts. Use of simple shapes of colour also supports the same motive. Same shapes same harmony and differentiation is kept minimum to the low contrast between the colours.

The study of Mono colour graphics and background colours resulted observation of red and yellow being the prominent colours on the composition and they are the ones that contributes towards creating a pattern. Black is observed to be only a tool to increase luminosity of other two colours.

7. Conclusion

The overall reading of graphics extracted of the above discussion suggests that there are three forms of interpreted rationales in the use of colour that are observed.

- Use of colour to amplify extrusions and non-extrusions of form.
- Use of less contrasting colours and similar extents of colour for intense waving between colour separated precepts.
- Use of black to enhance Luminosity of other colours used.

The graphics extracted of the initial graphics, represents the deconstruction of the visual percept of colour of those case studies selected. The theoretical background and supportive material would be of use in expanding the range of case studies for further studies. The use of colour in patterns and us of colour with integrated motifs are further studies.

Similar to the observation made with the case studies 2 and 3 regarding symmetry of line patterns; 'Exploration of thinking and the applied principles to build up the rhythm, balance and etc; behind patterns created with coloured lines' is also possible with these extracted graphics. Prominence of use of colour with relation to form, use of colour in different colour thicknesses, impact of colour in scenarios of use based on case studies and impact of differentiation in background colour are few of the possible studies out of the already colour separated graphics.

The consideration of socio cultural and emotional factors and responses on the analysed case studies focusing on overall perception of colour rather than visual perception would deliver a vast understanding on the native thinking patterns in use of colour. Moreover, thinking forward from this study; the change

of colour hue and impact, experimentation of colour use in different forms, application and experimentation of interpreted rationales could be tried out. Also, this study could step in on attempting to uplift, secure and to help move forward the *'Laksha'* craft sector in Sri Lanka.

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MUTUALISTIC ARCHITECTURE: IMPLICATION ON WILDLIFE SPATIAL HABITAT IN TOURISM RELATED BUILDINGS IN SIGIRIYA, DAMBULLA AREA

B.K.S.N. GOONAWARDENA[1] & S. UDALAMATTA[2]
[1, 2] Department of Architecture, University of Moratuwa, Colombo, Sri Lanka
[1]*sathya.bastian@gmail.com*, [2]*susirasen@yahoo.com*

Abstract
The research Support to comprehend the beneficial mutualistic relationship between architectural and biological systems and to investigate the mutualistic successive architecture (MSA) accommodate spatial habitat of wildlife in the tourism-related buildings within Sigiriya, Dambulla zone. The analytical study framework to analyse the local case studies critically through a wide discussion of MSA through the general "components" of architectural designs, investigating the concepts of the animal behaviour, understanding the connections of the site planning and design with ecology. The valuation of the constructed form and the natural habitats must be examined and created in order to determine how they interact in a mutually beneficial and symphonic manner. The architectural focus needs to be moved to pristine and vulnerable areas where tourism accommodation has left huge environmental impacts. Selected two cases to have extreme differentiate and similarity with two different scales. Wildlife habitat has permanent and temporal behaviour within this zone while both projects have caused the implications towards wildlife negatively and positively. Simultaneously that was the need to do the research about MS implications on wildlife within anthropogenic activities. Qualitative measures have converted to quantitative measures by using ratings and graphs. Mutualistic and resilience quality of both projects are similar to different approaches from the beginning. Hence, when considering the MSA in a project, it is essential to consider the materials and the life cycle of the materials and its performance. Considering architecture and mutual relationship in a human enclosure within wildlife habitats, the author has identified that long research has to be done to find out the MSA in a project, which engages wildlife habitats.

Keywords: *Mutualism, spatial adaptation, temporal, implication, anthropogenic activities*

1. Introduction

The inspiration to the whole investigation is moved by the way that the author's personal experience contradicts to find further exploration in mutualistic architecture and the implications of architectural components towards the non- human beings and how they adapt their personal spaces within the built environment. Early architecture was built and combined within nature and there were fewer boundaries for fauna. The temporal and spatial pattern of landscape change, human perception of landscape and affairs absent with time and incomprehension of the coexistence strategies in the landscape are the major causes of this. The areas with flawless and delicate characteristic ranges, it is important to focus in design engagement where the tourism industry was uncontrolled. Tourism-related architectural intercessions are progressively being seen as a risk to wildlife and ecosphere. By directing, reacting and getting involved in the sensorial ranges of particular species, architecture and infrastructure can become redefined as animal players in a much greater system. As a sensorial device, architecture would be accepted as a part attractor, part program container and a part animal interface. In addition, more than giving space for program and purposes, it is more effective if architecture could provide the visitor with the familiarity of engaging in a conversation with some other animal.

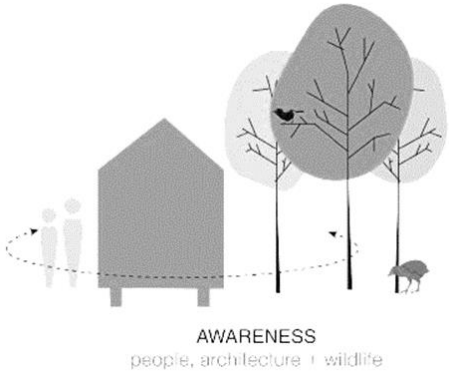

Figure 1: people, architecture, and animals
Source: Sound of silence, Hannah Smith, 2016

Impacts of anthropogenic activities are expressed at all ecological scales, from short-term and long-term changes. It is essential to have more beneficial mutualistic relationship between architectural and biological systems in such remote areas whereas design and the built environment has to improve the natural environment while supporting its human functions through spaces. Purpose of the research to investigate how built environment accommodate spatial habitat of wildlife in special reference to the tourism-related constructions in Sigiriya , Dambulla zone in Sri Lanka and their characteristic towards mutualism. The study will influence indirectly to conservational aspects of a wildlife approachable architecture to creating Mutual Succession attitude towards wildlife surrounded by the built environment. Ought to investigate the new age of designing which integrates with architecture by making superior liveable spaces for both human and animals. The challenge is to not ruin the very ecology we are attempting to save if the architectural purpose fails to attract occupants properly to the wildlife.

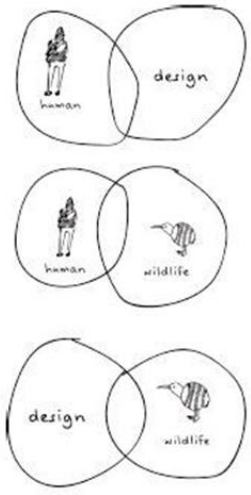

Figure 2: human-wildlife relationship towards the built environment: Silent user
Source: Sound of silence, Hannah Smith, 2016

Study combinations grant to investigate, the influence of built environment on the cooperative behaviour of animals with short term and long-term differences. This study will be undertaken through the Investigate 'by design' phase. The investigation included a study of written works about the general “components” of architectural designs (Andrea Simitch, 2014), Investigating the concepts of the animal behaviour and understanding the connections of the site planning for a mutualistic architecture. (Mehta, 1999). From the critical study of the literature review, the author creates the ideal analytical study framework to analyse the local case studies and critically observe the response to the wildlife spatial habitat through wide discussion of mutualistic successive architecture (MSA). This is an area of well-established personal interest, an expanded level of understanding was fundamental. Combined methodologies have used to establish areas of applicable preservation information.

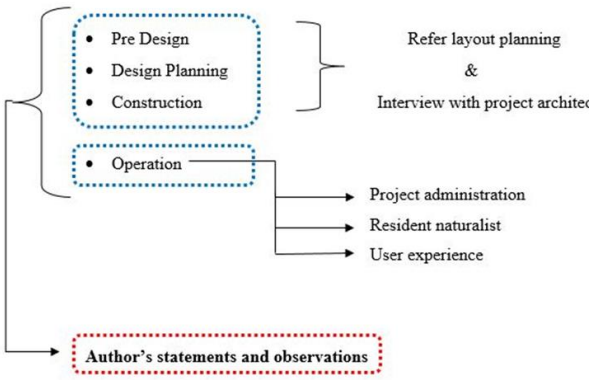

Figure 3: Flow chart for information collection process
Source: by author

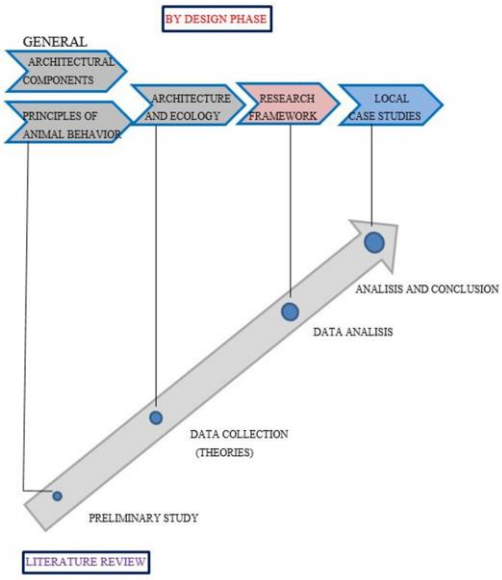

Figure 4: Chart for Methodology for the case study framework
Source: by author

2. Spatial habitat of Animals

The conditions define the behaviour of animals in a “spatial habitat “reveal their dread and desire. There is two distinct part in general bases for "territorial behaviour" in species and they are:

1. adaptive significance of the spatial habitat
2. The habitat should achieve such physiological needs

Mutualism

Ecological interaction of two or more species from which fitness benefits are gained by individuals of both species is described as Mutualism. As connected to design, the two life forms are the man-made built environment and the ecological system. The architectural design ought to be a sort of mutualism. (Vivian workman, 2004).Because of this complication that mutualistic architecture is in a special position to regenerate the regular existence and its non-artificial physical features in the building environment. The form of the mutualistic architecture ought to not be a particular “style” but reasonably a forms out that improves from a series of procedures.

Habitat clearance and modification

Reimbursement and change of natural surroundings are incorporated into this segment since it much of the time results in the decrease or vanishing of assets basic for key behaviours. Clearance of the habitat in sensible area is maybe the most genuine preservation risk to the world’s wildlife, and to consider with wildlife in the tourism-related buildings. Habitats might be cleared or adapted for wildlife tourism, through the development of the projects, outdoor gardens, streets, parking spots or outing regions. Territory discontinuity brings issues of edge impacts (R.J & Catterall., 1998), decreases habitats and home varieties.

3. Spatial mutualism of architecture and ecology

3.1. INTEGRATION OF ARCHITECTURE AND ECOLOGY

The homogeneous internal environment we create are detached from the nature of the site hence we become a separate entity within a selected context. We need to realize the fact that other species already inhabit a world shaped by architecture. Mutualistic architecture should always follow the natural surroundings without destroying it.

INTERDIGITATION
A spatially integrated pattern based on an intrinsic resource distribution pattern.
Example: ridges and valleys

NODE AND CORRIDOR NETWORK
A system of core areas combining the benefits of large core areas with advantages of connectivity.
Example: ecological network

Figure 5: spatial concepts for architecture and planning with landscape
Source: integration of landscape ecology and architecture, Jack Ahern, 2005

3.2 GENERAL COMPONENTS OF ARCHITECTURAL DESIGN

3.2.1. *Physical substances*

Building mass can be explained to make intrigue, concordance, and fascination inside their design. It is critical to watch the effect of structure, massing to the encompassing environments. The position of structures have changed the extent that the structure itself makes compositional space, way of life just as give a type of impact to the encompassing natural habitats. Which comprise the fundamental fascination, together With the native wildlife. The utilization of viewpoint on actual structure surface can incredibly change the spatial character and building space can be controlled evermore by utilizing surface.

3.2.2. *Ephemeral substances*

Space might be the guideline characterizing qualities of architecture. It might separate into two distinct part as inward and outside. As to wildlife, it is increasingly critical to talk about the outside spaces connected to the structure just as integration with the encompassing landscape, the building's structure can be made to blend in with and show up as an expansion of the natural habitat through sensibly planned exterior spaces. The scale identifies with the extent of an object contrasted and the space it possesses. It might be that the achievement of scale relies on the capacity to appreciate proportion and repetition in connection to some unit that is generally human-sized and close enough to the people and wildlife in a structure to allow them to quantify it against themselves. Lighting in day and night is a requirement in architecture and utility. Designers channel it through openings into their spaces and shape it on the surfaces of their masses by changes of plane, causing it to invigorate into their structures by appearing differently in relation to shadow. The presentation of artificial lighting likely spoke to the most drastic change people have made to the natural habitat.

Table 1: Analytical framework

Principles and strategies from the **Literature review** will analyze through selected case studies		Case study 01	Case study 02
1. **Analysis of the wildlife in and around the site**		-	-
2. **Principles of animal behaviors in and around the site**	• Adaptive significance • Physiological needs	-	-
3. **Negative and positive impacts of General architectural components**	• Physical Substances • Ephemeral substance	-	-
4. **Site planning and design**	• Zoning & physical structure siting	-	-

4. Comparison of implication on wildlife spatial habitat in Sigiriya, Dambulla area: Case study analysis

Project A -Kalundawa Retreat by Archt. Sanath.Liyanage
Project B- Galkadawala forest lodge by Archt. Vijitha Basnayaka

4.1. ANALYSIS OF WILDLIFE IN AND AROUND THE SITES

The core objective of the project A and B are to ensure that wildlife is not disturbed by architectural interventions. Both the projects used a different approach in the study. While Galkadawala Lodge project transformed deforested, consumed and denuded land into a vibrant ecological habitat by caretakers who worked tirelessly since 2006 till date, Kalundewa project initiated in 2005 enriched the surviving habitat ecosystem over the periods. Thus, there are favourable significant changes in the population and behaviour of the wildlife in and around the site. In Galkadawala, with the Secondary Succession, few species from the surrounding habitats exhibited the capability of thriving in the disturbed habitat whereas, in Kalundewa retreat, the entire habitat including the microhabitat was enriched and substantially improved.

4.2. PRINCIPLES OF ANIMAL BEHAVIOUR

The above projects clearly identify the difference of micro changes in animal behaviour and their adaptive quality, breeding success, level of predator avoidance, food availability and awareness of human presence. Before construction, Kalundewa site was already rich in roosting sites whereas, in Galkawadala, new habitats were introduced to the site with the construction that also identified the high adaptive rates in the animals. The analysis of data collected from the Naturalist in Project Administration reveals that there is a fluctuation in nourishment, population, and locations in roosting and nesting sites. Both architects were critically considered the arboreal and other pathways below and above the structures by taking into consideration of the spaces which were occupied by the wildlife, control of artificial lighting, noise and colours at the design stage.

4.3 ROLE OF GENERAL ARCHITECTURAL COMPONENTS TOWARDS WILDLIFE

The overall architectural components have turned out to be the most refined version of the existing nature, however, it has both positive and negative impacts towards wildlife. Both the architect's intention was to let nature take over the building and dwell with it. The two projects vary in scale and with the use of technology. They had been determined by the surrounding natural context and how the buildings have been occupied within the space. While Kalundewa Retreat used local language with the use of modem and contemporary technology, Galkadawala Forest Lodge only used vermicular local technology. The appearance and output of the projects have been enhanced through techniques, colours, surfaces, textures, volumes, proportions, replications and operations by merging with their surrounding environment. This has furthermore resulted in negative and positive impacts on wildlife.

4.4. SITE PLANNING AND DESIGN

The author suggests considering the integral use of land to cater to both human and wildlife circulation when preparing the site layout (including the structures and utilities within the premises). An extremely cautious planning is fundamental that considers factors like the safe distance from the migratory routes, reproducing and perching destinations, and the zoned areas. Environmental and social cognizant site planning have resulted in establishing mutual connection between the improvements in the tourism industry and wildlife enrichments. Buildings have been constructed carefidly to define the edges when segregating the indoor-outdoor relationship. Site master planning for both the projects have perfectly merged with the dense forest, marshy land and water bodies.

4.5. ECOLOGICAL SECTIONAL TEST (LIFE CYCLE RESPONSIVENESS)

Qualitative measures converted to quantitative measures by using ratings and graphs. Final conclusion based on MSA (Mutualistic Successive Architecture) of the projects analysis through the building centred (red) and animal centred (green) life cycle of the building. By comparing the ecological sectional

test and rankings done by the project architects, the author analysed the responsiveness of the building to the natural site. Hypothetical graphical variation of mutual succession has been used in the analysis of variations in Project A & B. Due to time and mutual succession, a gradient of line Red and Green is noticeable in both the projects. Due to the different approaches of both projects, in Kalundewa : building and animal succession might rise to climax point around 30 years and there might be anticipated decrement of building responsiveness after the climax point and the animal responsiveness continues constantly. In Glakadawala both attributes increase to the climax point simultaneously due to the secondary succession, hence the building responsiveness might have been decreased after 15 years keeping the animal responsiveness constantly in the site. A faster rate of adaptation has been observed in Galkadawala over the years and is expected to change in the future. In both projects the anticipated life cycle of the MS building has and there is a significant time gap between two projects. This would develop a correlation between building and wildlife responsiveness. The buildings and its architecture proposed in Project A & B are adaptable to wildlife animal succession. The primary and secondary Meta in the responsiveness of the building are material and technology respectively. The author has identified that long term research has to be done to fad out the MSA in a project which engages wildlife habitats. Considering architecture and mutual relationship in a human enclosure within animal habitats, the reason of the MS have been identified the overall material types and the life cycle of the materials.

tms (k) — mutual succession of Kalundewa Retreat
tms (g) - mutual succession of Gikawadala Forest Lodge

tms (k) < tms (8)

Mutual Successive architecture (MSA) in selected projects –
life cycle responsiveness

Ecological sectional test

Kalundewa Retreat

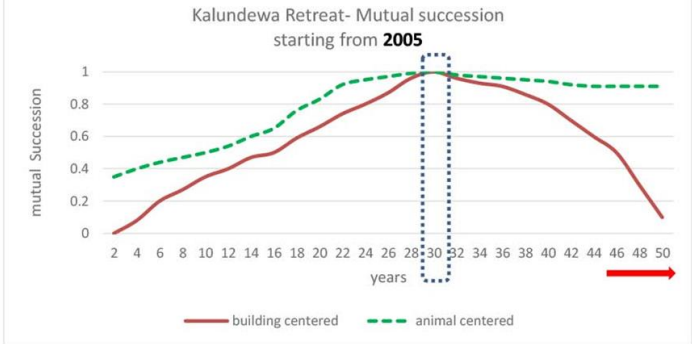

Figure 97: Chart of the expected time line of Kalundewa retreat
Source: by author developed through Findings from relevant professionals

Galkadawala Forest Lodge

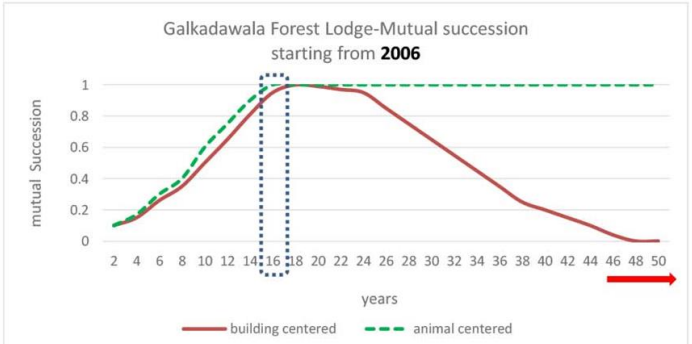

Figure 98: chart of the expected time line of Galkadawala Lodge
Source: by author developed through Findings from relevant professionals

1 – Climax of the mutual succession

0 – Initial starting

5. Conclusion

Most of all the site investigation and arranging systems in tourism-related architecture within sensitive wildlife habitats being rehearsed today are tragically objective, thus, fairly one-dimensional. Modern society tends to believe that any project can be eco-friendly with the use of various eco-friendly materials and other so-called sustainable components but to be addressed as mutualistic architecture, it is essential to have a deep understanding of the surrounding habitats which are shaped by the built environment and its performance. An abstract methodology is required to make an arrangement that is in all-out amicability with the current landscape. With regards to the environment hypothesis, comprehensive quality depends on the idea that non-living parts and living segments work together all in all as indicated by well-characterized biological laws. Everything is associated: people, plants, creatures, and non-living articles.

Both projects are surrounded by agricultural land, water bodies and dense forest in the intermediate zone with conditions of open habitats. Mutualistic and resilience quality of both projects are similar to different approaches from the beginning. The core objective of Project A and B are to ensure that wildlife is not disturbed by architectural interventions. Both the projects were initiated in 2005-06 and are in effect till date. There are visible changes in the population and behaviour of the wildlife in and around the site. Both architects critically considered wildlife spatial habitats and their performance within the designed structures. The key highlights in the projects are, decelerated construction process in Kalundewa and secondary succession approach in Galkadawala. The two approaches positively contributed to the implication of the mutualistic architecture in the concepts.

The overall architectural components have turned out to be the most refined version of the existing nature, however, it has both positive and negative impacts towards wildlife. Environmentally and socially cognizant site planning of both projects has a reasonable impact on making mutualism connection between the tourism industry improvements and wildlife enrichments. In the point of view of the architect's, both the projects let nature take over the building and demarcate relevant life cycle. After the construction period, there is a significant turning point in both the projects whereas similar results are anticipated in the final stage. In both projects the anticipated life cycle of the MS building has and there is a significant time gap between two projects. Comparing material selections and construction processes during the succession period has demonstrated a significant difference in both the projects. These are highly relevant for the ecological succession of the animal habitat. Durability in the eco-friendly building comes under the human point of view (human centred) hence when considering the MSA in a project, it is essential to consider the materials and the life cycle of the materials and overall performance of the architectural components. Considering architecture and mutual relationship in a human enclosure within wildlife habitats, the author has identified that long research has to be done to find out the MSA in a project which engages wildlife habitats.

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RELEASING THE BARRIERS OF OVER SANCTIFICATION OF A SACRED SPACE
Re-Evaluating Functional Configuration and Usage of Mosques in Dhaka, Bangladesh

HASAN MUNTASIR[1] & NOSHIN SIARA PROMY[2]
[1]Northern University of Business and Technology Khulna, Khulna, Bangladesh
[2]Khulna University of Engineering & Technology, Khulna, Bangladesh
[1]hasan.muntasir@gmail.com, hasan.muntasir@nubtkhulna.ac.bd
[2]noshinpromy@gmail.com, noshinpromy@arch.kuet.ac.bd

Abstract
The mosque is a very important component for the Muslim community. Dhaka, the city of mosques is accommodating more than 6,000 mosques which refer to at least one mosque per 0.05km2 area. It has its great influence in the surrounding community and social life. Generally, we know mosque as a sacred place for worshipping for the Muslims. But over the period of time mosques have been over sanctified as a place of worship forgetting its subsidiary purposes in the context of Dhaka, Bangladesh. For this, a psychological barrier is being formulated gradually to its users which represents a wrong perception about the usage of mosques. Islamic history reveals its evidence about the multidimensional usage (like learning centre, centre of community, economic activities etc.) of mosques. There has been a failure to communicate the pristine view of Islam and it is oiling religious fanaticism. This study aims about how the psychological barrier of over sanctified mosques can be eradicated and explore the potential attachment of its users. Four different community mosques of Dhaka city are taken for studying this particular issue in this context. Their spatial layout and connectivity with urban morphology are being analysed super positioning the theory of space syntax. Questionnaire survey as quantitative research has done to the local users for the study of perception and usage of mosques. These analyses give a comparative conception about the relationship between the mosques and its user's psychology. This paper discloses how both architectural elements and social morphology are influencing occupants' behaviour and responses of that particular mosques. This inter-relationship between the architectural features and social assemblage can be designated to articulate future mosques in Dhaka city.

Keywords: *Mosque, Over-sanctification, Urban morphology, Space re-evaluation, Dhaka.*

1. Introduction
A mosque can be defined as a Muslim religious institution where Muslim community offer their prayers, conducts other religious and social activities and controls the authority of the space in which the activities are held. From the initial era of Islam, Muslim architecture has been initiated from the foot print of mosque which was introduced by Prophet Muhammad (Sm.). Gradually Islam flourished and the concepts of mosque were circulated in various countries of the world.

With the invasion of Sultans and Mughal Subahdars in Bengal, the construction of mosque as a built form was introduced in clearly sacred identity but in secular architecture. Dhaka- as a provincial capital and important trade centre for the Muslims majority living here, housed significant number of mosques throughout the history and till to date. Although it is clear that these mosques become a strong degree of urban element in defining the characteristics of Dhaka city, it often failed to address its true role as a community service which can serve beyond the enclaves of five times prayer.

The idea of mosque as a sole religious space where only 'Salat' (Muslim prayer) can be offered has boosted the over sanctification of this sacred structure. This idea kept aloof the communal roles that a mosque could had performed in shaping the communities and expurgating fanatics within its jurisdiction. D. N. Wilber (1936) in delineating the versatile role of mosque on its immediate settings, stated in his *The Religious Edifice and Community Life* –

"Further, these calls to prayer were one of the factors active in bringing into being the feature that many of the streets of the town radiated directly from the court of the mosque. The court of the congregational mosque established itself as the centre of public life. From the first it was a spacious enclosure, in the beginning large enough to hold the entire male population of the town, to which all

the men could be summoned in time of war, or in which they could be accommodated during the great religious festivals."

From the notion of over sanctification, this paper investigate mosque as religious building type with its possible role in the community. The sample of four community mosques and their immediate settings (Figure 1) in this study was selected as a representative of diversified practice of mosque buildings in Dhaka city.

Figure 1, Satellite images of four community mosques and their immediate settings *(Source: Google earth images)*

2. Literature Review

2.1. MOSQUE AND DHAKA CITY

Dhaka- the capital of Bangladesh, is the largest city in Bangladesh with a population of more than 18 million, with 90 percent Muslim majority. Due to the rapid growth of Dhaka city in the late 1950s, the frenetic capital needed a large number of mosques to care for the increasing Muslim population. According to the Religious Ministry of Bangladesh Dhaka is currently accommodating more than 6,000 mosques which refer to at least one mosque per 0.05 square meter area.

2.2. EVOLUATION OF MOSQUE IN DHAKA CITY

Mosques have been at the centre for religious life in Dhaka, situated along the course of Buriganga, since shortly after the Sufi missionaries arrived in the 13th century. With a glorious past of 400 years of establishment as a capital city, Dhaka houses many mosques of the Bengali sultanate (which controlled the region until the 16th century) and Mughals-who ruled the area until the rise of the British East India Company in the 18th century. During Colonial period many mosques were established under the patronization of Nawabs. In the early years of independence after 1971, the city's mosque architecture was mostly mere imitation of foreign traditions like-Turkish domes, Mughal arches or massive Arab minarets which was more adaptive to global Islamic framework. Proliferation of mosques was another reason of growing Islamic sentiment that boosted in people to establish charity mosques. Most of these mosques are ill-planned in the both building and city scale. Until recently, some group of contemporary architects have been involved in mosque architecture and presented some exemplary mosques in the city life of Dhaka. Baitur Rauf Jame Mosque by Architect Marina Tabassum, Gulshan Society Mosque by Architect Kashef Mahboob Chowdhury, Mayor Mohammad Hanif Mosque by Architect Md Rafiq Azam are notable.

2.3. OVER SANCTIFICATION OF MOSQUE IN DHAKA CITY

Mosques function as the core religious structure to house the five times daily prayer, Jummah prayer (Friday congregation noon prayer), Iftar (breaking of fast in Ramadan month), Janajah (prayer after death) and some other core religious activities of Islam in the mosques of Dhaka. Public perception holds a holy and sacred notion about it where one cannot enter without proper ambulation. Most community conserves strict opinion that no social or philanthropic activities can be performed within the mosque premises other than performing 'Salat' (Muslim prayer). This over sanctification of this religious structure breaks the bridge of mental accessibility of the user from the physical presence in this holy space. Building mosque without the spatial quality to act as a multipurpose hub, lack of connectivity and direct physical accessibility along with confined in usages are the visible reasons behind over

sanctification. Lack of proper religious knowledge is hindering mosque from performing its social and political activities and turning it into an unreachable fortress. Which is inaccessible to the mass community and in the broader end it is boosting intolerance, disparity, fanatics along with building religious tensions and ambiguities.

2.4. MOSQUE IN VIEW OF ISLAM

Since the primary assignment of man on earth is to worship Allah, the whole of the earth has been declared a mosque for the Muslims (Bukhari, 7: 1). Though mosques have been performing tremendous effects on the lives of Muslims, it is sadly observed that it has been considered only as a place where daily prayers are offered ignoring greatly other roles it could have played in the lives of the Muslims. Most scholars have only concentrated on religious rulings or architectural designs of some mosques with little or no reference to the socio-economic and political use of mosques in the society. But it is in the mosque where practical learning of virtues are demonstrated and practiced in Islam. As Muhammad Ali (1973) has illustrated,

"Once within the doors of the mosque, every Muslim finds himself in an atmosphere of equality and love. Before their Maker they all stand shoulder to shoulder, the king along with his poorest subject, the rich arrayed in gorgeous robes with the beggar clad in rags, the white man with the black. Nay, the king or rich man standing in a black row will have to lay his head, prostrating himself before God, at the feet of a slave or a beggar standing in the front. There could be no more levelling influence in the world. Differences in rank, wealth and colour vanish within the mosque, and quite a new atmosphere, an atmosphere of brotherhood, equality and love, totally differing from the outside world, prevails within the holy precincts."

