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Envisaging Built Environments: Planning, Designing and Building for tomorrow

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Faculty of Architecture Research Unit
University of Moratuwa
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Journal Editor

Dr. Jagath Munasinghe

Technical Coordinator

AMS Attanayake

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Editor's Note

It is with great pleasure that I pen down these few words for the seventh annual research symposium of the Faculty of Architecture. On behalf of the Faculty of Architecture Research Unit (FARU), I congratulate all those who have received the opportunity to present their work at the FARU International Research Symposium 2013.

The aim of this symposium is to open up a forum for a wide range of research and scholarly work from the disciplines of Architecture, Building Sciences, Environmental Design, Engineering, Facilities Management, Landscape, Product Design, Project Management, Technology and Planning. In order to keep the symposium open for such a variety of disciplines and to address current developments in those disciplines the theme 'Envisioning Built Environments: Planning, Designing and Building for Tomorrow' has been selected. We are pleased to note that nearly forty interesting research papers have been selected for presentation and publication and the symposium is privileged to have the keynote address delivered by Professor Fergus Nicol, renowned for his work on sustainable built environment research, which has high relevance to the theme of the symposium.

The emerging city at the South of Sri Lanka-Hambanthota has been selected for the symposium and I sincerely believe that the developments going on at a rapid pace will be leaving many matters for discussions for all participants. I also believe that the event will be graced by many enlightening presentations and discussions. All those who were behind the success of the event, including the academic and non academic staff of the Faculty of Architecture, Members of the Scientific Committee, event sponsors and those who provided support and words of encouragement are remembered with gratitude at this occasion.

Dr. Jagath Munasinghe
Director, Faculty of Architecture Research Unit
Faculty of Architecture
University of Moratuwa
Sri Lanka

Message from the Dean, Faculty of Architecture

It is a great pleasure for me to have the opportunity to write this message for the seventh research symposium of the Faculty of Architecture Research Unit (FARU), University of Moratuwa. The research culture in the Faculty of Architecture has been growing over the years and faculty has acquired recognition through teaching, research and consultancies. Research activities are carried out at three levels; i.e. Faculty level, Department level and Individual level. Major mode of presenting research carried at Faculty level is to hold the annual research conference on a theme related to built environment. It has been decided by the Faculty to hold an International Symposium similarly to the previous years to provide a platform for wider range of research and scholarly work carried out by local and international researchers and practitioners who are involved in Architecture, Building Sciences, Environmental Design, Engineering, Facilities Management, Landscape architecture, Product design, Project Management Technology and Planning.

The theme of this year's symposium is the "Envisaging Built Environments: Planning, Designing and building for tomorrow." As a result of the rapid change in built environment, which had been emerged during the last quarter of the twentieth century, most of the countries have experienced challenges to manage their built environments. The prominent issues of this trend includes the loss of identities of places and the socio-cultural inferences, over emphasis on technology and communication, imbalances on natural systems and resultant natural disasters, failure to adapt for climate change, interference of politics and lack of good governance and national and global economic crises. It is important to address these issues at a greater depth in order to bring out the intellectual discourse at this symposium. It will also deliberate on the emerging issues related to the built environment and outline the future directions to create a sustainable built environment we live in.

In this context, FARU 2013, the seventh annual research symposium of the Faculty of Architecture Research Unit (FARU) of the University of Moratuwa, Sri Lanka intends to open up a forum for a wider range of research and scholarly work on the latest advancements of all future oriented disciplines including Architecture, Building Economics, Construction, Environmental Planning, Facilities Management, Landscape Design, Product and Fashion Design, Project Management, Technology, Urban Planning and Urban Design. A wider participation of both local and international research scholars and practitioners with high level of contribution, in the form of presenting papers and attending intellectual discussions is expected.

I am sure that Faculty of Architecture Research symposium 2013 would be an important milestone to expand the prospect of research carried out by the staff and students of our faculty.

I wish FARU Symposium 2013 all success.

Prof. P.K.S. Mahanama
Dean, Faculty of Architecture
University of Moratuwa
Sri Lanka

List of Paper Reviewers for FARU 2013

1. Dr. Angelique Chettiaram, University of Reading, UK
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3. Dr. Farida Nelufer, Bangladesh University of Engineering & Technology,
Bangladesh
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A Sustainable Road Construction Material for Low Volume Roads

W. K. Mampearachchi

Senior Lecturer, Department of Civil Engineering, University of Moratuwa, Sri Lanka
wk.mampearachchi@gmail.com

M. M. D. V. Gunatilake

Postgraduate Research Student, Department of Civil Engineering, University of Moratuwa, Sri Lanka, dhanuvida@yahoo.com

Abstract

The need of spending highway investments more efficiently is greater than ever before, due to escalation of prices of the conventional paving materials (asphalt, concrete). Hence, the road designers are in the verge of using alternative materials for the road construction which brings sustainable living conditions. Thus, focus has been on “Concrete Block Paving (CBP)”, a road construction methodology which is based on ancient road construction technology “Stone Paving”. In general, the applications of CBP are categorized according to the traffic condition as non-traffic, light traffic, medium traffic and heavy & very heavy traffic. The results of the study indicate that the life cycle cost of CBP is lower than the other paving materials although the initial construction cost is slightly high. When the performance of the three types of paving materials are evaluated, in addition to the low life cycle cost, the ability of accommodating and maintaining utility services, thermal comfort, aesthetic appearance and environmentally friendly behaviour can be highlighted as the key advantages of CBP.

Keywords: Concrete Block Paving (CBP), Interlocking mechanism, Sustainable road construction materials

Introduction

The past century has revealed an intense process of urbanization which has resulted rapid construction of roads and the infrastructure development. Different materials have been used for the road surfacing in these rapidly constructed roads, since the surface of the road should have the strength to withstand the vehicle load and resistance to wearing. Meanwhile, it should be durable.

Asphalt is the road surfacing material which is widely used in every type of road. The viscous nature of the bitumen binder allows asphalt to withstand a certain amount of plastic deformation, although it is possible for fatigue failure due to repeated loading for a longer duration.

Eventually, concrete also became a widespread road surfacing material for road construction. Concrete surfaces are created using a mix of cement, sand, coarse aggregates and water. Concrete roads became popular due to the higher strength and durability than asphalt roads. Higher construction cost could be stated as a drawback of this construction method.

Since the demand for road and infrastructure increased, it exposed the world to innovative construction methods which economize construction and increase durability. Thus, Concrete Block Paving (CBP) which is based on ancient road construction technology “Stone Paving” has been discovered as a better alternative than other conventional paving materials which have a lesser durability.

Objectives

The objectives of the study can be listed as follows:

1. Identification of the most economical paving material by considering the life cycle cost of several paving materials.
2. Performance evaluation of the selected paving materials.

Construction techniques

The three types of road surfacing materials mentioned above have different construction techniques.

Asphalt paving

Hot Mix Asphalt (HMA), generally known as asphalt concrete is a mix of aggregates with bitumen as the binding agent. It is produced at the HMA plant and delivered to the construction site by trucks. HMA which is transferred to the paver by the truck is spread as the surfacing material on the base layer constructed on sub base and sub grade. Compaction of the paved asphalt using different types of rollers is carried out consecutively (Gnasekaran, 2010).

Concrete paving

Concrete mix produced according to the required proportions of materials is poured on prepared base or sub base or sub grade depending on the design. Contraction and expansion joints are essential in concrete pavements in frequent interval to accommodate drying shrinkage and thermal stresses of concrete. Reinforcement is required to construct joint free concrete pavement and cost of reinforced concrete is significantly high compared to the plane concrete pavement (Karunaratne, 2011). After compaction of the paved concrete, it is left for the process of curing in order to gain strength.

Concrete block paving

Concrete Block Pavement consists of individual blocks of brick size arranged closely with joint space filled with sand on a bed of sand. The horizontal movement of blocks is constrained by the edge supports (curbs, etc.) The whole structure is supported by the sub base and sub grade. The load applied on the road surface is transferred horizontally to the substructure of the pavement. Hence, the interaction between the blocks, sand joints and support conditions are important (Concrete manufacturing Association, 2004).

Challenges in rural road construction

Many challenges have arisen in rural road construction due to various reasons such as insufficient funding, lack of proper construction technology and skilled labour, need of utility services due to urbanization.

Since the process of allocation of money for provincial level tasks from the central government varies due to different reasons as political influences funding may be insufficient to perform the required development in the area. In case of the technology used for construction, contractors in rural areas may not be aware of the proper techniques that should be adopted for road construction. They may not have sufficient skilled labour to work under them.

Once the construction of roads is completed, due to rapid urbanization, demand for infrastructure increases. Thus, there is a need to provide space for utility services such as water supply services and telephone services. In such situations, digging of constructed roads will be the only solution to accommodate utility services if it was not a consideration at the design stage of the roads. As a result, the stability and the durability of the road pavement are affected because the reconstruction of damaged locations would not take place afterwards.

Hence it is a necessity to introduce road construction methods other than the conventional methods which minimize the above mentioned complications.

However in the current state, the road surfacing material is selected arbitrarily by the road agencies in the provincial sector and life cycle cost is not considered in making decisions.

Cost comparison of alternatives

The life cycle costs of the three surfacing materials mentioned above (asphalt, concrete, CBP) were studied and the most economical paving material was identified.

Two major cost components are associated with road construction; initial cost and maintenance cost. Initial cost is mainly the construction cost of the road pavement. The cost due to the maintenance of the road surface is maintenance cost (Mamperachchi, Kosgolla, 2011). In each of the road pavement material, above two aspects were considered and the Net Present Value (NPV) per square meter for a design period of 20 years was calculated.

Net Present Value (NPV)

NPV technique recognizes the time value of money. The initial cost takes place in the year zero. The annual cost from the year zero to 'n' must be discounted to find the zero year value of such annual cost. The following equation is used to estimate the present worth of each annual cost.

$$NPV = \sum \frac{A_i}{(1+i)^n}$$

Where A_i – cost in i^{th} year
 i – Discounting factor
 P – Life cycle cost

Discounting factor

The value of money changes due to the effects of inflation and interest rate. Based on several economic parameters the discounting rate should be estimated. The discounting factor changes with the inflation and interest rate.

The mathematical relationship for discounting factor (i) is shown below.

$$i = \frac{(1+e)}{(1+d)} - 1$$

Where i – discount rate
 e – Interest rate
 d – Inflation rate

Interest rate – 10 % (Considering 10 previous years: Central Bank of Sri Lanka)

Inflation rate – 7 % (Considering 10 previous years: Department of Census and Statistics)

Therefore, **discounting rate (i) = 2.8 %**

Asphalt paving

Cost break down and the calculated unit cost for the construction of a typical asphalt pavement are shown in Table 1. Initial construction cost (Rs. 2554.83) is inclusive of the sub grade preparation cost, sub base, base and sub grade construction cost, costs for the application of the prime coat & the tack coat and the asphalt surfacing cost. Pothole patching, slurry sealing, crack sealing etc. are considered for the maintenance cost (Rs. 127.74) once in 2 years. In addition, resurfacing of the pavement is done once in 8 years. Application of tack coat, laying of asphalt and slight repairs of the base layer (about 5% of the initially constructed base) is considered in

this. The user cost due to additional maintenance activities is neglected in the calculations. Even if it was considered, the obtained unit cost would be higher.

Table 1: Cost break down of asphalt pavement construction

Description	Qty	Unit cost	Cost
Sub grade preparation	0.15 m ³	566.15	84.92
Construction of sub base	0.1 m ³	920.29	92.03
Construction of aggregate base course	0.15 m ³	4,525.24	678.79
Application of prime coat	1 m ²	195.24	195.24
Application of tack coat	1 m ²	52.41	52.41
Asphalt laying - 50 mm)	1 m ²	1,161.15	1,451.44
Total Initial cost			2,554.83
Maintenance once in 2 years (5%)			127.74
Resurfacing once in 8 years			1,571.73

The cash flow for the construction of an asphalt pavement for a 20 year design period is shown below.

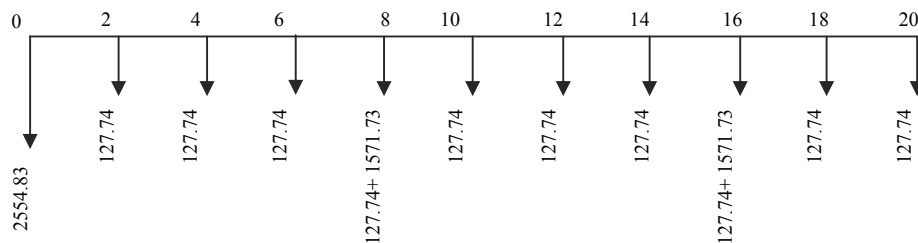


Figure 1: Cash flow for the construction of an asphalt pavement

Hence **NPV** of the asphalt pavement = **Rs. 4386.69**

Concrete paving

In the Table 2, the cost breakdown and the calculated unit cost for the construction of a concrete pavement are listed. Initial construction cost (Rs. 3279.07) is inclusive of the sub grade preparation cost, sub base, base and sub grade construction cost and the concrete pavement construction using Grade 30 ready mix concrete. Joint construction cost is also included for the calculation. It is considered that for a 3 m length, one joint is constructed. 5% from the initial construction cost is considered as the maintenance cost (Rs. 163.95) for once in 2 years. Sealing of joints and repair of joint faults and joint break is considered in this. User cost due to the curing process is not considered in the calculations.

Table 2: Cost breakdown of concrete pavement construction

Description	Qty	Unit cost	Cost
Sub grade preparation	0.15 m ³	566.15	84.92
Construction of sub base	0.1 m ³	920.29	92.03
Construction of aggregate base course	0.15 m ³	4,525.24	678.79
Concrete pavement construction (Grade 30)	0.15 m ³	15,600.00	2,340.00
Joint construction cost	0.33 m ³	250.00	83.33
Total Initial cost			3,279.07
Maintenance once in 2 years (5 %)			163.95

Source: Road Development Authority: Pavement rates 2013

The cash flow for the construction of a concrete pavement for a 20 year design period is shown below.

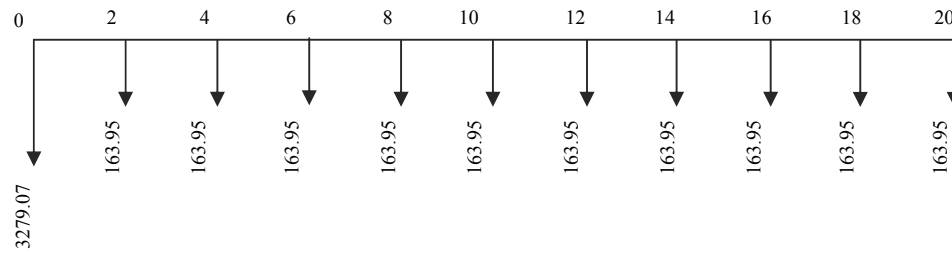


Figure 2: Cash flow for the construction of a concrete pavement

Hence **NPV** of the concrete pavement = **Rs. 4504.36**

Concrete block paving

For this calculation, 7m wide (full width of the road), 1m long road pavement is considered in order to include the costs of the edge restrains (curbs, etc.). Cost breakdown and the calculated unit cost for the construction of CBP are listed in Table 3. Concrete blocks of 30 N/mm² strength and thickness of 80mm are considered for the calculation. Maintenance cost is taken as 1% of the initial cost since it would be only the replacement of a few block units.

Table 3: Cost breakdown of CBP construction

Description	Qty	Unit cost	Cost
Block laying 30 N/mm ² - 80 mm thickness	7 m ²	2,926.70	20,486.90
Construction of the curbs	1m	1,350.00	1,350.00
Total			21,836.90
Unit cost (1 m ²)			3,119.56
Maintenance once in 2 years (1 %)			31.20

Source: Road Development Authority: Pavement rates 2013

The cash flow for the construction of CBP for a 20 year design period is shown below.

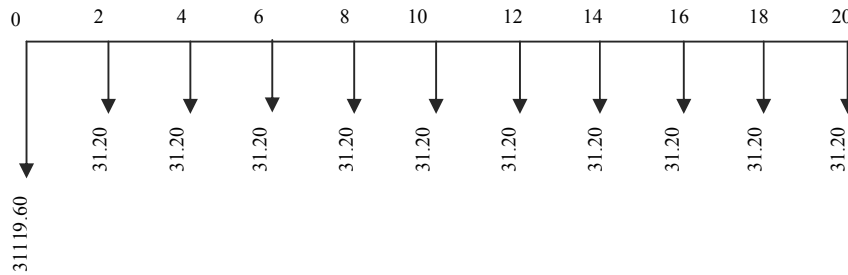


Figure 3: Cash flow for the construction of CBP

Hence NPV of CBP = Rs. 3352.77

Cost comparison

It is clearly apparent from the Figure 4, although the initial cost of asphalt is low the NPV for a design period of 20 years is high. Out of the three paving materials concrete has the highest NPV while CBP has the lowest NPV. Although CBP's construction cost is comparatively higher than that of asphalt and concrete, their maintenance cost is very much low. Thus a lower NPV is obtained. Hence it can be proven that CBP has the most economical life cycle cost from the selected surfacing materials.

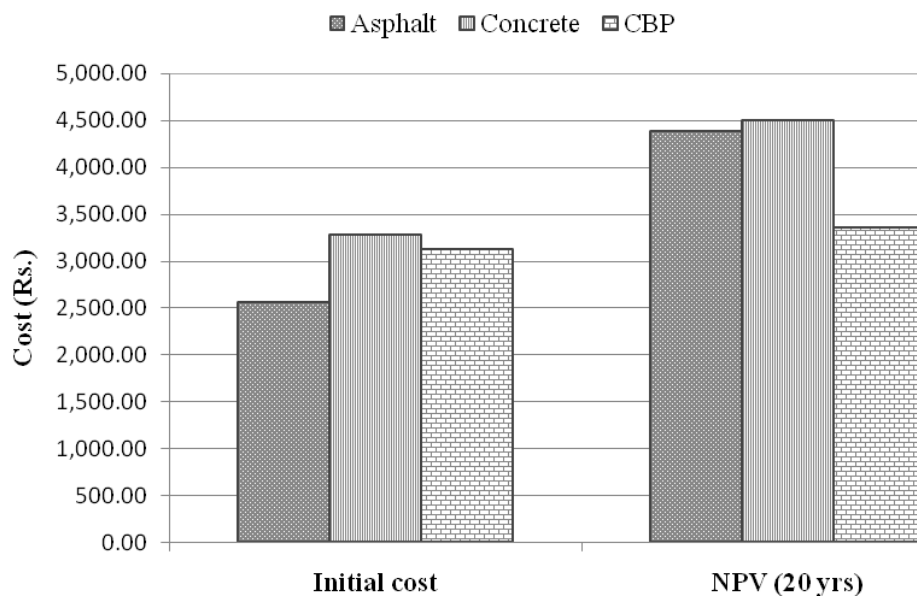


Figure 4: Cost comparison of the paving materials

Evaluation of performance

The performance characteristics of the three types of surfacing materials; asphalt, concrete & CBP differs under various aspects. A comparison of such characteristics is listed in Table 4.

Table 4: Performance evaluation of paving materials

	Asphalt	Concrete	CBP
Mix design	HMA is produced at the plant according to the bitumen content and the aggregate mix required for the construction	Concrete mix is produced according to the strength required for the construction	According to the application type mix design for the blocks are chosen
Site construction	Since HMA is transported to the site and paved, quality control measures are questionable	Since concrete is transported or mixed at the site quality control measures are questionable	Since precast concrete blocks are used high quality control can be expected (blocks are manufactured in a centralized location)
Accessibility to the traffic after construction	Some delay due to the compaction process	Closure for a certain period due to the curing process	Open to the traffic just after the construction
Strength	Moderate (can change due to temperature variations)	High	High
Deflection	Moderate (can change due to temperature variations)	Low	Low
Thermal expansion	Deformations can occur due to the variation of the viscosity of the asphalt when the temperature changes	Since joints are constructed there is no effect from expansion	Blocks are arranged leaving a 5 mm gap between two blocks and hence no effect from expansion
Skid resistance	Moderate	High	High
Access to underground utilities	Need to dig the pavement	Need to dig the pavement	Can be accessed by removing the blocks and these blocks can be replaced
Maintenance	High (resurfacing, crack sealing, pothole patching etc.)	Moderate	Low (replacement of a few blocks)
Life cycle cost	Very high	High	Low
Eco-friendliness	Not an eco-friendly material	Good	Good
Appearance	Moderate	Moderate	Very high

Source: Mamperachchi, Pilanavithana, 2011
 Gnasekaran, 2010
 Karunaratne, 2011
 Concrete Manufacturing Association, 2004

Sustainability of CBP for road construction

The information mentioned in Table 4 has proven that CBP as the most sustainable road paving material. Although, the initial cost is somewhat higher, the life cycle cost is reasonably lower than the other two types of paving materials. This would be ideal for rural road construction, since allocation of long term funding for maintenance etc. does not happen frequently. Hence, it would be more appropriate to use a paving material which requires less maintenance activities.

Another key benefit of CBP is the accessibility for utility services. Without much effort, some blocks can be removed and underground construction could be done. After the work is finished, the blocks could be replaced if they are not damaged.

CBP minimizes the user delays which occur as a result of the closure of roads, since the construction is easy and it can be open to the traffic immediately after the construction.

As the world is in a state where every single mechanism is moving towards fast and easy methods, CBP is the most suitable paving material, which meets the challenges in rural road construction.

Good practices in CBP construction

Applications of CBP are categorized according to the traffic condition as non-traffic, light traffic, medium traffic and heavy & very heavy traffic. Concrete blocks have become a widespread road construction material for low volume roads due to their simplicity in construction and low maintenance requirement compared to other types of roads. CBP is widely known as interlocking blocks because of the mechanism which generates restraining vertical, horizontal and rotational movement simultaneously, with the application of tire load (Algin, 2007, Knapton and Barber, 1979).

Grades and thicknesses

In Sri Lanka, standards have been established mentioning the strength and thickness requirement for each traffic category as shown in Table 5. When the thickness of the block is increased the frictional area of the block increases and the movement resistance ability increases. Hence, the deflection of the road pavement decreases.

Traffic Category	Grade (N/mm ²)	Block thickness (mm)
Non - Traffic	15	60
Light Traffic	30	80,100
Medium Traffic	40	80,100
Heavy to very heavy Traffic	50	80,100

Table 5: Grades and thicknesses of CBP

Source: Mampearachchi, Pilanavithana, 2011

Block shapes

Numerous block shapes can be found in the industry. Some of them are namely uni style, keystone, satin pave, cobble, honey etc. It has been discovered that uni style block as the most effective block shape since it allows geometrical interlock between vertical or side faces of adjacent blocks. In a study by Gunarathna (2009) it has been identified that uni style blocks have the lowest maximum deflection under the tire load as shown in Figure 5. Most of the other shapes are being used for their aesthetic appearance.

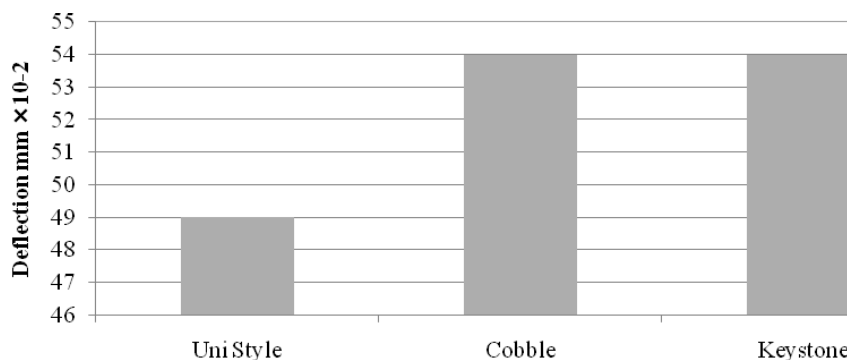


Figure 5: Block shape vs. maximum deflection

Source: Gunarathna, 2009

Laying patterns and laying angles

There are various types of laying patterns namely, herring-bone, stretcher, basket weave and stack bond. As per the previous studies (Gunarathna, 2009), stretcher bond and herring-bone bond types are the most appropriate laying patterns for road construction due to the lower deflections in pavements under the tire load (Figure 6). It is highly recommended to lay the block patterns in line or at right angle to the direction of traffic, since the interlocking action is more effective in this manner.

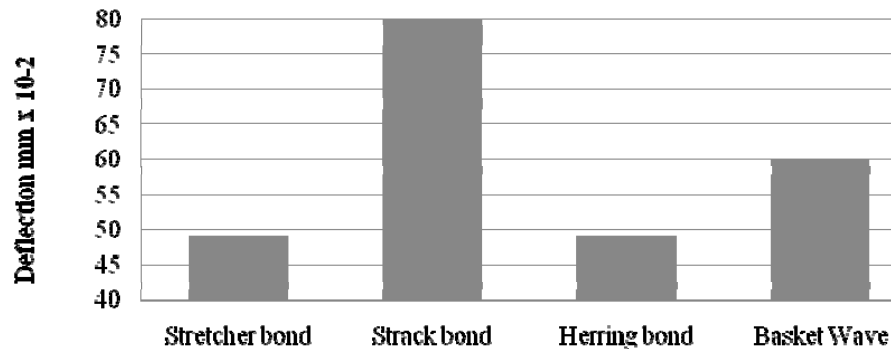


Figure 6: Block laying pattern vs. maximum deflection

Source: Gunarathna, 2009

Summary

- Although the initial construction cost of CBP is slightly higher than other conventional paving materials, it has the lowest life cycle cost
- Applications of CBP are categorized according to the traffic category and standard grades and thicknesses have been established with respect to that.
- Block shape with the highest performance is the uni style block.
- Most effective laying pattern is herring-bone pattern
- Block laying patterns should be in line or right angle to the direction of traffic, in order to achieve the best interlocking action
- The ability to accommodate and maintain utility services, thermal comfort, aesthetic appearance and environmentally friendly behaviour can be highlighted as other key advantages of CBP

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Architecture of emptiness: Human flows as generators of shapes in future architecture

Alexandre Mouriño Frdz. - Escuela Superior Gallaecia
alinhosvigo@hotmail.com

Pedro Fonseca Jorge, PhD - Escola Superior Gallaecia
pedrojorge@esg.pt

Abstract

In this article we will try to discuss the existence of a series of haptic and perceptual indicators that allow us to correlate certain spaces as the most adequate for determined activities in an almost unconscious manner. These 'potential' or 'aprioristic' spaces would be nodes or intersections of a map of invisible flows that would demonstrate an underpinning in which future cities could be established upon. Diminishing the contemporary architecture's mass would be a way through which the above mentioned flows could be materialized. We are not suggesting an 'organic' shaped architecture, only an architecture that is free from its Cartesian bonds, allowed to express itself a an ordered recreation of the chaos that is hidden below the corseted geometric systems that define today's architecture and urban planning. The human body would no longer be defined in its movements by architecture. By the contrary, architecture would be moulded, in its form and logic, by the human reason and shape.

Keywords: architecture, mass, flows/shape, perception, potential spaces.

1. The architectural object's mass historical evolution:

There are many parameters considered by historians and theorists when it comes to analyse architecture's evolution process since its first manifestations till nowadays. There is, however, an indicator that has been disregarded and that is the architectural object's mass and its variations through time, which can offer additional information in architecture analysis. Knowing its evolving process might become very useful when conjecturing future scenarios of our built environment. In order to understand this process it is necessary to historically contextualize certain periods, although we are fully aware that history is made of parallel flows that evolve discontinuously according, for instance, to its geographical location. Therefore, it is not accurate to bound history to a chronological scheme, as each historical flow as its own rhythm and braking points, but still we felt the need to simplify some historical moments in order to make it easier to clarify the purpose of this article.

Some architecture scholars and critics consider the appropriation of pre-existing natural structures as the first architectural manifestations. Even if in these actions there is no actual physical manipulation of the environment, it is undeniable that the cave's occupation and adaptation could be the first signs of a rational spatial appropriation and therefore, the prelude of architecture itself¹. With the cave as a starting point (whose mass would be equal to zero), there is a process taking place by man where technical progress would determine different turning points in the history of construction. After the cave the Neolithic hut would be the first 'artificial' manifestations of man's territorial appropriation. We can say that in this stage architectural mass makes its appearance as an architecture intrinsic element, even if its amount it is almost negligible². With earthen and stone construction processes appears a fundamental element: thickness. Cities like Catal Huyuk (7500BC), located in what is now Turkey's territory, are

¹ PEREIRA Alonso, José Ramón (2008), 'Introducción a la historia de la arquitectura' Editorial Reverté, Barcelona, p. 19.