The Prophet (S.M.) used the mosque as a centre for educational persuasion and studies in Islamic lifestyle. He elucidated the message revealed to him, explained the meanings of the revelations through sermons and lectures. Eventually, the mosque flourished as a centre of learning. As per history, in the fourteenth century, 12,000 mosques were used as centres of learning in Alexandria (Nakosteen,1964). Another notable contribution of the mosque to intellectualism is in the form of attaching libraries to some of the mosques which were later turned into universities.

At the time of the Prophet (S.M.), judgements, dispute resolution, announcement of punishment on offenders were made in the mosque. The mosque also served as a place for initiating marriage contract; place for resettlement, and for preaching empathy. Economic function were also performed in mosques such as- collection of Zakat (Islamic taxes) and Sadaqah (Islamic charity) from the rich and giving it to the poor. In addition, there are also mosques with shops in their premises or even attached to the mosque.

3. Objectives

The objective of this paper study the psychological barrier of over sanctified mosques and how it can be eradicated and explore the potential attachment of its users. Four different community mosques of Dhaka city are taken for studying this particular issue in this context. Firstly, their spatial layout and connectivity with urban morphology is being analysed super positioning the theory of space syntax. Secondly, questionnaire survey as qualitative research has done to the local users for the study of perception and usage of mosques. These analyses give a comparative conception about the relation-ship between the mosques and its user's psychology.

4. Methodology

To carry out the research in a rational way four mosques of Dhaka city were selected with different context and attributes. They are, *Tara Mosque, Chawkbazar Shahi Mosque, Sobhanbag jaam-e Mosjid, Azimpur Graveyard mosque (Mayor Hanif Mosque).*

This research has been carried out through three steps of analysis.

- Comparative analysis of the attributes and spatial quality of the mosques through filed studies.
- Contextual analysis of the mosques about its impact on urban morphology through space syntax.
- Perception of the users of the mosques through questionnaire survey regarding different attributes of the sanctification of mosques.

5. Analysis

5.1. COMPARATIVE ANALYSIS OF THE ATTRIBUTES AND SPATIAL QUALITY OF THE MOSQUES

Tara Mosque- A historical Mosque of Mughal style located in the old portion of the Dhaka city, Armanitola. This mosque is highly decorated with motifs and other Mughal style ornamentation. It has a grandeur effect in its existence which is accompanied by a big open courtyard and a star shaped waterbody in front. This mosque is also a very attractive destination not only for the common people here but also for the tourists for its historical and architectural value.

Chawkbazar Shahi Mosque- This mosque is located in one of the most distinct oldest commercial centre of Dhaka city, Chawkbazar. The mosque was constructed in 1676 and called 'Shahi Mosque' which had direct connection from the Buriganga River and served as central mosque for the Sultans. But chronologically this historic mosque has undergone many consecutive demolition and renovation phase resulting distortion to its original planning and exterior elevations. The adjacent areas gradually became over crowded with commercial activities and thus the initial open settings were lost with layers of consecutive extensions. Even its ground floor is totally occupied with commercial activities today. Now the total mosque is physically confined within commercial masses making it psychologically aloof from the people of the community.

Sobhanbag jaam-e Mosque- Sobhanbag mosque is located along one of the major route of Dhaka city, Mirpur road in Dhanmondi. And Dhanmondi is also one of the major residential area of Dhaka. This mosque is like a typical mosque in the Dhaka city residential context. The mosque has very little openings, with no court-yard. This is not only fortified with heavy elevation walls with very little openings but also surrounded by multi-storied residential buildings. Only the front elevation is open to one of the most busy and significant route of Dhaka; Mirpur road.

Azimpur Graveyard (Mayor Hanif Mosque)- Azimpur Mosque is located amidst the residential setting beside the Azimpur graveyard in Dhaka which was built in 1746 AD. The mosque was built during the reign of Mughal Nawab Alivardi Khan but sadly demolished to make modern mosque with increased capacity. Renowned architect Md. Rafiq Azam designed the mosque with through connection between community, mosque plaza and graveyard. This mosque had ample opportunities of public gathering in the mosque plazas which made a positive impact in the surrounding high density residential zones of Azimpur colony.

Table 1, A comparative chart showing the difference of physical attributes of the four studied mosque in Dhaka city.

Mosque	Year of establishment	Layering (Veranda/Central praying spaces)	Articulation of elevation	Spatial Grandeur (Open courtyard/plaza)	Subsidiary activity (Shops, Madrasa)
Azimpur Mosque	1746, demolished & rebuilt	yes	Contemporary (formerly	yes	no

	2018		Mughal)		
Chwakbazar Mosque	1676 demolition –renovation several times	yes	General (formerly Mughal)	no	yes
Tara mosque	18th century	yes	Mughal architecture	yes	no
Sobhanbag mosque	1991	no	General	no	yes

5.2. CONTEXTUAL ANALYSIS OF THE MOSQUES ABOUT ITS IMPACT ON URBAN MORPHOLOGY THROUGH SPACE SYNTAX.

The four mosques are analysed as the integration core using visibility graph analysis of space syntax. The degree of connection has been identified taking a catchment area of 500 by 500 meters, where the integration core i.e. the mosque with its surroundings is analysed Visibility Graph Analysis using Depthmap. The objective is to examine the extant up to which the mosque renders it effect as an urban element and explores relationship with its surroundings.

Figure 2, Visibility Graph Analysis of the four chosen mosques of Dhaka city. *(Source: Author)*

By comparing the visibility results of the four studied mosques in Dhaka city it is clear that Tara mosque shows an increase visual integration. This suggest that it plays a significant role in connecting with its neighbourhood. The positivity about this mosque is the open plaza in front of the mosque which is grand in proportion to the size of the mass of main structure of the mosque. The mosque is situated in an historic context of Old Dhaka and itself bears the testimony of past which acts as a point of tourist attraction into this beautiful mosque. The mosque has integrity from three sides with the surrounding which further explains the positive results in visual graph analysis.

Azimpur Graveyard mosque (Mayor Hanif Mosque) also displays a good degree of visual integration which is connected with the surrounding from two sides. It is not typical mosques which are mostly available in Dhaka rather an example of architecturally designed community mosque in contemporary time. It has an adjacent graveyard attached to it and the thoughtful design integrated the community and mosque with and open plaza which has a direct visual connection with the graveyard. The architectural

attributes clearly added positive contribution in demonstrating increased visibility of the mosque as an urban form.

The lower visual integration is displayed in Sobhanbag jaam-e Mosque and Chawkbazar Shahi Mosque, which represents the typical community mosques of Dhaka city. Both the mosques are enclosed from three sides with surrounding building masses and the approach is only from one side. No public integration space like courtyard, open space, plaza. The only visual connection with outside is through the window/openings on the outside elevation which is incapable of creating proper connection with the surrounding as an urban form.

5.3. PERCEPTION OF THE USERS OF THE MOSQUES

There are six questions asked to the users of community mosques of the four studied mosques to understand the perception of users towards sacredness or sanctity of mosque. At first, the general information of the respondents are noted. Then above three questions related to user perception of mosque in background to religious ideology is surveyed and last three questions involve the space and perception of architecture regarding mosque from user's perspective.

Table 2, Age of user

21-30	31-40	41-50	50+
5	12	18	5

Table 3, Academic Background of user

Primary (class 5)	Junior (Class 8)	SSC	HSC	Diploma	Hon's
6	13	9	6	4	2

The age of the respondents that take part in this study falls from 21 to above and nearly 90% is between 31 to 50+ years old. Their academic background varies from primary, junior, SSC, HSC, Diploma and Hon's.

Table 4, Mosque is only ritual prayer and meditation center for Muslim

Name	Strongly agree	Agree	Disagree	Totally disagree
Tara mosque	2	7	1	
Chawkbazar mosque	8	1	1	
Sobhanbag mosque	7	2	1	
Azimpur mosque		6	4	

Table 5, Mosque as a Centre for Community for Muslim

Name	Strongly agree	Agree	Disagree	Totally disagree
Tara mosque		3	6	1
Chawkbazar mosque		1	1	8
Sobhanbag mosque		2	6	2
Azimpur mosque	1	3	5	1

Table 6, Can other activity be operated in Mosque

Name	Strongly agree	Agree	Disagree	Totally disagree
Tara mosque		3	7	
Chawkbazar mosque		1	3	6
Sobhanbag mosque		1	7	2
Azimpur mosque		3	5	2

Table 7, Design of the mosque give a psychological impact to sacredness of the space

Name	Strongly agree	Agree	Disagree	Totally disagree
Tara mosque	2	8		
Chawkbazar mosque	8	2		
Sobhanbag mosque	9	1		
Azimpur mosque	6	4		

Table 8, Size, light and material used give some impact towards sacredness space

Name	Strongly agree	Agree	Disagree	Totally disagree
Tara mosque	2	8		
Chawkbazar mosque	7	2	1	
Sobhanbag mosque		7	3	
Azimpur mosque	4	6		

Table 9, Mosque area must be fenced/fortified to protect the sacredness of space

Name	Strongly agree	Agree	Disagree	Totally disagree
Tara mosque		6	4	
Chawkbazar mosque	1	7	1	1
Sobhanbag mosque	7	1	2	
Azimpur mosque		1	3	6

The questionnaire survey comes up with an interesting feedback. The frequency of answers about the perception of mosque function varies with the features and settings of mosque. The majority of users of Sobhanbag and Chawkbazar which mosques are fortified and not connected with the community express opinion as mosque to function only as prayer space with no other community activity. While, users of Azimpur mosque, which has a public plaza and open access, shows more liberal views and agrees with the notion of multipurpose use of mosque. Though Tara mosque has an open plaza in front but it is situated in the Old Dhaka in a community of orthodox mentality which explains the reason of their strict perception about uses of mosque.

The features and quality of spaces affect the sacredness of space which is more or less agreed by all. In case of fortification a notable difference is observed in the perception of users in Azimpur mosque. It clearly shows how a thoughtful design changed the perception of the community towards mosque.

6. Recommendation

The analysis conducted in this paper guides us to some thoughtful recommendations. They are mentioned below-

- Mosques should be adopted as a centre for community for Muslim masses in Dhaka.
- Besides obligatory daily ritual of prayer it should be designed as a multipurpose space where other social, judicial, political and philanthropic activities can be regulated.
- Plan of mosques should adopt more open-ended design principle to act as a platform for the communal activities.
- Architectural spatial quality, design and functional arrangement can act as a catalyst to break the fanatic mind-set of mass people.
- Mosque as a well fenced compound entrenched the mosque from its immediate locality henceforth boundary wall, fencing should be avoided.

7. Conclusion

The spatial quality of a mosque affect the mind-set of its users. Mosques with fortification or enclosed space affect its users to bear a narrow mind-set. On the other hand mosque with openness makes more connectivity with its users. Over the time the fact of over sanctification of mosque has dilapidated its pristine idea. And under the cover of over sanctification its versatile features are prohibited. The versatile features of a Mosque must be taken in account in present-time approaches.

Thus, mosques are not mere religious buildings. From the very beginning of its history it has diversified significance. Moreover, in such a Muslim context like Dhaka, mosque can be an active urban element. Which can greatly contribute in fulfilling the needs and aspirations of its locality and thus boost up positive mentality in the mass people of the community.

8. Acknowledgements

Special thanks to Istiak Ansary Kabbo and Pritom Sikder, students of department of architecture, BUET (’17 batch) for their heartiest effort to conduct the field survey. Also grateful to Shariful Alam Anik, student of department of architecture, BUET (’12 batch) for his kind support in Depthmap analysis.

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ANALYTICAL STUDY OF THE SPATIAL DIVERSITY IN ADDITIVE MODULAR ARCHITECTURE; WITH SPECIAL REFERENCE TO DUTCH STRUCTURALISM

M.B.M.C.B. GAWARAMMANA.[1] & W.P.S. BOTEJUE.[2]
[1, 2] Department of Architecture, University of Moratuwa, Colombo, Sri Lanka
[1]gawarammana.c@gmail.com, [2]pbotejue@uom.lk

Abstract
The research is based on stimulations of the modular architecture towards spatial diversity in buildings. The main attributes of the research is established on Dutch structuralism as the hypothetical base for the study. Comparing the typical buildings, their spatial arrangement of forms and spaces, which generate through structuralism comprise of high diversity alongside different spatial qualities. The complex form generated through the combination of small forms, creates distinctive spatial diversity in such forms contrasting with the typical building arrangements and its spaces. Rather than accomplishing organic forms, Structuralists regularly practice the hypothesis of modular architecture, which formulates solid forms to resulting with meaningful edges and spaces within the interior spaces. Local approaches to modular architecture have developed with simple modules for simple construction further their informal arrangement of functions. Considering modular architecture in Sri Lanka, the author has chosen two case studies with similarities and differentiate and critically analysis internal spaces in each case and support to comprehend the dimension of varieties in spatial diversity.

Keywords: *Spatial diversity, Additive principle, modular architecture, Dutch structuralism*

1. Introduction

The notion of well-being and the feeling of users always deals with Architecture. When designing a masterpiece, the vital factors of the final outcome is "Form" and "Space". The mutual relationship between Form and Space can interconnect with each other both positively and negatively. That relationship explains the development of space as an output of form, on the other hand, the development of a form creates spaces within it. The final outcome of the objective manifesto is when these two factors are balanced equally.

A building morphological system can be a keyword or a mind opener to generate programmatic basis or architecture and nature. Structuralism is a theory which is based on that particular building morphological system identified as an architectural structure. In history, the Dutch structuralists have focused into more informal methods of solving problems. Dutch structuralism is more into international problem-solving methods than local ones, in bigger areas and the problem-solving procedure was also in a different perspective, as the building process becomes increasingly complex, ambitious and global. One of the main concerns was forgetting the theortical features of the building and forcing on the function. When considering the building types and forms, more or less they all may look the same. Paying attention only for one element or a cell was a key feature on theory. Managing and organizing that simple cell into many formations and innovative structures as per need was designing position in that process. Structuralism introduced a way of thinking about architecture as part of a bigger configuration or morphology. And it offers a strong approach to think of the individual entity and the whole simultaneously.

When considering the spatial qualities of these buildings, the spatial diversity is minimal because of the clustered design morphological system, but when considering the larger area that will show the spatial diversity will increase the building size with the complexity. That lacking spatial diversity and its behavior with form will be discussed in this research. And also, there are some buildings which are designed considering all these factors as well. This research will more over conduct into the local context while discussing these international theories by considering modular and additive construction. Within the country and the spatial diversity of these buildings. And the design limitation with achieving more innovative spaces while designing. The research will consider and discuss the design gap within another type of buildings with this particular building type with a different perspective, spatial diversity.

2. Theoretical exploration on Dutch structuralism

With the worldwide economic crisis, abandoned buildings and urban sites have increased and has gained attention for alternative design practices. It paves the way into the concept of Structuralism, which concentrates on the ability to practice in transformable, adjustable, sustainable ways with changing circumstances and conditions. The first step is to learn the issues focused on architecture, urban design, and landscaping.

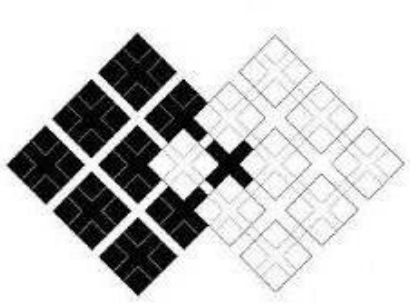


Figure 1: Structuralist forms
Source: open Structures, S.Frausto

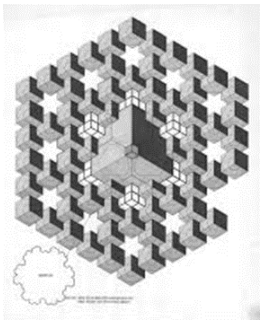


Figure 2: Structuralist forms
Source: open Structures, S.Frausto

Considering Dutch architecture, their culture was always innovative and as buildings got complex, they transformed within. Looking at the built environment, there's the possibility of learning and creating the opportunity for innovative architectural knowledge based on the collaboration between architects, designers, citizens, politicians and institutions.

2.1 THE ADDITIVE PRINCIPLE IN DUTCH STRUCTURALISM

The main concern in structuralism is the attention given to the role of architects and finding alternative definitions for architectural projects. Similar to notions such as openness and generosity, structuralism also faces issues regarding the understanding of the design and taking into account other spatial agencies.

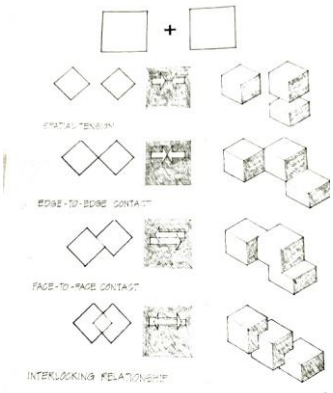


Figure 3: Additive forms
Source: Architecture space form and order

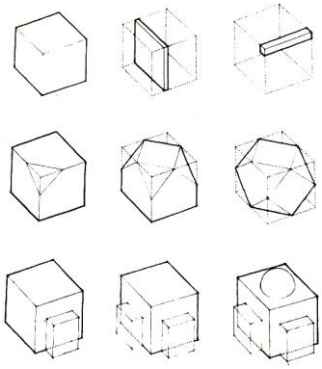


Figure 4: Additive and subtractive forms
Source: Architecture space form and order

Structuralism can be specified as a set of basic principles rather than a particular style. While being related to the whole system of users, inhabitants, budget and management issues, the previously mentioned openness and formlessness are also about being flexible in the designing phase. Having control of the single cell and being flexible and maintaining a certain control can be stated as the best thing about structuralist architecture.

2.2 APPLICATION OF ADDITIVE PRINCIPLE IN ARCHITECTURE; DUTCH STRUCTURALISM

When considering the use and misuse of spaces, when an architect designs a building, he is aware that that its original purpose would change. Again, with the factor scarcity, notions are relying on economic factors since it has proven that demolishing a building is more expensive than reusing it. Therefore, scarcity would be a great way to reboot the ideas about flexibility and openness in modern-day buildings.

2.2.1. *Spatial collaboration /Configuration*

Spatial arrangement and the spatial designing procedure are the main part when it comes to additive principle. This focus on choosing a particular module and adding it to create the intended spaces. Dutch structuralism tends to improve this quality of the procedure and created a unique way of designing problems regarding architecture.

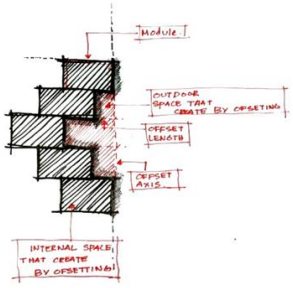


Figure 5: Spatial collaboration
Source: By author

2.2.2. *Constructional system*

After designing the spaces, the next part is the constructional system and method. In this process adding the additive principle into the constructional system helps to detail the construction parts, like the columns sizes and structural joints. Dutch structuralism takes place in these cases. They tend to dig deep into these theories and invent more practical and suitable design solutions even for small details.

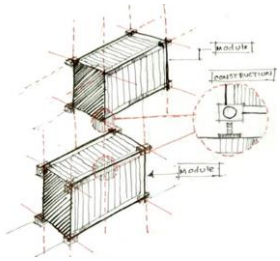


Figure 6: Constructional system
Source: By author

2.2.3. Building transformation strategies

After designing a building, the building will eventually transform through many paths. It may grow, extend or some parts can be reduced. And the building may be renovated to some extent. All these are form and space transformations. This process can be done by applying the additive principle.

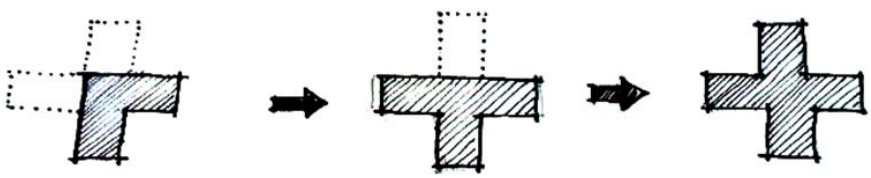


Figure 7: Building transformation (From transformation)
Source: By author

3. Theoretical insight of spatial diversity

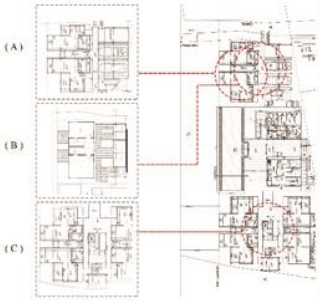
Space is a primary structure: which acknowledges people to understand external reality. The objects we act and their shapes, size, and relationship are decided by space. Instead of the space acting as the main structure a person's body moves with objects in places. Spaces provide ways of energetics movement to the surrounding without boundaries. Meaning can be gained through the actions applied to them. The idea of the material reality of things deems their "topics" neighborhoods. The effects of the real space realities are restored on symbolic things such as the principle in the existence of objects for us. The positioning factor can be explained, and understood easily in places where it can be used as a potential location. It is mandatory for any object to be loaded, in some cases removing another object. Therefore, the places of their definition are structured by various spaces. The composition of these spaces was ordered on the basis of their connection and interdependencies. There may be contradictions between the interior and exterior coatings and inconsistencies, such as transparency or metaphysis. Space has implied itself due to the state of the formation, between what is contained inside and what is kept outside.

4. Research design

Stage one

Identifying sectors

Identifying the sectors target for the analyze.



Stage two

Individual sector analysis

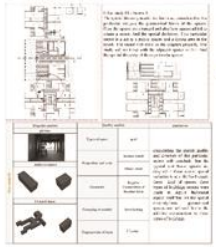
Analyzing each individual sector In descriptive method and also according to the theoretical frame work

Results 01

Stage three

Analysis Part 02

Analyzing the sectors individually In Figure ground method by using theoretical checklist.



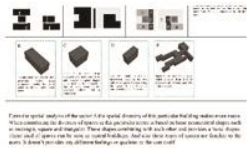
Results 02

Stage Four

Analysis Part 03

Analyzing the sectors individually By using the figure ground method Through a certain theoretical frame work (result 01,02 will analyzed).

Results 03



Stage Five

Discussion

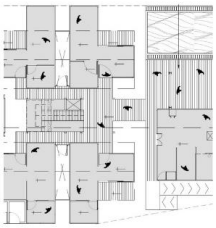
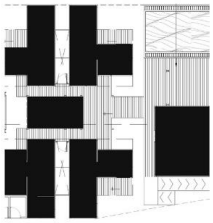
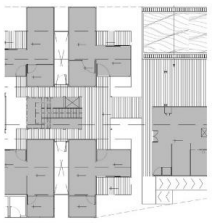
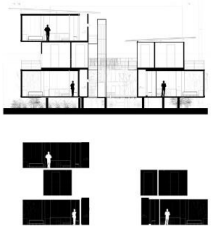
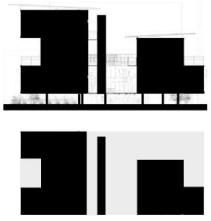
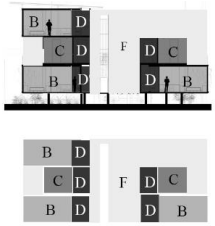
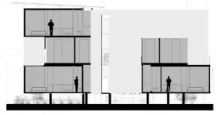
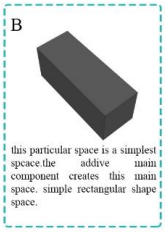
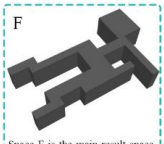
Discussing the overall result by referring the examples which have been studied in the chapter 03 (Result 03 will be analyzed)

Conclusion

5. Analysis

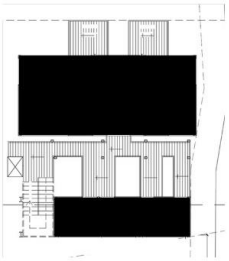
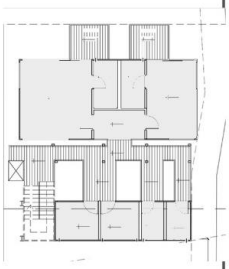
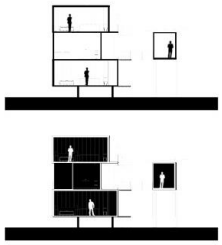
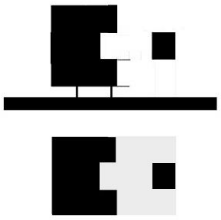
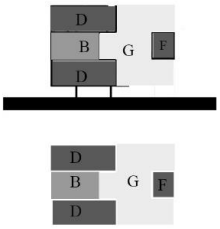
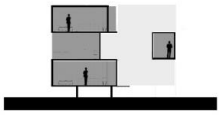
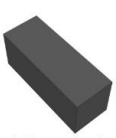
Case study 01: Petti Petti by Architect Sudesh Nanayakkara

Table 1:Case study 01 : figure ground-- sector A

	Case study 01- Sector A			
	Internal spaces			
	Scale	Solid and void cnonection	Volumetric variations	Connection inbtween spaces
Plan view				
Section				 in thi particular case the connection between two spaces are defined with another intermiaditae space D and D spaces connecting through the F space.
3 Dimentional	 this particular space is a simplest spcace.the addive main component creates this main space. simple rectangular shape space.	 space C is made from substracting the main space in to half. alsmost a square shaped space.this this particular case this type of spaces using as the secondary additive cell or component.	 space D is made out from the in-between space in the two additve components.when laying the space B and Space C automatically space D arrives.	 Space F is the main result space which is made from B C D spaces.mainly by using main two additve spaces.
conclusion	Form the spatial analysis of the sector A the spatial diversity of this particular building makes more mean. When considering the diversity of spaces in this particular sector is based on basic geometrical shapes such as rectangle, square and triangular. These shapes combining with each other and provides a basic shapes. These kind of spaces can be seen in typical buildings. And also these types of spaces are familiar to the users. It doesn't provides any different feelings or qualities to the user itself.			

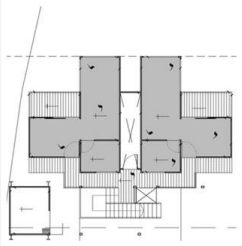
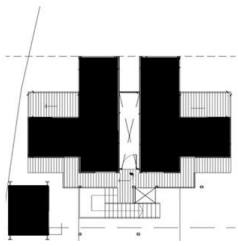
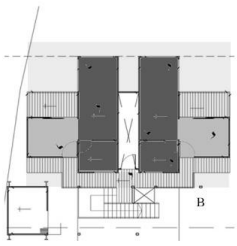
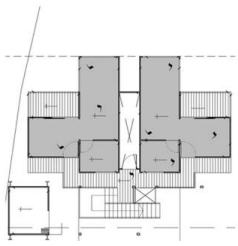
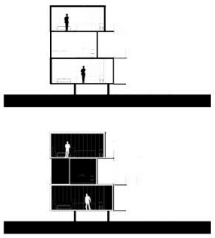
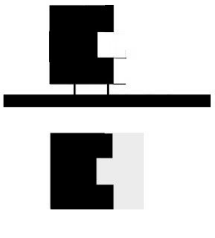
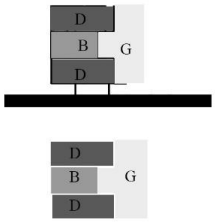
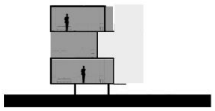
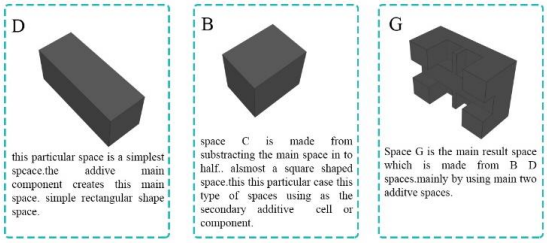
Discussion: From the information shown in the particular sector leads to the overall idea about the spaces created with the human scale. Considering the solid and void spaces and volumetric variations observations are made. The scale of the building is minimal considering with the human scale. These spaces give a typical and basic impressions. When considering the diversity of the spaces are much more similar as basic shapes.

Table 2: Case study 01: figure-ground-- sector B

Case study 01- Sector B			
Internal spaces			
Scale	**Solid and void cnonection**	**Volumetric variations**	**Connection inbtween spaces**
Plan view				
Section				 in thi particular case the connection between two spaces are defined with another intermiaditae space G spaces connecting through the F ,D and space.
3 Dimentional	 D this particular space is a simplest spcace.the addive main component creates this main space. simple rectangular shape space.	 B space C is made from substracting the main space in to half.. alsmost a square shaped space.this this particular case this type of spaces using as the secondary additive cell or component.	 F Space F is the main result space which is made from B C D spaces.mainly by using main two additve spaces.	 G Space F is the main result space which is made from B C D spaces.mainly by using main two additve spaces.
conclusion	Form the spatial analysis of the sector B the spatial diversity of this particular building makes more rigid. When considering the diversity of spaces in this particular sector is based on basic geometrical shapes such as rectangle, square and triangular. These shapes combining with each other and provides a basic shapes. These kind of spaces can be seen in typical buildings. And also these types of spaces are familiar to the users. It doesn't provides any different feelings or qualities to the user itself.		

Discussion: The created spaces are smaller in scale when comparing with the human scale. Basic shapes include with the design. The spatial diversity of this sector is higher in a certain way. But the spaces create with a limited number of faces and planes the scale of the particular sector is small when comparing with human scale. Spatial diversity is also minimal.

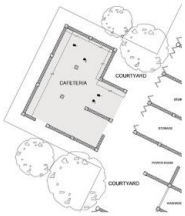
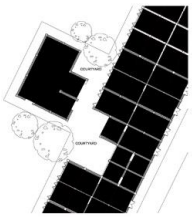
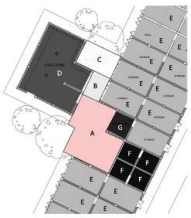
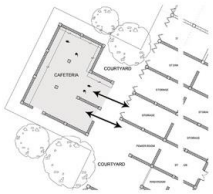
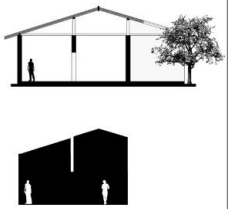
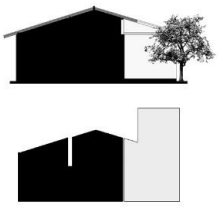
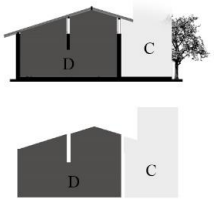
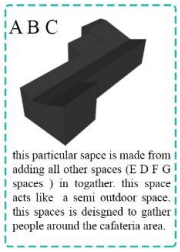
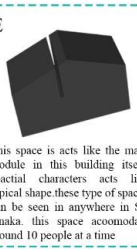
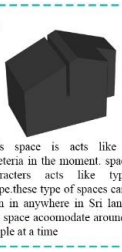
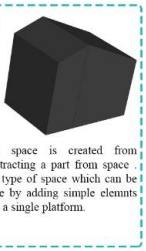
Table 3 : Case study 01: figure-ground-- sector

Case study 01- Sector C			
Internal spaces			
Scale	**Solid and void cnonection**	**Volumetric variations**	**Connection inbtween spaces**
Plan view				
Section				 in thi particular case the connection between two spaces are defined with another intermiaditae space G spaces connecting through the D ,B spaces.
3 Dimentional			
conclusion	Form the spatial analysis of the sector B the spatial diversity of this particular building makes more rigid. When considering the diversity of spaces in this particular sector is based on basic geometrical shapes such as rectangle, square and triangular. These shapes combining with each other and provides a basic shapes. These kind of spaces can be seen in typical buildings. And also these types of spaces are familiar to the users. It doesn't provides any different feelings or qualities to the user itself.		

Discussion: The particular sector is relating to the above sector. However, there are similar spatial qualities included in the above sector. The created spaces are smaller in scale when comparing with the human scale. Basic shapes include with the design. The spatial diversity of this sector is higher in a certain way. But the spaces create with a limited number of faces and planes the scale of the particular sector is small when comparing with human scale. Spatial diversity is ai minimal stage.

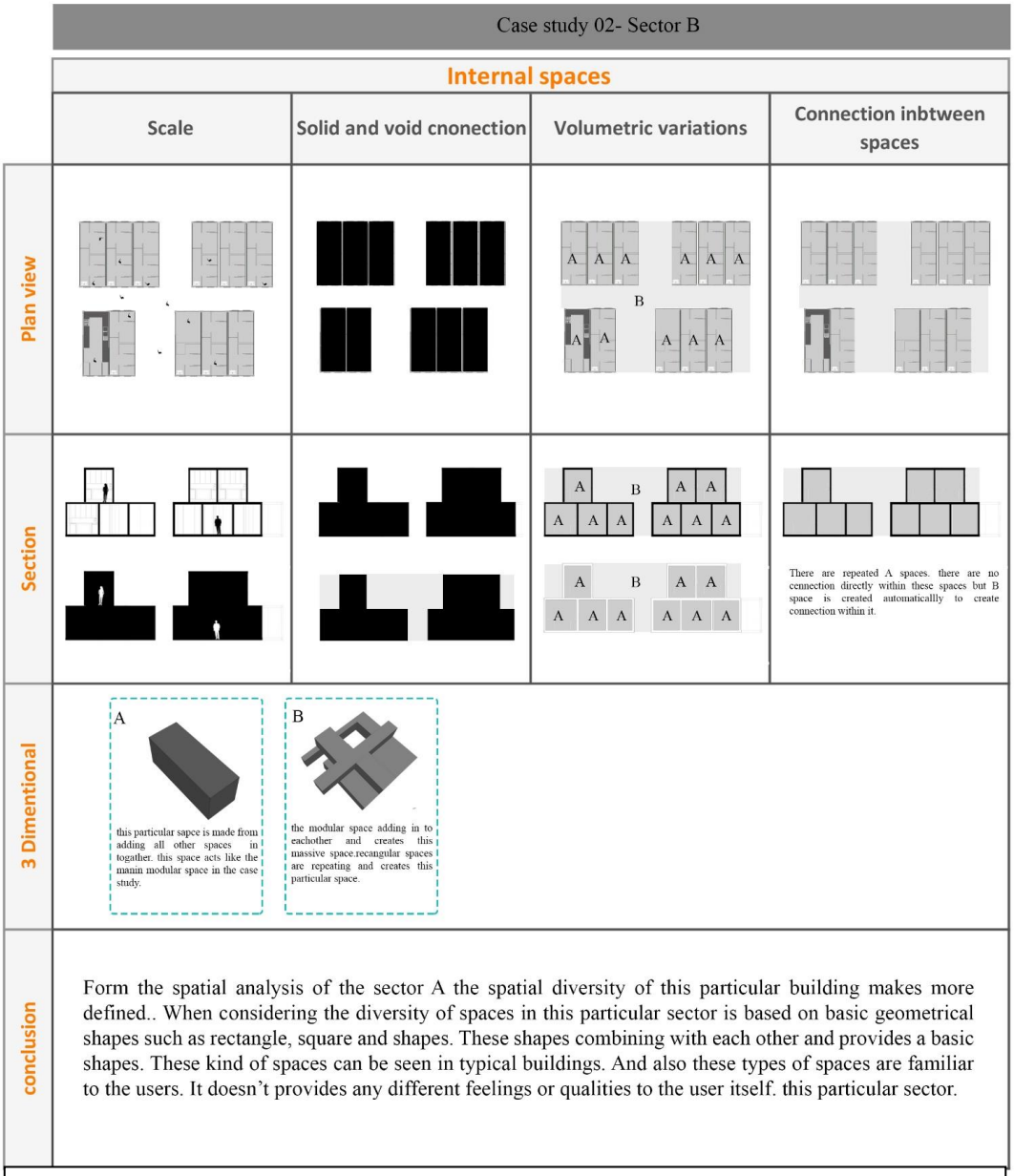
Case study 02: Economic enter and market, Keppetipola

Table 4 : Case study 02: figure-ground-- sector A

Case study 01- Sector A				
	Internal spaces			
	Scale	Solid and void cnonection	Volumetric variations	Connection inbtween spaces
Plan view				
Section				 in thi particular case the connection between two spaces are defined with another intermiaditae space D and E spaces connecting through the B space.
3 Dimentional	 A B C this particular sapce is made from adding all other spaces (E D F G spaces) in togather. this space acts like a semi outdoor space. this spaces is deisgned to gather people around the cafateria area.	 E This space is acts like the main module in this building itself. spactial characters acts like typical shape.these type of spaces can be seen in anywhere in Sri lanaka. this space accomodate around 10 people at a time	 D This space is acts like the cafeteria in the moment. spactial characters acts like typical shape.these type of spaces can be seen in anywhere in Sri lanaka. this space accomodate around 25 people at a time	 F this particular space Storage unit sapce in this particular building.spatial charactics are simple and also its familiare to people. typical spaces where can design in simple colaboration of elements.	 G This space is created from substracting a part from space . rare type of space which can be made by adding simple elemnts in to a single platform.
conclusion	Form the spatial analysis of the sector A the spatial diversity of this particular building makes more mean. When considering the diversity of spaces in this particular sector is based on basic geometrical shapes such as rectangle, square and triangular shapes. These shapes combining with each other and provides a basic shapes. These kind of spaces can be seen in typical buildings. And also these types of spaces are familiar to the users. It doesn't provides any different feelings or qualities to the user itself.				

Discussion: Considering the sector the spaces that creates modules are limited. But shape collaboration is in higher state. Rather than using a single type of basic shape. The connection between spaces is minimal so the space is limited to the faces and planes. Limited faces, limited planes, and limited connections. Less spatial diversity.

Table 5 : Case study 02: figure-ground-- sector B



Discussion: This particular sector is created with similar arrangement but considering the spatial diversity, narrow spaces and connections are higher. But the module arrangement is a simple typical arrangement. But there are no any unique spaces. No major connections through the modules and adjacent spaces.

4. Conclusion

All the identifications of spatial transformation patterns and the spatial study and empathies are discussed as a conclusion of each sector. The outcome of the study has demonstrated local cases that have used basic forms and shapes to generate spaces where the density doesn't vary. Through the analysis of the literature review and the international cases, the advancement of Dutch structuralism has significant achievement as complex spatial diversity. From the figure-ground study, an overall conclusion is discussed under the shapes and forms and their complexity of the space and the spatial quality. Attributable to the spaces generate through the theoretical framework, all the spaces contain define meanings. Project A refer to Petti Petti by Architect Sudesh Nanayakkara and project B refer to Economic enter and market in Keppetipola. Both projects are generated through simple forms with less variety of spatial qualities. According to the analysis of the spatial diversity in both projects with

modular construction, the spaces are not well defined to express meanings. In projects A and B, the designed spaces lack significant unique spaces and the most complex shapes caries a minimal number of faces and planes to it.

Comparing project, A and B, the overall idea about the created spaces and scale with the human figure are different. Considering the solid and void spaces, both has limited the modules neither shape collaboration is in a higher state. The spaces create with a limited number of faces and planes the scale of the particular spaces are small when compared with human scale and spatial diversity is at a minimal stage in the project A while Project B module arrangement is simple without major connections through the adjacent spaces. The achieved spaces with various shapes and forms are so complex in international case studies even though those spaces are designed within certain restrictions. The Spaces which are designed without limitations have developed into desirable spatial quality.

In local case studies, the advancement of this procedure isn't developed into a desirable level due to lack of variation in faces, levels, and volumes. For instance, the modular architecture with several modules is not capable of providing variation except giving a maximum level of two stories in the local context. There is a significant improvement in modular architecture in international practice comparatively. The author has identified that modular architecture has improved during the past years and that there is a possibility to change the spatial configuration in the interior scale, heights and volume in addition to the modular form. The structuralists have taken the modular architecture into an innovative level. For instance, the container box can be used to produce various spaces and arrangements. As a result, they have identified that these theories can be applied to develop well-defined spatial arrangements. According to the local case studies, the prefabricated units are the main consideration as the modular architecture but in international cases, the way they have interpreted the spaces are defined as the modular architecture.

Using structuralism instead of typical design procedure, the achievement of the spatial diversity is high as well as the framework helps to create pathways to achieving the desired spatial quality. Complex shapes contribute to achieving contrasting spaces and all the spaces including planes, edges and faces construct with meaning. The spaces can be defined with meaningful function along with theories in modular architecture. The author has identified that using the above theories would help achieve the efficiency in building functions and it is fundamental to consider this procedure in designing modular architecture while preventing dead spaces along with unnecessary visual connections. In the local context, the concept of modular architecture is at a primary stage where the final outcome of the research demonstrates that this level could be developed through innovative approaches.

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RE-EVALUATING PUBLIC SPACE IN URBAN SLUM: A CASE OF KORAIL BASTI

NOSHIN SIARA PROMY[1] & HASAN MUNTASIR[2]
[1] Khulna University of Engineering & Technology, Khulna, Bangladesh
[2] Northern University of Business and Technology Khulna, Khulna, Bangladesh
[1]noshinpromy@gmail.com, noshinpromy@arch.kuet.ac.bd
[2]hasan.muntasir@gmail.com, hasan.muntasir@nubtkhulna.ac.bd

Abstract
Slums are the undeniable truth in the urban fabric of developing counties. As per UN Habitat 30 percent of world's population live in slums and the vast majority of slums are located in and around urban centres. As reference, Korail Basti is Dhaka's biggest slum with a total area of around 110 acres of land. Due to spontaneous growth and density there is no viable public space for the intangible growth of the slum dwellers. But most often this crisis of such huge community is overlooked by providing bare necessities like- infrastructure for water, power, sanitation etc. with over-simplified, short term cheap schemes. However, on the deeper end it always fails to address the intangible needs of this community where cultural, recreational and social interaction can happen. This paper tries to re-evaluate the needs of viable public space in this type of dense urban slums, understand their present features from the existing public usage and analyses the constraints and scopes to incorporate public spaces addressing the challenge of swarming density. This research has been carried out through diagram preparation from GIS mappings, field survey, photographic survey, one to one interview with the locals and questionnaire survey from the slum dwellers. The findings suggest us a clearer vision about the present public domain in Korail, its dependence on slum infrastructure and the local's aspiration for a better living condition. This paper focuses on the sequential process of understanding public integration, public usage and spatial inclusion of infrastructure and public domain within slums to transform it into consolidated neighbourhoods for the betterment of the city.

Keywords: *Slum, Urban, Public space, Infrastructure, Korail*

1. Introduction

Due to rapid growth of population and intensified urbanization most of the developing countries in the world are facing accrued pressure of housing in case of poor and marginalized citizen. According to UN-Habitat, over 30 percent or roughly estimated over 1 billion people of the world's population live in informal housing settlements otherwise known as slums, barrios or favelas. Whereas most importance of this huge population living in such consolidated settlement are mostly provided on dwellings and houses themselves, the need of public or open spaces between the settlements where the socio-cultural development and humanistic growth can take place is hugely overlooked.

In developing countries like Bangladesh, cities are booming with urban sprawl and slums are consistently augmented with heavy densities. Dhaka, capital of Bangladesh with 16 million people, has 60 percent of its resident living in slums or squatters. Korail, one of the biggest slums located in the centre of Dhaka exemplifies one of such meagre yet compact urban marginalized settlement. Millions of people here are leading life on bare minimum with little to no scope to flourish and nurture their public life which can help developing their social, cultural and overall humanistic dimensions.

With the new agenda by UN-Habitat, Claudio Acioly (former chief Housing Policy of UN-Habitat and coordinator of the United Nations Housing Rights Programme) proposes –" streets as the natural conduits that connect slums spatially and physically with the city and treats streets not only as a physical entity for mobility and accessibility — through which water and sewerage pipes, power lines, and drainage systems are laid – but also as the common good and the public domain where social, cultural and economic activities are articulated, reinforced and facilitated." (UN-Habitat official web site)

In such a situation of global attention to public domain in slums, this paper aims to investigate the present condition of public space in Korail slum, highlight the pattern of public activity and analyses the critical condition and constraints of the public spaces of this overcrowded settlement.

Figure 1, Location of Korail slum *(Source: Google earth)*

2. Literature Review

2.1. THE CONCEPT OF SLUM AND ITS NEGETIVE ASSOCITION

UN-Habitat Global Report 2003 chooses to describe -*The term 'slum' … in a general context to describe a wide range of low-income settlements and/or poor human living conditions.'* (UN-Habitat,2003). The Merriam-Webster Dictionary (1994) defines slum as- *'a heavily populated urban area charterized by substandard housing and squalor'*. Which further elaborated in UN-Habitat Global Report 2003 as- *'this definition encapsulates the essential characteristics of slums: high densities and low standards of housing (structure and services), and 'squalor'. The first two criteria are physical and spatial, while the third is social and behavioural.'* (UN-Habitat,2003).

Flood (2002) tried to portray the negative association of slums as- *'Slums were identified as containing the poorest quality housing, the most unsanitary conditions, the poorest people: a refuge for marginal activities including crime, 'vice' and substance abuse; and a likely source for many epidemics that ravaged urban areas.'* Gilbert (2007) added as *–'Slums were dangerous to the people who lived there but, perhaps even more importantly, might launch an epidemic that would endanger everyone in the city.'*

But despite its negative association total expunges of slum is a mere dream which is rightly understood by UN-Habitat and it pledges the policy of upgrading projects rather than slum clearance.

2.2. THE DEFINITION OF PUBLIC SPACE AND ITS IMPACT IN SLUM

"Public space is the stage upon which the drama of communal life unfolds. The streets, squares, and parks of a city give form to the ebb and flow of human exchange. These dynamic spaces are an essential counterpart to the more settled places and routines of work and home life, providing the channels of movement." (Carr, Francis, Rivlin, & Stone, 1992) "Public space concerns not only the physical but also the social and psychological dimensions with a significant overlap among them. The physical dimension refers to the physical environment or "provision" of public space which provides a setting for social interaction, whereas the social dimension refers to the "use" or activities occurring in the space." (Carmona, Tiesdell, Heath & Oc, 2010).

Public space at slum plays a significant role in people's everyday life who resides there. It is interwoven in the day to day functioning of the community and directly affecting the socialising and sociability aspects of slum dwellers

2.3. THE EVOLUTION OF KORAIL SLUM

Korail is one of the largest slums in Bangladesh and is located in Dhaka adjacent to Gulshan-Banani Lake. In addition to the main Korail slum area, Beltola, Ershadnagar , Bhangawall and Godown Bosti are also part of Korail. The slums are gradually expanding across the lake by illegal encroachment and through waste and soil dumping. In 1961, the area was under the authority of Telephone and Telegraph (T&T), now Bangladesh Telecommunication Company Limited (BTCL). With increasing urbanization and rural urban migration the demand for urban poor housing increased. Under this demand,

unplanned and informal slum grew organically over the period of time which is still not recognized by the government. It is constantly expanding at an alarming rate without any viable public spaces for the huge population residing here.

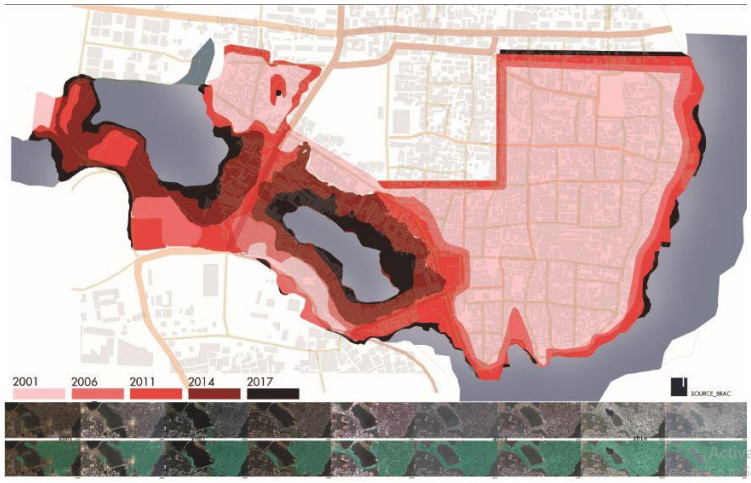

Figure 2, Expansion of Korail slum over the time period *(Source: Studio project of 12 Batch of Department of Architecture, BUET)*

3. Objectives

The objective of this paper is to re-evaluate the present availability of viable public space in dense urban slums, understand their condition and pattern from the existing public usage along with analysing the present critical conditions. And to conclude providing means to incorporate viable public spaces addressing the challenge of swarming density.

4. Methodology

This research study was arranged to develop a brief study of public space and activities in those public space in Korail slum. The total research has been carried out through some different study techniques; mapping, field survey, interview, photographic data collection and questionnaire survey.

Firstly, GIS map is used to prepare open space and land use mapping for identifying existing public space and availability of potential public space in Korail slum. The comparison of open space vs. build form ratio from Nolis's diagram provides clear perspective from this step. Field survey and interview of the slum people is done to portray the features of existing public activity and these identified features are categorised in a tabular form in step two. From on-site photographic survey, the mal-condition of existing public activity arenas and their close association to slum infrastructure is presented in step three. Lastly, in step four, with the help of a questionnaire survey the perception of slum dwellers towards viable public space helps to draw conclusion presented in this paper.

5. Analysis and Outcomes

5.1. EXISTING LANDUSE AND OPEN SPACE MAPPING IN KORAIL

Korail is one of the most dense urban slums in Dhaka. In an area of 90 acre the only dedicated open field is "Baromath" which is 1.5 per cent of the whole area. From Nolis diagram it is observed that about 95 percent is built structure with only 5 percent of open space which includes the roads, alleyways, infrastructure provision. Except "Baromath" no other public space is available for the Korail slum dwellers because of the scarcity of land and huge density of population which is clearly evident in the following maps.

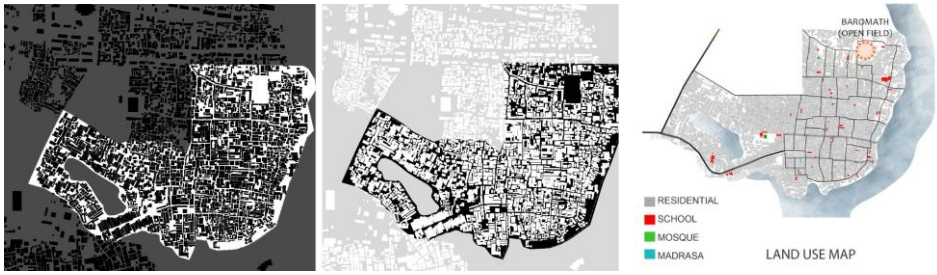

Figure 3, Noli's Diagram of Korail slum (left), Land use Diagram of Korail slum *(Source: Studio project of 12 Batch of Department of Architecture, BUET)*

5.2. EXISTING PUBLIC ACTIVITY IN KORAIL

Korail slum has a unique feature of bazars and markets intricate with its public settings. There is a huge density and excessive scarcity of land which made public space insufficient and inadequate for this large number of population. With an area of 90 acre only one open public playing field named as 'Baromath' is the only available dedicated public scape in Korail. From field survey the public activities are identified and interviewing the slum dwellers, major features of the public activities are noted.

Table 1, Features of different category of public activity in Korail slum.

Category of Activity	Features in Korail
Social	Social interaction for males mostly happens in bazaars and small shops like-tea stalls, repair shops, grocery shops etc. Female interaction and socialization happens in the courtyards, alleyways, water collection points like-tube-well or shared kitchen of the clustered house. Children socialize with one another and play in the alleyways, small courtyards of the clustered houses, beside drainage, garbage disposal, even on the lid of septic tanks in slums as there is a huge scarcity of open space. Only one play ground named as "Boromath" is present in this whole slum where children play in the leisure time.
Economic	The economic and commercial activities happen in the Bazaar areas of Korail like- Bou Bazar, Jamai Bazar etc. Besides there are different types of shops, tea stalls, chotpoti –fuchka(Bengali street food) shops spread throughout the slum. There are many mixed use household with shops as ground floor and living area on the first floor. Many women are also involved in the economic and commercial activities as shop-keeper, owner etc. and run the economic activities in the public domain of Korail
Cultural	Many concerts are arranged during festivals and celebration purpose in "Baromath". People from different background settled here which itself created a unique and versatile cultural setting. Public performances were organized in spaces where more people gathered for their daily activities (like Bazaar) or nearby tea-stalls where community members spend most of their leisure period and enjoy the evening.
Recreational	Television and Satellite channels are a major form of public recreation in Korail. People gathers in the bazaar and shop areas and watch Bangla cinemas, cricket, news etc.

Religious	Mazar culture is popular in Korail and there are two famous 'Mazar' in these two parts. In the 'Jamai bazar' there is 'Shah Ali Mazar' and in 'Bou bazar' it's known as 'Latalisha Mazar'. Every Thursday, the Mazar committee arranges spiritual songs. It starts from 6:00p.m. and ends as late as 3:00a.m. Eid prayers are offered in Boromath.

From the table above, it is clearly evident that majority of informal public gathering for social interaction occurs on the infrastructure lines and pocket spaces in between two houses. The infrastructure conduits like-streets,alleyways,drainage,swerage,water supply lines etc makes an indespensible part in the live and living of people in Korail slum. Scarcity of viable public space has bound then to use these provisions as a buffer to mingle among each other. Beside "Baromath" a mojor portion of public interaction happens in the Bazaars. Bazaars have crossed the perimeter of commercial finelines and spreadout as an intricate mixed use zone to support social,recreational public activites also.

5.3. PUBLIC ACTIVITY IN KORAIL AND THEIR ASSOCIATION WITH SLUM INFRASTRUCTURE

In Korail, roads, alleways even small setbacks for drainage also works as a place for people to mingle with their neighbours. Table 1 suggest us how infrastructure layout is presently used by slum people as public space in this dense condition of living.

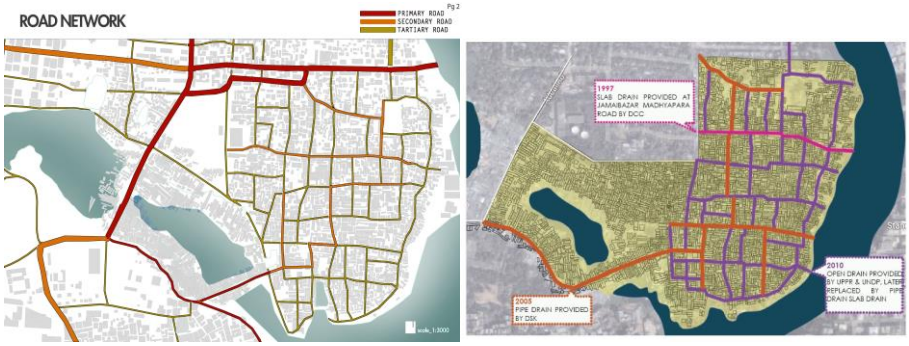

Figure 4, Road networking map (left) and drainage map (right) *(Source: Studio project of 12 Batch of Department of Architecture, BUET)*

The roads and alleyways are narrow varying from 10 feet to even 3 feet. People use these spaces as public spaces in their day to day life in Korail slum. The houses use them as an extension of domestic arena, bazaar and commercial zone use roads and alleys as a part to accommodate their outdoor public accommodation. Fuchka, halim, tea-stall and other street food shops are directly on infrastructure lines like-drainage, roads.

Figure 5: Slum children playing in the alleyways of Korail (left), Domestic activates are performed in group alongside the infrastructure lines (middle) *(Source: Author)*, Children playing along an abundant infrastructure pole (right) *(Source: Internet)*

The present condition of slum infrastructure is very precarious. Inadequate and illegal provision of infrastructure is affecting the lives of slum dwellers. As per recent The Daily Star report on July 20, 2017, *"at least 20 utilities "syndicates" are operating in Korail slum. The local police and several*

government bodies are also involved in the distribution scheme. For those not familiar with Dhaka's informal settlements, the details are alarming. The syndicates are associations of local residents who take on roles such as "lineman, rent collector, and manager," providing utilities in negotiated turf areas. Police officers and government utility employees take bribes to help establish and run the "unauthorised services."

The lack of formalization from government and public sectors is causing ill management and mal-condition of infrastructure in Korail. It is creating an adverse effect on the nearby Banani Lake which is one of the main two water channel running through Dhaka city. Water clogging is a huge crisis in Korail. Inadequate drainage, sewerage, waste management is creating unhealthy living condition which has direct effect on the social development of the slum dwellers.

Figure 6, Condition of waste dumping and encroachment of Banani lake. *(Source: Author)*

Figure 7, Poor, unhealthy and unhygienic condition of drainage and infrastructure in alleyways and roads. *(Source: Author)*

The people of Korail slums are left with only 5 per cent of open space among which lies roads, alleyways, infrastructure provision. The immediate solution only incorporates short term relief works providing the basics of living but it always overlooks how this minimum open space can still be incorporated as efficient public spaces to address the social, cultural, recreational as well as overall growth of the Korail slum dwellers.