² PEREIRA Alonso, José Ramón (2008), 'Introducción a la historia de la arquitectura' Editorial Reverté, Barcelona, p. 23.

considered the first (among the ones that are known) to use stone and clay as supporting structures. Therefore, mass is no longer a circumstantial element, but part of the technical solution³. From Egyptian architecture, that represented a great step forward in the use as mass as a constructive element, until the Baroque architectural style, monumentality was searched through the use of stone as its main building material. Like Sigfried Giedion said '...there is a direct tradition (...), that relates art of our time with the Nile Valley from 5000 years ago, as Greek artists made their learning from Egyptians, and all of us learned from the Greeks'⁴. Being aware of Giedion's statement and the historic correlation between classical culture and the Egyptian civilization, it is easy to understand why monumentality which is associated with mass and volume has been a common association among Egypt, Classic Greece and the Roman Empire.

Since these three stages and until Gothic, the building's mass or volume, mainly religious, military and those of the elites and leaders, was based in construction processes where stone and its heaviness were fundamental structural elements, necessary for an efficient structural behaviour of these types of buildings. Therefore, in most cases, mass was a need, not a porpoise, to achieve the intended monumentality. Yet, in those examples, when it was intended to lighten the mass of the building, limitations were imposed by constructive solutions that had hardly evolved since the introduction of the arch and the vault by the Romans. But mass, an active element until the Romanic style is converted in a three-dimensional vector system in the Gothic style, where this scheme obtained its major expression⁵. But the Renaissance, since it was based upon the interpretation of classical Greek and Roman orders, gave back to mass and volume the lost role in the Gothic architectural style⁶. Baroque, based upon a scenographic character and the pursuit of movement, manages to propose new shapes, but these were still bonded by the imposed structural needs⁷.

The 19th century and the industrial revolution would be the turning point where new materials (iron, steel, glass and concrete) and new construction techniques managed to reduce the building's mass through the use of lighter structures. That meant, in time, a cheaper and faster construction⁸. In a first phase these materials and building methods were still 'hidden', as it was intended to keep the classical features, in terms of mass and volume, throughout an optical 'illusion': iron and steel lightweight structures, for instance, were concealed under mouldings and claddings that would recreate typical classical orders, even if these new materials manage to achieve dimensions and proportions unknown till then⁹.

With the Modern Movement and its followers as its main promoters, the 20th century architecture employed 'curtain walls' where huge surfaces of glass over metallic structures marked the decisive loss of mass than began with the industrial revolution, but now in an intentional and well defined manner. Mies van der Rohe's motto 'less is more', is the main symbol of the architectural object's lightening.

The Consumer or Technologic Society of the 21st century is reaching a point of paroxysm, experimenting radical formulas of dematerialization: Virtual Architecture. 'All indicates that the architectural experience is changing from a material form to a visualization experience, reinterpreting the concepts of space and place'¹⁰.

³ TRACHTENBERG, Hyman (1986), 'Architecture, from prehistory to post-modernism', Academy Editions, London, p. 47.

⁴ GIEDION, Sigfried (1969), 'La arquitectura, fenómeno de transición', Gustavo Gili, Barcelona, p. 39.

⁵ PEREIRA Alonso, José Ramón (2008), 'Introducción a la historia de la arquitectura' Editorial Reverté, Barcelona, p. 113.

⁶ PEREIRA Alonso, José Ramón (2008), 'Introducción a la historia de la arquitectura' Editorial Reverté, Barcelona, p. 129.

⁷ PEREIRA Alonso, José Ramón (2008), 'Introducción a la historia de la arquitectura' Editorial Reverté, Barcelona, p. 157.

⁸ VALDEARCOS, Enrique, 'Arquitectura y urbanismo en los ss. XIX y XX', Clío 33 (2007).

⁹ TRACHTENBERG, Hyman (1986), 'Architecture, from prehistory to post-modernism', Academy Editions, London, p. 496.

¹⁰ NOVILLO, M^a Alejandra, 'Esencia y cambio en el concepto de límite' [Tesina Facultad de Arquitectura y Urbanismo]. Buenos aires: Departamento de investigación, Universidad de Belgrano; 2003.

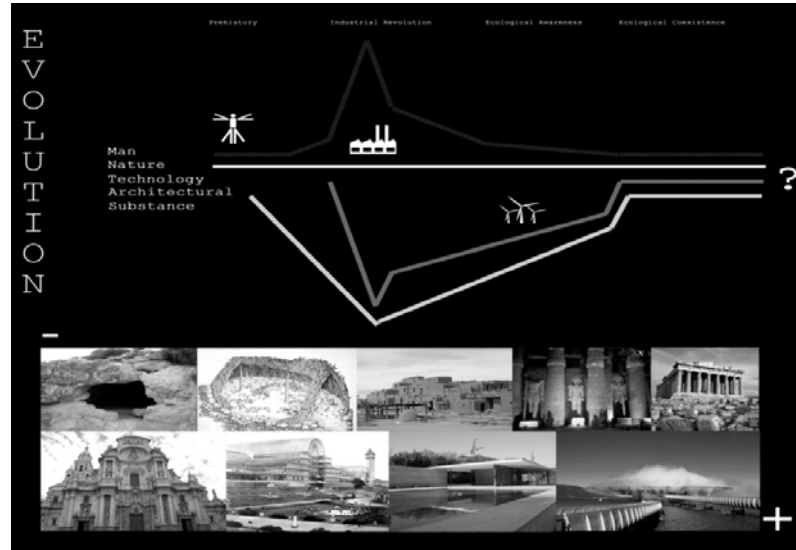


Fig. 1. Scheme comparing: the architectural mass, the available technology and the acceptance or rejection of man's natural environment evolving process throughout history.

2. Architectural mass in its simplest form. The Japanese School:

If architecture is the physical manifestation of Man's historical, social and economic moment¹¹, perhaps the latest generation of Japanese architects is the one closer to understand a new architectural expression connected to the Information Society: a social balanced environment amid the materiality of its contiguous surroundings and the virtual borderless world that new technologies have made possible. There is a return to past ideologies where there was a constant balance between Man and Nature. According to Norberg-Schulz 'Man yearn for their hometowns' narrow streets and irregular squares or try to escape seeking Nature'¹².

2.1 Toyo Ito. Diffuse boundaries architecture:

One of the first architects to be sensible to the drastic changes technology was imposing society was Toyo Ito. In the mid 80's the Japanese architect started to question himself how architecture could respond to the new social requirements.

To question the traditional definition of 'boundary' was the starting point of his investigation, since it no longer was adjusted to the Japanese society ephemeral and circumstantial everyday life. Opposing the concept of *conclusive architecture*, according to Otto Friedrich Bollnow '...to build a house is to raise an ordered space in the existing chaos...' ¹³, Toyo Ito argues that the definition of 'boundary' should be revised in order to describe something more diffuse and ethereal than the traditional wall with occasional voids. Toyo Ito refers that '...as long as we continue to separate the inside from the outside (...), nature will remain an outsider for architecture (...). It seems impossible to me to create an architecture well fitted in its surroundings, as long as we visualise the human body and architecture separately and unrelated with the external world'. New materials and building processes made possible experimental proposals where mass is practically non-existent, allowing an architecture translated into flows through the city, like in the 'Pao for the Tokyo nomadic girls' (fig. 2). At this point not only Man was nomad, but also 'his' architecture could be it.

¹¹ ITO, Toyo, (2000), 'Escritos' Ed. COAT Murcia, Murcia, p. 24.

¹² NORBERG-SCHULZ, Christian, 'La significación en la arquitectura', en: 'La significación del entorno', ed. SUST, Xavier (1972), Barcelona, p.21.

¹³ O.F. Bollnow, 'La morada del hombre', traducción de Takehido Kojima, Ed. Universidad Meisei (Departamento de publicaciones).

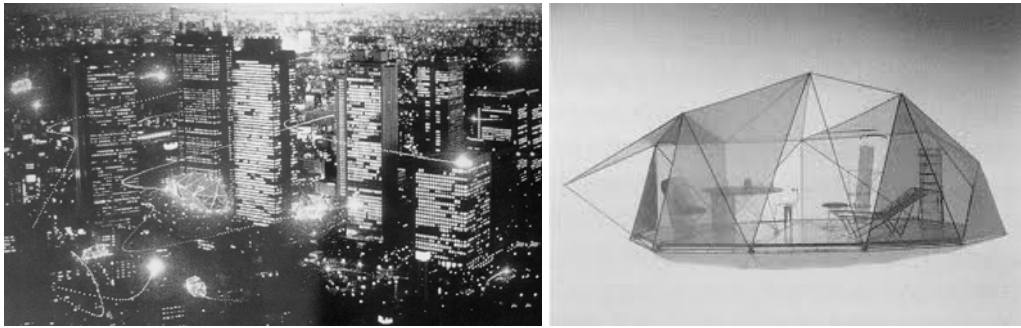


Fig. 2. Pao for the Tokyo nomadic girls. Toyo Ito, (1985).

2.2 Kazuyo Sejima y Ryue Nishizawa, towards an evanescent architecture:

Clearly influenced by Toyo Ito's new theories (Kazuyo Sejima herself worked for him between 1981 and 1987), SANAA architecture studio has experimented lightness and transparency formulas in order to define an architecture that dilutes itself in its own physical expression, being its dematerialization one of its fundamental points of research. This dematerialization is used to integrate their proposals like a 'collage' in its surroundings, using its reflection as a way of being assimilated in urban settings, or through the ubiquitous presence of green elements inside and outside the building diluting its limits in natural environments thus allowing a great level of liberty in the user's movements. One of Ito's main ideas is therefore attained: '...architecture that does not make us senses its shape is the least repressive in everyday life'¹⁴.

Another question aroused by the team's projectual efforts is the creation of artificial topographies in a way that natural and unconscious behaviours are encouraged while using them¹⁵. One of the more paradigmatic proposals regarding this question is their EPFL Rolex University Centre, designed for Lausanne, Switzerland, in 2005 and finished in 2010.



Fig. 3. EPFL Rolex University Centre. Art.



Fig. 4. Glass Pavillion in the *Toledo* Museum of Art.

2.3 Sou Fujimoto and the primitive architecture:

Among this group of Japanese architects, influenced by the ideas of Toyo Ito, besides other lines of investigation, we can mention Sou Fujimoto. His work tries to reattach the lost primitive interactions between Man and Nature¹⁶, since in his opinion connections or links are the elements that define space. According to him and his proposals space isn't defined or even divided, but

¹⁴ ITO, Toyo, (2000), 'Escritos' Ed. COAT Murcia, Murcia, p. 38.

¹⁵ MOSTAFAVI, Mohsen, 'Una conversación con Kazuyo Sejima y Ryue Nishizawa', El Croquis. 2011; N°155 : 6-16 [Traducción de Albert Fuentes].

¹⁶ TOYO Ito, Julian Worrall, 'Arquitectura teórica y sensorial: los experimentos radicales de Sou Fujimoto', 2G, N°50 : 4-23

intensified and with undefined limits, giving path to fluidic inhabiting experiences, instead of giving a specific function to every individualized space. This spatial concept's theoretical basis is the same that three decades ago led Toyo Ito to design the 'Pao for the Tokyo nomadic girls', where although every architectonic element consists in an autonomous component it can't avoid to be connected to its environment and even with itself. The study of boundaries that nourish the interaction between inside and outside is therefore one of the major obsessions of his career¹⁷. This primitive relation between Man and Nature is materialized in two of its most important works: the 'Final Wooden House' is a modern metaphor of the primitive cave, and the 'NA House' uses a typological system that makes its spatial appropriation similar to the one of a tree. To a system until nowadays majorly Cartesian is now given a three-dimensional character that makes way to a new line of investigation: an intuitive spatial appropriation opposed to functionalist architecture where every space has a pre-defined use.



Fig. 5. Final Wooden House.



Fig. 6. NA House.

2.4 Junya Ishigami, architecture is air:

This young architect has been the latest to use the decrease of mass in architecture and artwork as a strategy to achieve a closer relation between surroundings and proposed object. At the same time, through the analysis of the users' circulation flows, who appropriate his pieces, conceived as artificial structures cloistered by natural surroundings, it's possible to define a capillary symbiosis among Nature, Architecture and Man¹⁸.

With his project 'Architecture as air, study for château la coste', with which he was awarded with the 2008 Golden Lion for best project at the Venice Biennale, he manages to merge natural and artificial spaces in an almost mass-free architecture. He organizes part of a garden through a modular scheme composed by slender columns that mimics the trees around it. Tension between natural and artificial becomes a unified spatial perception where architecture offers the user what nature cannot offer by itself. Without a noticeable intervention in order not to betray nature's character, the architect manages to promote an honest interaction between pre-existing nature and the built proposal.

Another Project deserving some attention, through the use of the opposite strategy is the 'Kanagawa Institute of Technology Workshop'. Here, in a 2000 m² diaphanous space, the architect proposes the creation of a multitude of spaces through the strategic arrangement of 350 small section pillars. Their implantation manages to define different kinds of the space's visual perception, like those one would find in a wood. Open areas are therefore appropriated like 'glades', and circulation spaces are used as 'trails'¹⁹. The theories of Toyo Ito and its diaphanous limits, the austere lightness of the SANAA studio and the return to the primeval in the work of Sou Fujimoto's proposals are brought together in these Ishigami's two proposals.

¹⁷ FUJIMOTO, Sou, 'Futuro Primitivo', 2G, N°50 : 130-143

¹⁸ Serie de conferencias: 'A New Innocence: Emerging Trends in Japanese Architecture', Junya Ishigami lecture, 'Recent Work'. Cambridge 2011. Harvard Graduate School of Design; 2012.

¹⁹ FERNÁNDEZ-GALIANO, Luís. 'Dossier Junya Ishigami: Minimalism and Nature', AV Proyectos. 2013; N°055 : 6-16.



Fig. 7. 'Japanese Pavilion Venice Biennale 2008' Fig. 8. 'Kanagawa Institute of Technology'

3. Potential or aprioristic spaces theory. The Unsubstantial Architecture:

Spaces that we can assume as even or similar to voids are, according to Martin Heidegger, inexistent in common situations, either in natural or built environments. This supposes the presence of an invisible structure behind every space we see, but perceivable through a haptic point of view. Space is inevitably appropriated, later in a physical and plastic manner²⁰. This is the idea behind the understanding of 'meaning through our corporeal status, questioning construction through judgement'²¹.

American writer Marshall Berman shows that 'being modern is part of a universe in which, like Marx said, 'everything physical vanishes into air''²², and that is why being sensible to that 'air' becomes a stimulus to its use and appropriation, important as it is nowadays. The Japanese traditional perception of space, though the *Ma* (and the way it is perceived by contemporary architects) allows a more precise perception of this structure hidden behind the apparent space²³. Sou Fujimoto's definition of space is the one closer to this reality: 'A place is something that could be inhabited by a person. Nevertheless, it isn't something prepared to be inhabited. It's a place full of opportunities for a person to discover special places'²⁴, based upon the idea of a void as subjective space, rather than an absence, as it is defended by the Japanese concept of *Ma*. According to Günter Nitschke, when Japanese architects were to build a construction, they would go with their tea set to the chosen site, and would remain there all day.

By this mean they tried to capture the void, the absence of a house, as the first step in order to design it. The site's void, its empty space, was the first step to inspire the architect to create the thing-oeuvre-building²⁵. Therefore, it was a search of the surrounding potential spaces (an invisible scaffolding, Fig. 9) in order to latter be occupied by his architecture. Architect Tetsuo Kondo exploited his technic in his ephemeral installation "A Path in the Forest" (Fig. 10) for the 2011 Tallinn Festival in Estonia. He claimed that "walking along this path will give a slightly different sense of the forest. Instead of looking up at the trees from the ground, people will be strolling near the leaves, making their way between the branches. A structure made for the forest, a forest that exists for the structure: with no change in the shape of the forest, it will seem that the structure and the forest are one"²⁶.

²⁰ HEIDEGGER, Martin, 'Construir, habitar, pensar', (1954). Conferencias y artículos, Barcelona, Odós, 1994.

²¹ MERLEAU-PONTY, Maurice, 'Fenomenología de la percepción'. Editorial Planeta - Agostini. Edición 1993, p.45.

²² BERMAN, Marshall, (1988), 'Todo lo sólido se desvanece en el aire. La experiencia de la modernidad', Editorial Siglo Veintiuno, Madrid, p. 81.

²³ NITSCHKE, Günter, 'Ma. El sentido japonés de 'lugar' tal como se refleja en la confirmación espacial de la arquitectura y el diseño urbano tradicional y moderno' en AA. VV. JAPON. UNA NUEVA PERSPECTIVA, Cuadernos Summa-Nueva Visión, N°26-27, JUNIO, 1969, P. 48-49.

²⁴ FUJIMOTO, Sou, 'Futuro Primitivo', 2G, N°50 : 136.

²⁵ NITSCHKE, Günter, 'Ma. El sentido japonés de 'lugar' tal como se refleja en la confirmación espacial de la arquitectura y el diseño urbano tradicional y moderno' (1969), op. cit. p.50.

²⁶ Tetsuo Kondo Architects: A Path in The Forest | Kadriorg Park . Tallinn", última modificación el 30 de Abril de 2013.

<http://afasiaarq.blogspot.com/2013/04/tetsuo-kondo-architects.html>



Fig. 9. Right. Jose Manuel Ballester, (Untitled), Yellow River (China), 2005.

Fig. 10. Left. Tetsuo Kondo Architects, "A Path in The Forest", Tallinn (Estonia), 2011.

4. The space's intuitive appropriation. Feeling without knowing:

Generally, the main idea behind space appropriation in architecture is based upon direct appropriation of built space, in which its function is defined previously. A standard house is its paradigmatic example, where we recognise immediately the use predicted for each room: which are the bedrooms, which is the kitchen, the living room... Somehow the design process should follow the opposite procedure. That would mean that there shouldn't be specific spaces for specific uses, but rather to give path to the dweller to recognize in each one of them their function according to his needs. This is a strategy used in primitive architecture, as it has been defined by philosopher Kurt Koffka: 'For the primitive man each object communicates what it is, and what is for... a fruit says 'eat me', water says 'drink me', the thunder says 'fear me'²⁷. Even if nowadays making use of this ideas, even if simplified', would make no sense, we can use them as manifesto to defend the idea that the complex logic used to create our built surrounding is not enough or adapted to satisfy entirely our physical or psychological needs. Following this line of thought, Sou Fujimoto argues: 'The cave's occupants adapt themselves to their environment, improvising and discovering latent and multiple possibilities in a defined context. This is an unconscious and unplanned appropriation process, born in our primitive and animal essence. In these environments we search for a more comfortable location, like cats in a meadow'²⁸.

This intuitive spatial appropriation corresponds to the phase that Nitschke defines as 'unconscious stage', where the apparent nature's disorder is in fact the basis of every organization system. It's saying that man accepts nature and acts like its extension. A stage of intuitive and unconscious performance where there is a casual and accidental, but identifiable order (*Arare*, in Japanese culture) where the whole system's natural and geographical characteristics are emphasized²⁹. This potential spaces' selection process in our surroundings, with the help of new construction techniques, could lead architecture through something like a positive involution, in which the haptic sense has a role when it's time to choose the volume which will be cloistered by a solid casing (architecture). The ideal circumstances are therefore provided to make use of this space through its initial characteristics and qualities, to whose we can have the inherent qualities of our own architecture intervention, necessary to make them liveable.

An interesting experience should be to ask a group of people to enter a wood and request each one separately to choose different spaces for different uses: one for sleeping, other for reading, another to eat, etc. By confronting the results gathered from a large group of individuals we would come to the conclusion that the choices would be mainly the same, knowing for sure which would be the most suitable spaces for which use. The same experience, carried out in an

²⁷ KOFFKA, K. 'Principles of Gestalt psychology' (1935), Nueva York, Harcourt Brace. p. 7.

²⁸ ITO, Toyo, WORRALL, Julian, 'Arquitectura teórica y sensorial: los experimentos radicales de Sou Fujimoto', 2G, N°50 : 18.

²⁹ NITSCHKE, Günter, 'Ma. El sentido japonés de 'lugar' tal como se refleja en la confirmación espacial de la arquitectura y el diseño urbano tradicional y moderno' (1969), op. cit. p.10.

urban scale, could be used as a reference in an urban planning process without previous prejudice. As Edmund Husserl would say, 'meeting the reality of things'³⁰.

5. The spatial perception phenomenology. Explaining the unexplainable:

As a way to obtain knowledge, phenomenology can contribute with philosophical bases in order to overcome simple theories of perception, and obtain, with the help of psychological analysis, a complete sensorial spatial experience. This philosophical process completes the laws of perception and physiology, when it comes to study the entire process of physical and psychological of recognition by individuals certain characteristics in their surrounding spaces. Philosopher Maurice Merleau-Ponty thought that phenomenology the recognition of the human capacity of perceiving symbols through their corporeal status, questioning their human environment through its use and trial. Merleau-Ponty postulated 'the body, not just as a standing object in the world but as a mean of communication with it, and the world not as a sum of objects but as a hidden horizon in our incessant current experience that has no end, previous to any determinant decision'³¹.

Experiencing phenomena – experiences in time and space which are different from object's perception – comes from a distinct method of thinking architecture. Phenomenology, as a question of perception, leads us to experience architecture walking through it, feeling it, listening to it, pulling us into a new underworld of sensations even before architecture is made. All of this to allow the empathy of the places' essence and build in them, giving it a corporeal and significant shape, in order not to invade the natural context in its whole. It makes easy an architecture-nature symbiosis throughout the single occupation of the aprioristic areas that are identified and marked off through this process of knowledge. Even over the already built urban environment 'there is another superimposed city that has its origin in phenomena like sound, light, images, etc. (...). Can't we find the inner structure and historic and natural flows inside the constructions of the mechanical age, superimposing them the electronic age networks, making it all revive again as a phenomenological space?'³² It's to manage that architecture and nature start to generate a feedback process.

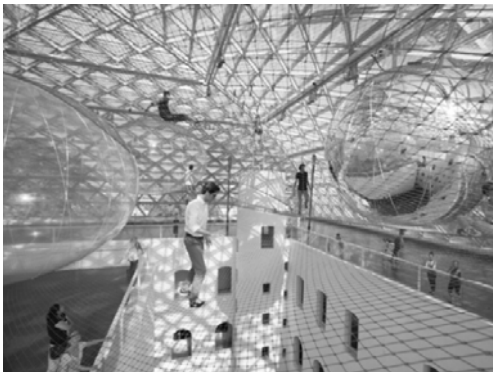


Fig. 11. Left. Tomás Sarraceno's 'in orbit' installation.



Fig. 12. Right. Frank Lloyd Wright's 'Falling water', examples of spatial, appropriations according to the local phenomenological characteristics. Sarraceno in a built environment, Wright is a natural one.

6. Symbiotic architecture. Architectonic capillary in nature:

'I believe that my architecture's meaning is like a metaphor: architecture was already here, but we couldn't see it, so we had to search for the little pieces that compose it and search for as process of combine them in order to solve problems that arouse during the process. This process

³⁰ HUSSERL, Edmund 'Investigaciones Lógicas' (2005), Ed. Alianza, Buenos Aires. p. 217.

³¹ MERLEAU-PONTY, Maurice, 'Fenomenología de la percepción'. Editorial Planeta - Agostini. Edición 1993, p.32.

³² ITO, Toyo, (2000), 'Escritos' Ed. COAT Murcia, Murcia, p. 141.

requires the creative ability to think. That's why I think about this kind of interaction: interaction with oneself, interaction with the environment, with the place, with people, all very exciting...'³³ This Sou Fujimoto's statement describes so far this article's theoretical development. The analysis of the correlation between built mass, available technology and occasional ecological conscience (the each moment's natural surroundings rejection level) makes us believe that future architecture will make use of technique to create 'membranes' that will wrap the so-called potential spaces found all around us. Appropriating space will no longer begin in a blank sheet, but as a reciprocal process with the natural environment, its physical support, and with which man will have a more straight relation, as it has been requiring for ages. Antonio Saggio said 'a building is no longer praiseworthy because it's functional (...). We are aware that this metaphorical process influences a great part of contemporary architecture, and that its fundamental aim is to bring inside the landscape and the relation between man and nature'³⁴.

We can define symbiotic architecture as the one that adapts itself to its site, respecting its fundamental features, boosting its most remarkable properties in order to respond to man's needs. Just when ecological conscience and sustainability are becoming increasingly important, this kind of approach when designing is what will bring back the equilibrium between architecture and nature that has been lost since our primitive past, but with all the commodities required by modern society. Sou Fujimoto's definition of 'Primitive Future' as part of his theoretical architectural approach can resume this approach.



Fig. 13. Conceptual mock-ups that can illustrate the symbiotic architecture theory. 'Futuropective architecture: Sou Fujimoto', September 10, 2013. Centro Cultural de Belém, Lisboa.



FIG. 14. The "Tree in the House" Project, designed by A.Masow Design Studio, is a glass house located in the Almaty city (Kazajstán) that sacrifices intimacy privacy in favour of a unique experience in harmony with nature.

³³ SOU FUJIMOTO. Conferencia inaugural de la exposición 'Futuropective architecture', 10 sep 2013. Centro Cultural de Belem, Lisboa. Respuesta a una pregunta en el turno de intervenciones del autor de este artículo. [Traducción Joanna Vécira Vasconcelos].

³⁴ PRESTINENZA PUGLISI, Luigi, 'Hyperarchitecture Spaces in the Electronic Age', Epílogo de Antonio Saggio. Ed. Birkhäuser. Turín, 1998, p.95. [Traducción al inglés Lucinda Byatt].

7. Flows as creatures of shape. The fourth dimension physical expression in the urban fabric:

Toyo Ito discovered what he has defined as 'flow areas', or *ryuiki*, a fluid vision, subtly ambiguous, of internal space. At the same time Arata Isozaki, Kazuo Shinozaki and the following generation of architects like Tadao Ando kept using minimalistic rhetoric, achieving an architectonic expression easily identifiable as 'Japanese' (although it has remained solely applied to architecture's outer shell), Toyo Ito submerged himself researching something that orthodox architectural investigation had left behind: the environmental, the fluidic and the consciousness of inhabiting³⁵.

Taking into account the 'nomadic' character of the today's citizen we shouldn't see life as taking place in specific spaces, but rather taking place in in-between (crossing) places. Human beings inhabit the world as travellers, not as occupiers of a specific space³⁶.

Defining space as a path implies the necessary use of 'time' as a dimension that can help us to understand the importance of these 'flows' in our society. Once these paths are freed from the dictatorship of rational urbanism, it will be possible to observe the path of human flows. A person's routes from one point to the other, if not conditioned by artificial external elements, are the expression itself of one's core in a chronological perspective. It's to understand one's core not as geometric concept but as reference to the muscular apparatus with kinesthetic and orientation properties derived from the force of gravity and an inner sense³⁷. This fingerprint will remain and can be read by current technologies.

Visualizing and analysing real time urban flows has become a powerful tool whose final purpose is to help citizens and urban planners to make informed decisions, and in a nearby future to reduce inefficient transportation in order to reduce our environmental footprint and time waste. But the analysis of this kind of mappings can lead us to the following question: is urban space connected in a natural way to our flows, or are these dependent from it?

Throughout the investigating work of the MIT's SENSEable City Lab, directed by the architect Carlo Ratti³⁸, we can see some disagreements between the urban fabric and human flow charts (Fig. 8). This means that the use of this kind of maps can improve the quality of city life by adapting urban paths to those of people, as long as possible and taking into account not only a person's movements but also the time they spend in a specific place. This way future planning would have to take into account these kinds of studies to create its new infrastructures, making them more efficient at every level.

³⁵ ITO, Toyo, (2005), 'Toyo Ito, Conversaciones con estudiantes' Ed. Gustavo Gili, Barcelona. p. 88.

³⁶ MASSEY, D.B (2005), 'For Space' Sage Publications, London. p.55.

³⁷ BLOMMER, C. Kent, MOORE, Charles W, (1982), 'Cuerpo, memoria y arquitectura' H. Blume Ediciones, Madrid. p.71.

³⁸ REAL TIME ROME [internet]. Massachusetts: Massachusetts Institute of Technology MIT, c2003
[Consultado 2013 Sep 14]. Disponible en:
<http://senseable.mit.edu/realtimerome/>



Fig. 15. Left. Real-Time Roma combines different data in a single interface: SIG data, real time data and raster images. In this picture the relives highlight time spent in each space (May 2006).

Fig. 16. Right. Chart created by Aaron Parecki through a three year period compilation of geo-positioning data from his GPS device superimposed over a Portland city map, is hometown. Different colours correspond to different years, and we can see how a person adapts himself to the urban fabric. If we introduce the 'time' factor, we managed to understand how the urban fabric is completely insensible to our routes and daily habits.