5.4. RESPONDENTS FEEDBACK OF EXISTING PUBLIC ZONES

There are six questions asked to the people living in Korail slum to understand the existing satisfaction level and need for public space for their social and communal life. At first the general information of the respondents are noted. Then their perception of social and public life is evaluated through questions. Next two questions involved the major arena of existing public activity i.e. alleyways, streets and sideways of houses. Last two questions involved infrastructural condition and their perception about it.

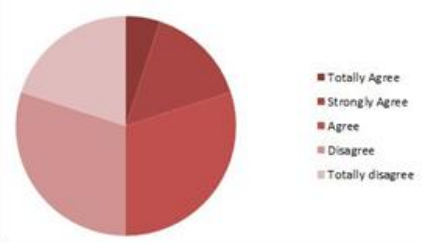

Figure 8, There is need for public space in Korail

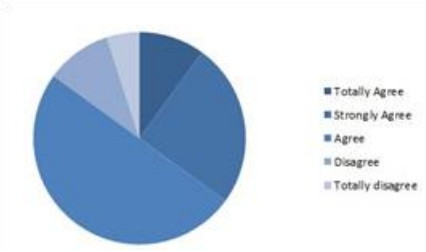

Figure 9, Public space like "Baro math" is needed in Korail.

It is evident that people are hesitant when the need of public space is asked. 50% people falls under disagree and totally disagree. Whereas, 75% respondents mostly agree with the need of "Baromath". Their direct involvement with "Baromath" help them to realize the need of open spaces in their community but sub-standard living and over density obscure their vision for viable public spaces.

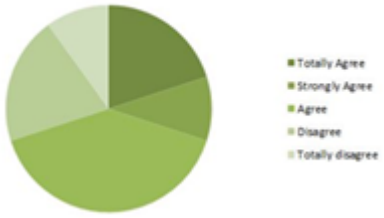

Figure 10, The multi-purpose use of alleyways, streets and sideways in Korail should continue in future

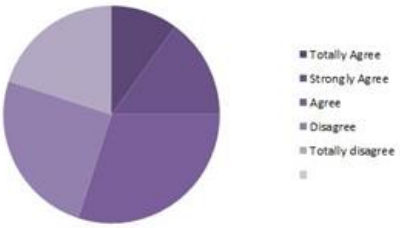

Figure 11, The condition of alleyways, streets and sideways are well enough to serve public needs.

70% respondents agrees to totally agrees with the multi-purpose uses as their perception says this is the only space left for them in the community to socialize and for their children to play. 55% respondents think the conditions are well enough where rest disagrees.

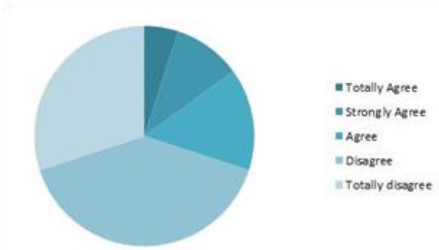

Figure 12, The drainage, sewerage and waste management system is sufficient in Korail

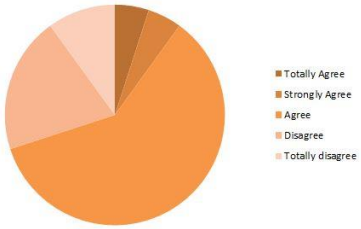

Figure 13, Improved infrastructure layout can develop the condition of Korail

While only 30% respondents agree that the infrastructure condition is sufficient in Korail, 80% of respondents believe that improved infrastructure condition can overall develop the condition of Korail and make it more liveable for them.

From the conducted survey it is clear that they understand the need of a better social and public life. Their understanding is clearly portrayed from their perception of "Baromath". They are habituated in the dense living pattern and multi-purpose use of spaces in street and infrastructure levels. They want the

improvement of the infrastructural system which in their perception will help them get a better living condition in their community.

6. Conclusion

The people of Korail slum is habituated with shared living pattern and multi-purpose use of space. Their existing public activity pattern suggests us to adopt this multipurpose use of spaces in future design in these type of slum.

To address the problem of density and scarcity of open and public space the infrastructural layout system can act as a huge potential space. Their present activity pattern also suggest us the same. The poor condition of infrastructural layout, unplanned land use and encroachment of Banani Lake can be addressed by thoughtful intervention of public space. The ill-management of infrastructure like-drainage, sewerage, septic tank can be addressed if it can be designed through architectural solution with multi-purpose usage. The assemblage of architecture -infrastructure can address the multipurpose design solution needed in this dense situation with land scarcity. Sustainable and green solutions can be adopted to address this unhygienic condition.

Improvement of public space to address the intangible growth of slum dwellers can be achieved from observing the present living pattern and tradition solution that exists in Korail. The undeniable truth of urban slums should not be avoided rather it should be faced from various aspects. The public aspects discussed in this paper try to portray the present condition and tried to understand from the aspirations of slum dwellers.

7. Acknowledgements

Special thanks to 2011 and 2012 batch of Department of architecture, BUET for supplying their findings of 4th year urban studio projects and housing projects in Korail slum.

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MULTIFACETED DIMENSIONS OF URBAN FORM TO REVITALIZING HUMAN INTERACTION IN DENSE CITIES

MD RAIHAN KHAN[1] & SADIA AFRIN TISA[2]
[1,2] Khulna University of Engineering & Technology, Khulna, Bangladesh
[1]raihankhan9@gmail.com, [2]sadiatisa1805@gmail.com

Abstract
Cities are the place of contested living that voiced congested physical development within its defined territory. In the era of material aestheticism, the notion of form design only brushed up physical attributes, which excluding connectivity and integrity with the human. Mere its functional qualities a permeable urban form has the ability to generate social spaces within a dense shabby environment and correlate human with its functionality instead of differentiation and separation. Alternatively, traditional cities have the flexible spatial quality to subsume activities, mass gathering. The shop-front and terraced facades are replacing by the modern typology of designed that characterized closed parking, services at ground level. The research focuses on to illustrate subjective dimensions of urban form particularly urban blocks under an analytical framework. Along with this, it has minced the field practices that have been evident since last few decades under the local and national regulations. Often the lack of concern of professionals and enigmatic behavior of planning authorities seem to be causing spoliation of the sensitivity of built-environment. The outcome of the research can be helpful for a global-level understanding of physical form under neo-liberal market condition. Predominantly, mid-sized dense cities seem a holistic detailing of form design to enable human interaction with surrounding built-environment.

Keywords: *Built-environment Human interaction, Urban form*

1. Introduction

Cities are the most complex form of spatial organization in the view of morphological terms; it also has been defined as the center of commerce that attracts people to live within its congested premises. Although it's congested growth, every year a vast majority of downtown's people move towards the urban center to ensure secured life. This continuous influx gives pressure on the physical and nonphysical layout in cities from all dimensions, such as economic, cultural, environmental, etc. The city fabrics and the settlements have been continuously impacted at different scale by this continuation. For example, urban tissues, which subsume street, street blocks, plots, etc. at small scale and to some extent the construction materials of open space, and urban block (Kropf 1996). The uniqueness of every city is dependent on a coherent relationship with these attributes. Since the mid-20th century, the physical planning sector has been given considerable attention to promoting sustainable and planned urban development.

In modern days, the physical layout of cities constitutes under the mandate of the master plan, which initiated in the early 20th century to secured urbanization and ameliorates built-environment. At city scale, the urban form influences the morphological dimension that plays significant role in achieving social sustainability. Scholars from different disciplines have been defining urban form by using distinct lenses, such as, according to *Kevin Lynch*, urban form means large spatial pattern and permanent physical objects of cities in relation with size, density, and its grain. The spatial pattern of the city largely varies by the morphological pattern, such as linear or corridor, regional, etc. However, the correlation between the physical pattern of forms and physical activities are the key to produce manageable cities from a sustainable perspective. To satisfy the functional and environmental needs, the concept of the compact city came as a mode of spatial organization that reduces travel distance, effective to adapt climate change, and promotes congested living to ensure comfortable life. Many conflicts and debates have found in many literatures about its long term effect. Many indicators have identified to reduce this, such as, permeability, legibility, functional usability, connectivity, density, etc. are common attributes to tie the people to things and the people to people, and Ali *Madanipour* (2010:352) emphasized in understanding the connective activities of planning by time and space.

During physical planning of individual street block priorities given on inhabitants need, but the design is rarely reevaluated its performance to achieve the objectives that were set. In traditional cities, the social mix promotes the diversity that enables human interaction in a different form, however, the debate on social diversity often politically fraught (Bacon, 1974). Additionally, the emergence of modern technologies has impacted the living pattern through generating concentric and individualistic development. In recent days, along with academics, private sectors also participate in understanding the city form, and find the processes that allow social diversity and social mix to produce a lively environment.

The study can give criticize on the design evolution of urban form where the urban block in particular in the context of developing countries and bring forth the factors that actively responsible to generate an introverted and typified physical form. By reviewing local planning policies of the study area and several empirical studies a framework has developed to measure the role of urban block to generate human interaction in dense areas. It also figures out the current debates on modern planning and traditional pattern of urban growth.

2. Urban form and sociability of space

In particular, 'urban form' is very popular term in many fields to describe the physical characteristics of an area by its size, shape, configuration, etc. where scale directs the process of analysis and illustrations. The openness quality of these physical forms offers people to engage with communal life and make a sociable space. Since few decades, the in-between spaces of neighbors and streets have been gained much attention in social science literature to comprehend human interaction with the surroundings. Numbers of analytical approaches develop to study urban form, spatial configuration and the human interaction at local scale; space syntax considers as one of most using method in urban design to study and improve the built-environment quality. Already, it has been observed that improved physical condition may have power to promote mass gathering, increase time spent of inhabitants where the blocks, streets, buildings play active role. The spatial arrangement of urban form contributes at morphology level, although, at localized scale but instigate all type of street side activities, such as, necessary, optional and social activities.

On the other hand, sociability of space indicates a kind of capacity to accommodate diversity that ensures people's participation in those activities. According to Henri Lefebvre, every society has a sort of uniqueness to produce own spatiality through both social practices and material conditions. Mobility is a crucial variable to measure the sociable character of space. The permeable space links this everyday task and transforms this space into a social space. Social interaction is the utmost to make the life healthier and happy. In today's hybrid city, the wireless community is developing due to excessive use of network where social safety means the using of cameras that ensure surveillance. In recent days, people like privatization, individualism rather participating in group activities, while high brick imperforated walls, metal gates and other barriers are using to protect physical territory. Social disorder is common in this type of gated community.

Alternatively, livability, interactive quality of spaces is influenced by the surroundings and its locational features from both tangible and intangible views. Sense of security and safety ensures the public participation, and consider as prerequisites to make lively urban environment while density has also impacted behind this vitality.

2.1 SPATIAL TRANSFORMATION OF URBAN FORM

The 19th century is known as the breeding time for industrial capitalism that brought up socio-economic changes in society, which directly affects the spatial transformation of urban form at a macro scale and urban block at the micro-level. As like developed countries, the morphology and typology has also been influenced by the market in developing regions. The traditional pattern of spatial arrangement has been replaced by the modern approaches of planning which have strict regulatory framework to control the

expansion. With time, those planning methods were futile to fulfill the dynamic needs of society and humans come to rearrange their spaces from own needs. Vibrant social spaces are rarely found in today's design human settlement at broader scale, and also in spatial arrangement of street blocks, plots or buildings. In that case, socio-cultural understanding of formation of urban form can contribute to revitalize urban vitality.

Particularly, this study elaborates and contends the role of urban blocks to increase social gathering and influence human interaction through providing services. Urban block can play meditated role to connect the social and spatial system. Unfortunately, todays urban blocks are unable to promote social gathering due to its rigidity of planning, enclosed boundary and lack of spatial permeability towards outdoor space. In traditional method people design based on needs rather following any typology and the layout varies usually. These variations have an impact on pedestrian movement by its flexibility, permeability, accessibility, etc. Jan Gehl (1980, 1987) mentions three types of activities generate at adjacent of pedestrian, those are necessary activities covers the everyday tasks, optional activities occurs if the time and place give a good environment and the social activities is the resulted of those two. But, the continuation of modern practices and capitalist market influence the shaping of plan and the form of building.

3. Methodology

The shaping of urban structures is guided by planning policies of local government primarily, market forces, the vision of the professionals and clients, etc. Two streets of Khulna, one has been grown organically and the other planned by the development authority, has selected to understand the relationship between the urban block and human interaction. Additionally, some individual building blocks have taken by their age of erection to illustrate the spatial transformation at the planning level. Spatial mapping, physical survey, informal discussion with professionals and stakeholders, photographs applied at field level to collect data.

4. Study area

Khulna is one of the fast-growing metropolis from the southern part of Bangladesh, and the 3rd largest city is being achieved the popularity in recent days for living due to infrastructural developments. The city has been expanding dramatically since last decade due to economic flexibility and living condition while the growth is taking place under a comprehensive master plan. The first master plan introduced in January of 1961, but the majority of physical structures do not follow the regulations properly while constructed, alternatively the master plan sometimes unable to meet the needs of dynamic physical growth.

In recent days the concern on social space in the field of physical planning is increasing rapidly, and the planners seek an idealistic approach, which can be flexible to cope with changes in societal needs. The land use has been grown organically at the very beginning that offers much diversity at planning and three-dimensional levels. Unfortunately, the modern approach represented a reverse that is not suitable for this context.

5. Assessing framework of Urban Form

Studying urban form is the key to make the cities more comfortable for living and to maintain a cohesive societal relationship. Jane Jacobs, an influential activist from America had emphasized on the heterogeneous character, small blocks, and the mix of aged buildings, which are responsible to make an interactive environment (Jacobs, 1961). Additionally, mixed-use development influences the vitality of life by opening up the options to users, she added. The thought of Jacobs influences the social issues of space, however, *Kevin Lynch* (1981: 47), identified the factors which control the spatial arrangement and integrate the objects with activities (ref). The interrelationship between these attributes opens up another term, 'urban diversity'. On contrary, the disciplinary perspective takes the scale as the base

indicator to describe urban form as a whole. Urban geography and urban architecture generally synthesises the urban form at detail level that contributes to development of urban planning and design. The study takes several empirical articles as a reference to identify the dimensions responsible for enhancing human interaction; however, an analytical framework has been formed to evaluate the space making the role of urban form. Multi-dimensional qualities of urban form tie up human behavior and spatial characteristics to ensure cohesive societal development. Multifaceted characters, mainly the subjective qualities have assessed by (Functional, Spatial, Temporal and Natural) these four dimensions with some indicators.

Dimension	Functional	Spatial	Temporal	Environmental
Indicator	Mixed use Diversity	Flexibility Accessibility Permeability Liveability	Visual image Aesthetic view	Open space Vegetation

Figure 1, Framework for assessing urban form (*Source: Omeir, 2017, Ghaedi & Mahdavinia, 2014)*

5.1. FUNCTIONAL DIMENSION

The efficiency of space depends on the quality of its workability and how it provides services to the users. Functionality is the prerequisite to increase spatial efficiency, Jane Jacobs, emphasizes the heterogeneous character where mixed-use and diversity plays a vital role to make the vibrant gathering. These attributes are not only influenced social gathering but also ensure the active participation of different social class in the assembly. In both ways, this diversification helps

In most cases, the mixed-use quality evokes different types of land uses which are directly connected with the human needs and ensure active sharing within different stakeholders. From the definition about the urban form of *Kevin lynch*, the first studied area *Nirala no.1 road,* shows different land uses that have been being developed since last two or three decades. Figure 2, presents diversified functions have grown to satisfy the users. Initially, the area was developed as residential purposes which have been transforming into a mixed land use zone through time factor (Figure 2a). At neighborhood-scale, the functional diversity provides services to dwellers all day long that make the area more vibrant at a different time of the day. Particularly two major crowding develop at *Nirala no.1* road; one is at early morning where people come to buy fresh vegetables which have grown at the pedestrian level. On the other hand, during late afternoon some other services, such as roadside snacks, moveable seasonal fruits have developed. Along with these, coaching, individual doctor chamber, grocery shops have generated at the ground level of the buildings that make bridge connectivity between neighborhoods to the neighborhood.

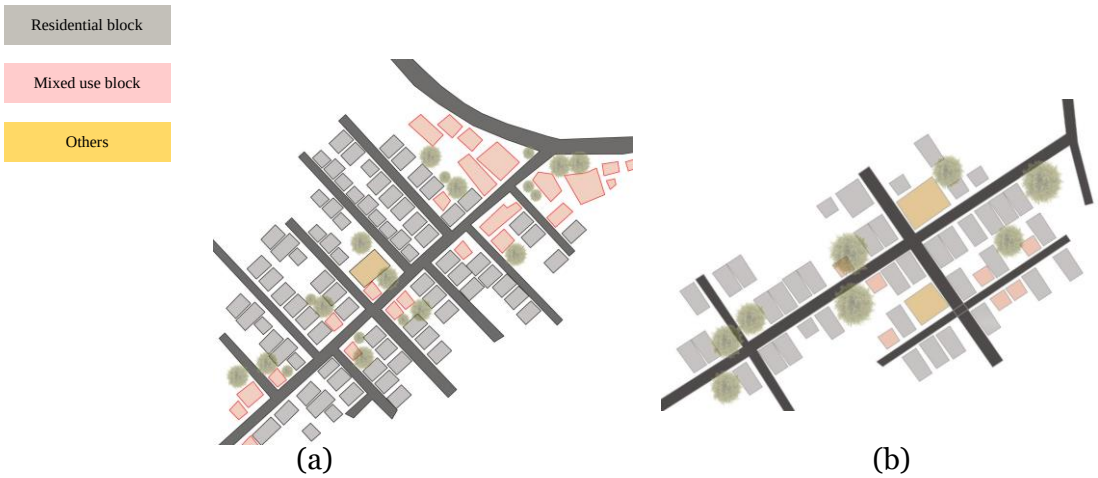

Figure 2, The left one showing the land use of Nirala (a portion) and right one showing land use of 2nd phase of Sonadanga (*Source: Authors constructed*)

An alternative scenario has found at 2nd phase of *Sonadanga* residential area, although, both areas have been developed by Khulna Development Authority under the constitution of site and service scheme. Due to the location in respect of the city, the land price is growing tremendously since last decade which does not allow different social class. A recent study shows that mostly the upper-middle class and middle class can afford this living cost of *Sonadanga* and these categories have a similar choice about the spatial level which reflects by way of their living. Only a few diverse functions have developed, which are not sufficient to attract gathering (Figure 2b). Mostly those functions are being developed by the own interest of the owner, although the development authority does not permit mixed-use growth in a planned residential area.

Figure 3, The ground floor is using for different purposes based on community needs, (*Source: Authors constructed*)

5.2. SPATIAL DIMENSION

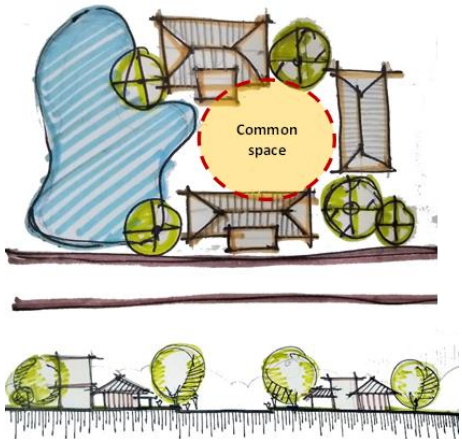

Figure 4, The layout (top) depicts blocks are sharing a common place for gathering (bottom), (*Source: Authors constructed*)

At settlement and individual plot level, the layout of urban form plays a pivotal role to increase the vitality of the space, and ensure active participation of users throughout all day and even in the night. These characteristics of spaces allow all age group to unfold their communal life and stimulate interaction between diverse social groups. Flexibility at the spatial level implies the degree of opportunities to the inhabitants to inhabit in diversified ways. At settlement level study area, *Nirala* no 1 road, shows that varied functions, such as grocery shops, pharmacy, educational coaching, doctor's chamber, etc. have developed to serve the entire dwellers of this residential area and outsider as well. Besides this, many street vendors also generated at the roadside which directly affects to tie up diverse social class. According to emphasized on this flexibility which is ideal to make an active public space that open to all to exercise their activities.

The opposite character has been evident in *Sonadanga* 2nd phase; mostly at settlement level the area is unable to produce an active environment due to fewer types of functions. The everyday spatial practice depicts their pattern of living and choices, and mostly a certain income group avails this cost of living. Although some functions have developed unable to encourage people to gather due to the absence of a

diverse social group. The absence of diversity also does not meet the needs of different age group, similarly; (figure 5) shows a common pattern of layout makes the area more monotonous.
Mixed-use ensures the accessibility of different aged group, such as, adolescent, working people, retired, etc. that produce an active place in different periods. In urban place making this crowding is vitality ensure safety and security of a place which exists in Nirala no: 1 road. The vibrancy averts crimes, social unrest and increases social surveillance that implies a key indicator in designing public realm, however, is significant to welcome all social groups to participate in diverse activities.

Figure 5, All blocks (*Sonadanga*) are showing same kind of monotonous façade and spatial development (*Source: Authors constructed*)

Regardless of, the permeability of space at settlement and plot-level enhances human interaction because of its transparency. This quality exposes the inside happenings to the outsider and merges external activities with indoor spaces. The layout of the ground floor and the mix of functions extend the indoor space to outside space that produces a harmonious relationship with surroundings. In Sonadanga, most buildings have a similar type of functions at ground level that brings monotony in the built environment. Mostly, an identical high boundary wall constructs outside of the buildings to ensure security, although it works as a separator. These settings generate social disorder between social class and unable to produce a liveable environment.

In the traditional method, the urban blocks always were maintaining a central place that used for social interaction and several activities performing at different times of the day and night (Figure 4). The openness, permeability, accessibility of this space allows all social class to ages people in the gathering, but in present urban blocks are aligned with focusing on the road only. In that case, roadside activities enhance by the connectivity with the ground floor and front façade of the road. Unfortunately, today's street blocks are introverted, which could not make any dialogue with this roadside scene.

5.3 TEMPORAL DIMENSION
Temporal dimension connected with visual attributes of the physical object. In modern era, the professionals were concerned in functional layout and the usability of spaces, although some argued that the modern form (physical) derived from needs of users. In recent days, experts are working on physical fabric from city and neighbourhood scale, however, *Collen* 1996, talked about the language between forms and surroundings, which he called as 'art of relationship'.

In urban design field, the experience of spaces is deeply interconnected with the human perception about place. Sometimes the physical fabric brings nostalgic environment to dwellers. The paths, nodes, edges are also crucial to widen legibility of space and extend the spatial practice. The survey shows similar elevation treatment from architectural perspective and common materials have used for finishing work at front side of the buildings from both *Nirala* and *Sonadanga* area (figure 5). Most of the buildings from both areas are aesthetically rich but people do not feel comfortable to spend time due to its massive scale and spatial quality at 2d level, alternative scenario has found in some structures that are grown organically. *Lefebvre*, defines this space as a social product.

As a whole, the visual image/transparency works as catalyst behind human interaction where colour, finishing materials, openness are significant variables. In some cases, aesthetically pleasant buildings

have extra monetary value that also influence people's gathering, along with, front side terraces improve visual permeability and makes the buildings as part of surroundings.

5.4 ENVIRONMENTAL DIMENSION

Green spaces are inexorable for designing good public spaces that welcome inhabitants to gather and spend quality time. It not only improves the societal relationship but also important to maintain environmental coherence within the city. Besides the park and large open spaces, the front greenery at plot level contributes to the community level in many ways. Most of the buildings in *Nirala* no:1 have small green spaces at the front side, and importantly this space visually and physically permeable (Figure 6). A low height wall or railing constructs to protect the trees from the animal. These types are influential for promoting human interaction.

Although, buildings from the present time do not keep open space for maximizing spatial usability, on the other term, capitalize the monetary value. Specifically the real estate companies take advantages from land, even violates the construction rules and regulations during construction time. Absence of open spaces brings monotonous built environment at plot and settlement level. Similarly, the vegetation types impact on human psychology

Figure 6, Road side vegetation promote the human interaction and mass gathering (*Source: Authors constructed*)

and promote human gathering. Dwellers prefer to plant flower trees to embellish and make the structure as part of the surroundings. Roadside trees, particularly at pedestrian level, accelerate the everyday spatial practices at a different time of the day and night. Different aged and social group gather to take rest, for gossiping or playing that makes a lively environment, (Figure 7).

6. Discussion

Field survey and discussion with stakeholders was the key for this research. Different types of data have collected and analyzed by using different methods. After that, a discussion has made based on these below,

6.1 PLANNING APPROACHES, REGULATIONS AND AUTHORITY

As like other cities, in Khulna the physical growth, urbanization has been controlling by the development authority, named Khulna Development Authority (KDA) since 1961 under a comprehensive master plan. From the beginning of introducing car-centric planning, approaches are not suited with this traditional city and failed to produce liveliness at the neighborhood level, albeit, the traditional way of making space attracts the people to participate in diverse spatial activities. At ground level, a shop designs to serve the community and make the pedestrian more active.

The construction rules and regulations are only emphasizing on building height and road width, which is futile to make hierarchical spatial order. Even though, the survey shows maximum house owners do maintain the construction rules properly, rather convert all remaining area with paved surfaces which kept for open green purposes.

Figure 7, Permeability of urban form makes the environment more amiable for spending leisure time (*Source: Authors constructed*)

6.2 PROFIT CENTRIC CULTURE

As mentioned earlier, the profit centric approaches of KDA promote a typified build form, and population growth has impacted unplanned development. Last 12-15 years the land price has been escalated 3 to 5 times in respect with regular price, as a result, land developers take maximum advantages while planning for selling of property. Based on the area, such as, Sonadanga, Nirala, Boyra the price of per square feet of floor varies immensely from 3500-6000tk that works behind the development of distinct social class in an area.

As a result, every square inch is very important real state companies form profit, where parking at ground floor also kept for selling. KDA emphasizes only in making of plot and road, rather considering individual urban block as production of social spaces.

7. Conclusion

Today's cities are the most complex area of living that has been continuously expanding through urbanization and infrastructural development. Absence of proper management and human-centric planning approach makes this congested living more critical. Large open space, green area, sociable environment all are missing in today's urban area, although, those had seen in traditional cities which has been generated by the everyday spatial practice of people. To ameliorate the present urban living and improving human interaction the connected disciplines are working together, such as the field of architecture extends their concerned from design and construction of the single building to the community and whole city fabric.

In this complex living, the urban form is a subtle part but it plays a crucial role in making sociable built-environment, where a commonplace connects both subjective and objective qualities of life. Study of the present spatial pattern of urban form reveals critical insight about current growth and particularly the modern typology of building the fabric. Mostly, professionals from different field are also responsible behind packed growth of urban form with the unfriendly built environment. Most of them emphasize the physical fabric at individual plot level rather considering subjective aspects and social attributes of community which interwoven strongly.

Alternative scenarios have found in traditional build form, owner consciously design according to needs that capable to generate social gathering, and in the dense area, this shop and front terrace spaces are animating social life all the time. Vitality is largely dependent on the density that makes the area a liveliness character, where diversity, mixed nature of space, facilities, and options are an integral part. In the last decade, the physical development in Khulna has appeared as a threat from the socio-spatial and socio-cultural continuum. Although, density is an obvious fact for present cities while a combination of cultural components of community and human behavior pattern with physical structures can produce a sociable built-environment.

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8.1 ACKNOWLEDGEMENTS

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TRANSITION FROM URBAN VOIDS TO URBAN REALM: UTILIZING ABANDONED SPACES BENEATH THE FLYOVERS IN DHAKA CITY

SHAUNI PRIYAM SIKDER[1] & FAHIM ALAM[2]
[1]Department of Architecture, Khulna University of Engineering & Technology, Khulna, Bangladesh
[2]Platform Design Studio, Dhaka, Bangladesh
[1]shauni.29arch.buet@gmail.com, [2]ar.fahimalam@gmail.com

Abstract
Even though flyovers are built to prevent congestion and be effective in reducing travel time, in Dhaka, the capital of Bangladesh, they often contribute to create infrastructural urban voids as a result of inefficient decision making and planning of the administrators and planners. These voids can be seen as spaces which distort the urban tissues neither act as private or public spaces rather they have been considered as negative spaces. Due to rapid urbanization and frequent expansion, Dhaka is facing scarcity of open and green spaces. It is very difficult to spare enough lands for public spaces in a densely packed megacities like Dhaka as lands are very expensive. In this situation, reclaiming the leftover space under flyovers can create better urban opportunities and they can act as a place for urban gathering, pocket parks and plazas or only just places for public activities. The research aims to find the potential of leftover negative spaces beneath the flyovers that can be revitalized through urban scale intervention and also to find out a suitable solution considering both environmental responses and public experience. This research was principally based on observation and field survey. Books, journals, documents from websites etc. are the sources of secondary data. The paper will be focused on the concept of urban voids, identifying and analyzing the types of voids and understanding how these voids have great potentials for turning into urban realm. The outcome will be presented as a prospectus for dealing with such infrastructural urban voids and turning them into new opportunities.

Keywords: *Urban Void; Adaptive Re-use of Abandoned Places; Negative Spaces under Flyovers; Urban Realm; Alternative Public Space.*

1. Introduction:

The growth of Dhaka, the capital of Bangladesh, is characterized by rapid urbanization and frequent expansion, due to which its urban tissues are transforming in a detrimental manner. Elevated pathways are often perceived as a symbol of development is aimed at eliminating traffic congestion, reducing travel time, establishing economic growth and upgrading connectivity with distant communities overlooking underneath urban voids. In recent years, the emergence of new flyovers in the dense framework of Dhaka city certainly represents the technological development of urban and transport planning of Dhaka however camouflages the life beneath such advancement. It is highly observed that most of these places are often forgotten, inaccessible and become a heaven for anti-social activities. Due to rapid expansion of population, motor vehicles and traffic congestion in Dhaka city; amazing flyover, overpass and elevated expressway projects are seem interlaced with the cityscape. The principle aim of elevated pathways is to provide high speed transport facility for the high to middle income group without concerning about the public life roaming slowly below. At present, mushrooming elevated highways are creating spaces under and along them and these areas have high possibilities to generate alternative urban pockets by integrating them with surrounding communities through proper urban planning that enhances the functionality of spaces while improving safety and aesthetic quality. This study aims to identify the existing haphazard situations of these urban voids and the possibilities to find out probable alternative re-use for such voids.

2. Literature Review:

- **Urban Voids:**

Urban voids are often known as neglected or forgotten spaces of an urban area. They are the frequent results of poor urban planning and infrastructure designing. Roger Trancik was one of those who first wrote about lost or under-managed spaces. According to Roger Trancik (1986), "Urban voids are undesirable urban areas that are in need of redesign making no positive contribution to the

surroundings. They are ill-defined, without measurable boundaries and fail to connect elements in a coherent way."

"Lack in planning, consideration of people's need, forecasting of demand, urban sprawl, haphazard development, change in trend with development is the primary cause of generation of void spaces in an urban area." (Azhar & Gjerde, 2016; Ruchita,Bhaskar & Jagruti, 2019)

"The usual process of urban development treats building as isolated objects and sites in the landscape, not as part of larger fabric of streets, squares and viable open spaces. Decisions about growth patterns are made from two dimensional land use plans, without considering the three dimensional relationship between buildings and spaces and without a real understanding of human behavior." (Trancik, 1986). From this quote from Roger Trancik, we can realize why people do not perceive urban voids during planning process. Being designed on the basis of two-dimensional plans, these spaces act a negative urban spaces as they fail to accommodate real requirements for the users and preserve quality of public life.

- **Classification of Urban Voids:**

Factors like topography, neglect and improper planning practice influence the formation of urban voids. According to N. P. Narayanan (2012), voids can be classified into three main categories;

a) Planning Void: Planning voids are the result of inefficient and faulty planning process. These voids are created due to planning in isolation without considering the urban fabric. Planning voids are the most visible one urban context. These voids can be perceived using figure-ground theory.
b) Functional Void: Functional voids are the dead vacant spaces created due to left over space or a built mass which has no functional use. When a space is not used according to its desired designed purpose the space becomes defunct. Such functional voids occupy precious urban lands and creates a gap in urban context.
c) Geographical Void: Geographical voids are created due to geographical feature of an urban context which are also the results of improper planning process. When city planners and urban designers do not consider the voids around a geographical feature (like river, nullah, etc.) unusable spaces are created around them.

But according to A. Ansari (2016), after refining according to scale and ownership, urban voids can be classified into four categories;

- Edge and Buffer Voids
- Infrastructural Voids
- Transportation Voids
- Large Scale Plots

According to these classification, flyover or Elevated Pathways can be classified as "**Infrastructural Void**", an urban void which is the result of improper planning and design of urban infrastructures.

- **Definition of Infrastructure Void:**

Urban Infrastructure is the term for basic system of public works including transportation, communication, sewage, water, electric systems, etc. basically all amenities those are required for the operation of an urban context. Often these infrastructural system produce residual spaces in between them. Among all systems, transportation structures like flyovers, overpass, elevated pathways, express ways, etc. creates urban voids and residual spaces in urban areas which is defined as "Infrastructural Voids" or in short " Infra Voids". Infrastructural voids are mainly the dead and negative spaces in and around public infrastructures. Such voids creates a gap within neighborhood context and becomes a space for illicit activities.

Fig 01: Infrastructural Void (Source: Internet)

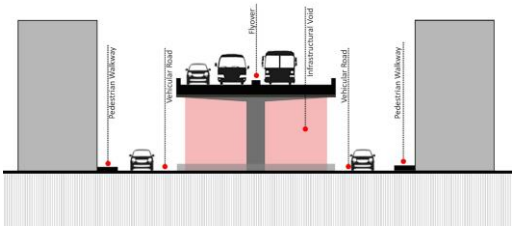


Fig 02: Infrastructural Void (In context of Dhaka City), Source: Internet & Author

3. Case Studies

Case study 01: (*Under Flyover Garden in Matunga, Mumbai):* Mumbai is a city starved of open and green spaces, and in recent year lots of public initiatives being taken forward to mitigate such scarcity. The residents of Matunga area, especially those residing near the flyover felt a need for space for walking and jogging. Soon after the flyover was made open to public, it became a hangout zone for the gamblers, hawkers, drug addicts. Over a period, unsocial elements had taken over the place and it became a den for illegal activities and also this place had become an eyesore due to dirty and unkempt places. But the residents of Matunga took an initiative to control such haphazard situation. The idea of converting the space under the flyover was a natural outcome and soon "one Matunga" resident's group approached Brihanmumbai Municipal Corporation (BMC) with a proposal to convert the flyover into a garden-cum-walking park. Later, BMC sanctioned funds tor redevelopment of space under the Tulpule flyover as per design suggestions. BMC started to develop this area in June 2015 and it was inaugurated in 2016 as only encroachment free under flyover space in Mumbai.

Fig.03 : Under flyover garden in Mumbai, Source:The Better India,2016

The garden has been designed to look like Narmada River. The 600m pathway is blue in color with a replication of rock formations as found on the banks of Narmada. This garden has 300 lights and 11 rotatable CCTV cameras to ensure security. The lights installed in the garden are colorful and are strategically placed, which change the look and feel on the space in the evening. This park has been used for walking, jogging, skating, public gathering, gossiping, etc. It is quite an achievement for the residents to ensure that an open space meant for the public is transformed into such a fascinating garden.

Fig.04 : Under flyover garden in Mumbai, Source:Internet

Case study 02: (*Deyalkotha, a Community Lantern under Tejgaon Flyover, Dhaka)***:** Deyalkotha is a "pilot project" under the Tejgaon link flyover in Dhaka, Bangladesh. It has been built as a temporary education platform for the slum children living in the adjacent area. It works as a multi-functional stage where the children will get to learn through playful activities and others will get social education through cultural activities such as theatrical performances. The Tejgaon Flyover site was the first initiative to restore existing underutilized by giving them some purposeful meaning. The site was deliberately chosen due to presence of a large number of marginal people within this area. As the flyover stands next to a residential area, the underneath road devoid of traffic circulation and that creates some opportunity spaces under the flyover to be used for community service.

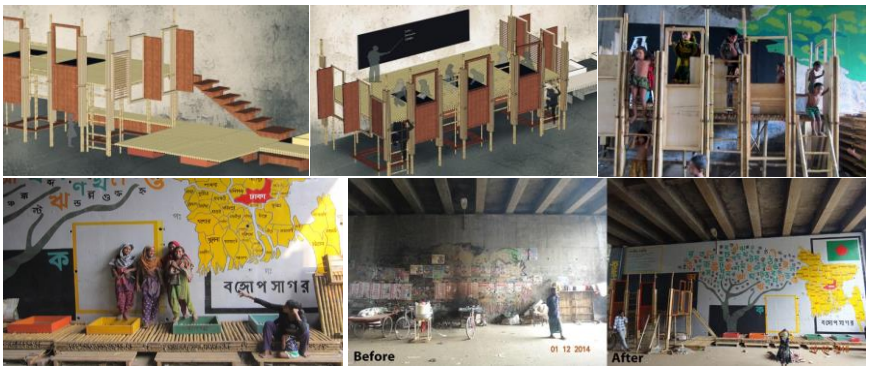


Fig.05 : Deyalkotha, Dhaka, Bangladesh
Source: https://contextbd.com/deyal-kotha-wall-attic-a-community-lantern-under-tejgaon-flyover-avantgardes/

4. Methodology

This is a generalized study and it is expected that the outcome of this study would be applicable in context of Dhaka city. Three major points of Mayor Hanif flyover have been selected for study. The study is focused on the prevailing activities that took place under Mayor Hanif flyover. The overall study has been conducted in several phases. The case studies are considered as the preliminary study on utilizing leftover spaces under flyovers. The primary data have been collected through visual observations, photographs, field survey, sketches and field notes. The paper represents the analysis of data that had been collected in site. Later computer aided drawings based on GIS map and field survey have been prepared. Finally, the analysis phase aimed to re-evaluate the potential uses of leftover lands below flyovers in order to convert infrastructural voids into vibrant public space.

5. Site Location & Context:

Jatrabari-Gulistan Flyover, one of the most significant flyovers in Dhaka city, also known as Mayor Mohammad Hanif Flyover, is an 11 km-long flyover opened on October 11, 2013 starting at Palashi near Gulistan Junction and ending at Kutubkhali. [06] This flyover is located at the confluence point of three important national highways Chittagong (N1), Sylhet (N2) and Mawa (N8) and also it is one of the major gateways to enter Dhaka. The route of flyover is marked in the following figure showing the route of flyover starting from Chankharpool and the pass through Bongo Market, Gulistan, Tikatuli, Wari, Narinda, Swamibag, Saidabad, Jatrabari and ends at Kutubkhali. In this research paper, we will consider three significant point including the starting point of the flyover (Chankharpul), Bongo Bazar and Gulistan point, of Mayor Hanif Flyover as our considerable site. Overall study and survey are conducted within these three points to understand the exiting condition of infrastructural voids in context of Dhaka. Again this study will find out strength, weakness and opportunity of this site and a suitable design intervention that will create an urban realm within this dense context.

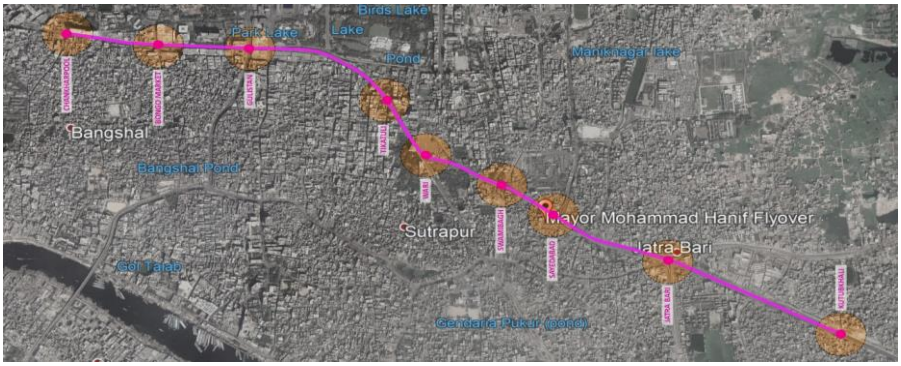


Fig.06: Mayor Hanif Flyover, Source: Google map

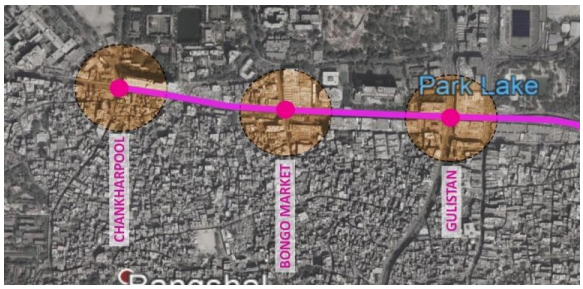


Fig.07: Indicating study areas, Source: Google map

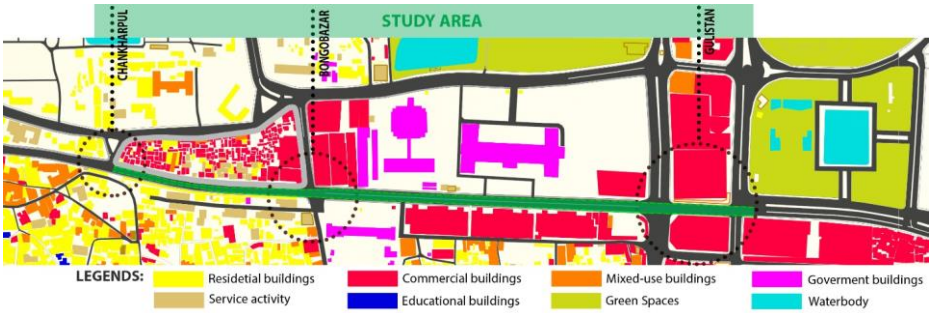


Fig.08: Land use map of study area, Source: GIS Map of Dhaka

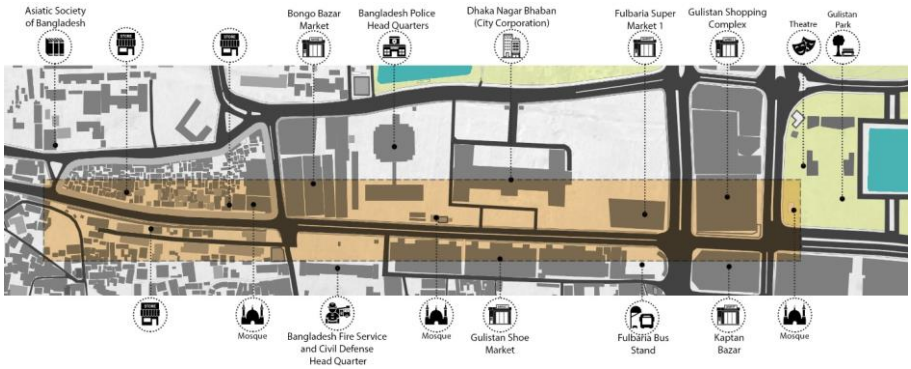


Fig.09: Infrastructure map of study area, Source: GIS Map and Survey data

6. Existing Situation around Flyover:

Study Area 01, (Chankharpul, starting point): Chankharpul is the starting point of Mayor Hanif flyover, a mixed-use area including residential buildings, markets, small business areas, restaurants, service activities. Chankharpul is the place for young generation as it is close to Dhaka University, Dhaka Medical College and BUET. People around this place do not understand the value of leftover lands below flyover. These spaces remain abandoned in most areas. Most of places are used for waste disposal areas, storage areas for surrounding shops and

as illegal van and horse cart parking areas. The existing situation of Chankharpul area can be understood from the following figure;

Fig.10: Existing situation of Chankhapul Area, Source: Author

Study Area 02, (Bongo Bazar): Market places always attract public activities. Bongo bazar is one of oldest and prominent markets of Dhaka city. But due to lack of public amenities and pedestrian friendly environment and also narrow pathways make it difficult to roam around the vicinity. There are two mosques, Police Headquarter and Bangladesh Fire Service and Civil Defense Head Quarter located within this area. As a result, many people visit this areas on regular basis. The places beneath flyover at this point should be planned properly to facilitate the existing public gatherings. But from our survey, it is evident that most of the places are illegally possessed by local vendors and for parking. At this point, most of the spaces remain abandoned and dirty. The existing situation of Bongo Bazar area can be understood from the following analysis;

Fig.11: Existing situation of Bongo Bazar Area, Source: Author

Study Area 03, (Gulistan): "Gulistan", a very busy street of Dhaka city as several important streets are connected to Gulistan. It is a place for crowded trade and commerce, public gathering and recreation. The land value within this area is too high. So it's high time to rethink alternative uses for leftover spaces below flyover in this area. But such vital void space remains occupied with illegal hawkers, vendors and homeless people without creating any urban relationship with its surroundings. The existing situation of Bongo Bazar area can be understood from the following figure;

Fig.12: Existing situation of Gulistan Area, Source: Author

7. Public Life around Flyover:

According to survey data and study, it is evident that the places beneath Mayor Hanif Flyover are definitely underperforming and the places have failed to create any kind of urban realm within its context. The places beneath flyover in Chankharpul, Bongo bazar and Gulistan areas have an appropriate urban setting along with diversified public activities for integrating them with surrounding communities through proper urban planning that enhances the functionality of spaces. Dhaka's one of the most

important bus stands, Fulbaria Bus stand is located here. This urban void has a suitable urban fabric as it is well connected with its surrounding settings. The presence of mosque, ground floor retail shops, market, restaurants, Dhaka Nagar Bhaban, Public Park, informal vendors within the area creates different public activities within this area. Almost thousands of people gather here for their work and recreation purpose. Most often people overlook the opportunity of reusing leftover spaces. A densely populated city Dhaka, can hardly keep any land as an abandoned one. It is evident from the study that these places are the active spine area of Old Dhaka. Life of people in Dhaka evolve around these streets. These voids are an integrated part of day to day public life around flyover. So it is high time to rethink the leftover places below flyover and create more integrated public life with modern and aesthetic public amenities.

Fig.13: Public gathering below flyover.

Fig.14: Horse and horse cart parking

Fig.15: Public interaction beneath flyover

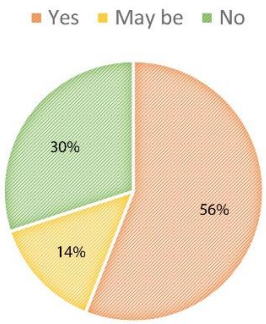
Fig.16: Tea stall & food cart below flyover

Fig.17: Temporary vendors at Gulistan

Fig.18: Police box below flyover

8. Survey Data:

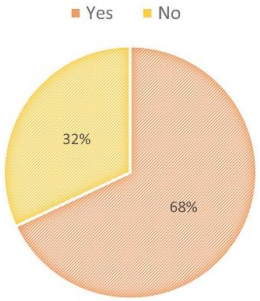
It is very important to shape the city according to people's need as cities do not exist without people. Public opinion is an essential part in case of rethinking urban space. The walking environment in cities, pedestrian priorities and well accessible urban pockets are a vital features of a well-planned city. During our study we conducted a survey among people in this area to understand public problems in this area.



Do you believe that this place has an opportunity to become a public

According to survey; out of 50 people, 34 persons don't consider this road as a pedestrian friendly one and 16 persons are ok with the present situation.

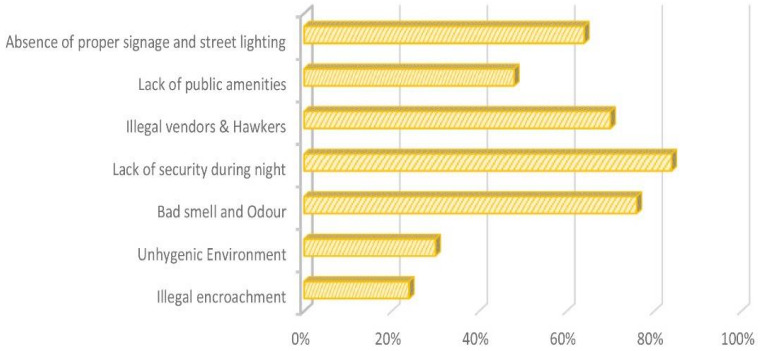
A survey has been conducted within this three study point (Chankharpul, Bongo Bazar and Gulistan). During survey, people identified several issues that are responsible for deterioration of quality of urban spaces in this area and spaces below flyovers. The survey was conducted among a group of 50 people.



Do you consider this road as a pedestrian friendly one?

According to survey; out of 50 people, 28 persons believe that this place has an opportunity to become a public space and 15 persons gave a negative feedback. Among them 07 persons are not sure about the consideration.

What Issues are Responsible for Deterioration of Quality of Urban Spaces in this Area?



	Illegal encroachment	Unhygenic Environment	Bad smell and Odour	Lack of security during night	Illegal vendors & Hawkers	Lack of public amenities	Absence of proper signage and street lighting
Series1	24%	30%	76%	84%	70%	48%	64%

9. Outcomes of the Study:

The overall outcomes of our study is presented below through a detail SWOT analysis report of each study point areas;

❖ SWOT Analysis for Chankharpul Point:

Strengths: • The starting point of Mayor Hanif flyover. • Important educational infrastructures like Dhaka University, BUET and Dhaka Medical College are located near this road. • A place of restaurants and hotels. • Diversified activity point.	**Weaknesses:** • Illegal van and horse cart parking. • Storage of boxes and containers for surrounding shops and vendors. • Low height areas are used as waste disposal areas. • Absence of public amenities.
Opportunities: • School and play areas for poor children • Food court and tea stalls for public gathering. • Storage for surrounding shops. • Landscape zone and nursery. • Pocket parks and public plaza.	**Threats:** • Illegal encroachment of lands under flyover. • Lack of security for woman and children during night time.

❖ SWOT Analysis for Bongo Bazar (Market) Point:

Strengths: • Bongo Bazar (Market) is one of the prime market places of Dhaka city. • Important infrastructures like Bangladesh Fire Service and Civil Defense Head Quarter, Bangladesh Police Headquarter, etc. are located beside this road. • A place for trade and commerce. • Easy access and well connectivity. • Presence of mosque and mazar.	**Weaknesses:** • Illegal bike, rickshaw and van parking. • Storage for surrounding shops and vendors. • Most of the spaces remain abandoned and dirty due to lack of proper waste disposal system. • Spaces below flyover are converted into horse firm for horse carts. • Discourage pedestrian movement & void of public interaction. • Absence of public amenities.
Opportunities: • Recreational facilities for public. • Food court. • Small kiosk for books, fruit traders and other local vendors. • Dedicated space for bike parking & Rickshaw stand. • Green pockets for absorbing road pollutants. • Dedicated zone for horses and parking for horse cart. • Landscape zone or urban garden or nursery.	**Threats:** • Excessive noise and air pollution due to Bongo market. • Illegal encroachment of lands under flyover. • Lack of security for woman and children during night time. • Smell for waste disposal and horses.

❖ SWOT Analysis for Gulistan Point:

Strengths: • Being Dhaka's one of the most vibrant public space along with easy access and well connectivity. • A place for trade and commerce. • Presence of public spaces like mosque, park and market. • One of the largest bus stand (Fulbaria Bus stand) is located here.	**Weaknesses:** • Illegal vehicle parking. • Illegal shoe shops and vendors. • Lack of proper waste disposal system & Unhygienic environment. • Lack of pedestrian interaction. • Absence of public amenities like toilet, pure drinking water facilities and street furniture. • No Proper road signage for roads.
Opportunities: • Waiting areas for bus passengers and public. • Food court & plazas. • Shops for local vendors and kiosk market. • Urban Park with landscapes. • Strategic parking zone for rickshaw and vans. • Proper road signage and street lighting facilities. • Maximizing green areas to reduce urban pollution.	**Threats:** • Excessive noise and air pollution due to Fulbaria Bus stand. • Illegal encroachment of lands under flyover. • Lack of security for woman and children during night time.

10. Conclusion

In Dhaka, flyovers are being built without considering its consequences on its surrounding environment and community. Nowadays Dhaka is constantly facing scarcity of urban parks, plazas, playgrounds and recreational spaces. So proper utilization of these void spaces can help to develop better living condition in a dense city like Dhaka. Detail studies on infrastructural voids below flyovers and its impact on urban

life will help to develop a better framework for planning urban voids. It is expected that this study will help urban designers, planners, city authorities and policy makers to understand the impacts of leftover spaces on its neighborhood and planning fallacies that occurred during flyover designs and also will help them in developing an improved framework for future designs of urban voids.

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HISTORY AS A LEARNING CONDENSER TO IMPROVE QOL (QUALITY OF LIFE)

SADIA AFRIN TISA[1] & MD RAIHAN KHAN[2]
[1,2] Khulna University of Engineering & Technology, Khulna, Bangladesh
[1]*sadiatisa1805@gmail.com,* [2]*raihankhan9@gmail.com*

Abstract
Spaces in history give that spaces another dimension to promote learning and recreational facilitates to people that enrich their way of life. By providing the context needs, it ensures people's participation and creating a platform to share and exchange views and beliefs. *Meherpur, historically one of the significant districts which situated in the south-western region of Bangladesh, in 1757, the sun of Bengal's independence was set for 200years again the proclamation of independence was read at village Baidyanathtola, now Mujibnagar, on 17 April 1971*. The present government has taken some initiatives to preserve that evidence of history through public accessibility, which is one of the modern approaches in conservation. The objective of the article is to comprehend the socio-cultural context and human needs of society. After that, analyzing the environment issues and considerations it ended up through proposing sustainable design solutions. Furthermore, it proposes to explore the possibilities to improve the quality of life for the community and extract the richness of the site condition into architecture by creating learning and sharing spaces. For doing this, the article applies mixed method (quantitative and qualitative method) to collect and analyze the required data. Spatial mapping, semi-structured questionnaire survey, participant observation, field survey, etc. methods will be used to collect data. The outcome of this research will improve and ensure the better quality of life through the historical and cultural fabric of Meherpur.

Keywords: *History, Learning condenser, Quality of life*

1. Introduction

History, carried our past, influencing our present and shaping our future. The craving for an interpretation of history is so deep-rooted that, unless we have a constructive outlook over the past, we are drawn either to mysticism or cynicism. Before our birth, consider how past ages of eternal time gave no concern, this is like a mirror that naturally holds up to our future time after our death. Spaces in history give another dimension to promote learning and recreational facilitates to people through public participation, which enriches their way of life by offering diversified functions by representing our past. By valuing the context needs, it ensures people's participation and creating a platform to share and exchange views and beliefs through promoting learning spaces, influenced by our history.

History or Cultural Heritage can express the ways of living developed by a community and passed on from generation to generation, including customs, practices, places, objects, artistic expressions, and values. Cultural Heritage is often expressed as either Intangible or Tangible Cultural Heritage (ICOMOS, 2002). Cultural Heritage produces tangible representations of the value systems, beliefs, traditions, and lifestyles as part of human activity which is an essential part of the culture as a whole, Cultural Heritage, contains these visible and tangible traces from antiquity to the recent past, is a wide concept. A history which shaping our future by creating learning spaces or environment to the future generation which improve our way of living. The term quality of life (QOL) addressed and understands by most people as "goodness of life" and being able to live successfully and happily within the environment (Brown and Brown, 2005) which influenced by our history. QOL should not be confused with the income-based concept of standard of living. Instead, standard indicators of the QOL include not only wealth and employment, but also the built environment, physical and mental health, education, recreation and leisure time, and social belonging (Gregory et al., 2009). All of these indicators of QOL influenced by the history of designing our spaces to feel, learn, observe and enrich our knowledge to enhance our living quality. Having at one time referred exclusively to the monumental remains of cultures, cultural heritage as a concept has gradually come to include new categories. Today, we find that heritage is not only manifested through tangible forms such as artefacts, buildings or landscapes but also intangible forms. Intangible heritage includes voices, values, traditions, oral history. Popularly this is perceived through cuisine, clothing, and forms of shelter, traditional skills, and technologies, religious ceremonies,

performing arts, and storytelling. Today, we consider the tangible heritage inextricably bound up with the intangible heritage. This paper aim is to preserve both the tangible as well as the intangible heritage to enhancing our learning sources which will improve our QOL (quality of life). UN-HABITAT (2012) in a recent report on city's prosperity has used QOL as an important component of measuring city prosperity index and states that "cities that improve QOL experience higher levels of prosperity; they are also likely to find themselves more advanced in terms of sustainability" and used their historical sites to convert learning spaces to improve their way of living. The Heritage Cycle diagram gives us an idea of how we can relate to the best part of our future (Simon Thurley, 2005).History or Cultural Heritage is a group of resources inherited from the past, which people identify, independently of ownership, as a reflection and expression of their constantly evolving values, beliefs, knowledge, and transitions. It includes all aspects of the environment resulting from the interaction between people and places through time (Faro 2005).

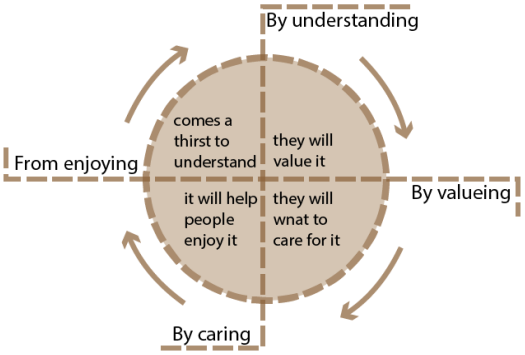

Figure 3, Heritage cycle,
(source: Simon Thurley, 2005)

Meherpur, the southwestern region of Bangladesh, takes as a case for this study. The small city contains significant resources of the past from more than 250 years. "Nil-kuthis's", now recognized as archeological sites to preserve the history of that time period, which improves the way of living by creating a learning and sharing environment for all groups of people. Local culture and identity give definite meanings to some places and to the urban space as a whole, (Madden, 2012). The linking element between history and culture is the public, (O.Neil, 2006). "When public spaces are successful, they will increase opportunities to participate in communal activity",(Carr et al., 1993).