8. Flows in natural environments. Synapses between potential spaces:

If in an urban context we start upon a predefined network, in naturally preserved environments the design of such a mesh can be the result of the potential spaces' study and its connections. Toyo Ito said that '...man's actions are complicated and we shouldn't limit any action to any given space...'³⁹. We can deduce from this notion that if it's the action itself that generates space, then space will not be restricted to its physical expression (architecture) but beyond this wrapping to ensure human wellbeing. Local connexions of this kind would generate a dynamic but gracious network. The resulting architecture would be something fluid, avoiding forced actions, in which the kinesthetic logic is bindings' free. This kind of space wouldn't need to be cloistered to be apprehended, just to be liveable for Man, who has a body and a life. In other words, this space's understanding is only possible once it is produced⁴⁰. It's a closed mutual circle, where flow creates space and it is lived again through its own flow, not in a prosthetic mode. Human character is, by nature, wonderer, divergent and adventurous and it requires an environment that allows and nourishes the practice and development of such behaviour⁴¹.

If in the design process we manage to obtain interaction between built object and its natural environment, we are promoting a man-nature relation without losing the architecture's character as shelter and protection. Architecture would be able to be a true vessel of our lives, our desires and hopes, and not a mere object, significant by itself (although this is a legitimate aim as a collateral reaction to the architect's good practice).

³⁹ TAKI, Koji, 'Una conversación con Toyo Ito', *El Croquis*. 2004; N°123 : 6-43 [Traducción de Albert Fuentes].

⁴⁰ LEFEBVRE, Henri, (1988). 'The production of space' Ed. Universidad de Sussex, Brighton. p.168.

⁴¹ DATNER, Richard (1969), 'design for a play', Van Nostrand Reinhold, Nueva York, p.44.

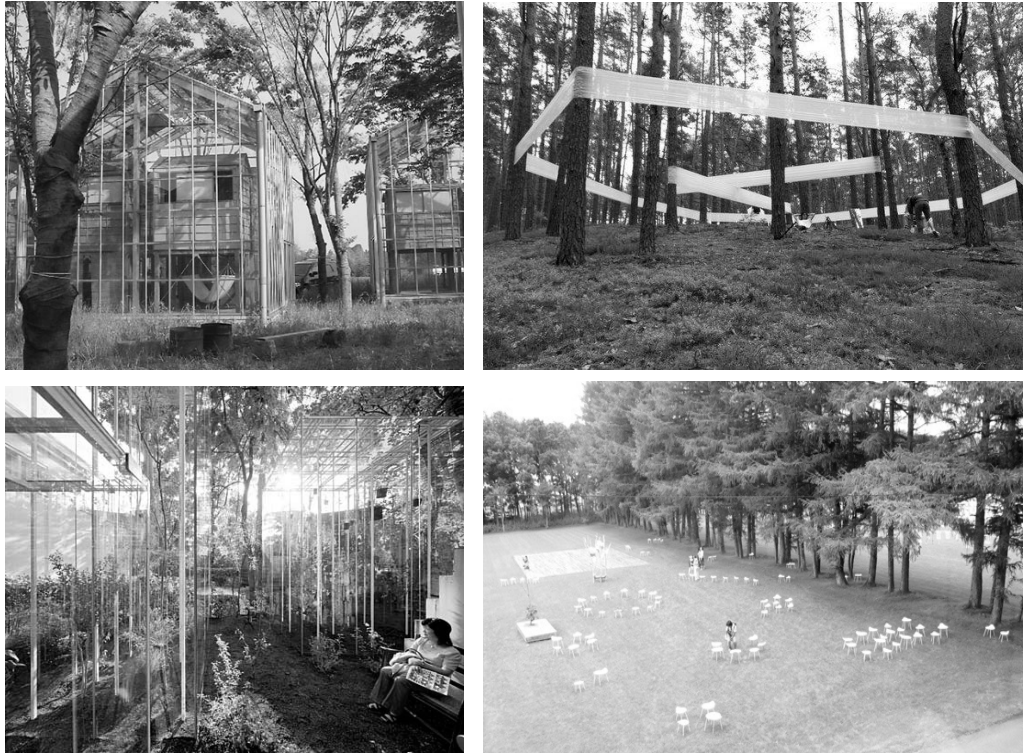


Fig. 17. From above to bottom, and left to right: 'Kurimoto Millenium City' – Japan;
Fig.18. 137 kilo studio 'Cross Country House', spatial appropriation, prior to the house's construction;
Fig. 19. Junya Ishigami's 'Japanese Pavilion', Venice Biennale 2008;
Fig. 20. Tetsuo Kondo Architects' 'Landscape with Chair'.

9. A new architecture for a new society. The digital condition as a disruptive element between architecture and society:

The digital society is living an historic moment that has just begun, and that has imposed huge changes in the way knowledge is communicated, the productive system and even in social relations. Along history there weren't many relevant technologies: the development of lithic technology, agriculture, industrialization and electricity have been so far disruptive technologies, which have imposed significant changes in society, and consequently in the architecture representing that same society.

According to polish sociologist Zygmunt Bauman and his 'liquid modernity identity' theory, if in the 18th century society was marked by well-defined social stratus according to which each individual was strictly classified, nowadays, with the social network's boom and the ICTs (information and communication technologies) global identities become fickle, volatile and fragile, and change according to consumer influenced identities. However, these elusive identities make us increasingly dependent of each other, and here is where we can find hope to establish the necessary conditions for growth in terms of humanity, collective consciousness focused on the individual wellbeing, and harmony towards nature⁴².

For these reasons, sooner or later, architecture will have to adapt to this new 'liquid society' in such a way that man is allowed to move from its selfish 'me', and the ecosystem's symbiotic, non-pyramidal hybridization. Adapting to new requirements, and a, more than ever, necessity for

⁴² PALOMAR VERA, Cristina (2007). 'Reseña de 'Identidad' de Sygmunt Bauman'. Espiral VOL. XIII (Nº. 38) p. 205-214.

environmental sustainability, become the only ways to assure our species survival in a medium and long term.

10. Discussion and conclusions:

According to the theoretical character of this article, it is always possible to make use of subjective ideas that, however, could be the basis of future discussions for those who are willing to consult this text and investigate similar themes. Methodologically the article's characteristics lead to a solution where we tried to create a strong line of argument in order to support the presented theoretical ideas and concepts, rather than to follow a traditional research process (although those same ideas were strongly supported by a deep investigation and the Japanese School's case studies. The aim of the carried out investigation, more than to give concrete answers, was to stimulate the discussion over the subject and to promote interest on a different approach of designing architecture. Undoubtedly, the use, in the future, of quantitative studies that offer concrete data can corroborate some of the referred assumptions presently achieved through theoretical approach by the architects, sociologists, psychologists and academic researchers used as references. To study more thoroughly some of the article's specific themes would also be useful, even to gathered them in some sort of compendium that would allow the use of the collected subjects to research further in architecture and other fields of knowledge.

According to the theoretical approaches presented, we can conclude that there are no precedents in the architecture design process where the usable potential spaces are first identified followed by the generated flows connecting these spaces and even inside them. Nevertheless it seems to have the possibility to become a very effective process of approaching architectural design giving a response to the needs of those bound to occupy the generated spaces. Their own bodies and movements will generate the foundation of what later will become the object's spatial occupation and use, which, thanks to today's building techniques (and the loss of mass in architecture) will be confined in a natural way, allowing a clear dialogue with the surroundings of every project. It also seems that this process of generating spaces benefits some degree of interaction with the natural environment, one of the mantras of present-day architecture: a stable and egalitarian equilibrium between natural and artificial, while helping to construct the longed ecological sustainability and reducing the social, environmental and economic costs at medium and long term.

For future researches it is recommended that the work and theories of the four above mentioned studios will be profoundly studied in order to create a personal philosophy when approaching new projects and challenges.

Thus, it is our desire that the presented research can cooperate in the search of new horizons in future architectural practice, opening new debates about the need and convenience to rethink approaching architecture's traditional methods, leading those to more correlated conclusions related to the changes that the digital age is operating in present and future society.

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Images:

Figure 1: Image taken from the Panel 1 'MNT Proyect' - Virtual Context International Desing Competition 2013.

Figure 2: Extracted from the internet:

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Figure 5: Extracted from the internet:

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Figure 12: Extracted from the internet:

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Figure 13: Photos taken by Alexandre Mouriño.

'Futuropective architecture: Sou Fujimoto', September 10, 2013. Centro Cultural de Belém, Lisboa.

Figure 14: Extracted from the internet:
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Figure 15: Extracted from the internet:
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Adaptations and Negotiations of Local People towards 'Development': Case of Hambantota, Sri Lanka

Shalini Mariyathas

Department of Town & Country Planning, University of Moratuwa
shalini.tcp@gmail.com

Kokila Sooriyagoda

Department of Town & Country Planning, University of Moratuwa
kokila2500@gmail.com

Abstract

"Planners, designers and architects are not paying attention in knowing how things work in cities. On the contrary, they have gone to great pains to learn how cities have to work and what have to be good for people" (Jacobs, 1961). This has made them create cities in a way which they found 'ideal' to achieve what they (mis)understood as 'development'. Furthermore, the trend of the recent city development in many parts of the world including Sri Lanka has been 'changing the existing according to what power wants'. All of which do not seem appropriate to the socio-cultural spaces that are produced by the local people in their daily life. The local people, therefore, adapt various strategies to transform what is given into how it can be lived. This research examines such adaptation process and the responsive negotiations of local people towards 'development' in the case of Hambantota, Sri Lanka.

Keywords: *Adaptation Process; Negotiations; Socio-cultural Spaces; Development*

1. Introduction

Understanding people's way of living and building is increasingly brought to the attention of planners as in many global cities planning is considered as changing the existing according to what the *power* wants. What is resulted is the "externally imposed spaces" on local people (Perera, 2007) which is not appropriate to the spatial practices of locals. The local people, therefore, adapt various strategies to transform spaces to best suit their purpose. This transformative capacity of people to familiarize the strange is viewed by Scott (1985) as "the weapons of the weak". Scott (1985) further argues that the indirect, informal, low-profile techniques of resistance followed by relatively powerless people are often the most significant and the most effective over the long run.

There are considerable amount of researches done emphasizing the importance of understanding people's way of living and investigating how they negotiate and respond towards the authorities' definition of 'development'. The key intention of such researches is to assist planners rethink their role to do what they do better. This research contributes to the same intention shedding light on Hambantota, Sri Lanka where the 'Planned New City Development' of government is presently taking place.

2. Literature Review

The negotiative capacity of local people over how authorities define 'development' is recognized by many scholars as part of their main work. Goh Beng Lan (2002) argues that people are never passive recipients of external initiatives, but rather always struggle within their own immediate contexts of constraints and opportunities to produce a meaningful life with their own particular values and goals (Goh Beng Lan, 2002). As people produce their own living space meaningful for

themselves for their social and cultural activities, the original space tends to transform. This transformation process of local people is observed by Giddens (2002). He highlights the capability of even the most dependent and weak persons to carve out spheres of autonomy of their own. As elaborated by Perera (2007), the local people's process of creating new hybridized cultural practice and spaces opens up possibility of redefining and negotiating the space. Familiarization, including indigenization, localization, and personalization are simultaneously forms of questioning, resistance, and adaptation of extant spaces and spatial structures (Perera, 2007).

Meanwhile, there are large number of studies on how the creation of cities by planners, designers, and architects has led to the struggle of the existence of lives. For example, Kalia (2004) has explored the city of Chandigarh in his book *Chandigarh: In Search of an Identity*. He elaborates that the city of Chandigarh is designed in compliance to a different set of ideals that totally disregarded the social, cultural and economic conditions of the society for which they were built. The design of this city imposed 'new forms of perception, experience and interaction'. Chandigarh had been intended to be a model city in terms of planning. However, it has failed both socially and culturally; it does not provide the economic setup to support all its inhabitants (Kalia, 2004).

Another example is given by Perera (2010) in *Crossing Borders: International Exchange and Planning Practices* in which he examines the planning and development of the Mahaweli towns in Sri Lanka. He argues that the sponsors, funding agencies, consultants, and government largely shared the idea of a 'universal' approach to development. Despite praising ancient Sri Lankan hydraulic schemes, the consultants on the Mahaweli employed Western models such as that of the Tennessee Valley development which had also been followed in the Gal-Oya irrigation project in the Eastern Province. Other Western theories such as Central Place Theory and post-war master planning were applied in conceiving the physical layout of urban centers. He further says that the project leaders viewed locality and inhabitants as the background setting, rather than as the figures animating the scene. The settlers were considered the recipients of better life, the target population, the object of development, with no agency or voice. For the purposes of planning, they were bodies in space that needed to be ordered and organized (Perera, 2010).

Therefore, it is important for the authorities and power bodies to develop cities recognizing the ability of people to control their own lives. City planning and development should acknowledge the desires and aspirations of the people and value their own efforts to achieve what they understand as development.

3. Methodology

The preliminary stage was a detail literature review which helped develop a theoretical framework. This was followed by a review of archival records in order to understand the historical context and the evolution of socio-spatial setting of the city of Hambantota. Further, interviews with selected officials and review of reports were carried out to understand the power bodies' way of development in the city. Finally, informal discussions with the local residents were conducted to get to know their perceptions on the present 'development' in their city. In understanding the responsive adaptations and negotiations of people of Hambantota, the informal conversations with local people were tremendously helpful than any other sophisticated data collection tools and techniques.

4. The Case Study: Hambantota, Sri Lanka

4.1 The Setting

Hambantota town is the major service center in the Hambantota District, Southern Province, Sri Lanka. It is located 241km south of Colombo (along the Colombo-Galle-Matara-Tissamaharama Highway). According to year 2001 census, Greater Hambantota Area has the total population of

206,588 within the total land extent of 113,200 Ha. Meanwhile, the total population of Hambantota Municipal Council area is 11,200. Greater Hambantota Area includes seven District Secretariat Divisions (DSDs) such as Ambalantota, Hambantota, Sooriyawewa, Tissamaharama, Lunugamwehera, Thanamalwila and Sewanagala.

The basic economic sectors of the town of Hambantota are fishing, agriculture, salt production and services. Other popular domestic small scale industries are *Kalu Dodol* (a native festive food), sweets making, pottery making, and brick making. The town and its surrounding region possess many environmentally sensitive land covers which include dry zone forests, tanks, ponds, and salt pans. Another main character of Hambantota town is that it accommodates all different ethnic communities (Sinhalese and Muslims, in particular). These different ethnic communities live together in harmony exchanging their cultural values in the same living environment.

4.2 The History of Hambantota

The historical records say that the kingdom of Ruhuna was established by King Devanampiyathissa of Anuradhapura in the southern region of the island. This region played a vital role in building the country and nurturing the Buddhist culture. Meanwhile, the natural harbor setting that was found in the south coast attracted travelers and traders from the Far East, Siam, China and Indonesia.

According to the narration of Charitha Ratwatta (2013) in *Colombo Telegraph*, human settlements originated around the port of Hambantota from the earliest times when it established itself as an important port. The Dutch, who wrestled the Maritime Provinces from the Portuguese, stationed a regiment at Hambantota. At this time the Kandyan Kingdom gained its supplies of salt from Hambantota. The Dutch who realized the importance of the salt pans as weapons in their attempt to bring the king under their power stationed a battalion in Hambantota. During the British period Hambantota developed further not only as a port, but as an urban center. During that period (until 1928) Hambantota port developed as a naval center. Messars Walker & Sons Ltd were entrusted with the maintenance of the port of Hambantota and according to the British administrative reports a number of ships called at this port each month. The British built Kachcheri regional offices, schools, a police station, a hospital and a court complex in Hambantota (Ratwatta, 2013).

There are many different stories said in various records for how Hambantota got its name. However, most commonly known story is, according to what the web source of the University of Ruhuna says, the vessels the traders traveled in were called 'SAMPANS' and their anchorage came to be known as 'SAMPANTOTA'. By and by, the area came to be called 'HAMBANTOTA'. Thus, 'Hambantota' refers 'the port for Hambans'. The town associated with this port as well as the administrative region around it came to be known by this name (University of Ruhuna, Southern History, 2013).

From its historical period, Hambantota was known for its extraction and distribution of salt to the rest of the country. The dry climate was ideal for salt production. The salt distribution was the monopoly of Muslim traders who took salt to the interior hills and bartered it for spices which they brought back to Magampura and exported. Certain researchers have shown that the development of Muslim communities in the interior of the island have been on this salt route. And, before the advent of the Europeans, the Muslims held the monopoly of the internal trade in salt and the external trade in spices.

Certain other sources mention that due to the proximity of Galle harbor, Hambantota was not a popular attraction for Dutch and Portuguese. Their interest was mainly due to the salt pans which had a wide distribution around the country from Hambantota. However, the prominence came to Hambantota during the British. The British moved the garrison to Hambantota and built their own city around the harbor. Even with all the attempts of Colonialists to make Hambantota a

better city to live, the district experienced a gradual decline during and after the colonial era. The only industries of any capacity were salt extraction and the dairy industry (Ratwatta, 2013).

4.3 Hambantota: What it was?

During the period from 1980 to 1995, Hambantota was considered as the country's most remote and poorest region. The majority of population led an existence surviving through fishing, small-scale agriculture and salt farming. Hambantota was a poor district with social indicators well below the national level at the height of the 1989-1995. In year 2000, 31% out of the total population lived below poverty line. Various poverty alleviation programs were introduced by the government and non-governmental organizations to uplift the quality of life of people of Hambantota. Further, Hambantota District is one of the worst affected areas by tsunami that hit Sri Lanka on December 26, 2004. The official death toll claim in Hambantota was approximately 4,500. In year 2008, it was announced by the government that the poverty level has been reduced up to 12.7% due to the various poverty alleviation and quality of life improvement projects and programs of the government (News Line, 2008).

However, the most crucial turn to the town was the year 2010 which rewrote the destiny of the town. This is due to the special political interests of the elected government on Hambantota, Mahinda Chintana political doctrine of the government and the resulted National Physical Plan 2030 of the National Physical Planning Department. Hambantota gained a huge importance nationally and internationally afterwards.

4.4 Hambantota: What it is going to be?

The vision of the Mahinda Chintana political doctrine of the present government is to make Sri Lanka an Emerging Wonder of Asia. This vision will be achieved through the proposed five hubs such as Navigation Hub, Aviation Hub, Knowledge Hub, Energy Hub, and Commercial Hub. The National Physical Plan 2030 which was prepared by the National Physical Planning Department in year 2011 is the national level development plan that implements the goals of Mahinda Chintana political doctrine. The key proposals of the National Physical Plan 2030 are conservation of the central fragile region of the country and creation of five metro regions each with metro cities. The major goal behind the metro regions is to reduce regional disparities and to distribute population growth in a planned manner.

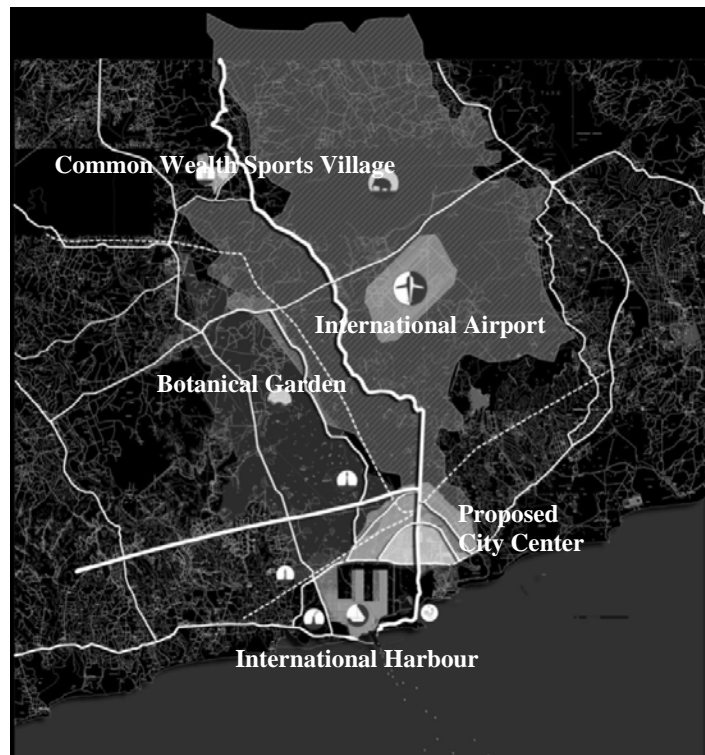


Figure 1: Major Projects of the Greater Hambantota Development Plan of Urban Development Authority.
Source: Urban Development Authority

One of the five metro regions is Hambantota Metro Region which is comprised of entire Greater Hambantota Metro

Area. The proposed Metro City within the Hambantota Metro Region is Hambantota town. This is how Hambantota town got into the power bodies version of 'development'. When the development of Hambantota Metro City became the priority of the present government, the Greater Hambantota Development Plan was prepared by the Urban Development Authority proposing many mega scale development projects to achieve the goals of the government (Figure 1).

The vision of the Greater Hambantota Development Plan is *A Gateway to Asia*. In order to achieve the said vision, the development plan adopted the approach of Mahinda Chintana political doctrine. Accordingly, the five hubs such as navigation hub, aviation hub, knowledge hub, energy hub, and commercial hub will be established within the town. Thus, the mega scale projects such as Magampura International Harbour, Mattala International Airport, Commonwealth Games Village in Sooriyawewa, Botanical Garden in Mirijjiwella, Hambantota City Center (with all kinds of high-end facilities) in Siribopura with administrative complex, international convention center, banking square, city hotels, tourism development along coastal belt, extension of Southern Highway up to Kataragama, Extension of Southern Railway up to Kataragama, and industrial areas were proposed. Some of the above mentioned projects are now completed, but all of them are scheduled to be completed in 2030.

It is noted that these development projects are not merely the outcomes of the Greater Hambantota Development Plan but resulted due to the present government's political interest on Hambantota.

4.5 Hambantota: What it is today?

Today the town looks different. The change is what is expected by the power bodies. It has both good and bad faces. There are newly built up areas which give a new look to the entire town. Meanwhile, there are empty neighborhoods and shopping streets which are also the outcomes of *development*. The progress of major constructions is visible. National and international tourists and visitors are coming in. There is a high migration of people into the town looking for jobs and opportunities.

The question that this research places at this juncture is, in the midst of such mega 'development' projects in and around the city, where have the local people gone? What happened to them? How did all these physical development projects find space to put up? Whose spaces (lands) are they? How local people view the development around them? How are they treated by the authorities during the development? How and what the people have transformed? All these questions can be viewed within the area of "the process of adaptations and negotiations of the local people" towards how the power has defined development.

5. Adaptations and Negotiations of Local People towards the *Development* of Hambantota

Flyvbjerg (1998) states in his most influential *Rationality and Power: Democracy in Practice* which traces the attempt of city of Aalborg to create a master plan for urban development, "...the basic idea of the [plan] was comprehensive, coherent, and innovative, and it was based on rational and democratic argument. However, during implementation, when idea met reality...". The Hambantota development plan and its projects are also highly similar to how Flyvbjerg interprets the city of Aalborg projects. When Hambantota development plan came out with projects for economic and infrastructure related developments they were viewed as the steps towards a golden future for the town and its people. However, when the ideas met the ground realities, private (power) demands won against public needs and aspirations.

This created ground for the local people to adapt and negotiate to win their desires and dreams. The intention of this research is to shed light on them. However, the underlying adaptation processes of locals towards the *development* of Hambantota are very complex and indefinable.

Therefore, in order to noticeably present the authors' observations within the scope of this paper, local's adaptation and negotiations are examined in light of the below key projects:

1. The proposed tourism development project in the old town
2. The proposed new city center in Siribopura
3. Hambantota port development project (the resulted road closure and the frozen village Mirijjawila)

1. The proposed tourism development project in the old town

"Decision First; Rationalization Later" (Flyvbjerg, 1998, p20)

The local residents who live and work in the present (old) town center were informed about the upcoming tourism development projects in their locality at the public meetings that were conducted by local politicians and authorities. Although the authorities viewed the coastal belt and the scenic beauty of the old town as tourism potentials, for the locals it is their own spaces of life, work, joy, feelings, and memories. There are Sinhala and Muslim communities who live in harmony sharing social values and norms over a period of time. They engage in businesses, their kids go to schools, they relax on the beach, they walk along the sea shore and remember their loved ones who got washed off during the massive tsunami attack in 2004. Fishermen fight with the tidal waves day and night to catch fish. The fish market near the fishery harbor is the busiest place at any time of the day. Vegetable and fruit sellers bring their fruits and vegetables close to fish market to find more buyers. "...[This] is the emergence. Planners should create conditions for the emergence to take place" (Hamdi, 2004). However, today it is a declared tourism development zone.

According to the Zoning Plan of the Greater Hambantota Development Plan of Urban Development Authority the coastal zone of the present town center is proposed to be coastal tourism zone (Figure 2).

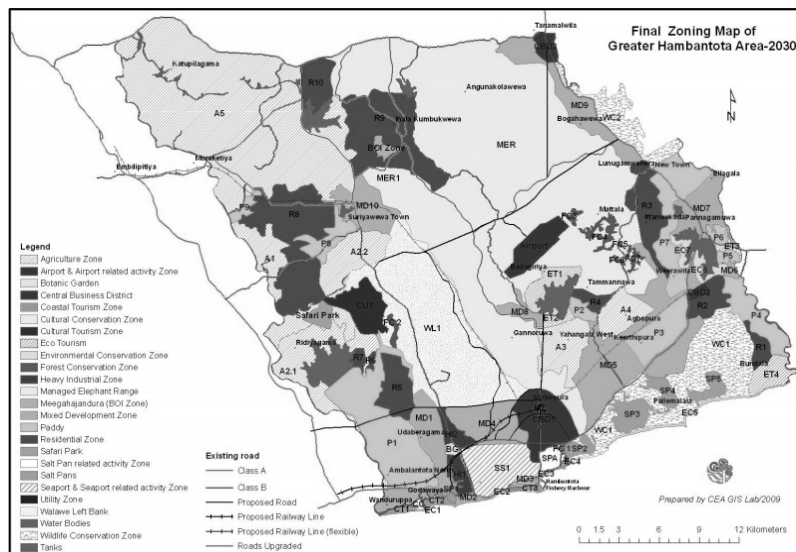


Figure 2: Zoning Map of Greater Hambantota Area 2030
(Source: Urban Development Authority)

People of this area were told that their lands will be acquired by the authorities for the tourism related projects and they will be given new lands in the new town center area. Their lives all of a sudden became uncertain. In everybody's mind there is one certain question which is due to the uncertainty and threat of land acquisition. They hesitate to tile their roofs or repair their houses. They do not know when they will be asked to leave. Nazeer, a business man who lives in the

Murray Street recounts, *'They told us that they will buy our lands. We don't know where to go. I am guessing where I will be given a place. But those places are economically not profitable for me'*.

What is happening around them is more real than how it sounds in this write up. They are put in a situation where they immediately have to respond and make decisions. There are many ways of negotiations, adaptations and responses which are invisible. However, two kinds of responses are highly visible. One is towards opportunities and possibilities. Other is towards threats and uncertainties. Although majority of the community feel the threat, certain section of the community is anticipating more livelihood opportunities. Few businessmen in the town mentioned that when the tourists and visitors arrive in the city there will be more demand for goods and services. Even today certain shops in the town center display sign boards in Chinese. The large number of Chinese workers who work in the construction projects in Hambantota are target of these businessmen.

Meanwhile, another segment of the community feels threatened due to the fact that their lands and livelihoods will be taken away. There are actions by the authorities to prepare people to serve the tourism. Kamala who lives with her family in the Target Road states, *'We have been sent letters by the government asking us if we would like to convert our home into a guest house for foreigners'*. Local people are scared to imagine how the tourism would impact their lives. They have to transform themselves and become new as how they imagine their future. It is, even for the locals, *"decision first; rationalization later"*.