This article will provide an insight into the current challenges concerned with heritage building being used as learning space and bringing forth the factors responsible to improve QOL so that the vast range of possibilities related to the revitalization of history or cultural heritage can be adequately explored. Cultural heritage is considered a combination of several elements, which are: human processes, activities, and urban elements, (Abdel Tawab, 2014). Several case studies have been conducted to under

Figure 5, blue-color making process-01(source: field survey

Figure 4, blue color making process -02(source: field survey)

stand the current issues of this current situation to improving QOL with historical spaces. Within the segments of the paper, the first section describes the background of the history of Bangladesh and how it relates to learning and shearing space arrangement. The second segment is based on the case studies

while finally focusing on the indicators of QOL influenced by history to promote learning spaces to improve ways of living, probable findings and public perception for heritage and public space, connectivity to promote learning space with cultural events which considered a catalyst that can promote tourism in heritage sites in the final section.

2. Literature review

History is a continuation of the life of a nation and a reminder of its authenticity. It makes the 'silent past' to human beings in a senseless and unbiased way. History, therefore, assumes the responsibility of unifying the pride and the stigma of responsibility. Throughout the history of the people, the hope of everlasting life flows from time to time.

2.1. UNDERSTANDING CONTEXT

Meherpur is a smaller district of the southwestern border of Bangladesh with cultural diversity. This district has about two thousand years of ancient history and tradition. In particular, Meherpur, historically one of the significant districts situated in the southwestern region of Bangladesh because, in 1757, the sun of Bengal's independence was set for 200years again the proclamation of independence was read at village Baidyanathtola, now Mujibnagar, on 17 April 1971. East India Company started nil-cultivation for the quality of its soil, which makes these spaces more significant. The planters started to exercise their power by inhuman activities, such as torturing, abusing, etc. The cultural variations are also not slight and hence cannot be ignored. But due to cultural ignorance do not know the deeper meaning of each culture and hence assume various stereotypes that exist even nowadays. Hence there is a dire need to educate the people and the visitors, exactly, about various rich cultures ad simultaneously encourage the cultural development, giving importance to the lifestyle of the artisans, craftsmen, etc. architecture can act as an important catalyst to bring about all of this (District Statistics 2011 Meherpur December 2013).

On this gray path of history, the border town of Meherpur, "Amm-jhupi" nil-kuthi stands in the middle of the city. One day a victory chariot of Mughal-general Mansingh descended on this path, the sculptor's barge of dust had blown the dust, raising the black hand of plunder, and the memory of Mr. Nawab Alivardi Khan, the master of Bengal-Bihar-Orissa. The blue design of Palashi's defeat was also written here - in this "amm-jhupi". It is reported that this was the last meeting of Mir Jafar and the conspirators with Robert Clive, and as a result, not only did the fate of Nawab Siraj-ud-daula disappear, Bengalis lost their independence. At the beginning of the English period, the blue-colored-blood of the oppressed people of Bengal developed "Amm-jhupi" nil-kutthi. Amm-jhupi stands with the memory of the torture, torture, and exploitation of Kenny-Simpson-Ferguson teammates. As a result of the agitation of the oppressed indigo cultivators, one day the blue cultivar was wiped from the chest of Bengal. With the change of hands, Nil-kuthi became the Kanchari of Modinipur Zamindari Company. After the partition of the zamindari, the chapter ended. Another history of evolution was born on the 5th of May, in the 'Amm-jhupi Session' of the Khulna Division Development Board. This history is a history of exploitation, deprivation, and torture of the past, and the history of the exploration of human interest and labor. At the meeting, "Amm-jhupi" was recognized as a tourist center. In an attempt to revive the rich memory of 'Ama-jhupi' in the adjoining area at a cost of eighteen million two thousand takas. There are two entrances to the blue sapphire. The entire "Nil-kuthi" complex is located on more than 3 acres of land. In the middle of the complex, the main building of the kuthi is located and there is a flower garden around it. In the middle of the main building, there are 5 rooms. The building also has a large hall, a dining room, a theater, and a guest room. Special mapping made the kuthi more significant to represent the context of the site, one the other hand, nil-kuthi carried many special building features like "kori-borga on selling", "kulungi" for lights, fireplaces, "motives" to represent the torture of the East India company. All of these features also play a significant role to feel the history of that time period which will help to create another dimension of life for the future generation to develop their way of living.

2.1.2. Learning from our past and designing our future

There has been complete historical negligence in the last few decades with the growth of Modern Technology. They are on the verge of losing their tradition and culture which represents history due to the influx of new modern equipment and the trend to Western Culture. The idea of adapting to Western Culture is considered prestigious and trendy among this generation as is advertised and promoted by global icons. The lack of promoting and encouraging may not only lead to cultural extinction but also affect historical tourism to a greater extent. First and foremost, the prevailing misconceptions about cultures need to be broken. Interest to learn to follow & adopt the culture will boost cultural value worldwide. Hence there is an immediate need to educate about the history and culture for home and abroad, which will help us to shape our future, influenced by history.

This article proposes to create historical sites as learning spaces which will help to improve the way of living, a place in history and cultures. Moreover, the availability of ample space gives another dimension along with other indicators of QOL. This space will have multi-character but act as a joint single space which will encourage the future generation to be interested in history. The architectural language will vary for each cultural pavilion, but unite them as a whole through various methodologies. The built heritage will integrate with the existing city fabric as well as stand out acting as global recognition for promoting another dimension for the city people to improve their way of living. The indicators of QOl like built environment, physical and mental health, education, recreation and leisure time, and social belonging, all of these will be influenced by history by creating learning and sharing spaces to feel the essence of the past.

3. Methodology

Method means a series of scientific processes to collect and analysis information and methodology refers to the whole process. The research adopted an observational case study methodology by mixed-method both qualitative and quantitative methods. The applied criteria that were subjectively selected are based on both data collected from the literature review and site observations according to stockholder demands. Spatial mapping, semi-structured questionnaire survey, participant observation, field survey, etc. methods are used to collect primary data, again Empirical researches, scholarly articles like Books, newspapers, magazines, journals, online portals, etc. are used for secondary data collection to understand the context.

After reviewing and comprehending history & the chronological development of the history of “amm-jhupi” nil-kuthi, needs to explore by proper illustrations under a specific heading. At first, with the help of community people, the archetype and spatial details have illustrated. The connectivity with surroundings is very crucial to ensure accessibility. Critical illustrations from an environmental perspective will make sure a sustainable development to provide the required expectation of the community.

4. Findings from case study

The history of oppression and torture of the “Nil-kors”, during the British rule in this country, the British established the “Nil-kuthi”, which was established by the British at that time for cultivating indigo in various parts of the country. Among them, Amjhupi, Gangni Bhatpara, and Bamandi Nilkuthi are significant to carry out history. Blue trees were boiled with turmeric water to produce blue-color. In one bigha land, two and a half to three kilograms of blue would be produced, which would cost 12 to 14 taka, but the farmers got only 3 or 4tk. The color that was made from the blue tree was the accumulated blood of the farmers' chests. These “Nil-kuthies” are not just filled with stories of indigo cultivation and torture of indigo cultivators, here is a glorious chapter in history, as we have the story of our glorious waking up.

4.1. AMM-JHUPI NIL-KUTHI

The defeat of Palashi was created in the confusion of the memory of Mughal generals Mansingh and Nawab Alivardi Khan, it is alleged that this sapphire was the last meeting of the conspiracy with English

commanders Clive Lloyd and Milla Jafar, the next story was all about torture and torture. The result of the conspiracy is the fall of Siraj-ud-daula, consequently, the independence of the Bengalis lost their independence. Then, one day in the blood of that tyranny, the "Nile-kuthi" was formed here. In the style of European architecture, these "nil-kuthis" was made. Again, the glory is the deprived and oppressed and tortured Nile cultivators who once defeated the English through the agitation and stopped the Nile cultivators. It has been reported that Robot Clive used to come to Nin-kuthi to spend time. The Nil-kuthi also had its contents, which have been handed over to the National Museum authorities for preservation. During the division of the country in 1947, when the British were leaving, they were handed over to the government of East Pakistan (Bangladesh), along with the property. The main house has a bedroom, snack room, dance hall, and deathbed. There is a tradition that the dancers had to dance. If a nation had expressed reluctance to pay rent or to cultivate the Nile, it would have been killed and thrown to a death-bed. The snack room is so smooth that snakes or ants can't move. There are horse houses, prisons, butchery houses and the residence of the deputies.

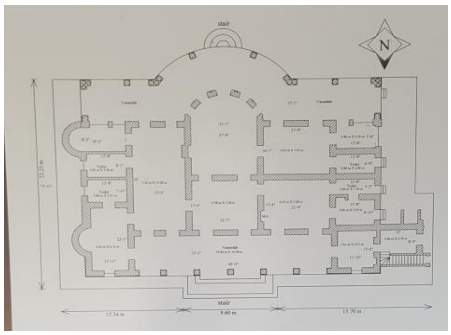

Figure 4, Plan layout of nil kuthim (source: field survey)

Figure 5, Amm-jhupi nil-kuthi (source: field survey)

4.1.1 Special Building feature of "nil-kuthi"

Kulungi: kulungi is an excavated kind of wall detailing feature, mostly used for creating light-shade in the interior, sometimes used as a wall shelf. In nil-kuthis the British used kulungi for the detailing purpose of the wall but this tradition came from our Bengali traditional house, they used this kind of space for light, sometimes as a window. This space also carried a significant story for the next generation which will help them to know history now converted as learning space, influenced their way of living.

Kori-borga in roof: In the past ages, kori-borga made of wood, used for roof construction, is another kind of feature used in "nil-kuthi" but now it's lost because of the advanced technology. People came here (nil-kuthi) to discover this kind of building feature to feel the past, to smell the history which influenced their way of thinking, creating softness about the past.

Figure 7, kulungi used in nil-kuthi(source: field survey)

Figure 7, kori-borga used in selling (source: field survey)

Khor-khorir's door and window: In "nil-kuthi", both door and window made by Khor-khori, another significant building-feature made by wood louver, could be operated as user need. Nowadays we

can't see this kind of window, if we can't take any initiative to preserve them it will be a great loss for the next generation.

Iron made railing: This kind of iron-based railing used in nil-kuthis to make a semi-outdoor-indoor connection, to make space to space connection with people. But nowadays this kind of railing not used because of the advanced invention of materials and also for the cost. But this railing also bears the signature of the historical significance of torture of the British controller.it is the sign of the glorious history of the nil-kuthis, carried from the past 200years.

Vegetation: Vegetation mapping of this nil-kuthis was more significant, most probably contains an indigo tree, mango garden and litchi garden in that period. Nowadays all of that vegetation, try to accommodate again to give the future generation the real essence of the history of torture on the cultivator. Already a few blue trees have been planted there.

Figure 8, khor-khori used in door and window (source: field survey)

Figure 9 & 10, khor-khori used in door and window and vegetation(source: field survey)

The ruthless house is now being built as a tourist hub, which can be converted as a learning space to preserve the glorious history of Meherpur. The rest of the house, except the main building, is on the verge of destruction due to lack of renovation. In 1978, the Khulna Division Development Board was recognized as a tourism center on 13th May and renovated and developed it, since then, the tyrant has been losing control of the tide. Eventually, this blue sapphire became a Tartu house of bloodshed. Various arrangements have been made to surround the house of the brutal consequences of Bengal by depicting the historical context of the exploitation, deprivation, and oppression of Bengalis through the use of indigo cultivation.

4.2. SPACES CONVERTED AS LEARNING SPACES

The present government has taken some initiatives to develop socio-cultural infrastructure, like these "Nil-kuthis" to explore their history, such as cultural and learning spaces to facilitate their living quality. The cultural variations are also not slight and hence cannot ignore. But due to cultural ignorance do not know the deeper meaning of each culture and hence assume various stereotypes that exist even nowadays.

Hence there is dire need to educate the people and the visitors about the history and simultaneously encourage the cultural development, giving importance to the lifestyle of the artisans, etc. while built-heritage can act as an important catalyst to bring about all of this. By ensuring social participation and learning spaces within historical spaces through permeability, it can also give another dimension to city life to improve their way of living to shape their future from the influence of past, basically from their history.

In line with this, the objective of the article is to comprehend the socio-cultural context and human needs of society. After that, analyzing the environmental issues and considerations it ended up by proposing sustainable solutions where social permeability, cohesion, creating economic opportunities are on top of the influence of their past history. Furthermore, it proposes to explore the design possibilities to improve the quality of life for the community and extract the richness of the site condition into architecture by creating learning and sharing spaces.

It will help the user group, also the visitors from a national and international perspective to feel the significant history (history of torture and oppression) of “Nil-kuthis”, which will also enhance their knowledge.

4.3. VALUES OF HISTORY AND QUALITY OF LIFE

History is essential to carry out the glory of culture that influences social life through disseminating resources to generation to generation. In one way, the intangible part provides information about social context, economy, beliefs, and so on. On the other hand, tangible portion allows experiencing physically and feeling the essence of the life of that time. An archeological site influences the living quality of locals and directly affects the dimensions of quality of life through its materialistic richness, details, spatiality, etc. Historically, Meherpur carries a significant part of the past of this delta, particularly the era of the British. The proclamation of independence took place in this soil.In recent days, the area is losing its value by diminishing physical infrastructures. Importantly, these places have the quality to promote learning and sharing spaces between visitors and local inhabitants about that worthy assentation of history. Quality of life encompasses several different dimensions; broadly, social, economic, culture and environment are major, where historical assets impacted all these directly and indirectly. In general, the socio-cultural portion plays a major role to make a happy life, while the place can be used for social gathering and for exchanging views and thoughts. Additionally, an archeological area opens up monetary options for the locals.In many areas, the government has been involving the community during preservation and conservation time, which tie up them inherently. As a result, many small outlets have developed for displaying crafts, artistic materials, and in both ways, it works as exposure of local artisans.

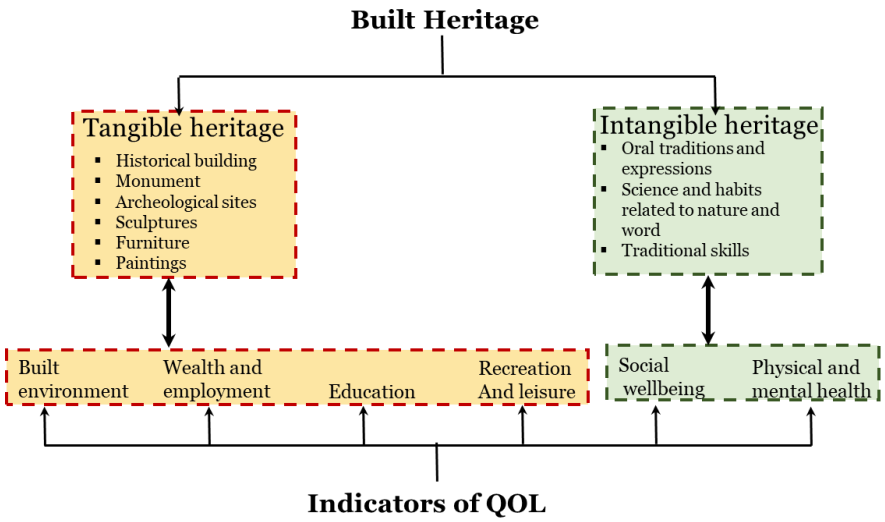

Figure 11, Relationship diagram between built heritage and quality of life *(Source: author constructed)*

In the modern world, utilize an archeological area as a public space is a very popular method for conserving and preserving. This connection makes the space more vibrant and alive, which steers individual learning with social interaction. These areas are the source of learning the place that contains lifestyles, local craftsmanship ...etc. in physical planning, the presence of past features may be influential behind the establishment of the present. Besides the educational qualities, it can be a place for spending quality leisure time and improve societal relationship within the community. On the other hand, most cases the non-accessible historical sites often face the destruction due to negligence and climatic impacts. Though public accessibility both objectives can be achieved, firstly it enhances the quality of life and can attract authorities about the significance of conservation and preservation of particular area.

5. Conclusion

The historical site can be converted not only as recreation or leisure space but also as learning spaces by preserving the history for the future generation, which will create a great influence in our way of living.

In spite of being a historically enriched city, Meherpur is not so advanced, due to lack of vision of the government. Although the facilities of the community center, echo park, shopping center, and others, the people of Meherpur go to Cuadanga or kustia for better service facilities. A historical site that carries out our past can also hold the character of learning space, where culture, business life, healthcare and administration fuse and profit via common facilities and locations. Multiple functions ensure life and activity throughout the day and the week – even after hours. Space can also be a symbol of a lively community that will represent the context of Meherpur nationally."Amm-jhupi" nil-kuthi is also being in process to preserve the history of torture by creating adaptive reuse, public activities to crate learning and sharing environment which will improve the indicators of Quality of life.

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6.1 ACKNOWLEDGEMENTS

The discussion with visitors and authorities was the key to get information about the tangible and intangible aspects of historical structures; I am very much thankful to them for their support. Grateful to the community people and professionals for sharing their valuable knowledge about the significance of these historical infrastructures.

This research is part of the B.Arch. thesis and I am showing my gratitude towards my supervisors for their critical thoughts and guidance.

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SINHALA FONTS AND DYSLEXIA.
Adopting Latin Script Based Research in to Sinhala Reading Materials.

MALINDI JAYATHUNGA[1], SUMANTHRI SAMARAWICKRAMA[2]
[1,2] Department of Integrated Design, Faculty of Architecture, University of Moratuwa, Sri Lanka
[1]malindijayathunga@gmail.com, [2]sumanthris@uom.lk

Abstract
Typefaces and fonts designed for the purpose of dyslexia and the dyslexic reader have increased over the recent years among scholars and designers due to the increase of literature on the disability and the development of research on the subject of typography. These research and designs are more focused towards the font's visual characteristics such as the stroke variation, size, space etc. meanwhile the cases discussed are predominantly based on languages that use Latin script. Research related to Sinhala typeface and fonts related to dyslexia is rare even though there are reading material and learning aid composed with the Sinhala script. As a pinor research this paper aims to findout the most appropriate Sinhala font to increase reading performance of children with dyslexia. To achive this the research discusses literature on Latin fonts and typefaces that addresses dyslexia in comparision to Sinhala fonts and futher addresses ways of adopting Latin font based research to Sinhala fonts. This paper is compiled with secondary data gathered through a literature review and primary data was gathered through a qualitative analysis on the selected three Sinhala fonts' and their characteristics to achieve the best parameters required for the reading performace test. As an outcome of this research it was identified that some concepts from Latin font based research such as increasing the legibility of letters by increased font size and spacing, could be adopted to Sinhala fonts despite the difference in the two scripts. However, it was further concluded that compared to phonological complexities of the languages, Sinhala dyslexic readers could benefit more from a visual solution such as type design. Hence, there is a need to further research and to identifying the visual parameters of Sinhala font that works best for dyslexic children. The findings of this research can be applied to learning aids for Sinhala dyslexic students. Moreover, it can be a guide for typographic design for reading disabilities in the future.

Keywords: *Developmental Dyslexia, Sinhala fonts, Readability*

1. Introduction.

'Reading', like speaking and listening, is a mode of communication that let humans share ideas, thoughts and knowledge. It can be defined as a process of "transforming visual symbols and converting them in to linguistic meanings" (Bessemans, 2016). Faults in this process can be identified as a 'Reading Disability'. Dyslexia is a reading disability that effects 1 out of 5 people in the world. It has 2 main forms such as: developmental dyslexia and acquired dyslexia. Developmental Dyslexia is considered to be genetic and present in a child from birth, hence, considered critical as it impairs one's ability to gather knowledge by reading since their birth. Acquired Dyslexia can occur due to brain damage at any age of a person's life. Dyslexic children are commonly misdiagnosed as less intelligent and/or 'lazy' due to their poor reading performance in school. Since the academic evaluations in school systems, especially in countries like Sri Lanka, are strongly based on a child's ability to read and write, dyslexic students often perform poorly despite being well prepared. This results in individuals with damaged self-image and self-esteem growing up to become adults with persisting frustrations, stigma and emotional effects (Sykes, 2008). This research only focuses on children with developmental dyslexia.

Some of the common signs of English reading children with dyslexia are: letter and/or word reversal, transpositions, inversion, trouble with sequence, avoiding punctuation, stress under pressure and substitution (Gregor and Newell 2000; Hoffmeister 2016). Sinhala dyslexic children show similar signs of word/letter reversal but also show omission and substitution of vowel modifiers (Wijesekara, 2018). A dyslexic child may not display, and may also not be limited to, all the above signs.

Over the years, many solutions has been presented to support and improve the reading skills of children with developmental dyslexia. In many western countries like U.S.A., educational institutions has a legal obligation to provide special support (additional time and notes) to students with dyslexia. It has been found out through research that typography effect the reading performance of dyslexic readers. However, all the research on dyslexia, fonts and readability are done based on Latin script. There are different language systems and script types in the world. For the purpose of this study, language systems

will be divided in to two as phonological and less phonological languages. English is a phonological language that uses an alphabetic script system.

Sinhala language in particular, is a more visually complex language rather than a phonologically complex language. It has 5 main visual forms as: vowels as letters, medial vowel signs, consonants as letters, combined consonants and other special signs (Samarawickrama, 2017). There are very few evidence on the effects of such languages on dyslexia. Therefore, evaluating the effects of different visual characteristics of Sinhala fonts help determine if a visual approach as a solution is worthwhile for Sinhala dyslexic readers.

Currently, there is little to no research related to dyslexia and Sinhala language. There is also no known effective and certified Sinhala typographic guideline to be used on their reading materials. Academic research, experiments or designs that explores the possibilities of Sinhala language in support of learning disabilities like dyslexia, is a crucial necessity. Adopting the findings from foreign research to identifying appropriate typographic parameters will lead towards developing effective learning aid for Sinhala dyslexic children that will help them overcome their struggles with reading.

2. Latin Script Research on Dyslexia and Typography.

Education systems in the western world, nowadays encourage dyslexic students to use computers for text manipulation as a successful method of alleviating problems where they are able to change the font size, font type and other parameters to suit their need. There are special fonts made for dyslexics, such as; Dyslexie, Read Regular, Open Dyslexic and Sylexiad. Existing font, such as; Arial, Helvetica, Calibri and Century Gothic have been recommended by accredited associations; BDA (British Dyslexia Association) and IDA (International Dyslexia Association) for use in materials for dyslexic readers.

2.1. MANIPULATING TYPOGRAPHY TO INCREASE READABILITY.

Readability directly depends on the legibility; i.e. the clarity of the presentation of type and layout of the text (Erdmann and Neal, 1968, cited by Hoffmeister, 2016). Strong legibility is when a text is easier to read and understand whereas low legibility is when the text is hard to read or comprehend by the standards of the general reader. In other terms: increased text difficulty challenges cognitive processing capacity of the brain resulting in poor reading (Hoffmeister, 2016). Increasing legibility of a text can be done by altering the text layout as well as altering the typographic characteristics such as font type, font size, spacing and the background-foreground contrast (Hughes and Wilkins, 2000).

2.1.1 Font size and spacing.

It is recommended to use larger font sizes for children around 6-7 years of age while using smaller font sizes for children around the age of 10 (Shaw:1992; Tinker:1959; Burt:1959; as cited by Hughes and Wilkins, 2000) . In 1991, Cornelissen, Bradley, Fowler and Stein did a research to find out the correlation between visual perception and special dimensions of text. They tested this by giving 3 different word lists, all in Helvetica font type, but in 3 font sizes. The results of their research show that the children make more errors in reading when the print size is reduced (as cited by Hughes and Wilkins, 2000).

However, for the dyslexic students, it is recommended by The British Dyslexia Association to use a font in sizes between 12-14 pt. or larger as per the child's request (BDA II, 2018). Some dyslexic research participants has even selected font sizes larger than 12 pt when given the chance (Gregor & Newell, 2000). According to Hoffmeister (2016), dyslexic individuals get easily affected by visual clutter. As Hill (2010) presents, "they are distracted by the words around the word they are trying to read" (as cited by Hoffmeister, 2016). Therefore, larger font sizes that provide more spacing between the letters are beneficial for dyslexic readers (Chung, 2007; Martelli, Di Filippo, Spinelli, Zoccolotti, 2009, as cited by Hoffmeister, 2016). According to Gregor and Newell (2000), the appearance of lacking enough spacing is why dyslexic readers does not prefer bold texts.

2.1.2. *Font type.*

Latin fonts can be divided in to two categories as serif and sans serif fonts based on their visual features. Serif fonts are the fonts with decorative element of fine extensions of lines at the top and bottom of the letters. The most common example of the font is 'Times New Roman' (in which this text is composed). Sans serif are the fonts without extensions of line or decorative elements. 'Arial' is the most common example. The only serif font recommended for use by International Dyslexia Association for dyslexia is Times New Roman (Rello & Baeza-Yates, 2013). The British Dyslexia Association specifically recommend using sans serif fonts such as Arial, Verdana, Tahoma, Century Gothic, Trebuchet, Calibri and Open Sans (BDA II, 2018), because they appear less crowded for dyslexic readers.

In a study by Woods & Scharff (2005) on the effects of typeface and font size on the legibility of children, it was discovered that Arial (sans serif font) was the most legible font among all grade levels (as cited by Hoffmeister, 2016). In another research done by Gregor & Newell in 2000, on the alleviating problems encountered by dyslexic readers using computer techniques, the sans serif typeface Arial was rated as the best by almost all the participants. The reasons as to why they preferred Arial was because it's simplicity. The participants of that research in fact explained Arial as a 'clear', 'basic', 'rounded' and 'straightforward' font compared to other 'flowery', 'complicated' fonts. This goes on to show that manipulating the font type or the visual parameters of font type could in fact effect legibility. Contrary to those findings, Arditi and Cho (2005) claims that, because of the added separation of the letters due to extensions, serif fonts may have an effect on legibility for the dyslexic readers.

What works for dyslexics among serif fonts and sans serif fonts is not yet clear. Hillier's research in (2008) suggests that what matters the most for readability is not if the font is serif or sans serif, but whether the letter form is clear, distinctive and different from each other. Therefore, it can be concluded that typographic characteristics in text presentation has an effect on the readability of people with dyslexia.

2.2. SPECIAL FONTS FOR DYSLEXIA

As discussed in 2.1.2, font Arial has a positive effect on the reading performance of dyslexic children. But, Arial, and other fonts commonly recommended for dyslexia, were not initially designed for dyslexic readers (Hillier, 2008; Rello & Baeza-Yates, 2013). This issue begs the question whether the typographic forms used in these fonts are the most ideal for dyslexic readers, or with more understanding of the condition could we specially design a better font for dyslexic audiences. Perhaps, that's how the idea of special fonts for dyslexia came to be. Sylexiad, Dyslexie, Read Regular and OpenDyslexic are some of the examples for specially designed fonts for dyslexia. According to Rello & Baeza-Yates (2013) the common theory behind all these fonts is to differentiate each letter of the font compared to regular fonts.

In 2013 research by Rello and Baeze-Yates, 12 latin fonts were tested to find out the 'Good Fonts for Dyslexia'. In their research they chose to test Arial, Arial italic, Computer Modern, Courier, Garamond, Helvetica, Myriad, Times New Roman, Times New Roman Italic, Verdana, OpenDyslexic and OpenDyslexic italic. Arial and Times New Roman was selected by them as the most common fonts used on screen and printed text. Helvetica and Myriad were tested as the most commonly used fonts in graphic design. Garamond had been tested as it claims to have strong legibility. Other fonts were selected to be tested as they were either recommended for dyslexic readers or are specially designed for dyslexia.

Through their research, Rello & Baeza-Yates found out that fonts designed especially for dyslexia such as OpenDyslexic, did not result in positive or negative change in readability. They concluded that Helvetica, Verdana, Courier and Arial are good fonts for dyslexia over fonts specially designed for dyslexia. On par with these results, Marinus et. al. (2016) & Kuster et. al. (2017) concluded through their research that dyslexic readers preferred fonts Arial and Times New Roman over Dyslexie. They also pointed out that Dyslexie font works only because of its spacing settings and not because of the letter shape design.

Similarly as Dyslexie, OpenDyslexic is a typeface developed by a fellow dyslexic, Abelardo Gonzalez and (Hoffmeister, 2016) and the letters have strong lines at the bottom as an attempt to anchor the letter on its right direction. Each letter also has a unique shape in order to prevent visual confusion. It also has wider spacing. Apparently, these new fonts were based on expired concepts on dyslexia such as perceiving letters and forms in reverse (optical reversibility theory of dyslexia) and inherent special disorientation (spatial confusion theory of dyslexia) (Velluntino et al., 2004). Therefore, these special fonts has not proven sucess as intended.

Sylexiad is a more successful typeface design. It is a typeface developed by another dyslexic, Robert Hillier, for adult dyslexic readers through research on legibility and readability (Hillier, 2008). He started with his font Dine 3 which had radical and unfamiliar word forms. By testing Dine 3 against Times New Roman, Arial and Sassoon Primary, he concluded that unfamiliar designs could reduce the readability for dyslexic readers. He further suggested that light letterforms and large interspatial word qualities can be favorable in minimizing effects of unfamiliar designs. By developing his font further he noticed that the letters took more conventional forms. Therefore, he concluded that familiarity of the font is what's important for the dyslexic readers. He utilized these findings in designing and developing the font Sylexiad. Sylexiad was designed with light letter strokes, long ascenders and descenders, clear & distinct characters and generous inter-word spacing. Sylexiad was preferred by dyslexic adults over Times New Roman when it comes to comprehension and visual ease.

According to all the above research we can conclude that it is not the design of the individual letterform that matters but the collective appearance of the font size, spacing, weight and overall form of a typeface. Arial is successful among dyslexic users as it is visually simple and letter forms are more familiar, which results in good legibility and readability.

3. Methodology.

In foreign font testing research, fonts has been selected based on recommendations, special uses, claims of legibility, and font popularity (i.e. frequency of use). Serif and sans serif features of font design had also been tested in many research though the years. When selecting Sinhala fonts for testing, fonts can be selected based on the popularity of the font use and claims of legibility since there are no recommended or special use fonts for dyslexic readers.

Visual features of Latin fonts are different from Sinhala fonts. Instead of serif and sans serif feature of letter form design, Sinhala fonts can be selected based on their modulated letter forms and mono-linear letter forms. But, as similar to Latin fonts, Sinhala font can also be recognized as with open counter designs and with closed counter designs. In Latin script 'x' height is used to measure the size of the fonts. In Sinhala language, ratio of the upper and lower portions of letter 'm' (pa) is used.

3.1 IDENTIFYING SINHALA FONTS USING THEIR BASIC VISUAL FEATURES.

Sinhala fonts are commonly categorized based on their design element of being a modulated font or a mono-linear font (stroke thickness). When testing the effects of type design in Sinhala fonts, it is better to compare the effectiveness of these two visual features.

For the purpose of this study three fonts wth different visual features were selected based on the frequency of use: most commonly used fonts in printed, screen or in graphic design and a font designed with strong legibility. FMAbaya, FMMalithi and Noto san Sinhala UI was identified as fonts with different visual characteristics with the help of a specialists in type design field. FMAbaya is also identified as the most commonly used font in Sri Lanka. It is also considered to be one of the best Sinhala type designs of all time. FMAbaya is freely available for use. FMMalithi was identified as the font commonly used in children's story book printing. Noto san Sinhala UI is the Sinhala font available in

android devices. It claims to have been designed with strong legibility due to requirement of mobile and other small screen viewings. Visual uniqueness among these fonts can be described as follows.

3.1.1. Modulated vs mono-linier type design.

A modulated font is when the font has both thick and thin strokes. A common example for a modulated Latin font design is 'Georgia' (figure 3.1). Mono-linier fonts, as by the name implies, has comparatively uniform thickness of the line throughout the letter. A Common example is the font Arial (figure 3.2). Likewise, FMAbaya is a modulated font where as FMMalithi is a Mono-linear font.

Figure 3.1: Visual comparition of Latin serif font (Georgia) and modulated Sinhala font (FMAbaya). Source: Author

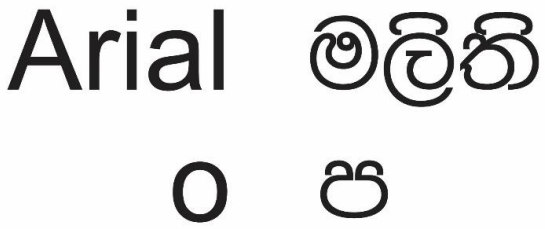

Figure 3.2: Visual comparition of Latin san serif font (Arial) and mono-linear Sinhala font (FMMalithi). Source: Author

3.1.2. *Difference in 'pa' height.*

The character size in Latin fonts are measured based on the measurements of the font's x character. The distance from the top to bottom of the x character is known as the font's x height. Whereas in Sinhala fonts the character size is measured based on the measurements of the font's m (pa) character. Hence it is called the 'pa' height. In Sinhala characters the pa height is the ratio between it's upper letter portion to the lower letter portion. Therefore it is presented as a ratio rather than a length. Therefore in adopting recommendations of Latin research for Sinhala fonts, the Latin font recommendation of x-height of 2.3mm can not be taken as the required pa-height for the Sinhala fonts. Because, with the difference of the ratios of the 'pa' height, the letter may appear contracted or expanded.

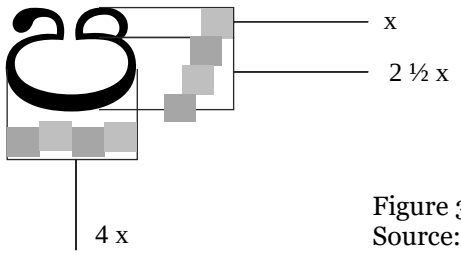

Figure 3.3: Measuring 'pa' height for Sinhala fonts
Source: Author

However, when considering the 3 selected Sinhala fonts, they all have different character sizes for the same font size of 18pt. Therefore comparable font sizes which have the same character size of ~2.6 mm was considered in comparing other features.

3.1.3. Counters and open counters.

Figure 3.4: Counters and open counters of the selected fonts (Source: Author)

In typography, a counter is the area of a letter that is entirely or partially enclosed by a letter form or a symbol (Maxymuk, 1997). Letter O is a letter with a counter in the middle. But letter C is not entirely enclosed. Thus it has an open counter. When considering the 3 selected fonts FMAbaya and FMMalithi seems to have features of both counters and open counters, but Noto sans Sinhala UI has more open counter features.

4. Most Appropriate Sinhala Font for Dyslexia.

According to foreign research on the effectiveness of special fonts for dyslexia and existing fonts, letter form have little to no effect on readability. On the otherhand, internal spacing and external spacing does. Generous internal and external spacing of a letter helps in clearly identifying the elements in a letter, hence resulting in accurate reading. Therefore, when considering Sinhala fonts, there is no need for exaguration of shapes, but differenciation of similar features is important as to keep the legibility of the letter which will result in good readability.

Sinhala font FMAbaya has more distinctive letter shapes within the typeface and withing other two selected fonts. On the other hand, if font familiarity is effective in the readability of text for dyslexic children, FMAbaya is one of the most commonly used fonts in Sri Lanka. Therefore, FMAbaya can not be recommended for the use in dyslexia materials by only considering the font familiarity factor, but familiarity of the letter form should also be considered. However, one may argue that since the thickness of the letter is focused on the bottom of the letter form, it helps to anchor down the letter, which will help reduce letter reversal in dyslexic readers. Even though English reading dyslexic readers show signs of letter rotation (ex: reading ‘b’ as ‘p’) There is no record of Sinhala dyslexic readers who rotate letters in reading. Therefore, it is difficult to recommend such modulation as an effective visual feature for dyslexia font designs.

Sinhala language has many similar letter forms with slight changes in the anatomy. As an example;

ෙ ම ඹ ඔ ග ශ හ භ ී ර රැ රෑ

ජ ඡ ෂ ප ක ත න ට ච ච

When comparing these similar letter forms in the three selected font; Noto Sans Sinhala UI seems to have the largest spacing. This extra spacing supports the claims of Noto sans Sinhala UI being a more legible font. Noto sans Sinhala UI also has a bigger character size in a given font size (see figure 4.1).

Based on the results of latin font research and visual characteristics of Sinhala font, Noto Sans Sinhala UI can be identified as a more appropriate font among the most frequently used Sinhala fonts. It has to be noted that Noto Sans Sinhala UI is designed to be used on android devices. It is not fully compatible with other operating systems. Therefore, there is the need for further developing the Noto sans Sinhala UI font or design a special Sinhala font for dyslexia using the effective features of the above discussed fonts.

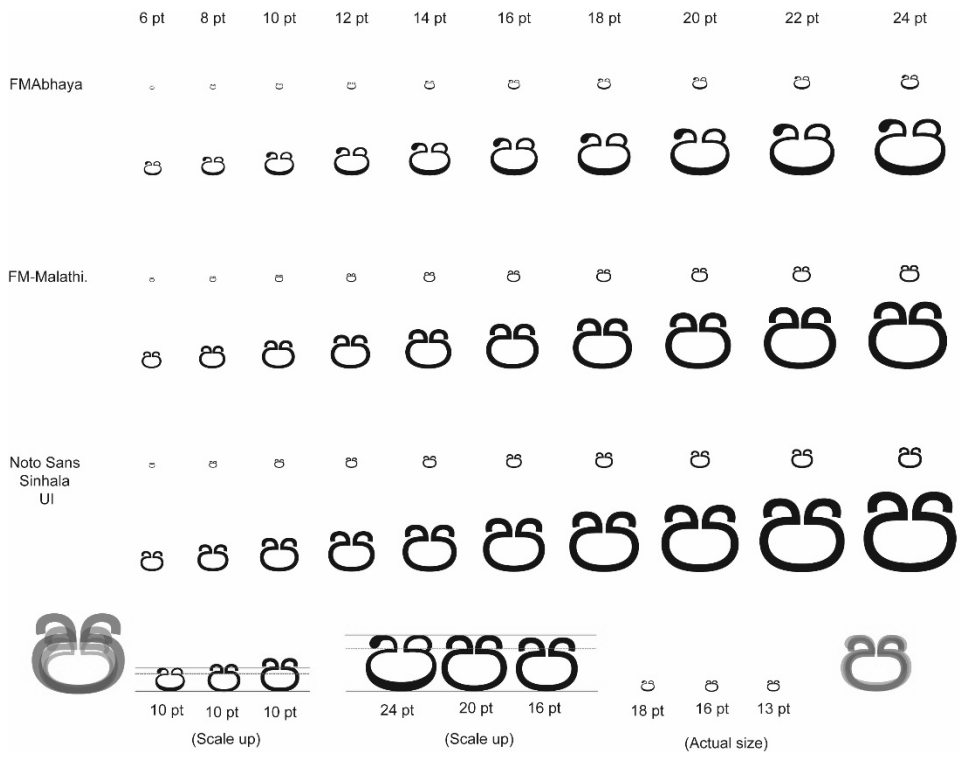

Figure 4.1: Comparing font sizes and letter spacing of selected fonts.
Source: Author

5. Conclusion.

Dyslexia is the most common learning disability accounting for ~20% of the words population. Multisensory educational materials are the most famous approach to supporting dyslexic children. Organizations like the International Dyslexia Association (IDA) and the British Dyslexia Association (BDA) has proposed typographic guidelines for the use of dyslexic children. There are both recommended fonts for dyslexia as well as specially designed fonts for dyslexia. In latin script based research compairing exsiting fonts and special font, it is found that font familiarity and generouse letter spacing are the key factors in improving readability for dyslexia readers. This theory was applied to the most frequently used Sinhala fonts. Noto sans Sinhala UI can be identified as an appropriate font for Sinhala dyslexic readers. However, for further accurate recommendations, there is the need for more research on both areas of Sinhala Typography and Dyslexia in Sri Lanka.

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THE GRAND CANAL
Envisioning Water Urbanism as the Basis of Metropolitan Resilience of Dhaka City

DATTA S.[1] & AHMED S.[2]
[1]Form.3 Architects, Dhaka, Bangladesh
[2]Military Institute of Science and Technology, Dhaka, Bangladesh
[1]shuvo@form3a.net, [2]sabbirahmed@arch.mist.ac.bd

Abstract
Dhaka, which has grown into one of the world's largest megacities, shows a very rapid rate of expansion in population, economy, and infrastructure. While River Buriganga in the south, River Turag in the west, Tongi Khal in the north and River Balu in the east define the boundaries of today's populous metropolis, history indicates that over 50 canals once flew through the city, helping its drainage of storm water and providing inland waterways. Dhaka has lost most of its myriad waterbodies, low-lying areas and the continuity of its canals, due to either poorly planned or unplanned land use development. As a result, dwellers have become increasingly prone to acute waterlogging, also leaving the city vulnerable to groundwater depletion, earthquake, and severe traffic congestion. Among disasters, Climate Change and Urban Heat Island effect have also come into play. The paper discusses the idea of "Water Urbanism" integral to the core development policies of the city; and water as the major driver of urban design, cityscape and urban ecology creating a firm platform for the city's overall resilience. The primary task to initiate this idea is to identify lost canals and connect waterbodies – gifting Dhaka much needed green corridors, groundwater recharge, natural storm water flow and better protection from disasters. This task can be accomplished with proper masterplan and surgical interventions with minimum demolition. The overall methodology of this research can be termed as a Case Study, comprising data collection from literature and field survey, GIS map survey, interviews– based on inductive reasoning method. This multidisciplinary study culminates in the proposal of "The Grand Canal" – a blue network across the city that will ease the city's environmental problems and provide useful transit corridors.

Keywords: *Water Urbanism, Urban Resilience, Blue Network, Urban Ecology, Urban Design.*

1. Introduction

Dhaka, the capital of Bangladesh, is one of the world's largest megacities with a population of 20,283,552 in its core area of 306.5 square kilometres and a density staggering of 23,234 people per square kilometre (World Population Review, 2019). It is located in central Bangladesh, on the eastern banks of the Buriganga River. The city lies on the lower reaches of the Ganges Delta where tropical vegetation and moist soils characterize the land, which is flat and close to sea level (Hough, 1995). The city has a distinct monsoonal season, with an average of 105 days of rain (Weatherbase, 2019). This 400-year-old city used to take advantage of its topography to handle this huge amount of rainwater, maintaining a balance between the life of inhabitants and the natural watercourses. Once characterized by numerous freshwater natural *khals* (canals) and wetlands, Dhaka has, over the decades, turned into a city of waterlogging and drainage congestion. The inland drainage conveyance *khals* have, in effect, become wastewater drains discharging into the peripheral rivers resulting in gross pollution of these rivers (PSCMEF, 2010).

The unplanned natural and man-made landscapes of Dhaka have always prioritized the grey structural elements which gradually created major urban problems like severe traffic congestion, groundwater depletion, effects of climate change and earthquake-vulnerability. As rapid urbanization requires more infrastructure for housing, business, and transport networks, the demands for such development are generally being met through the development of natural land areas (e.g., water bodies, cultivated lands, open spaces, etc.), which ultimately results in a considerable reduction in the open and green areas of this region (Kong, 2006; Swanwick C, 2003). Growing evidence suggests that this consistent loss of natural habitat is not only making the city vulnerable to natural hazards such as flooding (Ashraf M. Dewan, 2008) but that it is also reducing the quality of life (Amin SMN, 2008). In particular, the gradual extinction of waterbodies and other open spaces is reducing biodiversity and turning Dhaka susceptible and inflexible.

The paper holds the perspective of 'Water Urbanism' as one unified idea to improve the overall ecology and environment of the city. Integrated to the core development policies of the city, water urbanism for Dhaka envisions a 'Water Network' termed as 'The Grand Canal' as the major driver of urban design, cityscape and urban ecology creating a firm platform for the city's overall resilience. This paper takes the case of Dhaka and delineates a design proposal that takes relevant problems into account and mitigates them through macro and micro interventions to form a continuous blue corridor. For Dhaka, a way to achieve resiliency could be through reviving and connecting the lost inland canals (*khals*) as well as the waterbodies and fusing water-based urban activities with it for sustainable development and wellbeing of the inhabitants. Natural arteries will strengthen the city's capability to prepare, respond and recover from significant multi-hazard threats with minimum damage to public safety and health, economy and security in the megacity. With few studies addressing the critical evaluation of Dhaka's water systems and their possibilities, this paper addresses a crucial research gap while focusing on:

- Finding traces of existing and lost waterbodies of Dhaka
- Investigating the possibility of a plausibly connected water stream through Dhaka city promising major impact despite minimum disruption to existing infrastructures
- Proposing *The Grand Canal* designed to influence policy-making and strategic planning, while gifting the city a new route of navigation, decreased temperature, a means to combat climate change, sufficient groundwater recharge facility to reduce earthquake hazard risk and green corridors to revive the lost ecological affluence in Dhaka.

2. Methodology

This paper is a case study of a design solution, which addresses the current geopolitical landscape of Dhaka City and comes up with a solution called *The Grand Canal* – a water network as the basis of the overall resiliency of Dhaka. This paper justifies the design solution from the facts and information collected from a range of materials and background studies by the inductive reasoning method. This accumulates information essential for design-decisions in a number of parts as follows:

Table 1: Step-by-step Work Procedure

Steps	Method	Materials	Target
Step 1	History & Background study	a. Geological and topographical maps study	To identify the three-dimensional quality of the surface, specific landforms and its transformation through the ages
		b. GIS map study	To identify and characterize the existing structures, open spaces, and waterbodies
		c. Historical Map study	To identify the growth pattern, transformation, and lost waterbodies
Step 2	Investigation / Survey / Evaluation	a. On-site Survey of existing waterbodies & structures	To evaluate the existing waterbody's location, nature, physical conditions and connection with the adjacent structures or people
		b. Identify Problems	To identify the level of encroachment, its effect and reasons behind
		c. On-site Survey of Lost waterbodies	To evaluate the lost waterbody's location, year of extinction, conversion type and way to revive it
Step 3	Policies & Action plans	a. Study previous Detailed Area Plans [DAP]	To understand, predict and rationalize the failures of the strategic development plans for Dhaka Metropolitan Area
		b. Study Draft	To understand future development

		Structural plan [2015-2035]	plans (housing & other infrastructures) for Dhaka Metropolitan Area and identify proposals for waterbodies, canals and open spaces
		c. Study Policies and strategies	To understand the policies applied in Dhaka specifically for water-related issues
		d. Study Flood Action Plans [FAP]	FAP2 & FAP8 still work as the major catalyst to convert the canals into roads and build dams to protect Dhaka from river flooding. Understanding the details of the plan was a prerequisite
Step 4	Delineation of the proposal	a. Masterplan Preparation	To identify and propose a feasible masterplan and connection cumulating the outputs from the physical surveys, literature reviews and future legislative proposals
		b. Surgical study & intervention	To ensure minimum disruption to the existing habitat, micro level surveys were conducted to identify and propose a feasible blue corridor.
Step 5	Feasibility Study	a. Minimum demolition	The proposal was checked 3 times through physical surveys to ensure minimum demolition of existing buildings

2.1. HISTORY & BACKGROUND STUDY

Since establishment, Dhaka has grown inorganically. The patterns of aerial expansion and the urban form of Dhaka have been largely dominated by the physical configuration of the landscape in and around the city, particularly the river system and the height of land in relation to flood level (Islam, 1996). There are two dominant general patterns in the historical evolution of Dhaka (Nilufar, 2010): old Dhaka or the historic core and new Dhaka or northern expansion. Dhaka is surrounded by *Buriganga* in the south, *Turag* in the west, *Tongi khal* in the north and *Balu* in the east. *Khals* of Dhaka used to be connecting channels of rivers surrounded by the greater Dhaka district (Shahjahan, 2013) and wetlands. Over 50 affluent canals once used to flow through the capital. Most of these water channels have been fully or partially choked while the rest are under serious threat. Historical references indicate that Dhaka was crisscrossed by 3 main rivers (Mamun, 1993). *Rajdhani Unnayan Katripakkha* (RAJUK) has a list of 20 lost canals that once flowed through. Almost half of the canals are gone and the remaining 26 are struggling for their survival too (The Daily Star, 2016), as they have lost their flow, blocked by either roads or unauthorized structures.

The phases and consequent changes over the years (Afghan Period, *Mughal* Period, British Period, Pakistan Period, Bangladesh Period) have shaped Dhaka to its present structure. Dhaka's growth filled many low lands on the eastern and western sides, owing to a scarcity of land and consequent rise in its price. It is alarming to find that the yearly rate of loss of wetland during 1999-2003 periods was 5.67 percent whereas during 1989-1999 period; yearly rate of loss was 1.23 percent. (Islam, 2006). Several reports mentioned that the well-connected *Panthapath canal* in central Dhaka was covered by building a box culvert during 1988 by JICA. It used to connect *Dhanmondi Lake* in the west with *Hatirjheel* in the east of the city-centre (Figure 1). Landfills destroyed the whole eastern portion of the *Begunbari Khal* connecting *Hatirjheel* to *Dhanmondi* lake system (Mamun, 1993).

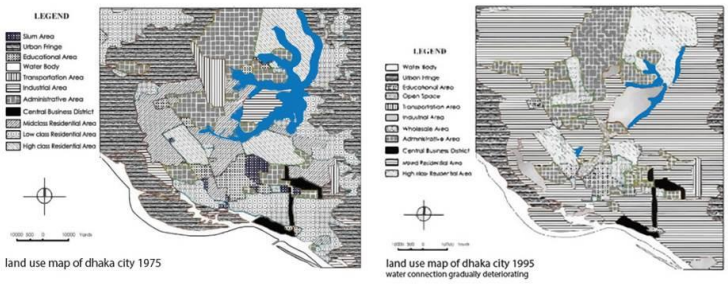
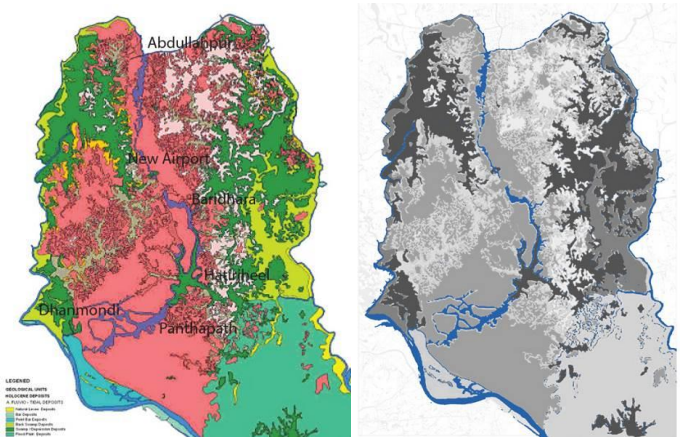


Figure 1, Existence of Panthapath canal and development (*Source: DCC*)



Figures 2 & 3, Geological Map 1953-1954 and Evidence of N-S water connection *(Source: 2. Geological Survey of Bangladesh; 3. Author)*

2.2. SURVEY & EVALUATION

Dwellers of Dhaka City face a plethora of urban problems identified through literature and field surveys. Some major problems are analysed as follows:

2.2.1 Waterlogging

Dhaka faces two types of flood: internal flood due to rainfall and external flood due to the rise of river water level. Dhaka faced major floods in 1954, 1955, 1970, 1974, 1980, 1987, 1988, 1998 and 2004. Flood plains and wetlands at the fringe areas used to swamp during heavy rainfall which helped to store and later drain out the excess water to the surrounding rivers through the topographical character of Dhaka. But insensitive policies, Flood Action Plans (FAP) and rapid urbanization together destroyed the natural course causing floods followed by severe waterlog for 4-5 days. 85% of the city (depth .3 to 4.5 m) was inundated during 1988 (JICA, 1991 and 1992). After the completion of FAP in 1998, almost 56% and in 2004 50% of the city was inundated (Alam, 2003). Land development through landfilling processes in the low-lying areas is causing a drastic reduction in water storage. Construction of embankments through low-lying areas without providing adequate drainage facilities has caused internal flooding adversely affecting the residents in those areas (Alam, 2003).

2.2.2. Groundwater Depletion and Earthquake Vulnerability

Dhaka currently relies on groundwater to meet the need for safe water with approximately 80-90% of it coming from this source solely. Dhaka Water Supply Authority (DWASA) is extracting more than 1800 ML/d of groundwater. However, the estimated sustainable and safe extraction is approximately a conservative figure of 600 ML/d (DWASA, 2011). As a result, earthquakes could strike the city as the groundwater table is going down 2-3 meters gradually due to a massive withdrawal of the water (Dhaka Mirror, 2012). If the rate of the discharge continues the groundwater level will go below 80m in some major parts causing major ecological problems (IWM & BADC, 2009).

2.2.3. Traffic Congestion

In the last 10 years, the average traffic speed in the capital has dropped from 21 km/hr to 7 km/hr which is slightly above the average walking speed, according to a report published by the World Bank. The traffic congestion in Dhaka eats up 3.2 million working hours per day. Opinions from experts illustrate that traffic jams could be abridged significantly with some low-budget projects such as introducing water transport facilities or coherence between the strategic transportation plans. Although Mass Rapid Transit will improve the scenario, integrating alternate modes of transport with an easier and simpler construction process is also mandatory for an effective outcome.

2.2.4. Climate Change

The city is less than three meters above sea level and many of the city's slums and informal settlements are located in the areas assigned for flood drainage which are exposed to chronic waterlogging. Specialists predict that river flooding and monsoon rains will become more frequent and intense due to human-induced climate change, putting extra pressure on flood prevention and drainage infrastructure. It will also cause heavy storms and erratic temperatures. Dhaka has recently recorded its highest temperature of 42.3 degrees Celsius.

2.2.4. Physical Survey

Through studying historical maps, sewerage maps, GIS maps, and data, two distinct continuous connection of canals have been traced inside Dhaka. The shorter one stretching from west (*Buriganga* river) to east (*Balu* river) and the longer one from the south-west (*Buriganga* River) to north (*Turag* river). Both of these connections crisscrossed the city but have lost their course by the time. The longer connection can be predicted to create bigger impact in the city. Along the selected route, three physical surveys were carried out thoroughly both in dry (February and March) and wet (August) seasons in different parts of Dhaka. The city, along its north-south axis, was divided into 9 zones which were then surveyed for 12 days in total (Figure 4).

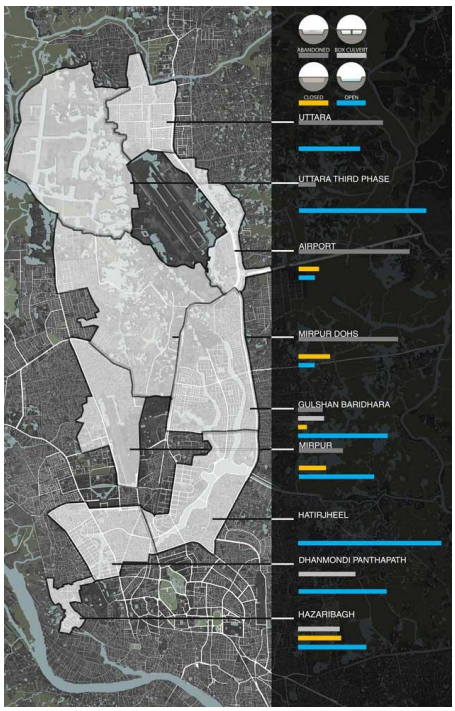


Figure 4, Survey results in 9 zones throughout Dhaka. *(Source: Author)*

The survey shows that a large portion of Dhaka's core area is restricted by Military bases and two airports. In the south-west portion, most of the canals have been converted to box culvert. In northern region the wetlands have been filled with sand to meet future housing needs. The large waterbodies in *Hatirjheel* and *Gulshan* lake at the centre works like the blue heart of the city. In the surveyed zones,

12% of the water channels have been closed with box culverts, with 32% abandoned due to negligence or encroachment and 56% still open having adequate flow of water (Figure 4). But, all the canals carry sewerage water for which the water quality is very poor and is unable to create impact around. In some cases, the channel is open but inaccessible due to inappropriate planning, mistreating the canals as back and neglecting the space throwing wastes due to lack of ownership and maintenance.

2.3. STUDY OF POLICIES

From the birth of Bangladesh in 1971, several strategies and policies to protect the canals and wetlands have been taken by the Government and its concerned authorities like Dhaka City Corporations, DWASA, Water Development Board, etc. In 1992, DMDP (Dhaka Metropolitan Development Plan) proposed control of land development within designated flood plain areas in order to avoid obstructions of water flow. Flood Retention areas were designated in order to ensure that they remain capable of fulfilling their primary function of water storage at times of flooding. But, similar strategic proposals at different times have always failed to retain the wetlands of the Dhaka Metropolitan Area due to corruption and poor administration.

Flood Action Plans [FAP 2 and FAP 8] in 1988 and 1992 proposed box culverts covering the canals in the city and dikes with pump stations beside the rivers to create roads and get rid of external flooding from rivers. Though it reduced external flooding to some extent but has incurred a potential threat for Dhaka. Little rainfall can often be the cause of the internal flood, because of which people of low-lying areas get stuck for several days damaging the lifestyle, economy, household and other infrastructures.