2. The proposed new city center in Siribopura

"Places that happen, happen to work; places that are made, don't work" (Hamdi, 2004, p58)

According to the Greater Hambantota Development Plan, the new city center is proposed in Siribopura which is located 5km from the present (old) town center. This particular city center is planned accommodating facilities such as high and middle income housing, city hotels, urban blocks, theaters, banking square, golf course, urban parks, diplomatic enclave, city square, civic square, transit hub, etc (Figure 3). According to the official's plan, the businesses, administrative, civic functions, and certain settlements of the old town will be shifted to the new city center. Administrative functions are already shifted to the new administrative complex. The local businessmen were told that

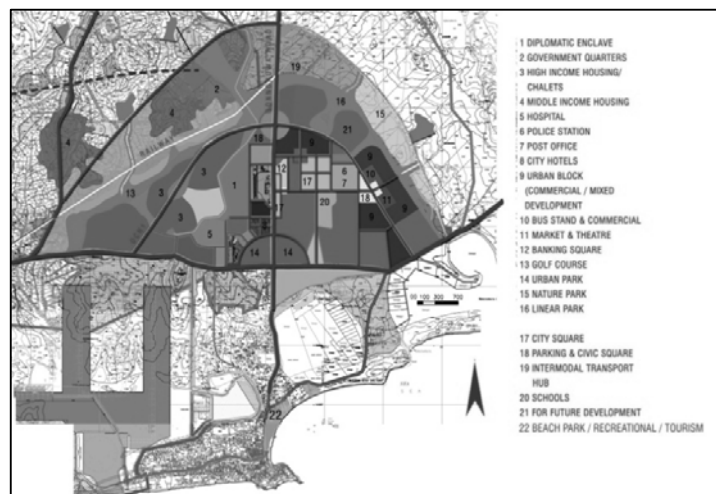


Figure 3: Development Proposals for the New City Center in Siribopura (Source: Urban Development Authority)

they will be given lands and more opportunities to do their businesses in the new city center. However, what people see is a huge distance and difference between what is made and what they want. For them, the proposed city center and its activities do not seem to be fitting for how they live their lives. City hotels, urban square, night market, golf course, and city square proposals of the new city do not give any meaning to local people. Further, they understand that the target of the entire *development* is towards an alien community which will be imported to their town in the near future.

Tharanga, a salesman who lives in the old town said, *'I was told that I will be given a space for shop in Siribopura. But I don't understand why I should go there. I have enough business here. My customers live here. They are coming to my shop every day. I am happy here'*.

The region that is identified for the development of new city center includes many neighborhoods which are new and old. Particularly, one community that feels threatened due to the high-end development in the new city area is the tsunami resettlements. When the tsunami attacked Hambantota in 2004, the tsunami resettlement housing projects were placed in the region that is new city center today. Further, the port project resettled many families to this area. Today one can see settlements with name boards such as Canberra Houses, John Keels Village, Care International Village, Waraya Gama, etc. The region was not demanded by the state or investors during the resettlements were taking place. However, as of today, all these resettled communities are falling within the region of new city center. As the people of the region experience the changes that are happening around them, they understand that their lands have become more expensive. Their situation is even worse since the people in the region do not have legal land rights. They understand that they might need to give away their lands and houses anytime if the luxurious city center development needs them.

The truth is that the people of Hambantota fit in nowhere in the development. However, they have been prepared to not to think in that way. Their thinking is shaped, modified, and thus, highly influenced by political influences. They have been told how to feel about the development. This has also led raised expectations in certain communities. They are *thinking* of establishing businesses, home gardens, tailoring services, sweet shops expecting that the new city center will provide them opportunities. Just like Hamdi (2004) states in his *Small Change: about the Art of Practice and the Limits of Planning in Cities*, "...they are trying to create a new meaning for their lives. This is their imagined future. This imagined future is good. Because they could be what the imagination conspires them to be rather than what the [authorities] say they have to be".

3. Hambantota port development project (the resulted road closure and the frozen village Mirijawila)

"Whatever exists, it is again and again transformed and redirected by some power superior to it..."
(Friedrich Nietzsche)

The port of Hambantota is planned to develop as a services and industrial related harbour. The government's objectives towards the construction of the port are to create a catalyst for major economic development in Sri Lanka and to reduce prevailing unemployment issue of the Hambantota region. Phase one of the port project commenced in 2008 and opened in 2010. The second phase is started in 2012. According to the port master plan, 33 vessels can be accommodated at the port at any given time. It has been positioned as an industrial port with facilities to transship vehicles and also provide bunkering services. The Hambantota Port is said to be Sri Lanka's biggest port and will give access to traffic on one of the world's biggest East-West shipping lanes.

According to the Sri Lanka Ports Authority, presently investment proposals from local and foreign investors are called to establish businesses within the port premises. The proposals include cement grinding plant, cement storage and bagging plant, fertilizer storage/processing bagging plant, LP gas distribution facility, warehousing complex, vehicle assembling plant, flour mills, food processing & packaging and any other business related to import and export sector. Investment proposals have been received from the investors of India, Pakistan, and Hong Kong. The needed land area for port premises has not been clearly informed by the government or the authorities. However, there are so many proposals and projects for expansion of port. There are new projects emerging every day. These projects should find land to be executed. The residents of Mirijawila, Sippakulama and Target Road (west side of old town center) who heard the stories of port expansion have made up their minds by now. They felt the news as a big shock many months ago. Now they spend every day expecting a letter from the authorities that would ask

them to give away their lands. “...They did not ask *why*. They needed to know *where* [to go]. The *where* is nowhere recognizable for them” (Verma, 2003). The result for today is the constant stress of uncertainty and instability. The town which was once owned by locals is now in the hands of power elite. The locals’ mindset about this can be best described by the quote of Hamdi (2010): “These shoes are made for walking – AWAY”

Another huge impact of the port project is the closure of Colombo-Galle-Matara-Tissamaharama Highway. This particular road was the major access point to Hambantota town for those who visit Hambantota, Tissamaharama and Kataragama. During Kataragama festival season, the businesses (mainly *dodol* and sweets business) of the town and beach areas were very busy as Hambantota town center and beach were the stopovers of pilgrims and visitors. Presently this particular road closure has cut down the connections and it is the major reason for why the town lost its functions and activities. It is reported that 75% of the businesses of old town center is closed down due to the road closure.



Figure 4: The Location of Mirijjawila Village, the Port Project and the Closure of CGMT Highway

However, the most significant impact has been on the Mirijjawila village. Mirijjawila is located on the coastal belt, on the west side of the port and is situated along the Colombo-Galle-Matara-Tissamaharama Highway (Figure 4). This particular village is completely frozen due to the road closure. Mirijjawila was well known and well served for the pilgrims and visitors of Kataragama. Also, the local stories say that Mirijjawila got its name due to the fresh water pool which was used by pilgrims heading to Kataragama. There are 526 families in the village, many of them are engaging in fishing and salt production. It was an active vibrant village mainly due to its location close to Hambantota town center.

Today, due to the land acquisition for port construction, Mirijjawila has lost its 60% of land. Due to the loss of connection to Hambantota town it also lost its functions and activities. By and large, presently it is with no life. The villagers have lost their livelihood. In addition, the unplanned land filling of port development has caused flash floods in the settlements. The life has been turned out nothing but a struggle for them in every way.

For the locals, Hambantota development is simply “building big; building more; and building faster”. Everything is built according to the ideals set by the power. All are in the interests of ensuring national development and economic growth. That is in another words, ‘If it were possible for bacteria to argue with each other, they would be able to say that of course their chief justification was the advancement of medical science!’ (Hamdi, 2010, p143).

The mindset of the locals of Mirijjawila can be best expressed through their following recounting:

- Thilakaratne, a resident of Mirijjawila and a brick maker (Age 50):
'We were the ones who sacrificed everything for the port development, but most of the jobs inside the port were given to outsiders (people from Weeraketiya, Sooriyawewa, etc). Also, there are conflicts between villagers and Chinese supervisors during this port construction. So, none of us are going to work there'.
- A fisherman who lives in Mirijjawila:
'They took our Ma del wadiya (fishing spots) to build the harbour. Now we don't have a place to fish or to keep our boats. Even if we catch some fish, we struggle to sell it with the people in the new market. We go to Sooriyawewa junction and get hold of people to sell our fish, before they reach the new market'.
- Tharuka, a resident of Hambantota and an undergraduate student at Ruhuna University (age 24):
'Nowadays most youngsters leave school at the early stage to get odd jobs in the projects. With these developments, they choose money over going to school. What we are losing is educated and skilled younger generation that is supposed to operate these developments in future'.
- Sanjeevani, a housewife (age 41),
'The foreign workers who have been working in the port construction have become part of our village now. Most of the villagers have rent their own houses for these workers and staying in a small room. However, we are afraid to stay in our own village having foreigners in the village. There are illicit activities and other social issues spreading around'.

Conclusions

The way Hambantota is getting developed is similar to what the world's planners, politicians, decision makers and professionals speak about development everywhere. In case of Hambantota, the decisions and the objectives behind the decisions are repeatedly justified and rationalized by the *power*. What is not there is an open evaluation of how well the development is succeeded meeting the needs of people of the town, in another words, in actually achieving the objectives. Therefore, as a conclusion, the authors' own evaluations are presented.

First, the local people of Hambantota realize that they fit in nowhere in the 'mega development' that is happening in their town. The life that people had was taken away from them and the new life that is promised by the 'development' does not even seem appropriate to how they want to live their lives. Thus, as Hamdi (2010) states "It all belongs to someone other than the people who live there..." (p44). Second, there is no one development path for Hambantota in the hands of authorities. According to an official who works for one of the project implementation agencies in Hambantota, new projects emerge everyday without any relevance and *rationale*. Politicians play huge role in finding investors for their projects. This makes the authorized development plan ineffective. The Greater Hambantota Development Plan is no longer active due to the development projects which emerge then and there from nowhere. Third, despite the incompleteness of the development in terms of its meaning and direction, any decision that the authorities make has succeeded as the space and territory are majorly controlled by the government. The locals of Hambantota do not have the power to oppose any authority in their own town.

However, the local people uphold their own values by negotiating and adapting to the changes of their environment. When their needs and aspirations are not taken into account in building their city, they fit their needs to what is decided and given. This happens in various ways as elaborated in the previous sections. “Another way of achieving development is....through translating locals’ knowledge and aspirations into plans and projects” (Hamdi, 2004). In another words, this is *planning for real*.

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Forging Sustainable Urban Futures for Asian Cities through Urban Waterfront Regeneration: Comparative Studies in Colombo, Bangkok and Singapore

Lai Choo Malone-Lee

Director, Centre for Sustainable Asian Cities, NUS
sdemalon@nus.edu.sg

Heng Chye Kiang

Dean, School Design & Environment, National University of Singapore, sdehck@nus.edu.sg

Reese, Melissa

Researcher, Centre for Sustainable Asian Cities, NUS
sdemar@nus.edu.sg

Abdul Hamid, Abdul Rahim

Graduate Student Researcher, Centre for Sustainable Asian Cities, NUS abdulrahim@nus.edu.sg

Abstract

Urban waterways and waterfronts have always played an important role in the early development of Asian cities. However, over time, many of them have become polluted, abandoned and derelict. Nonetheless, they remain relevant to the social, economic and in many instances, political and cultural life of cities. The challenge for planners is not only to revitalize these areas to reclaim their rightful roles and functions in the city, but also to harness their potential positive contribution to a more sustainable future for Asian cities. In this paper, we develop and apply a conceptual framework to analyse and define what constitutes successful and sustainable outcomes of urban waterfront renewal, primarily through the lenses of community participation. Three case studies have been selected for this analysis from the cities of Singapore, Bangkok and Colombo. In examining these cases we asked how economic imperatives can be balanced with social and cultural sensitivity, while addressing critical environmental and infrastructural challenges, as well as the role of the local community in all these aspects. The paper concludes that local community involvement is important to forge a sustainable urban vision while recognizing that this can take many forms.

Keywords: Urban regeneration, Colombo, Bangkok, Singapore, waterfronts, community participation

Introduction

The intersection of land and waterways has always been a significant space for development within cities, whether it is for trade, transport, defence, industry, housing, recreational or other purposes. This space, the urban waterfront, is often also the site of continuous change and redevelopment in cities as economies continue to evolve and social development takes place. This is particularly the case in many Asian cities, where the rate of urban change is rapid, given the relentless pace of urbanization. The processes are complex straddling the economic, social, environmental and institutional dimensions. In this context of constant change and its wide-ranging implications, this paper seeks to examine what constitutes successful waterfront urban regeneration projects, as well as how they would contribute to urban sustainability in Asian cities. This paper has been developed out of a larger research project that involved in-depth comparative studies of urban regeneration projects drawn from a fairly large database of urban regeneration case studies in Asia. A conceptual framework has been developed by the research team which reviews the context, processes, outputs and outcomes of urban regeneration to help evaluate the success of urban regeneration projects in relation to the pillars of sustainable

development. Three cases which focus on waterfront redevelopment in Singapore, Bangkok and Colombo have been selected for detailed analysis by applying the conceptual framework.

Definition and Significance of Urban Waterfronts

Much of the current literature on waterfront regeneration which are derived from more developed cities in the West, has focused on major bodies of water, the sea, bays, rivers and port areas (Bergman, 2011, Krieger, 2004, Sairinen and Kumpulainen, 2006, Roberts and Sykes, 2000, Smith and Garcia Ferrari, 2012). Taking a broad definition of urban waterfronts as any space within an urban area where the land and water intersects, it would become clear that the complexities relating to the redevelopment of such areas are due in part to the wide variety of land uses that have evolved in and around these areas over many years, many of which are deeply entrenched, overlapping and inter-dependent. The wide range of waterfront land use typologies include deep sea ports, military bases and defence strongholds, industrial and warehouse developments, recreational parks and beaches, river promenades, floating markets, storm water management systems, and a host of other activities that may or may not be directly related to trading or sea transportation activities.

In many cities in Asia, these intersections of land and water have been long established as living communities, with both formal and informal housing, community networks and even agricultural uses. For example, the Singapore River in the 1970's and earlier displayed many of these overlapping uses including squatter housing, farms, boat yards, street hawkers, markets and wholesalers, and a variety of commercial uses relating to Singapore's mercantile functions (Figure 1).

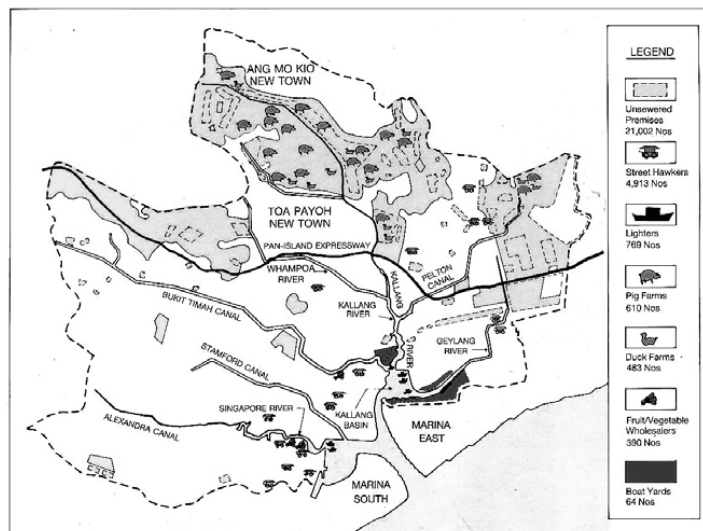


Figure 1: Map of land uses around the Singapore's River in the 1970's
Source: PUB 2010

In some Asian cities, instead of a single water body, waterfronts may be composed of a network of natural lagoons and streams, or various sizes of water bodies such as the sea, rivers, lakes, lagoons and canal systems. In Bangkok for example, there are a myriad of urban canal systems that are deeply ingrained into the entire cities' social and urban fabric (Figure 2). These canals not only provide a means of local water-based transportation, agriculture activities, as well as space for floating markets, but are also designed to manage flooding, although the 2011 floods across the city would seem to indicate that the system may no longer be adequate to fulfil this function in the face of severe storm events.

Apart from Bangkok, another city with such comprehensive waterfronts serving as storm water management systems is Colombo in Sri Lanka. Its Lunawa Lagoon is an example of a network of lagoons and streams, surrounded by formal housing, squatters and industries. This area has been the location of severe floods (Figure 3) and will be further studied in this research. Furthermore, in the more developed Asian cities such as Shanghai, Hong Kong and Singapore there are also major waterfront redevelopment projects in the city centre, focusing on economic revitalisation and urban renewal. Many of these projects take on a very different form from similar projects in western cities due to the rapid pace of urban development, the deeply entrenched urban infrastructure and their primarily government-led redevelopment efforts (Giblett and Samant, 2011).



Figure 2: Bangkok's Flood prone areas and canals
(Dark Blue = 0 m above sea level)

Source: Bangkok Flood Elevation Map
(<http://bkkbaseface.wordpress.com/2011/10/24/bangkok-flood-elevation-map/>)



Figure 3: Lunawa Lagoon Project Area

Source: Lunawa Environment Improvement & Community Development Project Office 2012

Relationship to Urban Sustainability

Given the multiple land uses and extensive economic and social linkages, waterfront redevelopment has always attracted the attention of both urban practitioners and scholars. The inherent connections to a city's history, economic structure and community life are well recognised. Jane Jacobs specifically noted that “(t)he waterfront isn't just something unto itself, it's connected to everything else” (cited in Kreiger 2004). However, these characteristics of historical, social and cultural relevance are the very qualities that have rendered them as “... one of the most complex and challenging urban lands in cities” (Butuner, 2006, cited in Giblett and Samant, 2012).

As cities grow, urban waterfronts are constantly subjected to the push and pull of urban change as a result of evolving economic and social priorities and competing physical land demands. Many cities have recognised that regenerating, repositioning and re-purposing waterfront land as imperative to mitigate urban decay. The priority given to such redevelopment efforts has been largely driven by three critical concerns. Firstly, urban waterfronts' environmental degradation and associated social problems have serious impacts on the economic life of cities. Secondly, from a more positive perspective, the proximity of waterfronts to the city presents numerous opportunities for growth and development in terms of available land, existing infrastructure and associated economic synergies. Thirdly, due to their economic, social and architectural

associations with a city's past, they are often seen as integral to a city's identity and intrinsically linked to the interests of the local community.


From the perspective of urban sustainability, regeneration of urban waterfronts offers a potentially positive pathway to attaining longer term social, economic and environmental goals. Giblett and Samant (2011) have noted that "the inclusion of the waterfront in urban development plans becomes essential when striving to improve the sustainability of a city". The contribution to sustainability is evident in several fronts. Waterfront regeneration enables land preservation through the processes of recycling and reuse of previously developed land, including abandoned ports and disused industrial areas. In the process, cities are able to develop in a more compact manner instead of spreading outward, while harnessing the opportunity to create more environmentally conducive environments to work and live. Also, revitalization of waterfronts offers opportunities for enhancement of architectural and aesthetic qualities, touristic values and social life in cities, often with tangible economic upsides and land value enhancement.


However, due to their significance in the physical realm and the mental space of a city, urban waterfront regeneration projects are undoubtedly most controversial in the social sustainability aspects. For example, in developed cities, there are numerous examples of redevelopment of derelict dockland areas which have today become some of the most exclusive commercial and residential locations in city centres, and many of these have been criticised for the inadequate attention given to existing communities and social sustainability. Thus, the conceptualisation of a better future offered by the process of regeneration is sometimes at odds with social and cultural systems that are already deeply ingrained in the subsisting living communities. Sensitive and guided conservation efforts in these regeneration projects may yet attain positive outcomes leading to overall better quality of city life (Sairinen and Kumpulainen 2006, Bergman, 2011), but maintaining existing social networks which are often at risk when redevelopment takes place, or rebuilding them, remains one of the most demanding challenges for such projects. This suggests that active engagement of the multiple stakeholders, in particular those representing the weaker segments of the affected community, becomes a key factor in the success of such waterfront regeneration projects.

Case Studies

The three cases studied in this paper, each in Singapore, Bangkok and Colombo, were primarily selected based on their rich and diverse experiences in terms of multi-actor redevelopment efforts that are amenable to scholarly research and analysis. The three projects are briefly described in Table 1. They are selected from a data base of over thirty (30) Asian urban regeneration projects which are compiled as part of a larger research project. These waterfront urban regeneration cases have been documented and analysed from a review of public documents and scholarly articles, site inventories and analysis, field observations, onsite interviews with key stakeholders and analysis of primary project documentation.

Table 1: Selected Case Studies

Singapore River		Singapore	Cleaning up the polluted Singapore River and its surrounding neighbourhoods, through a multi-agency approach which addressed the pollution at source and relocated polluting businesses and squatter residents, and in the process, promoting economic revitalisation along the river.
Bang Bua Canal and Community Regeneration		Bangkok, Thailand	An <i>in-situ</i> , informal settlement upgrading project carried out in collaboration between non-government organisations (NGOs), private consultants, the government and local residents.

Lunawa Environment Improvement and Community Development		Colombo, Sri Lanka	A project that simultaneously deals with cleaning up a polluted lagoon and its canal system, while seeking to improve the housing for the squatter communities within the lagoon's watershed, all through community participatory approach.
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Theoretical Framework for Analysis

In order to assess how successful an urban regeneration project is in achieving sustainability goals, a framework for analysis must take into account how well environmental, social and economic sustainability is integrated into the urban regeneration revitalization process. While internationally, many assessment tools are available which evaluate the sustainability of development projects, for example, LEED (USA), GreenMark (Singapore), and BREEAM (Europe), these are rating tools that are primarily designed to assess new projects and focus mostly on environmental factors. Also these tools typically tend to focus on built structures and rate the measurable environmental outcomes of the planning, design and construction processes. They do not comprehensively examine how projects deal with the existing social and economic conditions of a space and the complex processes involving multiple stakeholders that are involved, as urban regeneration projects must account for. Taking these considerations into account, and the existing theoretical discourse presented by other scholars (see, for example, Alterman, 1995, Doratli, 2005, Steinberg, 1996), the authors developed from first principles and theoretical knowledge, an assessment framework for sustainable urban regeneration projects (see Malone-Lee et al., 2013). The various aspects which comprise this framework are elaborated upon in this paper, with the framework diagrammatically presented in Figure 4.

This framework examines not only the physical and environmental aspects of urban regeneration projects, but also analyses the social and economic conditions. These four aspects are examined as components of the ongoing revitalization programs, and critically consider the motivations of the various stakeholders, the development and social pressures encountered, as well as the impacts of the redevelopment processes. This evaluative approach is comprehensive, and is not a one-off assessment of the state of the areas, nor only of the outcomes of the processes. The proposed factors that are considered in the assessment process were developed by reviewing approaches to historic preservation and upgrading projects similar to urban regeneration, and through in-depth comparative analysis of a large database of case studies (Doratli, 2005, Steinberg, 1996). *See the blue "Program" portion in Figure 4.*

Recognizing that the existing context of the city and redevelopment site greatly shapes the regeneration process, these are also accounted for in the framework. This would include consideration of the economic development drivers, the existing obsolescence of the site (Doratli, 2005), and the overall economic structures and urban profile of the city (Alterman, 1995) as they all have significant implications on the success or otherwise of an urban regeneration project. *See "Site Context" and "City Context" in Figure 4.*

The assessment framework also takes into consideration the implementation methods and strategies for urban regeneration, which can include numerous stakeholders and their roles, program methods and tools, as well as the legal and financing mechanisms (Doratli, 2005). Understanding that multiple methods can occur simultaneously the framework's "Implementation" portion considers quite a broad range of factors.

Next, the outputs, which are the tangible products, services, or facilities delivered through the program, must be clearly identifiable. These are evaluated together with the outcomes—which are the urban, environmental, and institutional changes, as well as benefits, including economic and social, to the existing systems—all of which must be discernible in order to determine its overall success or otherwise (Alterman, 1995).

Finally, one of the distinguishing characteristics of this framework is that it is not linear in structure but acknowledges that positive outputs and outcomes of the urban regeneration processes must feedback into the on-going revitalization activities, thereby supporting a project's contribution to the urban sustainable development. *Represented by the orange arrows in Figure 4.*

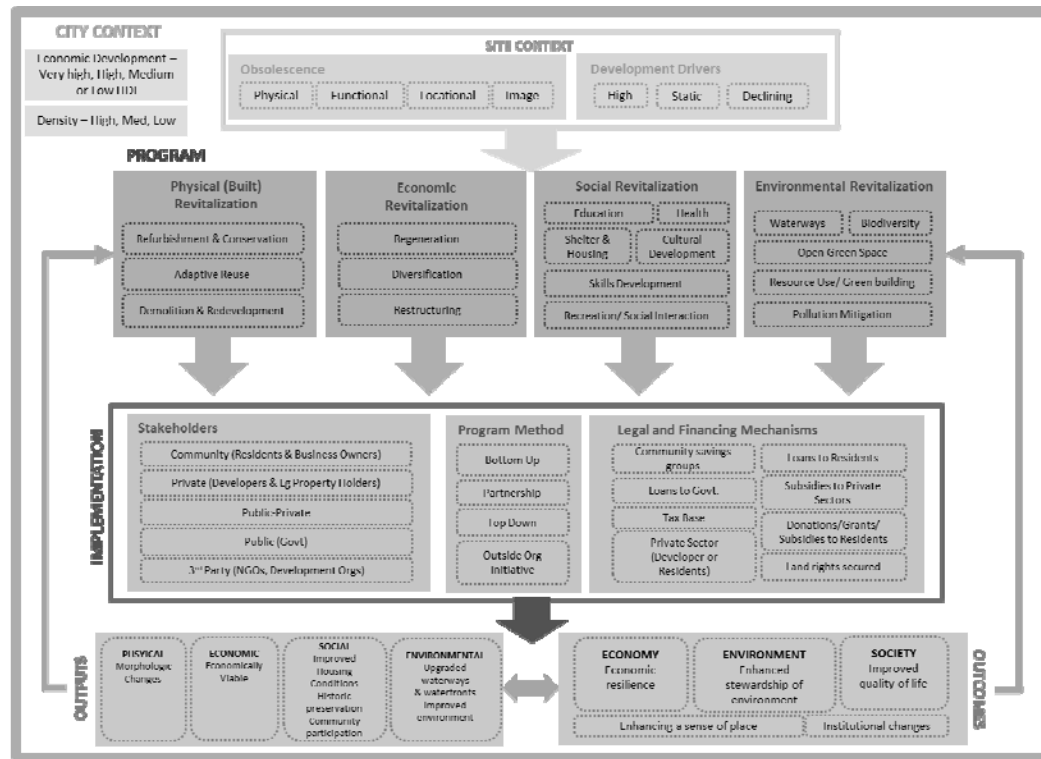


Figure 4: Assessment Framework for Sustainable Urban Regeneration Source: (Malone-Lee et al., 2013)

Application of Framework to Case Studies

In operationalizing the framework, we analyse each project to understand its site and environmental context, the types of revitalization programs that were utilized, how they were carried out, who the primary stakeholders were and their respective roles, how they were funded, and finally what were the outputs and outcomes of the respective projects. Each aspect represented in Figure 4 has been individually evaluated through a triangulation of methods, namely, field observations, interviews with stakeholders and finally published reviews and other available documentation. The process is evaluative, and the strength or intensity displayed by the factor considered, or if the project exhibits the condition under the context, or utilizes a certain program or method, the final assessment is qualitatively indicated as “X”, “XX” or “XXX”⁴³, as shown in Table 2. It is important to note that the evaluation is not intended to be quantitative, but seek only to present a systematic and rigorous process, to guide the investigation. The following sections use this framework to present an overall qualitative assessment of these three waterfront cases studies.