Structural Plan 2016-2035 shed some limelight to retain the waterbodies by providing some legit guidelines along with typical policies. But, the plan is still in a draft phase waiting to be approved for more than 5 years now. It proposed a blue-core at the centre of the city connecting Dhanmondi Lake, Hatirjheel, Gulshan-Baridhara Lake and a sub-blue-core in the north-west part of the city.

2.4. DELINEATION OF THE PROPOSAL

The whole city was surveyed several times to find the best possible route for the connection. Though 67% of the wetlands have already been converted to build entities but the current hydrological map extracted from GIS shed limelight to this research.

Three possible routes were identified starting from the south-west portion named *Hazaribagh* area to *Abdullahpur* area at north of Dhaka. Each of the routes was then surveyed again to identify the obstacles in the plausible route (Figure 5).

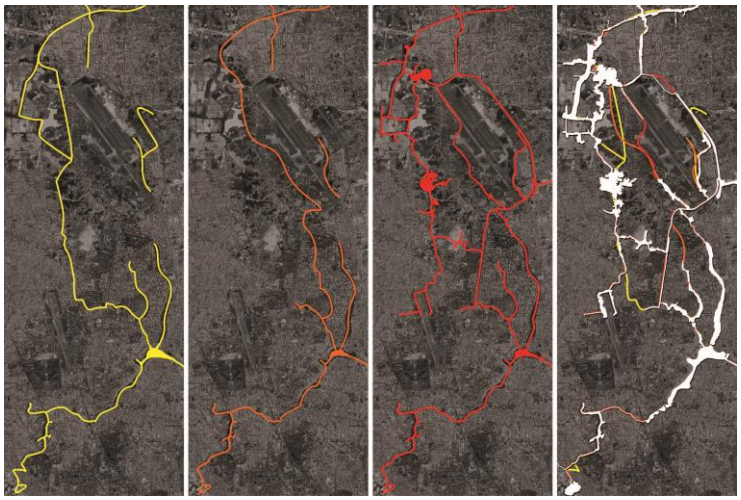


Figure 5, Possible water connections and superimposed scenario. *(Source: Author)*

Finally, from the superimposed routes a continuous connection is selected having the least interruption in the existing setting. Major demolition has to be done in Panthapath box culvert and government staff quarters at the *Chairmanbari* area. The final route is being termed as '*The Grand Canal*'. The Grand Canal is proposed to be approximately 35 km long. This is deemed as the most feasible option with minimum demolition and construction, having two branches and chunks of retention areas. The proposed canal starts from *Hazaribagh Bai* lane. The route is as follows:

Branch A: (Southwest) *Buriganga River* > *Hazaribagh Bai Lane* > *Hazaribagh Box Culvert* > *Tannery Area* > *Pilkhana Area* > *Dhanmondi Lake* > *Russel Square* > *Panthapath Box Culvert* > *Hatirjheel* > *Banani Lake* > *Karail* > *Chairman Bari* > *Airport Road* > *Nirjhar R/A* > *Matikata* > *Shaheen Lake* > *Uttara 3rd Phase* > *Abdullahpur* > *Turag* (North)

Branch B: (Southwest) *Buriganga River* > *Hazaribagh Box Culvert* > *Dhanmondi Lake* > *Panthapath Box Culvert* > *Hatirjheel*> *Gulshan Lake* > *Gudaraghat* > *Kalachandpur Road* > *Baridhara DOHS* > *Airport Road* > *Airport Area* > *Uttara Sector 1* > *Uttara Model Town* > *Abdullahpur* > *Turag* (North)

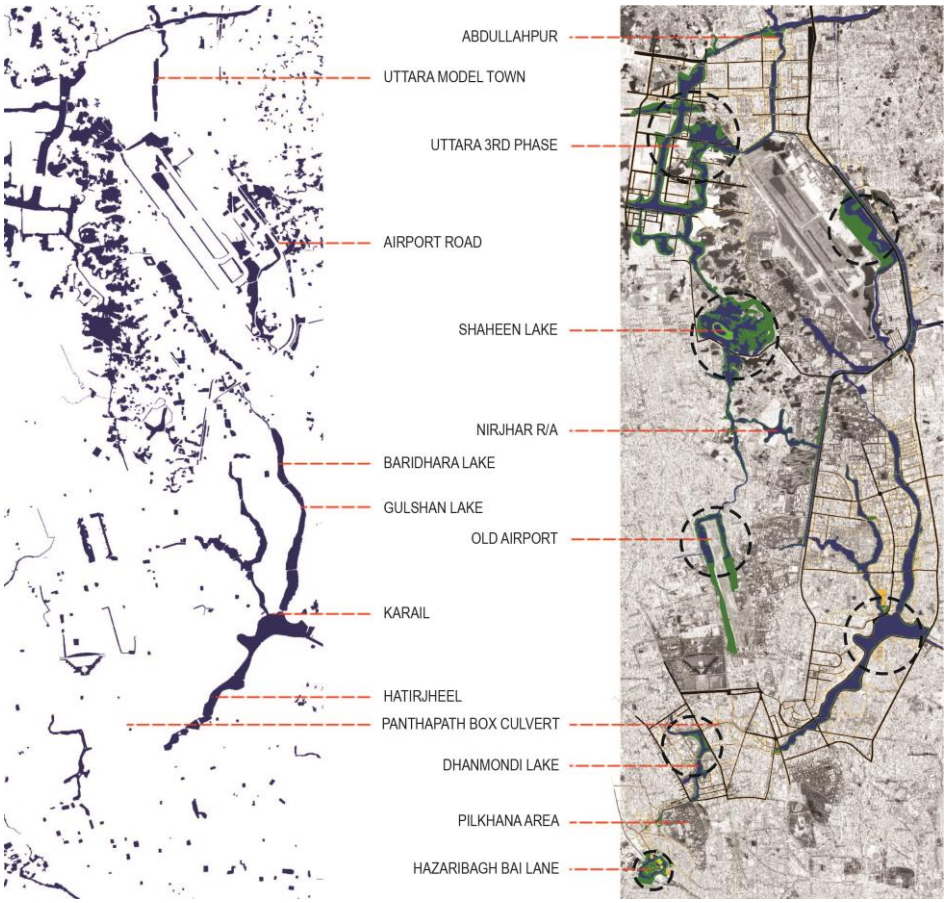


Figure 6, Existing and Proposed Water Profile (*Source: Author*)

4. Conclusion

Rigorous studies and meticulous surveys have set a strong backbone for the given proposal. *'The Grand Canal'* will function as an influential phenomenon for future growth and development policies of Dhaka. It will reduce traffic pressure on existing roads significantly, reduce temperature up to 4-5 degrees, minimize the impact of climate change, enhance quality of habitat for dwellers as well as for other species, reduce waterlogging, eliminate adverse effect of waterlog, recharge more groundwater, provide adequate recreational areas and facilitate the city with so many other benefits that we cannot even

imagine. This proposition could be implemented jointly by city authorities such as RAJUK, DWASA, DNCC, and DSCC, as per their best interests, and to the best interests of their citizens.

No matter what it costs – time, money or life – we are building layers of concrete flyovers through densely populated residential areas, elevated expressways filling up water bodies, MRT vanishing all the trees in the median of the city, BRT causing much congestion, new roads demolishing buildings and private lands, new residential and CBD areas filling all the wetlands, strong promenades, and dikes to protect so-called highlands. On the contrary, this research shows the path for a much easier, feasible and ecological solution. This masterplan is proposed only with the requirement of demolishing a few box culverts, some tannery industries in *Hazaribagh*, four government buildings at *Chairmanbari* area and a partial demolition in some congested areas like *Panthapath* and *Uttara Sector 1*. It is constructible with lower cost, time and hustle than the development plans we are currently executing. This study could be useful for city authorities, urban designers and researchers and could pave the way for further research on the urban ecology of Dhaka. We have been destroying our city for a long time now. It needs some time to get cured. Let's invite nature, the root to lead this process. Let's start to believe a liveable city like it was before. Let nature take place here. Let the channels flow.

5. Acknowledgements

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PERSONALITY TRAITS OF SINHALA FONTS ON ROAD INFORMATIVE SIGN BOARDS: ON READERS' PREFERENCES TEST

SHYANIKA ERAMUDUGOLLA[1] & SUMANTHRI SAMARAWICKRAMA[2]
[1,2]Department of Integrated Design, Faculty of Architecture, University of Moratuwa, Sri Lanka
[1]*shyanikaeramudugolla01@gmail.com,* [2]*sumanthris@uom.lk*

Abstract
Sri Lanka is a multi-lingual country and Sinhala, Tamil and English languages are used for communication purposes such as advertising, packaging and wayfinding etc. Among those communication tools, road signs help to keep road safety and efficiency. Road signs communicate important information about road safety, through type and symbols. Therefore message on road signs should be impressed to road user within very short time period. Hence high legible typefaces are used for road signs as well as type personality helps to recognise words easily. Therefore, this research focuses on the font personality of Sinhala typefaces in road informative signboards. Existing Sinhala typeface in road informative signboards is DL-Araliya and it was designed for print-based materials. Throughout the literature review based on type personality based on Latin script, personality traits were loaned from Latin road signboards: fast readable, unique, individual, short, heavy, fashionable, classic and solid. The stimuli were completed with adjective pairs of each personality trait. Also, a name of an unknown city in Sri Lanka included being a mark on a Likert scale. Six sample typefaces with similar anatomical features were selected for Tinker user preference test. The sample group consisted of individuals familiar with Sinhala typefaces on road informative signboards in Sri Lanka. The group was asked to mark their preference on the stimuli and the results were analysed with a mean value of each personality trait. In conclusion, the research proved that each Sinhala font had its own personality. FM-Ganganee was identified as the most appropriate font that has the required personality for road informative signboards.

Keywords: *Readers' preference test, Sinhala font, Informative signboards*

1. Introduction

Sri Lankans are used to communicate Sinhala, Tamil and English languages. Also, three different scripts are used to communicate those languages. Sinhala language communicates through Sinhala script, English script communicates through Latin script and Tamil language communicates through Devanagari script. Those three scripts composed on packaging, advertising signs, road signs, etc. among those communication tools, road signs are important to keep road safety and efficiency on road. Therefore three scripts are important to convey messages on road signs. For this manner, type personality plays important role to identify distance and destination on road informative signboards within very short time period, while drivers operate vehicles.

Three different scripts communicate through three different typefaces on road signs in Sri Lanka. Sinhala typeface is DL Araliya, Tamil typeface is Kalaham and English typefaces are Highway English and Clear view font (Interview Sudath RDA, 2018). Scripts display on road signs should be high legible and also should have required type personality to recognise the destination within very short time period. Shaikh, 2006 cited type personality and legibility are important factors to communication purposes (Lewis and Walker, 1989; Shaikh, 2006).

Miles Tinker, legibility and typography researcher was introduced reader's preference test to recognize type personality (Sofie, 2012). According to background research and literature survey based on road informative signboards in Sri Lanka, it was identified Sinhala typeface display on those boards had not design base on reader's opinion or aesthetic characteristics of Sinhala typeface.

2. Background

2.1 FONT PERSONALITY

"The persona of typeface and text" is the typeface personality and it gives the tone for a document (Brumberger, 2003). Also, the typeface persona builds through the unique features of typefaces.

“Typeface can convey mood, attitude and tone” (Brumberger, 2003). Also the typeface persona builds through unique features of typeface. Shaikh and Brumberger state that “Typeface can convey mood, attitude, and tone” (Brumberger, 2003; Shaikh *et al*, 2006). Type personality and its style give linguistically primary meaning and first impression of written word (Lewis and Walker, 1989; Shaikh, 2006). Hyndaman explains in 2016 that a word can easily be recognised based on reader’s preference and also Lacher explains in 2010; Type personality helps to identify words. Display typefaces on road signs should be clear, neutral and be highly readable from a certain distance. Clear view typeface, Frutiger and Helvetica are used for Airport signage, also display typeface on road signboards should be short, fat and simple (Smiley, 2006). Typefaces display in supermarkets need to be aesthetic, neat, clean and stylish. It helps to interaction with consumers’ buying behavioural experience inside the supermarket (Hyndman, 2016). Information on road sign boards, directly communicates vehicle drivers, therefore typeface on-road signboards should be created according to driver’s preference and requirements (Stevens, et al, 2002).

Literature survey based on type persona, it explains that typeface personality directly execute the meaning of the text. Typeface personality is based on letter features and style of typeface since it depends on the context of type display. Type personality depends on reader’s perspective, such as aesthetic sense, physical and psychological interactions. The research discusses the type personality of Sinhala typefaces and the user’s response.

Through the background research it was identified that the existing typeface on Road Informative Sign Boards is DL-Araliya and it was designed for print-based materials. Therefore research objective is to identify reader’s preference on the aesthetic characteristics of Sinhala typefaces used in road informative signboards.

2.2 ROAD INFORMATIVE SIGN BOARDS IN SRI LANKA

Traffic control devices keep road safety and road efficient in a suitable manner. According to the Road Development Authority, traffic control devices are categorised such as traffic signs, road markings and traffic signals; it shows figure 01.

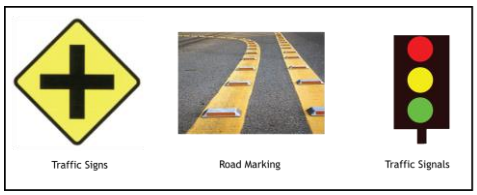


Figure 1, Categorisation of traffic control devices

Traffic control devices standardised according to its shape, size, and colour. Road signs, among traffic control devices, classified into three main categories, such as danger warning signs, regulatory signs, and informative signs it explains table 01 (Ministry of Highways and Road Development and Road Development Authority, 2017).

Road informative signboards composed with three scripts; Sinhala, Tamil, and English, arrowheads, numerals and icons. Also, it used in both highway and expressway in Sri Lanka. Direction communicates through numerals and three scripts; destination communicates through arrowheads on road informative signboards. White scripts on a blue background are used for RISB in expressways and green background is used for RISB in highways (explains in figure 02). RISBs layouts are composed on reflective sheeting material (Premium micro prismatic) (Interview Sudath RDA, 2018).

Table 1, Categorisation of road informative sign boards

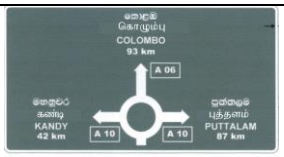
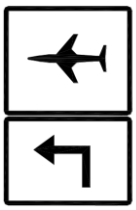
Type of RISB	Content and composition of RISB	Image (example)
1. Advanced direction sign	• Destination name written in Sinhala, Tamil and English. • Letter height - 75mm-150mm • Map type- layout with pointed arrowhead towards destination • Stack type- gives direction and destinations stacked one on top of the other	
2. Direction signs	• Direction of the destination showed with pointed arrowhead	
3. Overhead mounted direction signs	• Letter height – 200mm-300mm	
4. Direction sign for expressways	• Blue background with white text • Letter height -175mm	
5. Direction symbols	• Indicates the direction with a symbol	
6. Place identification signs	• Shows the boundary between two administrative districts	
7. Confirmatory signs	• Gives Information on major towns with distance	
8. Special regulation signs	• Gives information about traffic arrangement	
9. Route number signs	• Indicates the road number/s	
10. Service facilities signs	• Indicate special facilities on location	

Figure 2, Road informative sign board on express way and highway

3. Method

1. Most of legibility and type personality research and tests had done for Latin scripts. Therefore Primary data is collected throughout literature survey based on Latin scripts. Also Latin, Devanagari and Sinhala scripts display together on RISB in Sri Lanka therefore three scripts should have same personality also road users want to recognise those scripts within very short time period. Then identified personality traits based on Latin script on international road signboards throughout literature survey (There are no researches base on Sinhala script and Devanagari script). This section is elaborated in section 3.1 and
2. Throughout the literature, it was identify type personality depends on visual properties of letters. Throughout the interview had with Deputy General Road Planning division in RDA it was identifies existing font used on RISB is DL-Araliya therefore selected six Sinhala typefaces based on visual properties of existing Sinhala font (DL-Araliya) on road informative signboards. Also features of six selected typefaces are different from each other. It is elaborated in section 3.3.
3. Conducted a survey to identify eight personality traits of selected six Sinhala typefaces based on readers' preferences. (Participants were marked their preference on stimuli with Likert scale). Selected eight personality traits were identified throughout the literature survey based on Latin scripts, those research were conducted by Hydman, Smiley and Lund.
4. Data was analysed based mean value of readers' preferences for selected six fonts and identified which font have specific personality traits for RISB also different personalities of each font.

3.1 SCOPE AND LIMITATION

Type personality is directly impacted on visual properties of typeface. Therefore throughout this type personality test for RISB in Sri Lanka it can be identified what type of typeface required by road users also it can be used for identified visual properties of required typeface for RISB. This research paper only discuss about the required Sinhala typeface personality for RISB based on Tinker's readers' preferences test.

3.2 RESEARCH BASED ON TYPE PERSONALITY

Tinker's typeface personality test

Tinker was conducted research to identify; how an aesthetic value or page arrangement does impact on ease and reading speed. To fill this gap he did a comprehensive study on reader preferences on different typographical arrangements. The typographical arrangements were lowercase and upper case letters, styles of typefaces, combinations of coloured print and colour papers, paper layout such as on leading, size of type, line width, paper surface and quality, lowercase verses italics, a simultaneous variation of line width and the line between column alignments.

In this experiment, participants were asked to arrange stimuli in order from most legible to least legible. Stimuli were prepared with five paragraphs printed in 10 pt. Scotch Roman letters. Throughout this research Tinker was found the effectiveness of value on aesthetic printing arrangements was greater than the efficiency of printing specifications (Tinker and Paterson, 1942).

Sofie Beier's typeface personality test

Throughout Tinker's preference test, Sofie Beier has conducted research to "understand the reader's experience in a given reading situation. She was explained when design a display typeface, it is important to know reader's opinion and motivation.

She was conducted a research to test the above mentioned objective, therefore participants were asked to rank their own preferences on adjective aesthetic value of typefaces (figure 3) (Beier, 2012).

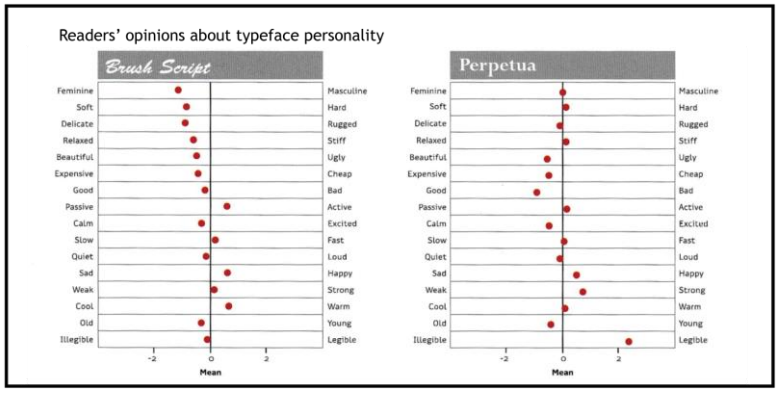


Figure 3, Readers' opinions about typeface personality (Sofie Beier, 2012)

Hydman's typeface personality test

Hydman was conducted an experiment to understand that "typefaces have uniquely different personality and questions if there is a significant arrangement within different personality types?" for this experiment, participants marked their preference rank on personality traits of 25 regularly used typefaces. It showed results as "typefaces do have uniquely different personalities and that they do significantly agree on the personality types" results explain table 2 (Hydman, 2016).

Table 2, Personality of selected typefaces (Hydman, 2016)

Typeface	Personality
Bodoni poster	Performer, Confident and dramatic
Comic Sans	Comedian, friendly and novelty
Times New Roman	Intellectual, confident and neutral
Helvetica	Everyman, conventional and neutral
Baskerville	Intellectual, traditional and neutral
Georgia	Intellectual, dependable and classic

Shaikh's typeface personality test

Shaikh and team conducted an experiment to determine whether or not participants consistently attribute personality traits to a variety of fonts presented on-screen; they used 20 font samples for this test. It used 15 personality adjective pairs based on 4 point Likert scale as shows in figure 4. Also, result shows in table 3, it explains the relationship between font factor and personality (Shaikh *et al*, 2006)

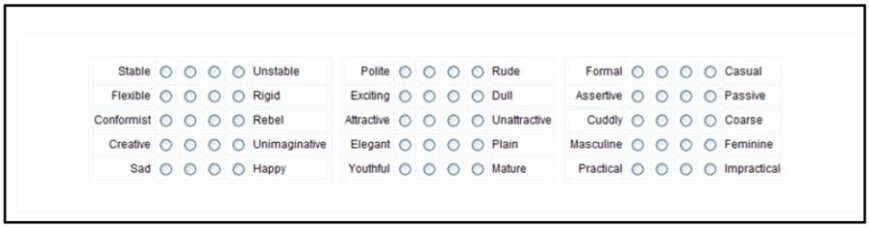


Figure 4, 15 personality adjective pairs based on a 4 point Likert scale (Shaikh, Chaparro and Fox, 2006)

Table 3, relationship between font factor and personality (Shaikh *et al* 2006)

Font factor	Personality
Script/ funny fonts	Youthful, happy, creative, rebellious, feminine, causal and cuddly
Serif fonts	More stable, practical, mature and formal
Modern display fonts	Masculine, assertive, rude, sad and coarse
Monospaces	Dull, plain, unimaginative and conforming
San serif fonts	Did not score extremely high or low on any personality traits

Throughout different personality tests based on Latin scripts, it was guided to conduct a personality test base on Sinhala fonts. Also, identify different fonts has different personality traits according to different purposes. Therefore it is important to identify personality traits for road signs.

Personality traits for the test

Hyndman explains personality traits of font on road signs should be traditional, professional, confident values, practical and the style to be classic (Hyndman, 2016). Also Smiley explains font on road signs need to be short, fat, simple and fast readable (Smiley, 2006). In the public debate on Jock Kinneir's road sign alphabet, Andorson's report on traffic signs for motorways explains font on road boards should have unique individual personalities. Herber Spencer, a designer to a government committee, explains personality traits for road sign alphabet to be of taste, tradition, relevance, fashionable and heavy (Lund, 2003).

Results base on those researches for Latin scripts it was identified specific personality traits for font on road signs, therefore those traits to be used in Sinhala font on road sign in Sri Lanka.

3.3 SELECTION ADJECTIVE PAIRS FOR PERSONALITY TRAITS TO TEST

Most readable (fast readable)-least readable(slow readable), most unique- least unique (common), most individual-least individual(group), most tall- least tall(short), most heavy- least heavy(light), most fashionable-least fashionable (unfashionable), most modern- least modern (classic) and most solid- least solid (void).

3.4 SELECTION OF SINHALA FONT TO TEST

Samarawickrama cited base on the anatomical features of Sinhala fonts it is categorised into two types such as monolinear and modulated (Samarawickrama , 2016). Existing font used for Sri Lankan road sign is DL-Araliya. Other fonts were selected according to the features of DL-Araliya font. Therefore selected six fonts have same features such as monolinear, contains solid flesh with a high grey value, non- contract font. Also, have vertical and horizontal terminals and omitted iris eyes with open and closed counters. It explains figure 5.

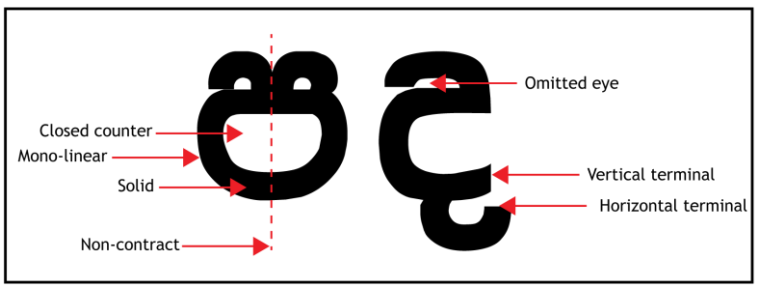


Figure 5, Visual features of DL-Araliya

Therefore selected five fonts are Anuradhapura, Amalee KH, FM-Malithi, FM-Ganganee, FM-Gemunu and DL-Araliya shows in figure 6.

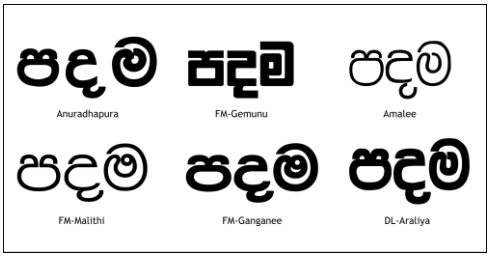


Figure6, Selected font for the experiment

Stimuli

Six stimuli cards were prepared for each selected six fonts. Each card composed with a same name of an unfamiliar city in Sri Lanka. It was printed in white on a black colour background. The personality traits were placed on either side to the Likert scale. Sample stimuli show figure 7 with the left side indicates least and the right side indicates most desired adjective pairs of personality test for Sinhala font on road signs.

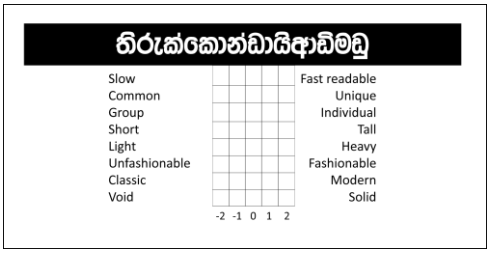


Figure7, Sample stimuli

3.5 PARTICIPANTS

60 participants who familiar with Sinhala font display on road informative signboards in Sri Lanka were selected for the test. Each participant was given six different stimuli and marked on the Likert scale, according to their preference for 8 personality traits either side.

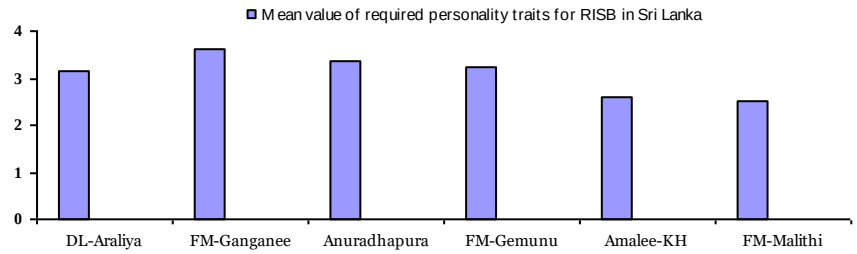
4. The result and analysis

Results were analysed based on participants' preferences marked on Likert scale. Each adjective pair got a number with a value of 1 to 5. Mean value of each personality trait on selected six font was calculated. If the mean value was greater than or equal to three (>=3) that trait categorised as 'most'. If the mean value was less than three (<3) that trait categorised as 'least'. According to the calculation, specific personality traits were identified for each selected fonts, it explains in table 4.

Table 4, Personality traits for each selected fonts

Font Name	Identified Personality Traits for RISB
DL- Araliya	Most readable, Most common, Least individual, Least short, Most heavy, Least fashionable, Most classic, Most solid
FM-Ganganee	Most readable, Most unique, Least individual, Most short, Most heavy, Most fashionable, Most classic, Most solid
Anuradhapura	Most readable, Most unique, Most individual, Most short, Most heavy, Most fashionable, Least classic, Most solid
FM-Gemunu	Least readable, Most unique, Least individual, Least short, Most heavy, Most fashionable, Least classic, Most solid
Amalee KH	Least readable, Most unique, Most individual, Least short, Least heavy, Most fashionable, Least classic, Least solid
FM-Malithi	Least readable, Most common, Least individual, Least short, Least heavy, Least fashionable, Most classic, Least solid

Among those personality traits on selected fonts, data analysed to identify which font was achieved required personality traits for road signs in Sri Lanka. Therefore the mean value of required personality traits on each font was calculated. Results show FM-Ganganee has the most significant personality traits for Sinhala display font on-road information signboards in Sri Lanka. Graph 01 shows it.



Graph01, Mean value of required personality traits on each font

5. Conclusion

The experiment proved different fonts have unique personality traits throughout reader's perspective. The research identified required personality traits for RISB were fast readable, unique, individual, short, heavy, fashionable, classic and solid.

FM-Ganganee, Anuradhapura and FM-Gemunu have significant characteristics for RISB in Sri Lanka. While the existing font used RISB is DL-Araliya ranked fourth. Also, research proved the micro context of a font personality is anatomical features of a font.

6. Recommendations

When creating a best Sinhala font for RISB in Sri Lanka, typeface designers should be highly concerned overall study of atomic features of Sinhala letters and anatomical features of FM-Ganganee, Anuradhapura, FM-Gemunu and DL-Araliya fonts.

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