⁴³ In terms of method of implementation, several cases have multiple implementation modes, or use more than one program typology, and as such those that are more intensively used are indicated by “XX” or “XXX”. For example in the case of Bang Bua under “Social Revitalization” educational and health programs were provided along with some space for recreation in the community. However since provision of housing was the primary goal this is indicated with “XXX” which the other programs received an “X”

Table 2: Application of Assessment Framework to Case Studies

			Singapore River (Singapore)	Bang Bua Canal and Community Regeneration (Bangkok)	Lunawa Environment Improvement and Community Development (Colombo)
		Case			
City Context	Economic Development (HDI)	Very High	X		
		High			
		Medium		X	X
		Low			
	Density	High	X		
		Medium		X	X
		Low			
Site Context	Obsolescence	Physical	X	X	X
		Functional	X	X	X
		Locational	X		
		Image	X	X	X
	Development Drivers	High	X		
		Static		X	X
		Declining			
Program	Physical Revitalization	Refurbishment/Conservation	X		X
		Adaptive Reuse	X		
		Demolition & Redevelopment	X	X	X
			X		X
	Economic Revitalization	Regeneration	XX	X	
		Diversification	XXX		
		Restructuring			
	Social Revitalization	Shelter/Housing	XX	XXX	XXX
		Education		X	X
		Health	XX	X	X
		Cultural Development	XXX		
		Skills Development			XX
		Recreation/Social Interaction	XXX	X	X
	Environmental Revitalization	Waterways	XXX	XXX	XXX
		Open Green Space	XX	X	X
		Biodiversity	X		X
		Resources Use/Green building	XX		
		Pollution Mitigation	XXX	XX	XXX
Implementation	Stakeholders	Community (Residents & Business Owners)	X	XXX	X
		Private (Developers & Property Holders)	XX		
		Public-Private			
		Public (Govt)	XXX	XX	XXX
		3rd Party - NGO, Development Org		X	XXX
	Program Method	Bottom Up		XXX	
		Partnership	XX	X	XX
		Top Down	XXX		
		Outside Org Initiative			XXX
	Legal & Financing Mechanisms	Loans to Residents		XX	X
		Community savings Groups		XXX	
		Donations/Grants/Subsidies to Residents			X
		Tax Base	XXX	X	X
		Private Sector (Developer or Residents)	XX		X
		Subsidies to Private Sectors	X		X
		Loan to Govt			XXX
		Land rights secured	XX	X	X
		PHYSICAL: Morphological Changes	XXX	X	X
		ECONOMIC: Economically Viable	XXX	X	X
Outputs & Outcomes	Outputs	SOCIAL: Improved housing conditions	XXX	XXX	XXX
		SOCIAL: Historic Preservation	XXX		
		SOCIAL: Community Participation	XXX	XXX	XXX
		ENVIRONMENTAL: Improved Environment	XXX	XXX	XXX
		ENVIRONMENTAL: Upgraded waterways & waterfronts	XXX	XXX	XXX
		ECONOMY: Contributing to economic resilience	XXX	X	X
	Outcomes: Primary Changes to System	ENVIRONMENT: Enhanced stewardship of natural capital	XXX	XX	X
		SOCIAL: Improve quality of life	XXX	XXX	XXX
		Institutional Changes	XXX	XXX	XXX
		Enhancing a sense of place	XXX	XXX	XXX

(XXX = each characteristic is exhibited to a higher intensity or extent, XX = medium intensity, X = low intensity,
Blank = does not display characteristic)

While each of the three case studies assessed have different contextual and methodological elements to their urban regeneration efforts, all three have begun with extensive physical and image-based obsolescence. They are all sited in areas known to be degraded sections of the city or “squatter” areas before regeneration. The extent of their physical deficiencies has, in all of the projects, required that government agencies and the community be fully engaged in the redevelopment efforts. However, each case is unique in the way these stakeholders went about working together or in different ways, giving rise to differentiated outcomes. The following sections provide an analysis of these three case studies based on the assessment framework presented.

The Singapore River

The project has been widely acknowledged by both local and international bodies as a “successful” urban regeneration project (UN ESCAP, 2003, UNEP, 2005), primarily for the efforts of transforming the site from a derelict brown field into an economically vibrant waterfront district within a relatively short period of time (See Figures 5 & 6). The key success factor was widely attributed to the adoption of an integrated management approach in a multi-sectoral institutional setting (Chou, 1998).

City and Site Context

The Singapore River revitalization project, beginning with the river clean-up in 1977, offers valuable insights as to how a top-down, multi-government agency approach can reinstate the role of the river as a quintessential part of the city’s living heritage and later bring back economic life to the river and its surroundings. The urban regeneration program began as a River Clean-Up project, necessitated primarily as a consequence of the economic changes experienced by the port city in the 1970s, where the advent of container shipping had left the river in a state of physical and functional obsolescence. A secondary driver was the perceived incompatibility of unsightly polluted river and its dated infrastructure with the image of Singapore as a growing commercial hub and developing modern city (Chou, 1998). It also occupied land in an area where space was a high premium thus under-utilizing the economic potential for other investment opportunities if redevelopment did not take place.

Programs and Implementation

The strong government-led initiatives in the Singapore River Clean-Up project have focused on prevention of future pollution rather than enforcement alone, and this is done with collaboration amongst different government agencies, and leveraging the private sector’s development strengths. The political will to carry out this project is most often attributed to the personal intervention by Singapore’s then Prime Minister Lee Kuan Yew, who exhorted the civil servants to “clean up the river within ten years”. This strong political support from the government leadership, the endorsement from Parliament and resultant financial support accorded are the key factors that has enabled such a large scale project to be made possible. The extensive coordination across the many government ministries and national agencies could be executed, due in part to Singapore’s unique situation as a city-state where development decisions do not require the vertical integration that is so often lacking in cities where various levels of government are involved.

From the perspective of planning and implementation strategies, with the support of multiple agencies as key stakeholders, the project was able to develop and implement an integrated revitalization plan that focused on various physical, environmental, economic and social aspects. This plan was effective because it looked beyond the immediate state of the area to evaluate the

sources of the river's pollution and consider how changing the land uses throughout the entire catchment area of the river would prevent further pollution. The relocation and resettlement issues are complex and affected large sections of the urban eco-system. For instance, for each type of polluting industry that needed to be relocated, their individual spatial, functional and locational needs had to be considered when exploring the appropriate new facilities that must be provided. This relocation exercise straddles small workshops to formal factories, open street hawkers to newly built enclosed hawker centres, fruit and vegetable stallholders to wholesale markets. The multi-agency coordination needed was enormous, but a significant outcome of the exercise was that it laid the foundation for institutional changes toward a "whole-of-government" approach that has become the hallmark of many other large scale development projects that came after.

While the clean-up and relocation aspects of this project involved primarily the government agencies, the private sector stakeholders were subsequently drawn in for the redevelopment processes. Through the land sales programme, private sector entrepreneurship and capital were brought into play, as the planners began the tasks of allocating new land uses to the area based on a comprehensive master plan with newly defined urban design guidelines for the river and its surrounds. By leaving the redevelopment of this land, including adaptive re-use of the historic buildings, to the private sector, the land holders and other developers had the opportunity to respond to market demands which are, in alignment with their economic expectations and profit motivation. This promulgated a positive investment climate that provided the entire project with a push to proceed at a faster pace than would have been the case if the government were to undertake the development within the limits of its financial, professional and other resource capacities. This divestment approach is particularly evident in the redevelopment of Clarke Quay, a section of the River, in 2006, into a food and entertainment destination for tourists and young urban professionals, under the management of CapitaLand, a large private enterprise that won the land for redevelopment under an open bid system.

In this project, while environmental and economic development has been well-addressed through capital investment with direct implementation of new projects and infrastructural improvements, social sustainability was primarily addressed through rehousing the residents and preserving/restoring the historic shop houses along the river. In total, 26,000 families were relocated from squatter huts to new Housing Development Board flats (Chou, 1998). For historic conservation, the shop houses were restored and adapted to new uses according to urban design guidelines that were developed by the Urban Redevelopment Authority (URA, 2004).

Outputs and Outcomes

Overall, while the Singapore River Revitalization Project has been assessed to be successful in terms of the physical and economic transformation, there were criticisms revolving around local cultural issues, including lack of references to the river's past through historic preservation efforts, over-emphasis on the global verses local identity dichotomies, and the privatization of public space (Chang and Huang, 2011). Additionally others have criticized the river restoration as a "very economically driven and very functional" approach by the government and private enterprise, with less attention on the social aspects, particularly the needs of the people who had lived near or enjoyed the urban space near the river (President, Singapore Institute of Architects, *The Straits Times*, 11 May 2007 quoted in Chang and Huang, 2011). The follow-up efforts by the Singapore Tourism Board to making it a thematic zone with a focus on the tourism sector is also seen another manifestation of this orientation toward economic outcomes in terms of employment, business activity and an income generator (Savage and Huang, 2004).

Finally it can also be said that there was a general lack of direct community involvement in the urban regeneration process due to the single-minded pursuit of physical improvement and economic revitalisation, through a zealous and effective bureaucracy. Various documentations have nonetheless shown that the affected community has been resettled in new housing estates

and business locations. Overall, it can be said that the enhanced sense of ownership on the part of the Singapore resident pursuant to the river's rebirth as a clean waterway and the reinstatement to its rightful place as a central piece of the city's natural and cultural capital may not have been so evident at the point of completion of the project. Some writers have expressed the opinion that while many of the historical buildings have been physically restored, the symbolism of the urban transformation may not have struck at the core of the ordinary citizen's sense of the place, its cultural references and collective memories (Chang and Huang, 2005, Chang et al., 2004, Kong, 2007).



Figure 5: Robertson Quay, the Singapore River in the 1970s
Source: Urban Redevelopment Authority



Figure 6: View of the Financial District after Singapore River regeneration from Boat Quay 2009
Source: Urban Redevelopment Authority

Bang Bua

The case of the Bang Bua community and canal project demonstrates an essentially bottom-up approach to informal housing upgrading and environmental improvement that embraces the values of self-help and resilience. The project serves as a significant example of canal-side, community-led urban regeneration. It is also well known as Bangkok's first ever case of public land being leased to a network of canal-side squatter communities (Angel, 2000, Asian Coalition for Housing Rights, Satterthwaite, 2004, UN HABITAT, 2009a). The analysis of this case presents a positive narrative of community self-help, beyond this project's achievements in housing outcomes. It also reveals a strong community-driven development process that has helped to improve this body of water and its surrounding environment.

City and Site Context

Set on the outskirts of Bangkok, the Bang Bua community is a relatively poor community, composed mostly of squatters who work or formerly worked at the neighbouring military facility. Being in a flood prone area along the canal the development drivers in this area were relatively static. However the functional, physical and image obsolescence drove the community to improve their own space for the sake of safety and for security of tenure.

Programs and Implementation

This project is considered successful primarily due to the early establishment of a community organization, which led the improvement programs and other community projects before, during, and after the upgrading project. In addition, this community sought to revitalize not only their personal homes, but also their surrounding environment while developing other social benefits for the disenfranchised community in the form of skills development, education, welfare

programs, and even rental units subsidized by the rest of the community. Therefore this project used a combination of social, environmental and physical revitalization programs, with the primary focus on providing shelter and housing for the affected community.

Before other organizations, such as the government or local university, became involved in this project, members of the Bang Bua community organization in 2003, led by a very strong community leader, began cleaning up the canal in front of their respective homes. To the government authorities, this community-led clean up indicated how important this location was to these “informal” residents as they invested their personal time and money into a place that they did not actually own. This community also used its strong networking power to start community-based savings groups with the end goal of upgrading the housing for the entire community. Due to these community-led environmental and economic efforts, local and national government programs were subsequently more willingly to invest in this project through the Community Organizations Development Institute (CODI) which is a public organization that administers the Baan Mankong Program upgrading financing program (Boonyabancha, 2009, Boonyabancha, 2004, Boonyabancha, 2005). The collective action of the community led to an enhanced sense of stewardship for both their natural and built environment, as early outcomes of this project proceeded to shape the revitalization programs that were implemented later on with the assistance of government stakeholders.

Outputs and Outcomes

Noticeable environmental improvements have been made to this portion of the canal, including removing trash from the canal itself, designating new centralized community trash receptacles (see Figure 8), and constructing a permanent two meter access road/sidewalk along the canal (see Figure 9) to prevent further erosion and to provide better accessibility within the community. However, there are still other larger environmental concerns in this area as a whole which demonstrated the need for further government involvement. Importantly, the community-led canal clean up and upgrading to elevated cement houses has not solved the problem of severe flooding. During the 2011 floods, which threatened the whole of Bangkok and shut down businesses for months, the Bang Bua Canal communities also suffered. Residents recalled that they had standing water in or around their homes ranging from a few centimetres to one meter for a period of two months (see Figure 7). Observations also revealed that there are problems with maintaining a canal clear of trash. This range of long-lasting problems indicate that further partnerships between the local community organization and strong government agencies’ involvement would be necessary in the future if the canal clean-up process were to expand. As the Singapore River case shows, a comprehensive clean-up process requires multiple parties to be actively involved in addressing the pollution sources in and around the entire river catchment, as well as active enforcement of the flow of the waste in it.



Figure 7: Flood line on Bang Bua homes from 2011 floods



Figure 8: New trash receptacles in the community



Figure 9: Two meter access road/sidewalk in Bang Bua Communities



Figure 10: A new alleyways with vegetable gardens in Bang Bua

Source: Melissa Reese, August 2012

The community of Bang Bua stands out among its neighbours in its ability to maintain a strong community network under the direction of a strong and committed leader for over ten years. One might observe that the strong and consistent leadership of the community head plays a very crucial role in the success of this project. His leadership style not only consisted of negotiating with outside agencies but he also led by example. For instance many people did not completely trust that the housing upgrading would come through, so as the community leader he volunteered to have his house demolished first and reconstructed last, so that he and his family had to occupy temporary housing longer than any other residents. Given this strong and committed leader, the question arises as to how replicable its success would be without a similar amount of political will.

The Bang Bua Community's upgrading effort demonstrated how a community-led approach worked as a case that incorporated government assistance which offered a wider scope for the upgrading exercise. Although this community made much progress on its own prior to the offer of a large government program to help, government support facilitated the raising of enough capital to fully complete the upgrading process in a comprehensive manner. Likewise government intervention in the provision of loans to the community alone would not have been as successful without a strong existing community organization that had already developed the values of disciplined savings and thrift. As other scholars of informal settlement upgrading and relocation programs in Bangkok have noted in order to ensure "long-term sustainability of the project," the government and project leaders should focus not just on the physical revitalization and financing mechanisms, but also "community empowerment, sense of togetherness and belongingness" (Viratkapan and Perera, 2006). This is exemplified in Bang Bua, where the extensive and deep existing community networks and bonds further helped these residents to be invested with a sense of commitment and ownership in the process of regenerating their portion of the city. While neighbourhood level networking in this community is exemplary though, further efforts could be made to enhance cooperation between upper level institutions to deal with the larger urban regeneration issues surrounding this community and the rest of Bangkok (Usavagovitwong, 2005).

Lunawa Environment Improvement and Community Development Project

In Colombo, the Lunawa Environment Improvement and Community Development Project is assessed as an example of a successful waterfront project that is led by multiple institutions and supported by the public, all collectively pursuing the goals of economic revitalization and social integration. Unlike the Singapore River project which began as a government-led project, or the

Bang Bua project which was initiated as a community-driven project, Lunawa is an example of joint efforts across government agencies, UN Habitat and NGOs to find a solution for upgrading their homes and lagoon near to which they live.

City and Site Context

The Lunawa Lagoon is located just south of Colombo, straddling the border of two municipalities: Dehiwala-Mt. Lavinia and Moratuwa. The regeneration project examined the entire watershed around the lagoon which included 18,112 households and over 360 industries. The householders were comprised of a mix of upper and middle class formal households and low income squatter householders. The original conditions of the area included about four to six major floods per year, leaving the area functionally obsolete as well as an eyesore to the neighbouring middle and upper income housing area. Being located on the edge of the city in a very flood prone area the original development drivers were relatively static.

Programs and Implementation

For this project, community participation began as a result of the initial survey of the residents' physical property and their views on upgrading or relocation (Hewawasam, 2009, Perera, 2006, Dassanayake, 2011). As a consequence, the project management decided to modify the plan to allow for single story, single family dwelling units, as well as providing many options for the communities to choose, for example, whether they would like to be relocated within the same area or to take their entitlement package to purchase property elsewhere.

Although the resettlement aspects of the project has not been fully completed due to delays in the process of land surveying, valuation and acquisition, the community participation and consultation processes used to plan for resettlement and upgrading have been lauded as successful by UN HABITAT (UN HABITAT, UN HABITAT, 2009b). Most notably, the process of using existing NGOs to work with communities and creating a community-based organization which did not initially exist was very helpful in building mutual trust between project stakeholders. Furthermore, the project leaders worked to develop a Community Information Centre (CIC), an innovative "one stop shop" for community members to come forth to facilitate the paper work or to raise concerns where they occur. The CIC served as the project office, and brought together a team of staff from Sri Lankan government agencies, volunteers from Japan which are connected to project funding from the Japan International Cooperation Agency (JICA), NGO representatives, and UN Habitat representatives into one physical space. Unlike other projects in Sri Lanka where government officials would be juggling multiple projects at once while working from different agency headquarters, having a dedicated project office with a fully-committed team was in itself innovative. It serves as an example of institutional improvement which is arguably a positive outcome from the project. This system was effective only because the staff themselves, especially those of a higher management level, were willing to place themselves within such easy reach of public. This was a positive move to gain the respect of residents who had come to the office to vocalize their concerns about the project and expecting to meet officials.

Outputs and Outcomes

With regard to the physical improvements, the technical aspects of the project have also been regarded as successful because the project area has not seen any large-scale flooding to date. This is so as even in the destructive floods in 2010 when other parts of Colombo, including the Parliament building were underwater, the Lunawa catchment area was able to adequately discharge the raging storm water (Figure 11).

However, the environmental aspects of the catchment area are still of concern for many officials and community members (Figures 12 & 13). One community member both praised the clean-up process for effectively attracting diverse bird life into the area, but also raised concern that trash from households and businesses has appeared to re-emerge in the environment (Guneratne, 2010). Field studies show that there could be three types of pollution still affecting the lagoon and canals, namely, household solid waste, sewage overflow, and industrial wastewater. Although all three could be dealt with at the pollution source before they have the opportunity to enter the water body, a coordinated effort to enforce existing pollution regulations is needed, and this will require intervention at multiple levels of the government as the case of Singapore has exemplified. Hence, while community involvement has been instrumental in project initiation and implementation, longer term maintenance of successful waterfront regeneration requires more wide-ranging institutional reforms within a larger framework of urban sustainability.



Figure11: The main canal in 2010 during a major flood in Colombo, successfully diverting storm water
Source: LEI&CDP Office, obtained August 2012



Figure 12: Trash along the Lagoon



Figure 13: Grey water draining directly into the canal

Source: Melissa Reese, August 2012

Hence, an important follow-up would be to promulgate the idea of a larger community who takes responsibility for the well-being of the catchment and its residents, and in the process promotes environmental stewardship among a broader citizenry. Notwithstanding the positive role of all parties in the present waterfront regeneration project, the longer term need for maintaining the canal and lagoons is for all residents and industries to collectively recognize the importance of not polluting the water body and assuming shared responsibility, rather than rely on the maintenance and upkeep work of the Municipal Councils.

The Lunawa Project has contributed significantly to improve the water catchment area both physically and socially. Currently, the project is lauded from the perspectives of environmental

improvement, community development, and stakeholders' integration, and some degree of institutional change. For the future, and in the context of urban sustainability, collective care for the entire catchment is necessary to forge a culture of stewardship so that natural capital can be effectively preserved for future generations.

Lessons Learned

As highlighted earlier in this paper, the main impetus for many waterfront regeneration projects is environmental degradation and associated social problems which have serious impacts on the economic life of cities. Yet, the economic imperatives must also be recognised due to the location of many of these areas close to the city, their development potential represents a vast pool of inherent economic wealth of the city waiting to be tapped. In addition, with their historical, architectural and social associations with a city's past, waterfronts are often regarded as part and partial of a city's identity and intrinsically linked to the interests of the local community. All of these issues are conceptually related to urban sustainability as an overarching concept built upon the concerns of environment, economy, people, culture and the future. By applying the proposed framework for evaluation to these cases the balance of the physical, environmental, economic and social approaches to urban regeneration can be better distilled, while highlighting the linkages between these areas of sustainability. Furthermore, the framework allows the various drivers behind the revitalization programs as well as the implementation mechanisms to be examined while expressing the linkages between all of the elements of a regeneration project. The three case studies chosen demonstrate many of these linkages strongly.

In Asian cities, waterfront areas are some of the most complex and challenging urban landscapes, and successful waterfront urban regeneration projects that can effectively balance the three aspects of sustainability, namely, environmental, economic and social, can present many useful lessons to guide future waterfront redevelopments in other Asian cities. Some of the lessons learned from these case studies include the following:

Firstly, waterfront regeneration projects that improve the natural and built environment of the waterways can also benefit the local economy, with potentially-wide spread improvements of social well-being. This is demonstrated in the Luwana and Singapore River projects where physical improvements are accompanied by economic revitalisation through inclusive planning policies. The Singapore River project harnessed the resource capacities of the business community, and in the process, contributed to large scale urban renewal that advanced the local economy and improved the quality of life of the city's residents. The Lunawa project demonstrated a waterfront project that was able to improve the physical environment, while engaging the key government stakeholders and incorporating the concerns for the local community. As noted by Giblett and Samant (2011), successful waterfront cases in the West specially provide for "...increase in public space" and "improve resident's quality of life". This principle is likewise demonstrated in the preceding case studies in Asia but their execution has required different approaches that relate to the local and institutional context. Both the case studies are essentially top-down interventionist processes, with the Singapore River drawing upon the bureaucratic powers of government agencies to deliver positive community outcomes, and the Luwawa project harnessing the collective efforts across government agencies and international development organizations, both of which actively consulted the public toward a common good.

Secondly, engaging the local community is particularly important when considering how historic areas are taken care of given that the "prominence of community consultation will generate a sense of ownership and identity, while promoting ideas of heritage and preservation" (Giblett and Samant, 2011). The Bang Bua case study effectively demonstrated that an enhanced sense of ownership of the project can help promote community stewardship for the natural environment. On the other hand, in the Singapore River and Lunawa cases, the communities which did not have as much involvement in initiating the physical clean-up and as such there was some concern that the projects could be less likely to engender a lasting sense of ownership to be in alignment

with urban sustainability principles and aspirations. Nevertheless, since the completion of these projects, the transformed landscapes, particularly in the case of the Singapore River, has engendered a reinforcement of its links to the city's past through the conservation and adaptive reuse efforts and hence, in its own way, preserved the sense of history and local interest.

Finally, community involvement is recognisably a key element in all three of these cases in forging a sustainable urban vision for the waterfront redevelopment. These cases demonstrated that community involvement can take on many forms, including grass-root community organizations, harnessing the resources and profit interests of the business community, as well as multi-actor collaboration across various stakeholder groups, from both government and non-government. Regardless of the methodology applied, they all upheld the principle that "waterfront land is too valuable in Asian cities to allow developers to continue to dominate regeneration" (Giblett and Samant, 2011). The Bang Bua project exemplified this as it began as a community group-led project which subsequently attracted the attention and support of government housing upgrading programs and financing. In the case of the Singapore River which is primarily led by government agencies, engaging private land holders and developers is a form of participatory engagement. The lack of involvement of the affected community may be seen as a weakness of this project (see Chou, 1998), but given the urgency of the tasks at hand, it may also be viewed more positively as an expeditious pathway toward wider improvement to quality of life in the city. Lunawa presents a third procedural approach, as it was led by a coalition of government agencies and international development groups that recognized the importance of community participation in various activities during which the community's views and concerns were sought out, as well as helping to create community-based organizations where none had existed before.

Conclusion

In conclusion, for waterfront urban regeneration projects to contribute to urban sustainability in Asian cities, two key principles can be drawn derived from the case studies. Firstly, a balanced approach that takes into account all three pillars of sustainability is necessary in that projects that are focused on improving the natural and built environment of the waterways must also deliver benefits to the local economy while ensuring wide-spread community well-being. Secondly, where projects have to be implemented in a top-down manner, the process must include forms of community engagement that are appropriate to the social, cultural and political context. The broader aim is to bring about the meaningful outcomes of collective ownership, institutional improvements, enhanced capital investments and long term preservation of natural and cultural capital.

The importance of community involvement in forging a sustainable urban vision for waterfront urban regeneration projects cannot be underestimated. However, no one method of participatory involvement can be prescribed as the best solution for Asian cities. As these three cases have demonstrated there are multiple methods of involvement that can lead to more sustainable cities. While the case of Bang Bua took a bottom-up approach with the community leading the project, the Singapore River presented an approach of a government-led project that sought the engagement of private land holders and developers as a form of participatory engagement necessary for the implementation and maintenance of the project. Finally Lunawa was led by a coalition of government agencies and international development groups that sought out the community's views and concerns from the beginning.

Hence, the assessment framework as validated in this study can be very useful, primarily because it is comprehensive, and includes evaluation of the specific site and city social, political and economic contexts that affect the implementation methods, programs and eventually the outputs and outcomes of each project. Urban regeneration can be a positive pathway towards a more sustainable future for Asian cities, if its urban waterfronts are effectively harnessed to meet the wider environmental, economic and social goals of the city.

Photo Sources:

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How Construction Sector responds to the Economic Recession: Identification of Adverse Effects and Sustainable Responsiveness

Perera K.T.P.K

Department of Building Economics, University of Moratuwa, Sri Lanka
treshani.perera102@gmail.com

Waidyasekara K.G.A.S

Department of Building Economics, University of Moratuwa, Sri Lanka
anuradha@uom.lk

Abstract

The construction industry is a significant source of income generation to the economy contributing more than 9% of the GDP in Sri Lanka. Thus, the construction industry is concurred a direct positive correlation with the cyclical nature of the economy resulted in a stagnation during the economic recession. In general, practitioners adopt various strategies in response to a recession to realize firms' continued existence and development. However, the current responsiveness to mitigate adverse effects identified became reactive which only considers the short-termism. Hence, the recession responsiveness must be aligned with the sustainability for a long term proactive implication. Therefore, this research study aims to assess the adverse effects and the sustainable responsiveness during the recession. The research gap was then approached through a questionnaire survey among construction practitioners to gather ordinal data on criticalness of adverse effects and appropriateness of recession responsiveness. Then, the research was concluded by extracting appropriateness of adopting sustainable responsiveness to mitigate adverse effects. The analysis derived cost control strategies have given more sustainable responsiveness supersedes the other strategies. Thus, it is recommended to be aware of the recession rather beware.

Keywords: Adverse effects, Construction Industry, Economic Recession, Responsiveness, Sustainability

1.0 Introduction

The financial crisis which has shaken the global economy during 2008 - 2009 was considered as the most devastating economic downturn since the great depression of 1930s. The highlights of recent economic developments published by the Central Bank of Sri Lanka (CBSL, 2012) explained that the market confidence in international financial markets is deteriorated by the European sovereign debt crisis led to heightened volatility in capital flows of Asian economies. Thus, it flagged in descending of Key Economic Indicators (KEI) of Sri Lanka (CBSL, 2012).

The global recession caused by the financial crisis having an impact on the real economy and signs are visible in the construction sector, mainly in the form of postponing investment or abandoning of proposed contracts. Further, construction companies face financing difficulties and in some extreme cases, even bankruptcy (Nistorescu&Ploscaru, 2010). Additionally, unemployment rates of construction professionals have increased as a result of the crisis. Thus, contractors adopt various strategies in response to the recession to realize firms' objectives of continued existence and development. However, many survival strategies innovated are reactive and short-termism focuses on economic perspective.

Though, sustainability as a term in isolation has gained merits, sustainable construction has not yet identified as a recession responsive strategy in the prolonged recession. Thus, innovative survival strategies are needed to be found out immediately in order to cure its appalling effects on

the construction under the prominence on sustainable development in the long run. Thus, this paper aims to:

- To identify the adverse effects in the construction industry during the recession.
- To identify the current responsiveness to mitigate the adverse effects recognised in the construction industry.
- To recognise the concept sustainability and sustainable responsiveness in the construction sector.
- To assess the adverse effects' existence, current responsiveness and sustainable responsiveness in case of Sri Lankan construction industry.

The paper structure begins in the following sections with a review of literature on economic recession hit building construction, adverse effects and current responsiveness for a recession and then ascertain the sustainable responsiveness. The next section presents the research methodology followed by data analysis. The paper finally presents discussions and conclusions of the research study.

2.0 Literature review

2.1 Economic recession and its impact to construction industry

2.1.1 Overview of economic recession

There is a clear demarcation of two terminologies Recession and Depression. The depression is the most severe version of a recession. Thus, trough dates marked at the depression while the recession is the negative inclination in the business cycle (NBER, 2012). The contraction is therefore commonly identified as the recession which brings about a significant decline in KEI (Moore, 2012). Moreover, illiquidity, credit crunch, currency devaluation, and bankruptcies are the further effects posed troublesome in weakening the financial system of interdependent economies

2.1.2 The impact of economic recession on KEI of Sri Lankan economy

The challenges faced in achieving the growth in 2009 included the synchronized downturn in major economies and the heightened security concerns with the escalation of the conflict in the North of Sri Lanka (CBSL, 2009). Moreover, KEI in the macroeconomic environment marked significant movement during 2009 as illustrated in Figure 1. The high openness evident from the external adverse effects during the recession was reasoning to a gradual decline in demand in developed countries for imports thus led to lowering net exports. Further, rising international commodity prices put significant strain on the balance of payments, with the current account deficit reaching the highest. Furthermore, the rupee depreciation resulted due to high foreign debt repayment which can reduce meeting other expenditure. Also, average inflation dropped to lowest level and monetary policy was amended to result in a falling treasury bill rate to a level below the inter-bank money rate, provided a gradual upturn in money supply. However, despite of gloomy prospects for employment in the world, unemployment and labour migration in SL remained at an exceptionally low level.

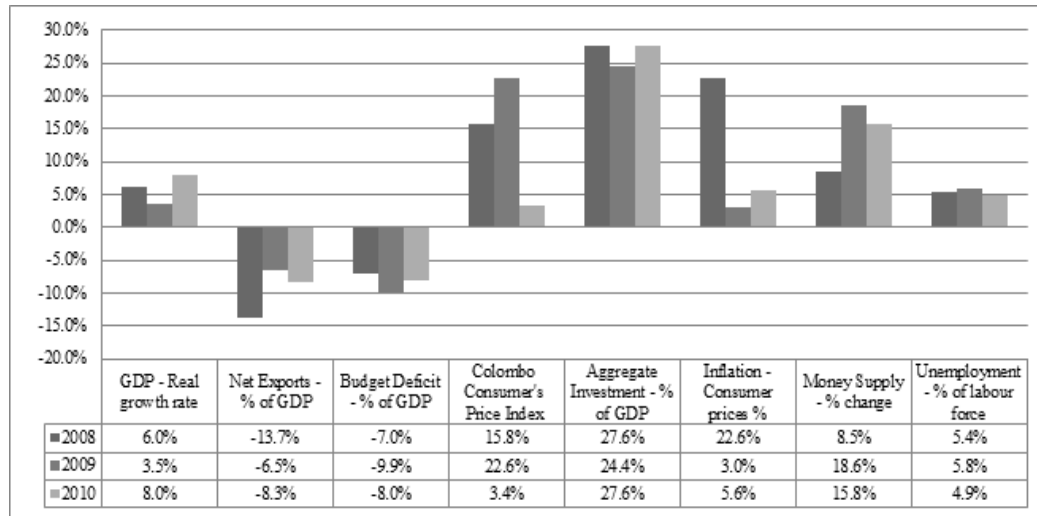


Figure 1: Fluctuation in Key Economic Indicators of Sri Lanka
Source: (CBSL, 2012)

2.1.3 Construction sector's influence to the recent economic recession

The year 2009 appeared as a significant deterioration. According to Verick and Islam (2010), the global crisis was emerging as isolated turbulence in the subprime segment of the US housing market mutated into a full blown recession by the end of 2007, which was known as the housing bubble burst. As a result of the overhang in the supply of housing opened up for financial institutions to extend vast numbers of mortgages at attractive rates. Consequently, the fundamental cause of the crisis was the combination of a credit boom and a housing bubble (Acharya & Richardson, 2009). Moreover, the capital regulations on banks reduce the amount of capital to hold against assets which was then resulted in the risk of mortgage defaults in the banking sector and rendered them insolvent when the housing bubble popped.

2.2 Adverse signs in construction sector during the recession

The construction industry plays a vital role in the national economy and gets affected by macroeconomic fluctuations. In Sri Lanka, construction industry contributes 9.39% of GDP in the year 2012 (CBSL, 2012). Iteratively, result in adverse inferences to the national economy. Thus, the impact to the construction sector is explained as follows:

Adverse effects	Description
Financing	Construction companies face financial difficulties due to tight credit conditions and result in bankruptcy in the worst case (Nistorescu & Ploscaru, 2010). The reason was higher reliant on bank lending while being more exposed to late payment by clients. Subsequently, banks withdraw lending for construction projects. For instance, bank credit granted for housing purposes registered a decrease by 1.5% in Sri Lanka during the year 2009 (CBSL, 2009).
Demand and Supply	Economic fluctuations influence both demand and supply in the construction industry. The fall in overall demand for construction was mainly due to the sharp decline in the value of public sector contracts (Goh, 2004). Thus, competitiveness has been increased and tender bids were underestimated (Gunaratne, 1993). In the supply perspective, the profitability of construction firms worsened by a sudden increase of lending rates due conservative risk management during the crisis. Further, sectorial interlink with the construction

Adverse effects	Description
	sector propagates the effect on market amplifying the overall economy. Thus, overall equilibrium moved downward even though mega construction road network development, flyover construction existed during 2009.
Unemployment	The high unemployment is a response to the shortfalls in aggregate demand, signaling the unstable economy. Thus, during the recession high labour costs mean the sacrifice of many labourers' jobs and contractors' profits. Similarly, drop in contribution of employment in Sri Lanka during the crisis was mainly due to the construction sector (CBSL, 2009).
Constraints on material and plant	The economic crisis is followed by the knock on effects of reduced demand for building materials and capital investment in machinery and equipment (CBSL, 2009). Therefore, building material manufacturing currently operate at close to half their capacity. CBSL (2009) stated that there was a drop of building material imports by 24.1%.
Procurement and supply chain	The procurement function is faced with a dilemma: it needs to reduce spending without increasing the pressure on suppliers who are on the edge of bankruptcy in a recession (Cherif&Maira, 2011). For instance, the drop in supply chain can be proven by the slowdown in construction resulted in decelerating of the construction sub-sector (CBSL, 2009).
Future prospects led by customer confidence	The consumer confidence gets terrified during the recession. In the worst case, the recession ends up into a liquidity trap in which people hoard money and refuse to spend no matter how much the government tries to expand the money supply which leads to reduce construction spending (Goh, 2004). Thus, many clients tend to adopt "wait and see" approach due to the uncertainty.

2.3 Current responsiveness to mitigate adverse signs in recession

Current responsiveness in the construction sector are the strategies to realize firms' objectives of continued existence and development in response to the recession. Thus, crisis responses have identified under three categories as Contracting-related actions, Cost-control related actions and Financial-related actions (Lim et al, 2010).

2.3.1 Contracting-related actions

Contracting-related actions are adopted by contractors in finding every possible way of procuring work to maintain their turnover (Hillebrandt, Cannon & Lansley, 1995). The companies were reluctant to undertake projects that are too large or beyond their experience which stretch their available resources and capabilities (Lim et al, 2010). Subsequently, contractors accept less work to maintain market share. Further, it was suggested that contractors would need to be "disciplined aggressive" in their business venture and place greater emphasis on cost, risk and resource management. At the same time reputation with clients plays important roles in dictating their ability to obtain sufficient jobs to tide over the recession (Green, Larsen & Kao, 2008). Lim et al (2010) listed contracting-related actions according to the frequency of adaptation by the Singaporean contractors in the recession. Thus, 'Bidding for more projects within the firm's

competency' and 'Setting limits on the project size which offset the failure of one project to the firm's operation' have ranked at the topmost.

Further, Hillebrandt et al. (1995) stated that the lower bid pricing strategy with a tiny or zero profit margins during recession periods can be attained by minimizing the cost of rework, negotiating lower prices for supplies and direct sourcing of input material. Drucker (1980) stated contractors should return to their fundamentals and core competence in line with the business environment for opportunities in potential markets instead of diversifying. Consistently, defensive strategies such as aggressive pricing, diversification and forming joint ventures are short-termism. In a longer slow-down these strategies are not sustainable. Furthermore, the effective corporate governance may be considered as a quick remedial action to overcome from the recession (Jayaramana, Ibrahim and Guatc, 2011). Moreover, according to the Michael Potter's generic strategy 'Diversification' and 'Differentiation' strategies are aligned with the contracting related responsiveness (Kaplan Financial Limited [KFL], 2010).

2.3.2 Cost control–related actions

The need of a more active role in managing projects and the company's cash flow and procurement procedures during the prolonged recession is highlighted under the cost control related actions (Lim et al, 2010). Thus, Lim et al (2010) listed cost control-related actions which are more toward site management, financial management and human resources management. Similarly, Gunaratne (1993) stated that the cost saving measure is especially important in a recession where the client looks at value for money. Further, restructuring of the workforce into teams enabling share skills and maintaining a lean group of core staff becomes a cost saving in crisis (Choppin, 1991). Similarly, Michael Potter's cost leadership strategy is aligned with the cost control actions to improve the firm's performance by cost cutting (KFL, 2010).

Moreover, imposing wastage rates for construction materials on site, material recycling, inventory management and Just in time (JIT) delivery concept, strengthening the procurement function by internal and external collaborations and partnering with key suppliers also highlighted (Tam & Tam, 2006).

2.3.3 Financial–related actions

'Creating uncommitted financial resources', 'Negotiating for alternative loan services' marked the frequently practicing financial-related actions in the Singapore contractors during the recession (Lim et al, 2010). Furthermore, contingency fund allocation mitigates the lagged impact of the recession on the business operation (Lim et al, 2010). Besides, borrowing money from banks to finance debts and increase working capital is common during a recession. The remaining companies, on the other hand, claimed to operate within the working capital and adopted the "wait-and-see" mode because of the unwillingness to overstrain the debt obligation. Apart from "cash rich" companies others have to negotiate for alternative loan services in response to economic disturbance (Hillebrandt et al, 1995). In response to invest in highly liquid assets, Dulaimi and Hong (2002) found that 50-70% of construction equipment have been leased financed which is a cost effective strategy.

2.3.4 Government policy–related actions

The way to reestablish the customer confidence in a recession is to pump government spending to expand the money supply as per 'Keynesianism', nevertheless Friedman and Swartz introduced 'Monetarism' which recommends keeping the money supply steady to allow for the growth of the economy and adjusting inflation, unemployment and output level according to market demands (Friedman and Swartz, 1963).

An even bigger outbreak on Keynesianism came from Robert Lucas stated that the recession is self-correcting once it is realized. Thus, government should do nothing but await the correction out. Simply, people in the economy make choices based on their rational outlook, available information and past experiences (Derakhshan, 2011).

2.4 Sustainability and sustainable responsiveness in the construction sector

The sustainability meets the needs of the present without compromising the ability of future generations to meet their needs (Brundtland Commission, 1987). According to Kibert (2008), sustainability addresses three mutually reinforcing pillars as the ecological, social and economic issues which aligns with the triple bottom line concept. Thus, it is a single indicator prescribing sets of multi-disciplinary indicators. Policies and practice that support sustainable development have become more widespread following concerns over the extent of man's activities on the natural environment. Deforestation, decimation of water catchments, destruction of endangered fauna and flora, soil erosion, landslides, waste creation, pollution, desertification and the like have become a critical problem (Kibert, 2008). Hence, sustainable initiatives emerged as a solution to cure the adverse impact.

Sustainable construction can be defined as a construction process which is carried out by incorporating the basic objectives of sustainable development, bringing environmental responsibility, social awareness, and economic profitability to the built environment and facilities for the wider community (Asad and Khalfan, 2006). Further, sustainability can be incorporated within the whole construction process which resulted in the incorporation within the Process Protocol as a Sustainability Management Activity Zone (Asad and Khalfan, 2006).

Hence, the sustainable responsiveness have explained according to the authors' interpretation as the long term strategic solution to mitigate adverse effects in the construction industry in the prolonged recession. The responsiveness supports with the sustainable benefits to survive in the long term beyond the consideration of economic perspective about the short term profit maximization. Thus, sustainable responsiveness extend to the environmental responsibility and social responsibility when selecting the survival strategies for the long term existence.

2.5 Exploration of the research gap

Aforementioned literature findings conveyed that the construction industry generally faces a critical adverse conditions which stagnating the forward movement of the industry during the recession. Although, there are many responsive strategies existed and innovated through previous studies are post-mortem applications which use as a reactive approach once adverse conditions are identified. Though, sustainability as a term in isolation has gained merits, however sustainable innovation has not yet identified as a survival strategy in the prolonged recession. Therefore, as to mitigate the threat existence and enhancing the opportunity, it needs to investigate how and in what angle the benefits of sustainable responsiveness attain to survive in the recession focusing on the Sri Lankan context as explored the research gap in Figure 2 below.

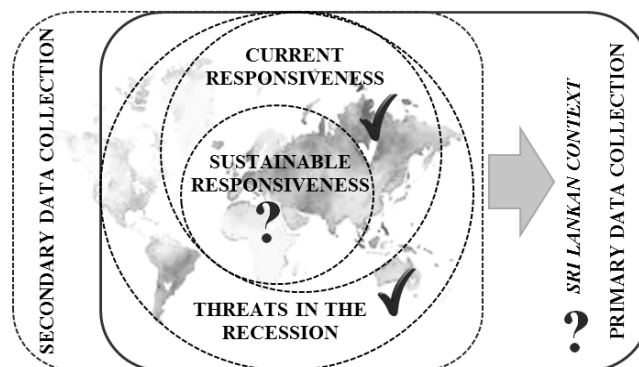


Figure 2: Research gap

3.0 Methodology

An extensive literature review was carried out to investigate adverse signs in recession, current responsiveness and the sustainable construction in isolation. Then the research gap was further elaborated to guide the approach. The study then carried out on a survey approach to investigate the adverse signs recognized under the Sri Lankan context and the current responsiveness adopted by the Sri Lankan construction practitioners under the worst economic conditions.

A questionnaire survey was carried out among a sample (35) of construction consultants, contractors and financial officers in the construction industry. The approach was more towards collecting qualitative ordinal data. Respondent's self-assessment of criticalness and appropriateness respectively of adverse effects and responsive strategies were according to the Likert scales given below.

Likert Scale 1: Adverse effects in the construction industry during the recession

1	2	3	4	5
No influence	Somewhat influential	Influential	Very Influential	Critical

Likert Scale 2: Recession responsive strategies

1	2	3	4	5
Poor	Fair	Good	Very Good	Excellent

Thus, Likert-type data analysis was based on the significant measurement by using the Relative Importance Index (RII) to rank the criticalness of adverse effects and the appropriateness of responsiveness. The following formula was used to compute RII from the data where the RII shall change from 0% to 100%. Weightage was as per the Likert scale weighting 0 being the least and 5 being the highest. Where; W = Constant expressing the weighting given to each response, A = The highest weighting, n = The frequency of responses, N = Total Number of the Responses.

<p>Relative importance/difficulty index =</p> $\frac{\sum w}{AN}$
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Source: Gunawardena et al. (2004, p.6)

Subsequently, the results were validated by using central tendency which is the median of the data set. Subsequently, the current responsive strategies were categorized under sustainability and non-sustainability interpretation by the sustainability experts. Finally, concluded the research finding determining the extent of practicing sustainability measures and the appropriateness practicing sustainability in the Sri Lankan context as recession responsiveness.

3.0 Data analysis

3.1 Adverse Signs recognized in the construction sector during the recession

One aspect of the above mentioned research objective is to assess the adverse effects existence during the recession. The list of 21 adverse effects was extracted from the literature review and a survey was carried out to assess whether the respondents have recognised the particular adverse effect during the recession and the level of criticalness on the construction industry according to the Likert Scale 1. The term "Recognition" is the percentage frequency of adverse effects recognition.

Table 1: Critical adverse effects recognised by Sri Lankan practitioners

Adverse Effects / Threats	Recognition	RII	Rank
Late payment by clients	100%	0.89	1
Financial difficulties due to tight credit conditions	100%	0.87	2
Demand on competitiveness has increased	100%	0.85	3
Leaving the liquidity of firms in hazard	100%	0.80	4
Clients tend to adopt “wait and see” approach	91%	0.78	5
Postponing investment in property	100%	0.78	5
Experiencing low investment levels	100%	0.77	7
Growing the number of unsold built construction facilities	86%	0.73	8
Decline in the value of public sector contracts	77%	0.72	9
Profitability of construction firms was worsened	100%	0.71	10
Withdrawal of lending by banks	94%	0.71	10

Top 10 critical adverse effects were ranked according to RII is illustrated in Table 1. Over 80% respondents have experienced in all the adverse effects. ‘Late Payment by clients’ was marked as the most critical issue gaining the relative importance of 89%. Considering the critical influence of the top 10 effects in segregation, it has dispersed between 18% range, which is from 89% to 71% of RII emphasising all effects have recognised as critical. Further, the top 10 critical effects can be categorised under 3 headings; ‘Financing’, ‘Demand and Supply’ and ‘Future prospects led by customer confidence’ as described in the literature review. Most importantly, adverse effects related to financial matters have ranked in the 1st and 2nd positions.

Moreover, the central tendency of the top 10 set is 4 (‘Very Influential’) for all the effects except for the effect ranked 10th ‘Decline in the value of public sector contracts’ is 5 (‘Critical’). It is expressing the validity and the consistency of the results generated from the ranking according to RII. Though, the central tendency and the RII rank are contradictory in the 10th ranked effect which is due to the least recognition of the effect compared to all factors in Table 1. In other words, the above top 10 data set generated a moderate positive linear correlation coefficient (r) of + 0.70 between Recognition and RII. Consequently, lesser recognition of the 10th ranked adverse effects was resulted in lower RII in contrast with the highest median obtained. Therefore, the contradiction between RII and median can be solved.

Table 2: Non critical adverse effects recognised by Sri Lankan practitioners

Adverse Effects / Threats	Recognition	RII	Rank
Drop in the volume of building material imports	100%	0.62	17
Reduced demand for building materials	89%	0.56	18
High unemployment of non-professionals	71%	0.45	19
Drop in capital expenditure on machinery	94%	0.38	20
Increasing labour redundancy cost	23%	0.11	21

The bottom 5 adverse effects were ranked according to RII is illustrated in the Table 2. Eventhough the 4 effects have recognised by over 70% of the respondents, however, ‘Increasing the labour redundancy cost’ has recognised only by 17% of the sample. Similarly, it has ranked at the bottom earning the lowest relative importance of 10%. Alike, the central tendency of the data set is ranged between 3 (‘Influential’) and 2 (‘Somewhat Influential’), expressing the lesser criticalness of the adverse effects except, the 10th ranked effect which denotes non-criticalness.

Moreover, reviewing the literature findings, the unemployment rate in Sri Lanka remained at an exceptionally low level, despite of gloomy prospects for employment in the world (CBSL, 2009).

Accepting the literature statement, the survey results proven that the adverse effects ‘High unemployment of professionals and non-professionals’ have not recognised as a critical issue in Sri Lankan industry.

3.2 Recession responsive strategies

Another aspect of the research objective is to assess the Sri Lankan practice of recession responsiveness in the construction industry. The list of responsive strategies is extracted from the literature synthesis under the headings of contracting related actions, cost control related actions and financing related actions. However, government policy control action had not been taken into the consideration due to its uncontrollability. Further, the data collection was supplementary carried out to assess the possibility to convert the recession adverse effects into the opportunity.

Then the survey was carried out to assess whether the respondents have practiced the particular strategy during the economic recession and the level of appropriateness of the strategies according to the Likert Scale 2. ‘Level of practicing’ is the percentage frequency of strategy practiced by respondents. The survey respondents were asked to rank the appropriateness, even if not practiced due to constraints imposed on the real construction practice. However, if a respondent unmarked any row it is deemed to be assumed that the strategy is ‘Inappropriate’. Accordingly, RII ranking was established for higher and lesser appropriateness of the responsive strategies.

3.2.1 Contracting related actions

The list of 25 contracting related recession responsive strategies were extracted from the literature synthesis. Appropriate contracting related actions are tabulated in Table 3 and bottom 5 lesser appropriate strategies are tabulated in Table 4.

Table 3: Higher appropriate contracting related actions during the recession

Contracting - related actions	Level of practicing	RII	Rank
Minimising the cost of rework by quality output	83%	0.86	1
Forming partnership and reputation with clients	86%	0.78	2
Forward contracts with suppliers and subcontractors	89%	0.75	3
Bidding for more projects within the firm’s competencies	71%	0.75	4
Negotiating the lowest prices for supplies	83%	0.72	5
Emphasising on cost, risk and resource management	83%	0.71	6
Specialising in a core expertise	74%	0.71	6
Venturing into overseas markets	74%	0.70	8
Undertaking short-term and fast track projects	80%	0.68	9
Subcontracting work from other contractors	69%	0.64	10

According to Table 3, over 69% of the respondents have practiced all the top 10 responsiveness. ‘Minimising the cost of rework by quality output’ ranked at the top gaining the RII of 86%. ‘Forming partnership and reputation with clients’ ranked 2nd and following ‘Forward contracts with suppliers and subcontractors’ which has the highest level of practicing of 89%. Similarly, the central tendency of the data set is 4 (‘Very good’) for all top 10 contracting related strategies. It is expressing the validity and the consistency of the results generated from the ranking according to RII.

In contrast to the findings of Lim et al (2010), strategies such as ‘Minimising the cost of rework by quality output’, ‘Negotiating the lowest prices for supplies’ and ‘Emphasising on cost, risk and resource management when bidding’ have to be ‘considered as appropriate strategies under the Sri Lankan context.

Table 4: Lesser appropriate contracting related actions during the recession

Contracting - related actions	Level of practicing	RII	Rank
Acquiring projects from defunct companies	54%	0.44	21
Putting equity into projects	43%	0.35	22
Forming joint venture with other contractors	29%	0.34	23
Adopting merger and acquisition	34%	0.26	24
Bidding for projects below the cost	37%	0.18	25

Level of practicing of strategies in Table 4 has marked below 54% of the respondents and the RII has also minimal below 44%. According to the findings of Lim et al (2010), the above listed lesser appropriate contracting related actions marked a lower frequency of practice in the Singapore construction industry too as illustrated in Table 1 in the literature review section. Moreover, ‘Acquiring projects from defunct companies’ has the central tendency of 3 (‘Good’) and 1 (‘Poor’) for the strategy ‘Putting equity into projects’ and the remainder is ‘Inappropriate’ according to the central tendency. Therefore, the central tendency is aligned with the RII ranking. Thus, validate the result obtained by both measures.

Apart from the contracting related strategies identified through the literature reviews, respondents have suggested the following: *‘Develop systems for checks and balances’*, *‘Education and training’*, *‘Plant hire’*, *‘Renegotiate the terms of the contract (reduce the contract scope where appropriate)’*, *‘Rescheduling of projects’* and *‘Public private partnership’* as further appropriate strategies.

3.2.2 Cost control related actions

The list of 23 cost control related recession responsive strategies were extracted from the literature synthesis. Top 10 appropriate cost control related actions are tabulated in Table 5 and bottom 5 lesser appropriate strategies are tabulated in Table 6.

Table 5: Higher appropriate cost control related actions during the recession

Cost control - related actions	Level of practicing	RII	Rank
Implementing stricter site management to reduce wastage	100%	0.87	1
Effective human resource management (HRM)	100%	0.81	2
Inventory management	100%	0.79	3
Freezing staff recruitment	100%	0.74	4
Exploring the use of alternative construction materials	91%	0.74	4
Implementing stricter procurement procedures	100%	0.69	6
Implementing stricter financial management on cash flow	80%	0.65	7
Adopting energy efficient practices	91%	0.62	8
Maintaining a group of core staff	77%	0.57	9
Restructuring of the workforce into teams	86%	0.53	10

According to Table 5, over 77% respondents have practiced all the top 10 responsiveness. 'Implementing stricter site management to reduce wastage' ranked at the top gaining the RII of 87% and the maximum central tendency of 5 ('Excellent'). The central tendency of the other strategies above the cut-off line ranged from 3 ('Good') to 4 ('Very Good') expressing a positive acceptance to the recession responsive strategies. In contrast between top 10 contracting related actions and top 10 cost control related actions, it denotes a higher concentration to cost controlling in the current construction practice, compared between frequencies of practicing.

Table 61: Lesser appropriate cost control related actions during the recession

Cost control - related actions	Level of practicing	RII	Rank
Laying off employees	80%	0.33	19
Freezing salaries of employees	77%	0.31	20
Converting permanent employees into temporary placements	54%	0.30	21
Cutting employees' salaries	34%	0.18	22
Employing foreign professionals on a contract basis	23%	0.13	23

Levels of practicing of recession responsive strategies in Table 6 have marked below 54% of the respondents, except the strategies 'Laying off employees' and 'Freezing salaries of employees'. Though 80% and 77% of the sample laying off employees and freezing salaries of employees, they are not appropriate in terms of ethical perspective. However, RII of below 30% demonstrated the inappropriateness of all the above strategies to cure recession adverse effects. Moreover, the central tendency of the data set is ranged in the Likert rating from 0 ('Inappropriate') to 2 ('Fair') validating the results generated from RII.

In contrast to the findings of Lim et al (2010), the results of the survey have given a greater emphasis to HRM for utilising the available local staff effectively by maintaining a core staff and restructuring workforce. Instead of being unfavourable to employees like, 'Laying off employees' which is simply hiring and firing them according to the economic dynamicity, 'Freezing salaries and bonuses', and 'Employing foreign professionals' as described in the literature section.

Apart from the strategies identified through the literature reviews, the respondents have suggested '*Variation management*' as a further cost control related strategy.

3.1.3 Financing related actions

The list of 8 financing related recession responsive strategies was extracted from the literature synthesis. The appropriateness of each strategy is tabulated in Table 7.

'Negotiating for alternative loan services' is the strategy marked at the top of the list gaining the RII of 74% and practiced by all respondents. The central tendency of top 4 strategies has been marked the Likert rating of 4 ('Very good'). However, 'Adopting the "wait-and-see" mode' is a strategy which has the second highest level of current practicing, nevertheless by simply accepting the risk cannot be traced as an appropriate strategy. Meanwhile, lowest prioritised two strategies according to RII 'Investing in machinery that has a high liquidity value' and 'Creating uncommitted financial resources' have marked inappropriate according to the central tendency.

Table 7: Appropriateness of financing related actions during the recession

Financing - related actions	Level of practicing	RII	Rank
Negotiating for alternative loan services	100%	0.74	1
Security agreements with project owners & financial institutes	80%	0.73	2
Investing into R&D to further explore business opportunities	69%	0.55	4
Lease financing construction equipment	31%	0.56	3
Investing surplus funds in financial investment	31%	0.49	5
Adopting the “wait-and-see” mode	91%	0.44	6
Investing in machinery that has a high liquidity value	31%	0.30	7
Creating uncommitted financial resources	29%	0.20	8

In contrast to the findings of Lim et al (2010), the strategy ‘Creating uncommitted financial resources’ has not widely practiced by Sri Lankan construction practitioners and level of appropriateness was marked 20%. However, it marked at the top most financial related strategy of the Singapore contractors in the prolonged recession.

Apart from the strategies identified through the literature reviews, the respondents have suggested *Innovative financial arrangements with contractors (contractor funding with rearranged payment options)* and *Exploring project finance ventures* as appropriate financing related recession responsive strategies.

3.2.3 Viewing recession as an opportunity

Based on the survey findings, appropriateness of converting adverse effects (adverse effects) of recession to opportunities can be attained by the strategy ‘Reformatting the firm’s strategic objectives’. Currently, all the respondents are up to some extent reformatting their strategic objectives during the recession and gained the RII of 71% with a central tendency of 3 (‘Good’). ‘Developing aggressive marketing response’ is another strategy during the recession ranked 2nd gaining 55% RII and a central tendency of 3 (‘Good’). However, invest aggressively to overtake competitors was only practiced by 33% of the sample and appropriateness of that is 34% RII. Additionally, it is suggested *Review the current practices and make amendments* and *Practicing innovative procurement methods, like Built Own Operate (BOT) model* to get the maximum out of the recession viewing in a different angle.

3.3 Sustainable responsiveness: Sustainability focussed strategies in the recession

The aforementioned literature reveals that one of the key reasons for the current economic downturn is due to unsustainable business practices and being very much concerned about profits and not adequately focusing on making a balance between monetary gains with social and environmental aspects. Thus, sustainability focussed responsive strategies have been extracted from the strategies addressed above by the experts in the field of sustainability. The expert opinion was obtained and Mode was used to determine the central tendency of direct answers (YES/NO). Thus, the analysis results are tabulated in Table 8 and Table 9 along with the explanation. Concurrent questionnaire was used to collect data in the opinion survey.

3.3.1 Sustainable contracting related actions

Table 8: Sustainable contracting related responsiveness during the recession

Type of responsiveness	Level of practicing	RII	Rank
Minimising the cost of rework by quality output	83%	0.86	1
Forming partnership and reputation with clients	86%	0.78	2
Forward contracts with suppliers and subcontractors	89%	0.75	3
Bidding for more projects within the firm's competencies	71%	0.75	4
Emphasising on cost, risk and resource management	83%	0.71	6
Specialising in a core expertise	74%	0.71	6
Venturing into overseas markets	74%	0.70	8
Practicing Corporate Governance principles	83%	0.61	11
Diversifying into other construction-related business	60%	0.54	12
Sustainable Construction	69%	0.49	14
Limiting project size (Complexity)	77%	0.49	16
Approach towards Socially Responsible Investment	77%	0.49	16
Diversifying into different non-construction business	46%	0.47	20
Education and training (suggested)			
Develop systems for checks and balance (suggested)			
Public private partnership (suggested)			

Out of 30 contracting related strategies 14 were categorised under the sustainable interpretation. In more emphasis 7 strategies were marked as sustainable out of top 10 contracting related strategies tabulated in Table 3.

3.3.2 Sustainable cost control related actions

Table 9: Sustainable cost control related responsiveness during the recession

Type of responsiveness	Level of practicing	RII	Rank
Implementing stricter site management to reduce wastage	100%	0.87	1
Effective human resource management (HRM)	100%	0.81	2
Inventory management	100%	0.79	3
Exploring the use of alternative construction materials	91%	0.74	4
Implementing stricter procurement procedures	100%	0.69	6
Implementing stricter financial management on cash flow	80%	0.65	7
Adopting energy efficient practices	91%	0.62	8
Maintaining a group of core staff	77%	0.57	9
Restructuring of the workforce into teams	86%	0.53	10
Partnering with suppliers	80%	0.53	11
Lowering the illiquid stock holdings	74%	0.50	12
Material recycling	66%	0.47	14
Water filtration and reuse	69%	0.47	14
Adopting Just in time (JIT) delivery concept	57%	0.41	16
Creating green jobs	60%	0.39	17
Use of bio-fuel for various construction machineries	54%	0.35	18
Variation Management (suggested)			

Out of 23 cost control related strategies 17 were categorised under the sustainable interpretation. In more emphasis to top 10 cost control related strategies tabulated in Table 5, nine strategies are marked as sustainable responsiveness in the recession.

3.3.2 Other sustainable related actions

Out of 9 financing related strategies tabulated in Table 7, only 3 were aligned with the sustainable interpretation. They are 'Security agreements with project owners and financial institutes', 'Investing into R&D to further explore business opportunities' and 'Investing surplus funds in financial investment'. Furthermore, 'Reformulating firm's strategic objectives' and 'Practicing innovative procurement methods, like BOT model' are long term strategies to the recession. This change management is an opportunity during the recession.

However, the opinion of the construction expert is that the sustainability is a long term benefit arrival mechanism. Thus, cherry picking of strategies may not be beneficial during the worst time. It must be incorporated in the current system. Therefore, increasing the current level of practicing will result in gaining the experience of real benefits during the recession. However, the right strategy must be integrated at the right time.

4.0 Conclusions and recommendations

The construction industry is a significant source of income generation to the country's GDP which leads to a direct consequence in stagnation of the industrial position during the economic recession in a dynamic moving environment. The deterioration in financial conditions due to 'Late payment by clients' and 'Financial difficulties due to tight credit conditions' have marked critical adverse effects facing by a developing country like Sri Lanka acts as a barrier in moving forward.

Current strategies to overcome difficulties in the economic recession have been considered inefficient and appeared the need of an optimal extraordinary solution to mitigate the adverse effects in the construction sector. As far as survival strategies have been developed mainly on economical perspective that leads to short term wealth maximization which is not a strategy to sustain in the long run. Sustainable construction is a long term value creation which companies are currently pursuing behind. Achieving the right balance between the three pillars of triple bottom line supports true sustainability. Current responsive strategies in the construction sector can be grouped under, contracting related actions, cost control related actions and financing related actions. 'Minimizing the cost of rework by quality output', 'Implementing stricter site management to reduce wastage' and 'Negotiating for alternative loan services' were marked at the most appropriate strategies under each respective heading. However, some of them demonstrated proactive measures align to the sustainable interpretation without referring to the term sustainability as an adjective directly. Thus, it has been extracted under a clear heading "sustainable responsiveness" to cure threat existence in the recession as research findings.

Therefore, it can be concluded that sustainability favourably responds the recession to mitigate adverse effects in a greater extent in the construction industry. Thus, sustainable responsiveness enable the construction industry's forward movement even at an economy's stagnation by directing the long term strategic establishment within the construction practice. However, the public awareness must make for the real benefit out of this research finding.

However, the scope of this paper is limited to identify adverse effects and ranking the most appropriate sustainability focussed strategies for long term existence. Hence, this paper gives the preliminary findings of an ongoing research process which is then intended to categorize recession responsiveness by different construction stakeholders through an expert interview survey. Further, a framework will be developed to illustrate specific adverse effects focused sustainable responsiveness to mitigate appalling effects in the recession. Furthermore, the real sustainability advantage to avoid threats in the recession is intended to assess based on the ST (Strength-Threats) quadrant of SWOT analysis to derive at the conclusion of the research process.

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An Investigation of Integrated Facilities Management Functions in Sri Lanka

R. P. N. P. Weerasinghe

Department of Building Economics, University of Moratuwa, Sri Lanka
nilminiweerasinghe@ymail.com

Y. G. Sandanayake

Department of Building Economics, University of Moratuwa, Sri Lanka
ysandanayake@uom.lk

Abstract

Facilities Managers often confront with the issues of people, technology, and processes in the built environment. Therefore, they need to be armed with the new business solutions and technical innovations in order to cater organisational requirements. Integrated Facilities Management (FM) is one such solution in which two or more firms collectively perform FM functions. Although it is a commendable concept, it has given less attention in the recent history. This study, therefore, investigates the applicability of integrated FM concept in the built environments of Sri Lanka. Literature review revealed that the key dimensions which determine the nature of integration are the ownership/management, distance, and core business of organisations. The integration could be either in the form of facility services, utility/infrastructure, and/or information. Multiple case studies were selected for investigating the concept to the built environments of Sri Lanka. The study is concluded with identifying possible nature of FM integrations in the built environment. The study found that the integration is strong when the firms are at a close proximity, under a same ownership, and in a same core business, whereas integration is weak when the firms are at a long distance, under a different ownership, and in a different core business.

Keywords: *Integrated Facilities Management, Distance, Ownership, Core Business*

1. Introduction

Facilities Management profession has recently become a significant proponent in the built environment. Barrett and Baldry (2003) defined FM as an integrated approach of maintaining, improving, and adapting the buildings of an organisation in order to create an environment that strongly supports the primary objectives of the organisation. Noor and Pitt (2009) stated that effective FM encompasses multiple activities under various disciplines and combines resources, hence it is vital to the success of any organisation. However, FM has changed its discipline and involved in finding solutions in innovative ways of addressing core business challenges (Kaya, Heywood, Arge, Brawn, and Alexander, 2004).

Isolated FM units in early days are now integrating with neighbours, competitors or other organisations in order to conduct FM operations collaboratively. Integrated approach could be a realistic solution for built environments. Few researches have studied the integrated FM concept and identified the formation of networks, partnerships, or inter-organisational collaborations between built environments as approaches in delivering excellent services to the core business. Although it is a commendable concept, building owners and Facilities Managers have given less attention for integrating FM functions, and facilities are shared among the businesses in ad-hoc manner. Therefore, there is a need to investigate the existing integrated FM functions in Sri Lankan built environments. Hence, this paper reviews the concept of Integrated Facilities Management and investigates the existing integrated FM functions in Sri Lankan built environment.

The first section of this paper reviews the literature on integrated FM followed by the research methodology of the study. Fourth section presents findings of the case studies followed by cross case comparison and analysis of integrated FM functions. The last section concludes the study with recommendations.

2. Literature Review

2.1 Integrated Facilities Management

Collaborative business relationships, including strategic alliances, joint ventures, clusters, and consortia are popular mechanisms for dealing with resource constraints, accelerating technological advancement, and sensitive levels of competition in the global marketplace (Palakshappa and Gordon, 2007). Accordingly, Facilities Managers are also involved in formal, informal, or voluntary based collaborations in built environments, which required concrete knowledge for successful formations (Storgaard, Larsen, and Olsen, 2010). Kincaid (1994) stated that managers must be equipped with knowledge of facilities and management to carry out their integrated support role in order to attain effective integration in field of FM.

Many researchers have developed number of collaborative relationships in the field of Facilities Management. Introduction of new concepts such as integrated FM (Kincaid 1994), Centralising effluent treatment plant (Clara, 1998), Industrial Districts (Meneghetti and Chinese, 2002), collaborating infrastructure services (Cant, 2005), Joint working (Andrew, Donald, Pitt and Tucke, 2008), District heating and cooling (Aumente et al., 2011), Strategic alliance in Airport FM (Pitt, Werven and Price, 2011), Industrial symbiosis (Meneghetti and Nardin, 2012), and Industrial cluster (Huang and Xue, 2012) further emphasised the importance of collaborating or sharing diverse FM functions among organisations in different forms.

In the concept of strategic alliance, Pitt, Werven and Price (2011) highlighted that formation of a network structure or alliance with cooperation between two airports or between an airport and a third party for managing facilities to share knowledge or resources has become the current trend in air port industry. The main reasons to form alliances can be categorised as the creation of synergies, sharing risk, access to raw materials, access to resources such as facilities and expertise, sharing research and development costs and enhancing or retaining competitive advantage through economies of scale, or image (Vyas et al, 1995). Further Pitt, Werven and Price (2011) pointed out that strategic alliance would enable FM to spread the risk of testing new technologies such as energy management and integrated building management systems among organisations. Cant (2005) investigated effectiveness in collaborating infrastructure services in regional retail centres using one of the largest inner-city redevelopment schemes in Europe. Author highlighted that independent FM functions would fail to meet the expectations of scheme owners, retailers, and customers. Thus, it is recommended to pursue a collaborative approach of FM at a strategic level and collaborating with the other professionals is identified as important in delivering best value for the client. Huang and Xue (2012) elaborated benefit of centralising supply chain among same ownership firms. Those firms have been operated more productively through centralising supply chain. Further, authors noted that clusters present opportunities for an organisation to streamline and shorten its supply chain, as those partners and related resources existed in a concentrated area.

Andrew, Donald, Pitt, and Tucker (2008) illustrated the experience of a group of public sector Facilities Managers who decided to work jointly. Authors identified following joint works that can be used to enhance business operation;

- Common database for sharing information and the systematic development of benchmarks (cost/m², energy performance, and m²/occupant)
- Common strategy for collocation of services on property to benefit customers
- Eliminate conflicts through joint working and cooperation
- Integrated office standards policy for shared accommodation

- Joint body for procurement and management of the building
- Respond emergencies services together more closely

Industrial district is another concept of integration which empowers to enjoy the benefits for either client or FM service provider. An Industrial District is a geographically determined productive system, formed by a large number of small-medium sized firms, which are involved at various stages and in various ways, in the production of the same product (Pyke and Sengenberger, 1992). Meneghetti and Chinese (2002) exploited the characteristics of all possible integrations in industrial district through aggregation matrix as shown in Figure 1. Aggregation matrix focused on the technical and physical features of industrial districts from an external observer's point of view and recognised two dimensions as (i) Level of homogeneity in service demand and (ii) physical proximity of firms.

	Physical Proximity	Physical Distance
Homogeneity	Centralised facilities and management	Replicated facilities and polices
Heterogeneity	Distributed solutions	Specific facilities and management

Figure 1: The Aggregation Matrix for Facilities Management in Industrial Districts
(Source: Meneghetti and Chinese, 2002)

Authors have detailed four quadrants of Figure 1 as follows.

- *Centralised facilities and management*: Centralisation is technically feasible and avoids redundancies if there is a homogenous demand in a sufficiently small area
- *Replicated facilities and polices*: This avoids additional project costs for the design of tailor-made and specific services, typical of heterogeneous and sparse customers
- *Distributed solutions*: The generation of different by products, which can be useful to another group of firms or a single firm, as a support service or even as a core-business factor
- *Specific facilities and management*: Specific facilities and management policies must be developed only for enterprises characterised by a combination of a highly specific demand and relative physical isolation from the other enterprise

Meneghetti and Nardin (2012) stated that the industrial symbiosis has enabled FM to operate successfully. According to Ashton (2008), industrial symbiosis encompasses collaborative resource management by diversifying firms in geographic proximity in order to achieve environmental and economic benefits such as reductions in operational costs and emissions, more secure access to inputs and basic utilities, and increased longevity of the resource base. Moreover, Chertow, Ashton, and Espinosa (2008) identified four types of resources that could be shared under industrial symbiosis as;

- *Utility/infrastructure sharing* – The pooled use and management of commonly used resources such as steam, electricity, water, and wastewater,
- *Joint provision of services* – Involves firms collectively meeting their ancillary needs, which relate to materials and services not directly related to the core business of a company. Fire suppression, security, cleaning, catering, and waste management are examples of ancillary services that have environmental implications,
- *By-product exchanges* – The use of traditionally discarded materials or wastes as substitutes for commercial products or raw materials, and
- *Information* – To increase the collective efficiency of their operations, and coordinate planning, project management and regulatory permitting.

District heating and cooling system is another opportunity for FM which distributes heat from a centralised location for residential and commercial heating requirements (Ionel, Popescu, and Dungan, 2011). Clara (1998) indicated that the centrally located effluent treatment plant could be named as one of the ideal options in clusters where there are low operational cost and initial cost. In the context of the built environment of Sri Lanka, Karunasena and Kannangara (2012) suggested a centralised waste management system that could be shared by all factories in free trade zones in Sri Lanka.

All aforementioned studies are focused on integration of FM functions within an organization or between organisations. However, there is a lack of an established definition for integrated FM when two or more firms collectively perform FM functions. Therefore, having considered the above studies, integrated FM can be defined as “*exchanging or sharing utility/infrastructure facilities, facility services and information, and collaboratively performs FM functions by two or more organizations in order to optimise FM functions*”.

2.2 Nature of Integrated Facilities Management

The aforementioned concepts embraced great opportunities for Facilities Managers. However, it was noticed that there are different characteristics combined in those collective approaches. Gang, Fua, Sarkisc and Xue (2010) demonstrated that the industrial symbiosis based on the synergistic opportunity arising from geographic proximity in sharing physical resources. Huang and Xue (2012) identified that physical proximity, core competencies, and relationships could be some main characteristic of clusters in integration. Meneghetti and Chinese (2002) noted that managerial commitment, a well-grounded economic and strategic motivation, along with a consistent organisational structure are required for successful integration. Cluster of supply chain also has taken the advantage of sole ownership and geographical location in initiating cluster supply chain. Meneghetti and Chinese (2002) proposed that the distance between organisations and nature of core business as the two dimension that facilitates integration in industrial districts. Considering the holistic view of industrial and non-industrial built environments, distance between organisations, core business, and ownership are considered as the governing factors of FM integration in this study and shown in Figure 2.

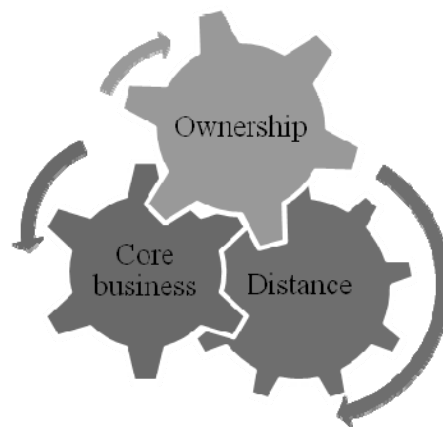


Figure 2: Dimensions of Facilities Integration

Organisations may engage in exchanging and sharing of different facilities and collaboratively performing FM functions. This study, therefore, investigates the integration of following functions among the organisations in Sri Lanka:

- (i) *Utility/infrastructure sharing*: physical facilities such as water, electricity, fire, generator distributions system and other real properties,

- (ii) *Facility services sharing*: building related services such as security, cleaning, catering, and waste management, and
- (iii) *Information sharing*: documents, standards, best practices, and other operational data.

The study further investigates the possible exchanges of integrated FM functions among the organisations. Therefore, a conceptual framework developed for this study is presented in Figure 3. It shows the integration of utility/infrastructure, facility services and information among organisations under different dimensions of integration, i.e. distance between organisations, core business and ownership.

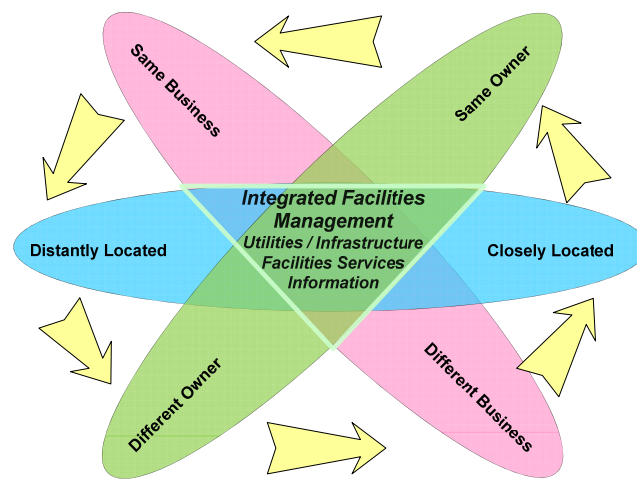


Figure 3: Conceptual Framework for Integrated Facilities Management

3. Research Methodology

A comprehensive literature review was carried to understand integrated FM concepts and to develop conceptual framework for this study. When considering the aim and the nature of the research study, it was obvious that this study needs holistic and in depth investigation into integrated FM functions in Sri Lankan context. Case study involves the study of a phenomenon in its real-life context (Yin, 2003) and incorporates the views of participants in the case under study. Further to Yin (2003), case study is an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident. Having considered the exploratory nature of the study, the conceptual framework was then tested using multiple case studies. Aforementioned framework recognised three dimensions which diverse the integration as distance, core business, ownership of the organisation. Therefore, eight case combinations were selected to exploit the integrated FM concept in Sri Lankan built environment as explained in each quadrant in Table 1. Semi structured interviews were carried out with the corporate level Facilities Managers who have experience in facilities integration.

Table 1: Case Study Combinations

Distance	Ownership	Core Business	Case Combination	Nature of the Organisations	
				1	2
Closely located	Same ownership	Same business	A	Five factories in a zone	
		Different business	B	Hotel	Restaurant
	Different ownership	Same business	C	Commercial buildings in a zone	
		Different business	D	Hotel	Commercial
Distantly located	Same ownership	Same business	E	Factory	Factory
		Different business	F	Hotel	Residence hotel
	Different ownership	Same business	G	Commercial	Commercial
		Different business	H	Commercial	Apartment

4. Case Study Findings

Case Combination - A: (Closely Located, Same Ownership, Same Business)

Organisations selected under the case combination - A are located in the green industrial zone in Sri Lanka which spread over 165 acres. The industrial zone has been rebuilt by one of the largest textile chain in the Sri Lanka to place their textile manufacturing factories, while achieving corporate long-term goals. Development has segregated into three sections as industrial, training and leisure and accommodation. Currently, there are five factories under the same ownership in the industrial section, about 200 houses in the accommodation section and huge facilities in the training section. However, maintenance of the zone has been assigned to a separate FM team.

The interviews have been carried out with the Senior Manager in the FM team (Respondent A1) and Plant Engineer (Respondent A2) in one of the factories. Table 2 presents the summary of shared FM function between factories.

Table 2: Integrated FM Functions in Case Combination - A

Utility/Infrastructure	Facility services	Information
<ul style="list-style-type: none"> ▪ Water distribution system ▪ Electricity distribution system ▪ Fire hydrant system ▪ Steam distribution system ▪ Water & effluent treatment plant ▪ Gym / entertainment facilities ▪ Training centre ▪ Staff accommodation ▪ Cafeteria 	<ul style="list-style-type: none"> ▪ Implementation of operational and maintenance standards ▪ Implementation of ISO-14000 ▪ Engineering services ▪ Corporate level fm ▪ Engineering expertise skill 	<ul style="list-style-type: none"> ▪ Energy data ▪ Engineering related information ▪ Health and safety information ▪ FM operational related information ▪ Best practices and knowledge

At the initial stage of the development, aforementioned utilities have been designed as centrally located and distributed among factories. Except those utilities, air conditioning system, generator power supply system, security service, janitorial services, maintenance, and other FM functions

held separately by a small FM team in each factory. Respondent A2 stated *“There is a special team who is responsible for those utilities which I can focus my other works and reduce number of technical staff. Less initial cost and maintenance cost is another advantage. For an example, I have rejected the concept of individual sewerage treatment plants and connected the same to the centralised system since it is profitable”*. Respondents commonly agreed to this integration which was apparently profitable for both the service provider and the factory. However, establishment of zone cafeteria was rejected by several factories due to the expensiveness of foods.

According to the respondent A1, there are monthly engineering, health and safety meetings with the factory Facilities Managers in order to discuss operational issues, further improvements and to share the expertise knowledge in open forums which added value for participants. Corporate database further assists in reviewing energy data, consumption data, and new practice for specific managers in the group as an internal benchmark. Accordingly, factories use common processes and procedures in order to standardise their operations. It is also observed that the factories are collaboratively conducting FM tasks within the zone as well as have certain inter relationships between other firms in the same group.

Case Combination - B: (Closely Located, Same Ownership, Different Core Business)

The organisations selected under the case study B belong to same ownership in hotel business. Both built environments are located close proximity to Colombo. Distance between the facilities is approximately 80 feet. The luxury five-star hotel has nine storey building. The restaurant is a newly constructed property with four storey building which operates from morning to mid night. The restaurant is specialised in Italian food and includes luxury facilities such as gymnasium, spa, swimming pool, and cafeteria.

In the initial construction of the restaurant property, the parent company had made a decision to facilitate non-core business activities using the hotel team. Thus, the parent company has legally handed over this property to the hotel in order to manage the property. During the interviews with the Chief Engineer (Respondent B1) in FM team, it was revealed that the both properties are managed by a central team was executed for both properties. Following Table 3 presents common FM functions for both entities.

Table 3: Integrated FM Functions in Case Combination - B

Utility/Infrastructure	Facility services	Information
<ul style="list-style-type: none"> ▪ Steam distribution system ▪ Fire hydrant system ▪ Generator power distribution system ▪ Security (CCTV) monitoring system ▪ Fire detection and prevention panel including sprinkles, heat detections, smoke detection ▪ Telecommunication system 	<ul style="list-style-type: none"> ▪ Implementation of operational and maintenance standards ▪ Engineering services ▪ Housekeeping services ▪ Pest control ▪ Security service ▪ Laundry service ▪ Corporate level FM ▪ Tool and equipment 	<ul style="list-style-type: none"> ▪ Energy related information ▪ FM operational related information ▪ Procurement related information ▪ Financial planning ▪ Best practices and knowledge ▪ Documentations – standard operating procedures, energy, preventive maintenance

The Chief Engineer stated, *“This integration is cost-effective. For an example if we have installed separate fire pumps, it has high initial cost and also high maintenance cost. Further, it requires additional staff for the operation. Having a centralised system for two properties is handiness for me to handle the operation with less involvement of staff.”* Further, all monitoring and controlling panels for both entities such as fire

alarm system and generator changeover panel are installed in central location in the hotel. Hence, cost of operation is distributed among the entities, based on their consumption.

The both organisations have integrated maintenance and operations for the steam generation process and hence both companies are enjoying less maintenance cost, time, and the hassles. According to the Chief Engineer, restaurant has registered as a commercial property, while hotel has registering as a hotel facility. Therefore, there are different tariff plans for both the properties. Thus, water, electricity, and air conditioning cannot be integrated. Further, due to some practical and safety issues, gas distribution system and car park have not been shared.

As being under the same ownership, similar procedures, documents and processes have easily shared between properties. It is notice by findings that the organisations had not recruited additional staff and equipments since the facility integration and hence FM staff work under pressure. Hotel had rescheduled their operations in order to cope up with the situation. The two building are functioning well due to the benefits of the integration.

Case Combination - C: (Closely Located, Different Ownership, Same Business)

The organisations selected for case study C are located in a privately held zone and they are in the businesses of IT, software development, and business process outsourcing services companies. Zone spreads over 14.5 acres and currently 250,000 square feet have been developed including six rentable properties with modern facilities such as gymnasiums, food courts and in-house parking facilities. Zone accommodates nearly 3750 occupants in 20 popular companies in the IT industry. Distance between all facilities is approximately 50 meters. Property developer maintains both in house and outsourced FM team in order to manage their property.

Case study interviews were carried out with the Head of the Facilities Management team (Respondent C1) and the Director FM (Respondent C2) of the facility. Table 4 presents the common FM functions carried out within the Zone. FM team is responsible for providing utility facilities for the tenants and other services will be provided based on the tenants' requirement in accordance with the agreement.

Table 4: Integrated FM Functions in Case Combination – C

Utility/Infrastructure	Facility services
<ul style="list-style-type: none"> ▪ Water distribution system ▪ Electricity distribution ▪ Generator power supply ▪ Building management system ▪ Sewerage and drainage system ▪ Gymnasiums ▪ Food court 	<ul style="list-style-type: none"> ▪ Engineering services (Annual maintenance and other breakdowns) ▪ House keeping ▪ Security services ▪ Pest controls ▪ Same suppliers ▪ Tools and equipment

Findings emphasised that FM team is responsible in providing utilities for the properties. Some of the utilities are located centrally while some utilities such as air condition units, fire prevention and detection system are attached individually to the buildings. These systems are connected to the central building management system. Respondent C1 stated, "*Centralised monitoring and controlling system facilitate the management of time, resources, money, as well as quick response emergencies*". However, the study found several mismatches in the integration. Common transportation system for the zone has been rejected by individual organisations. Management of the Respondent C2 has been built a separate food court for their staff since common food court has less room and its' expensiveness. However, Respondent C1 stated that the organisations prefer individuality in obtaining services as being the competitors in the same industry.

Respondent C1 shares human resources such as technical staff in providing FM services to all properties while operating from a central location. Some organisations have requested the shared facilities and services such as janitorial and security while others outsourced these services. It is evident that although firms are located in close proximity, none of these organisations are in collaborative approach in carrying out FM functions.

Case Combination - D: (Closely Located, Different Ownership, Different Core Business)

Case combination - D studied the integrated FM functions between a commercial building and a hotel facility located in close proximity. Commercial building has two towers of 39 stories each. Commercial building is designed to provide rentable office and business space with modern infrastructure facilities. Hotel is in a five-star category which has 17 stories including a basement floor, a lobby level and a mezzanine floor.

Both organisations operate individually under different ownerships. The study interviewed a Senior FM (Respondent D1) in the commercial property and the Chief Engineer (Respondent D2) of the hotel. Case study found that the two organisations share their car park facilities. Respondent D2 mentioned, *“The first respondent D1, has requested a common emergency evacuation access and a shared car park to solve two critical issues.”*

Commercial building is operating from 8 a.m. to 6 p.m. The commercial organisation noted that space available for car parking for their tenants and customers is insufficient during daytime which is the peak time for their business. However, during the night, the same car park is abandoned due to low demand from the tenant. In contrast, it is found that hotel car park slots are available during daytime. However, the hotel management was unable to satisfy car-parking demand during night due to large number of guests demanding for lodging, attending banquet functions and having dinners. Considering the situation, two FM managers from both parties have agreed to share car-parking facilities in two premises. The agreement was to allow using the car parking slots in the other facility, whenever their parking slots are filled.

Facilities Manager of the commercial property said, *“Due to the nature of the operations in both businesses, our demand on car park varies. However, due to this decision, problem of insufficient car parking has been solved. In addition, the Corporate Management is happy on the decision of integration. The decision adds value to the customer.”* Although both organisations have realised the benefits of integrated facilities, it is observed that they are reluctant to integrate further FM functions or facilities. Facilities Manager of the hotel facility said that, *“The existing regulations restrict the integration of facilities such as utilities. There should be a win-win situation in order to integrate the FM functions. Factors such as mutual trust between parties, transparent agreements, and involvement in top management are essential to conqueror the integrated situation.”*

Case Combination - E: (Distantly Located, Same Ownership, Same Business)

One of the reputed apparel manufacturing chains is selected for case study E. The chain consists of eight factories that spread over Sri Lanka. There is a separate in-house FM team in each factory. Study interviewed Senior Manager (Respondent E1) who is responsible for FM functions of all factories and Plant Engineer (Respondent E2) of one of the factories. Discussion findings are shown Table 5.

Table 5: Integrated FM Functions in Case Combination - E

Utility/Infrastructure	Facility services	Information
<ul style="list-style-type: none"> Central BMS monitoring and controlling system 	<ul style="list-style-type: none"> Implementing operational and maintenance standards Corporate Facilities Manager Same service provider Central finished good transportation system 	<ul style="list-style-type: none"> Data base for utilities Best practice and knowledge Supplier information FM operational related information Documentations – standard operating procedures, energy, preventive maintenance Financial planning Procurement related information

The chain has a single central database which displays all relevant information to Plant Engineers and Head Office management. In addition, Building Management System in each factory is linked to the Head Office in order to assist, monitor and control some services such as air conditioning system. The Head Office controls the performance of each factory using utilities data. Respondent E1 stated that “*sharing the data was one of the biggest issues. Therefore, we have now converted to an automated system.*” The shared data facilitates performance appraisal, internal benchmarking, preparation of budgets, improvements, and further decision making.

Interview discussions highlighted that the parent company sets controls in order to standardize the FM operations. Thus, all factories follow the same processes, procedures, audits, and document formats. Respondent E1 said, “*Initially some staff members resisted in standardisation due to the fear of losing their flexibility. But with the involvement of top management, we were able to control the resistance.*” Eight Plant Engineers with the Central FM team held meetings frequently at a selected plant. Respondent E2 emphasised that “*frequent meetings with plant engineers were mostly benefited, where discussions were held on issues, best practices, and progress openly. We do always update our knowledge.*” Further, it helps to identify a common efficient service provider to provide services to all factories. In addition, there is a centrally coordinated transport system for the delivery of finished products in order to avoid delays. Further, it is cost effective and adds value to the organisation.

Case Combination - F: (Distantly Located, Same Ownership, Different Business)

One of the buildings selected for this study is a five star hotel and the other building is also in hotel category which provides apartments for long or short stay. Both organisations are managed by one of the reputed international chains in the world. The five-star hotel is a 19 storey building with over 380 guest rooms and the other hotel is a 33-story building with 175 apartments. There is a separate FM team for each hotel. Case study presented the interview findings with the Hotel Chief Engineer (Respondent F1), FM Executive (Respondent F2) and Housekeeping Executive (Respondent H3) in the residential hotel.

Both entities share certain FM related activities as it is being under one management as presented in Table 6. However, entities found it difficult to integrate infrastructure/ utilities due to the distance between two buildings which is 3.1 Km via road.

Table 6: Integrated FM Functions in Case Combination - F

Facility services	Information
<ul style="list-style-type: none"> ▪ Implementation of operational and maintenance standards ▪ Food and beverage ▪ Toiletries and other items ▪ Laundry facility ▪ Internal sales ▪ Tools and equipment 	<ul style="list-style-type: none"> ▪ Common data base for share energy, occupancy satisfaction, employee works, best practices and knowledge ▪ Documentations - audit format ▪ Procurement related information ▪ Best practices and knowledge

If any of the hotel guests requested a suite, the hotel directs them to the residential hotel. Accordingly, this study recognised several examples for informal sharing between the entities. The auditing is handled by one company and hence knowledge and skills are shared. Further, fire, light, and safety audits are done by the Director Operations of entities. The two entities share food and beverage, toiletries and other similar items when one organisation is out of stock. Further, there is a common laundry for both facilities. Moreover, the parent company shares information on energy performance, best practices, and guest satisfaction through a web portal. Although two entities are in different core businesses, the organisations are taking the advantage of single ownership in sharing FM functions.

Case Combination - G: (Distantly Located, Different Ownership, Same Core Business)

Case combination - G consisted of two competitors who rent office spaces and provide FM services. Two commercial properties are 16 storey and 11 storey buildings located in 1.4 km distance. Both entities perform their FM operations independently. However, it is revealed that a common pool of janitorial staff and equipment are sharing among the properties with the supervision of janitorial service provider. Therefore, the study interviewed the corporate Facilities Manager (Respondent G1), Maintenance Manager of the properties (Respondent G2), and the Area Manager of the janitorial service (Respondent G3).

Two properties have outsourced their janitorial services to one service provider who handle around 110 sites in Colombo region. Two properties are separately getting the help of 53 and 10 janitorial staff from the outsourced company. The service provider has allocated permanent staff and additional staff for each property. It is also found that the excess staff members are normally transferred to the sites that need extra staff and hence company performance is optimized.

Case Combination - H: (Distantly Located, Different Ownership, Different Core Business)

Case combination - H includes a commercial building and an apartment complex. The commercial building has two towers which provide rentable office and business spaces to prospective clients. Apartment complex is a mixed development with eight multi-tower apartment complexes with hotel, shopping mall, food court, and theatres.

Interviews were conducted among the Senior Facilities Manager (Respondent H1) of the commercial property and the Manager (Respondent H2) of apartment complex. Management Council of apartment complex has outsourced total FM function to the commercial property FM team. Thus, commercial building and apartment complex share common operations summarised in Table 7. The two properties are distantly located via the road (8 Km), and hence it was difficult to share utility/ infrastructure.

Table 7: Integrated FM Functions in Case Combination - H

Facility services	Information
<ul style="list-style-type: none"> ▪ Engineering services ▪ Common pool of technical and operational level staff and security staff ▪ Engineering expertise ▪ Corporate level Facilities Managers ▪ Special tools and equipments ▪ Same suppliers 	<ul style="list-style-type: none"> ▪ Procurement related information ▪ Documentations – standard operating procedures, energy, preventive maintenance, procurement policies ▪ Best practices and knowledge ▪ FM operational related information

The interviews revealed that the FM service provider has assigned with a separate FM team for both properties. The corporate level facilities managers are jointly involved in facility planning, decision making for both parties. Thus, most of the management functions such as procurement, maintenance, and human resources management are similar. Both companies are sharing common pool of staff.

5. Analysis of Integrated FM Functions

All case studies presented in the previous section share various FM function at different scales. Table 8 presents the summary of FM functions that are shared among different built environments.

Table 8: Summary of Integrated Facilities Management Functions

	Integrated functions	A	B	C	D	E	F	G	H
Utility/infrastructure	Water distribution system	x		x					
	Electricity distribution system	x		x					
	Fire hydrant system	x	x	x					
	Steam distribution system	x	x						
	Water and Effluent treatment plant	x							
	Generator power supply		x	x					
	BMS or other controlling units (fire, CCTV,)		x	x		x			
	Sewerage and drainage system	x		x					
	Telecommunication system		x						
	Car park				x				
	Cafeteria	x		x					
	Gym / entertainment facilities	x							
	Training centre	x							
	Staff accommodation	x							

Facility services	Integrated functions	A	B	C	D	E	F	G	H
	Operational and maintenance standards	x	x			x	x		x
	Engineering services	x	x	x					x
	Housekeeping services		x	x					
	Security service		x	x					
	Pest control		x	x					
	Laundry service		x						
	Common pool of operational level staff (engineering, housekeeping, security)							x	x
	Corporate level FM	x	x			x	x		x
	Engineering expertise skill	x	x			x			x
	Same suppliers		x	x		x		x	x
	Tool and equipment		x	x				x	x
	Food and beverage, toiletries and other items						x		
	Internal sales						x		
	Central finished good transportation								
Information	Energy related information	x	x		x	x	x		x
	FM operational related information	x	x		x	x	x		x
	Procurement related information		x		x	x	x		x
	Financial planning		x			x			x
	Best practices and knowledge	x	x		x	x	x		x
	Corporate data base	x	x			x	x		x
	Document formats					x	x		

According to the Table 8, closely located firms have integrated utility/infrastructure. However, case combination E has shared BMS monitoring and controlling functions, although the firms are located distantly. Yet, there are restrictions in sharing water, electricity, and air condition system due to legislations. Case combination A and C are significant examples for industrial symbiosis and industrial district as per the literature. However, developments have not exploited substantial opportunities of integration within the zone.

Firms which belong to same ownership are collectively operating FM functions by implementing operational and maintenance standards, expertise skills through corporate facilities managers.

Findings also highlighted that different ownership organisations and case combinations G and H are integrated FM functions through an outsourced service provider. Thus, companies can be benefited by outsourced service providers who use common pool of human resources, tools, equipments and standards.

The research findings revealed that most of the owners have implemented corporate database for sharing information. Building Management System (BMS) would be the ideal method for sharing information in facilities integration. However, there is a strong integration in FM functions between closely located, same ownership and same core business firms. When firms are distantly located, different ownership and different core business integrations is weak.

Integration of FM functions creates a win-win situation for all parties who are exchanging or sharing utilities/infrastructure facilities, facility services and information. Accordingly, facilities managers can encourage and assist company management to integrate facilities in order to optimise business performance. The findings of this study will guide industry practitioners on possible utilities/infrastructure facilities, facility services and information that could be exchanged and shared under different organisational settings such as distance, core business and ownership to confront the emerging business challenges.

6. Conclusions and Recommendations

Organisations implement FM as a tool to overcome their workplace problems, while enhancing the value of core business. The rapid development of management concepts and technologies forced organisations to implement innovative FM strategies. Integrated FM is a novel sustainable approach for any of organisations to meet the core competencies of the business environment.

Preliminary investigations through case studies and discussions with FM experts have revealed that there are examples of integrated physical facilities and FM functions among the built environments in Sri Lanka. Nevertheless, it is evident that there is a less motivation for integration of FM due to several reasons.

The study found that the distance, ownership, and core business as the driving forces for the facilities integration. If firms are in geographical proximity, utility/infrastructure could be centralized and easily shared. Collective approaches are suitable for the firms who are under same ownership. Distantly located firms could not easily share utility/infrastructure. However, there is a high tendency of centralising utility/infrastructure among the organisations in a clusters or located in a zone. Some organisation share FM functions though an outsourced FM service provider. As being under a same ownership or management, there is a high potential of sharing FM functions. Although organisations are distantly located, they could easily share information. Sole ownership is one of the reinforcements for information sharing.

In conclusion, when the firms are in close proximity, under the same ownership, and in the same core business, there is a high possibility of sharing utility/infrastructure, FM services and information. Long distance, different ownerships, and different core business act as a barrier for integration of FM functions. Apart from the distance, ownership and core business, there are significant features which could drive integration such as investment, top management commitment, mutual trust, contractual agreement, culture of organisations, and initial design. The integrated FM functions presented in this paper would be useful aids for designing and implementing integrated FM concept in built environments in Sri Lanka in order to optimise the performance of facilities management.

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The Key Factors affecting Design and Structural Technology for the Efficiency of Clay Cooking Pots: Special Reference to Culinary Item “Hattiya”

Ranasinghe W.M.N.D.,

Department of Integrated Design, Faculty of Architecture, University of Moratuwa
wmndr@yahoo.com

Abstract

Water, fire, air, earth and space are the basic natural elements in the planet. The processes of clay ware manufacturing can be described as a result of the above mentioned elements. At the beginning clay was used as a material to create figures and sculptures rather than manufacturing objects. Sri Lanka is famous for the pottery industry from beginning of the civilization and it has a great history. Gradually it was developed as a cottage level industry. It can be identified as a knowledge transferring craft from generation to generation. However, with the passage of time clay culinary items became less popular. It has been found that they have not been paid proper attention and concern about the design. It is not updated to cater the present social context. The main objective of this research is to explore key factors to uplift the culinary product in Sri Lanka. It has been inspired to conduct this research; otherwise it will become a dying traditional craft in Sri Lanka.

This research followed the quantitative and qualitative research methods. The required data were collected through an extensive literature survey, case study use of different types of Hattiya and structured questionnaires given to the urban and rural consumers in selected areas.

The result of the data analysis reveals that there are five key factors affecting the design and technology of Hattiya. The main findings of this research show that the key factors such as shape and form, texture, value, proportion and balance are needed to be considered when designing and manufacturing clay cooking pots.

Keywords: Design, Technology, Manufacturing, Efficiency, Culinary

0.1 Introduction

Man is a distinctive creation of nature and he has marvelous talents for creativity. When people became modern, their needs also got changed and complicated. They tried to find new techniques and new objects for a sophisticated life style. Most of the objects were produced considering functional usage and design aspects. Therefore new methods and new technologies were adapted to suit their life style. This was done by using their creative abilities and talents. New ways for producing objects for daily needs were developed through many experiments and experiences. As a result of their numerous experiments, clay was identified as a quality and a flexible material which can be used to produce objects. The art of ceramics is one of the oldest known, dating to prehistoric times. Clay is a special kind of earth, found all over the world that is easily worked when moistened, but can be hardened and made waterproof by exposure to heat. The earliest forms of construction were pinched that is, the clay is formed with the fingers to the desired shape (Jirousek, 1995).

Clay is an available material on the earth, which is soft and flexible to the hand, when hold a lump of it. When it is pinched and pressed it takes shape; almost by it self. This piece of earth gets life of its own when touched with fingers. It changes the behaviors when mixed with water and fire. Using their experience, people tried to make different objects out of clay. Most of the designs were simple and creative. Functionality was the main aspect of the products which were designed by people. Because most clay is plastic; it can be shaped and formed and will retain that

from when dried. Another principle is that fire hardens clay. A third is that adding various substances to clay can improve its properties and usefulness (Rice 1987).

People tried to make new utensils by doing experiments and using different types of materials. It was a case of trial and error. Natural resources could not fulfill their daily requirements. For example, they needed storage facilities to gather and to prepare foods. Clay was identified as a material to create utensils and objects. At the beginning people used less sophisticated pots to cater to their needs. Earlier the product was manufactured to satisfy people's personal needs, or as a service, but with the passage of time objective of the manufacturers have changed and it has now become a paid work. The changes of the society, culture, and living pattern and human needs, have been the concern factors in this innovation. With the passage of time clay culinary products became less popular because they did not pay proper attention and concern about the design. It is not updated to cater present social needs; they are not in good condition for the product functionality rather than the previously used products. This research tries to identify key factors to uplift the culinary products.

0.2 Literature Review

Three areas such as the literary sources, archeological remains and the current usage of the prevailing tradition can be explored in order to understand the chronology of the local pottery production and usage. As a result of the archeological investigation carried out in the country it has been reported that the pottery chronology from 900 BCE up to the present (De Silva and Dissanayake, 2008). Somadewa (2006) indicates a continuity of the pottery using cultural occupation of the area from 900 BCE to 1400 CE. Traditional clay cooking pots were designed to cater their day today needs because they were designing their own products. Due to this they had a good knowledge and experience about how it needs to be designed and changed.

Among the existing products veddas' pots can be identified as good products that are designed out of basic considerations. Designs were in a primary level as they only wanted to fulfill their basic requirements and aesthetic values. This led to new experiments and innovations widening the scope for multidisciplinary usage. They developed their creativity and talent of pottery manufacturing processes according to their experience and experimentations. Vedda makes very rough pots (Seligmann and Seligmann, 1993). These pots have a small unfinished orifice, the special character is that they used a loop for hanging the pots. These were used to collect honey. Vedda used simple decorations to make the product attractive.



Figure 1: Development stage of "Hattiya"
Source: (Seligmann and Seligmann ,1993 p.328)

The potter served the people and performed an important function in all period of the evolution of Sri Lankan society. Starting from the pre-historic time the use of pottery has been attested in the earliest stage of the appearance of our ancestors thousands of years before recorded history. Along with implements of hunting and food gathering earthenware have been used for storing, cooking and eating purposes (Tilakasiri, 1994).

2.1 About Earthenware Products

According to the excavators the first evidence of Sri Lanka crude earthenware (red brown ware) association with stone tools (De Silva and Dissanayake, 2008) can be identified the origin of the local earthenware goes reverse towards period of hunter gather of the Sri Lanka. Earthenware is the stage of development of a terracotta (750°C – 850°C) body. It can be grouped under two types such as low temperature earthenware and high temperature earthenware. Low temperature earthenware is fired at around 750°C -1000°C, and exact type can be identified from the colour of the body and the strength. Most of the culinary items, water containers and pans can be categorized under the low temperature products. It has the quality of water absorption (porous body) and also less heat resistance. Tilakasiri (1994) stated that Earthenware clay is the common red clay found in nature and mixed with sand and grit, mainly used for making bricks and tiles, the subsequent dirt –free layers of clay being used for making pottery (p.48). Earthenware clay which contains stones and sand compounds is not good to produce clay cooking pots, it should be a fine and a clean clay compound. According to De Silva and Dissanayake (2008), “The production of pots and pans in Sri Lanka was a well established craft which continued for the last 4000 years, little mention was found in literal sources, yet archaeological excavation carried out in different parts of the island has provided sufficient information to understand the quality and the method of production , art, form, typology, distribution, usage, trade and technology of production of pottery during different periods of Sri Lankan history”(p.12).

Cooking pots and pans can be categorized under the domestic products. Domestic products are generally used in the kitchen. Cooking pots can be divided into three main categories according to the purpose of the usage, as these products can be used for several purposes. It is one of the special features of earthenware culinary products. Ceramic vessels have served a variety of culinary and non-culinary purposes for ten thousand years or so, but in domestic and culinary roles they were used for carrying liquids, storing dry substances, or heating contents over a fire. Each use places different demand on the vessels, and so it is suitability for a particular task on its design (Rice, 1987). Earthenware products are used for various functions in the kitchen. Rice (1987) stated that according to their function, domestic containers can be categorized as follows:

- 1.Processing Products
- 2.Transport Products
- 3.Storage products

2.2 The purpose of Earthenware Processing Products

Processing products are more important than the transport and storage products. This is due to the (preparation products) same products are used for transportation and storage purposes. Processing objects are mainly based on the purpose of heating and non-heating method. Boiling, steaming, frying, roasting can be identified under the heating method and mixing, washing, soaking, pounding; removing can be categorized under the non-heating system. One product can be used for several purposes. It is a special feature of clay vessels. Some of the vessel forms are used for these functions and are expected to get the maximum use of the heat from the fire. They are generally likely to have a round shape rather than angled to avoid the thermal shock. In addition round contours permit greater exposure of the vessel's base, walls and content to the heat.

The shape of orifice is very important to the processing objects and their functions. Vessels can be named as unrestricted and restricted orifices. Unrestricted orifices (open lip) help adding and removing food, but slightly constricted vessels which have narrow necks would prevent overcook of food by reducing evaporation. Vessels used for simmering or frying may be more open and have slightly flat bases. “*Hattija*”, consists of a wide mouth with unrestricted orifices, wide body and flat or round base. Cooking pots have a grip to hang or for carrying purposes.

Thickness of the vessel is an important fact for the purpose of processing. Thick wall makes the clay vessels strong, so that pounding, stirring or mixing food in them can be done properly and easily. Thickness of the rim helps to hang the object properly and also it can be a disadvantage for cooking, as it would pave the way to waste fuel by taking long time for cooking food.

0.3 Research Methodology

This research is carried out by literature review and case study in order to understand present clay “*Hattiya*”. Three sizes of “*Hattiya*” will be used to observe its importance, drawbacks and developments. The following areas which are famous for earthenware cooking pots have been used in this study. From Kandy District: Menikhinna, Urispaththuwa, Wattegama, from Kurunegala District: Abagaswewa, Paduwasnuwara, from Rathnapura District: Eheliyagoda, Nakandala, Gampaha District: Biyagama, Kegalle District: Molagoda. Questionnaire survey is used to identify the current situation and development of the product. It will be helpful to identify consumers’ experiences and to obtain their valid opinions regarding the development of clay pots. Open ended questionnaire surveys were carried out with consumers in rural and urban areas such as Kandy and Colombo because they have a trend to use clay pots and still the traditional cooking methods are followed in rural areas.

0.4 Results and discussion

4.1 Results and discussion of the case study: Introduction about “*Hattiya*”

There are six type of “*Hattiya*” used in present society. These objects are used to get a clear idea about products and its functionality through consumers and manufactures.

4.1.1 Identification of “*Hattiya*”

“*Hattiya*” can be described as an important culinary product. De Silva and Dissanayake (2008) explained that “General terms under for vessel are “*Valam*” or “*Hatti*”, “*Mutti*””(p.20). Coomaraswamy (1979) stated that generic terms for vessels are “*Heliya*” and “*Valada*”. Yet the term “*Helivalam*” measures four pieces used to cook a rice meal which are namely “*Muttiya*”, “*Heliya*”, “*Hattiya*” and “*Nebiliya*”. There are several sizes of “*Hattiya*’s” in use as of today, and size differences can be identified from province to province. They varied in size, functional features and aesthetical aspects. “*Hattiya*” is also called as “*Athiliya*”. This also differs according to the province. In Southern Province a larger “*Hattiya*” is known as “*Athiliya*”. Yet in the Central Province, “*Athiliya*” is identified as a small “*Hattiya*”. It is shorter than the “*Hattiya*”. “*Appallaya*” and “*Haliya*” are the other terms for “*Hattiya*”. In the past, the “*Hattiya*” was known as “*Appalla*” in the Central part of Sri Lanka. “*Haliya*” and the “*Hattiya*” are called as an “*Athiliya*” in Southern Province. Pottery sellers say that people come and ask for “*Podi Athili*” and “*Loku Hatti*”. “*Hattiya*” is more spacious and normally used to prepare curries with gravy. It is bigger than the “*Athiliya*”. It is a simple restricted vessel with composite contours. This vessel is shallower than “*Athiliya*” but some types are deeper than “*Athiliya*”. It has a convex spherical body and this helps to boil and mix curries properly. The round body helps to take the contents out with a spoon. The orifice or the lip has a greater thickness but thickness is gradually reduced at the bottom. The bottom is not round but it has an angular shape. Occasionally the top of the outside surface is adorned with simple decorations.



Figure 2: A “*Hattiya*”



Figure 3: A “*Kundahattiya*”

“*Kunda Hattiya*” is another version of the “*Hattiya*” which seems as “*Athiliya*” and currently it is rarely used in practice. This is more spacious and normally used to prepare big curries with gravy. “*Hattiya*” is also used as a container to set the curd. Before introducing the machine made curd pot “*Muttiya*”, “*Kunda Hattiya*” and “*Athiliya*” were used to prepare the curd. Clay body has a quality to set the curd. It helps to absorb the water content from the curd because of the quality of porosity. “*Hattiya*” is used as long term storage for the curd processes; and is called “*Kiri Hattiya*”. Man made clay pots take the shape gradually reducing the wall thicknesses from orifice to base. It helps for heat absorption and fixes clay particles as a bond.

“*Hattiya*” is used as long term storage and also for the short term usage. When preparing “*Malu Ambulthiyal*”, “*Hattiya*” is used as long term storage until the fish pieces become seasoned. It provides a good smell and a good taste for the curry. “*Hattiya*” was in a good standard which had quality and functionality. Gradually the qualities of the product were decreasing because of the arrival of other alternative products. “*Hattiya*” is produced using a potter’s wheel, and a symmetrical form.

“*Hattiya*” can be described as a product which is developed during the process of manufacturing the “*Muttiya*”. Globular shape is a steady structure which controls the volume of a liquid. Usually the shape of a product provides safety, and gives an aesthetical appearance despite the different forms that it gets restricted or unrestricted. It promotes the concept of well packing item too. Although the shape of the “*Hattiya*” maintained its standards such as proper size and etc. at the beginning, qualities like proper design and the functionality were not paid much attention.

Presently “*Hattiya*” comes in six sizes and lid comes in four sizes. The size of the “*Hattiya*” is designed according to the family size. Nowadays families are consisted of less number of members such as two or three. Therefore, the size of the product also has been changed to facilitate their needs. There were ten or twelve members in one family in the past and they had to use larger size culinary products. When comparing small and large sizes of “*Hattiya*”, small “*Hattiya*” has less design qualities as they have a good market for small size products. They have time to pay more attention on the objects with larger sizes. Although functionality is an important aspect of products, people did not consider much about it. Hence problems related to the functionality arise when the products are being used. This drawback makes consumers unhappy and disappointed about clay products.

4.1.2 Characteristics of “*Hattiya*”

The size varies in height and width of the object. Their orifices, bellies and base segments have slight differences, but more differences can be seen in angle, thickness and shape of the base. Sometimes the shape and the proportion of the “*Hattiya*” vary from place to place. As mentioned above, “*Hattiya*” can be classified into six groups and it is common for all areas. From area to area the size variation can be in between 1cm and 1.5 cm. It is totally neglected here and the main value of the product is taken into consideration. The length and width are used to take the mean value. There are no significant differences in shape and form of the product in different areas.

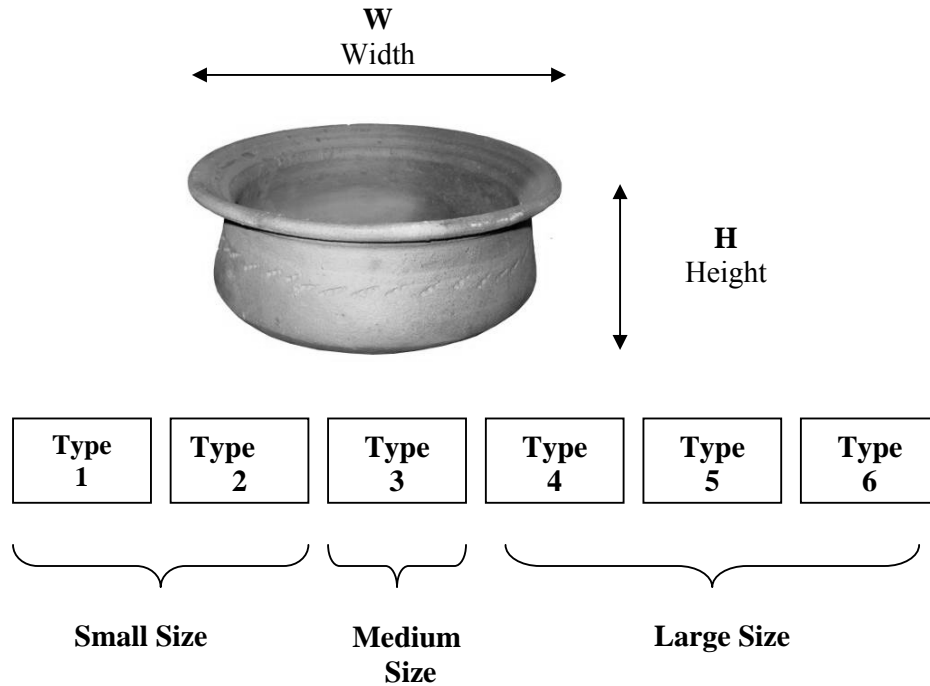


Figure 4: Size Variations of Present “Hattiya”

There are three types of “Hattiya” (Type-1, 2, 3) which can be used to prepare curries for day-to-day needs, and the other three are used in special occasions (for large preparations). Small objects are of less quality but large “Hattiya” are of good quality. As a result, small pots can be sold quickly but it takes time to sell large pots. Manufacturers have to pay more attention when producing large “Hattiya”. This improves the quality of the product. They produce small “Hattiya” quickly, without considering product efficiency or functionality of the product. This would reduce the usage of earthenware products.

As a structural quality product proportion can be identified as a compulsory aspect of the production processes. Proportion refers to the relative size and scale of the various elements in design (Park, 2010). Product balance is always combined with the proportion visual weight helps to give first impression about the product. There are two types of balances as, symmetrical and asymmetrical balance. Balance gives a feeling of stability. Most of the earthenware products have center points because most of them are created using a potter’s wheel. Vessels have a radial balance. Asymmetrical balance creates a feeling of equal weight on both sides, even though the sides do not look the same. Asymmetrical designs also are called informal designs because they suggest movement and spontaneity.

Product shape and form full fill the main features of product functionality. Much more limitations need to be obtained when designing a product, because it has technical and material limitations. Angular shapes placed diagonally in relation to gravity suggest in stability and shapes that exhibit softly curving surfaces suggest quite comfort and sensuality (Jirousek,1995). Shapes of circle suggest infinity and it gives a feeling of protection. As an example most of the domestic products basically get circular shapes and finally they take spherical forms. Therefore cooking pots contain a feeling of protection and infinity. Surface texture is important to increase the heat absorption, Skibo, Walker & Nielsen (1995) stated that, exterior texture improves a vessel’s heating effectiveness by increasing the exterior surface area and textured exterior surface also improve a pot’s resistance to thermal crack. The body thickness of the bottom part of the vessel should be reduced gradually if not it will affect to have a bottom crack. Rather than that textural surface creates a grip between the clay surface and the hand. When concerning about the validity

of the product it can be identified as social value, cultural value, aesthetical value and physical value. A quality of heat absorption ,cooling, porosity, thermal shock resistance, weight are main qualities of the physical value. These are the main considerations that can be identified from the current usage “*Hattiya*”.

4.1.3 Structural Analysis of “*Hattiya*”

Clay pot is mainly consisted with three parts, Orifice, Belly and Base. Concerning these three elements is a very important fact to create a completed product. The body shape of “*Hattiya*” is developed by changing of corner point. When corner point varies, the overall shape and the form of the pot also change. It helps to create unrestricted or restricted shapes. Following drawings explain the changes of bend points;

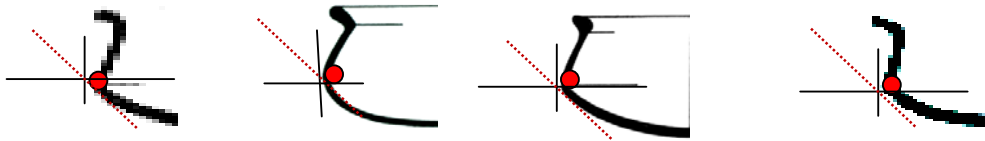


Figure 5: Bend point Changes and structural development of the “*Hattiya*”

Bend point has a direct effect to change the product when profile. Generally the bend point of the “*Muttiya*” is in the upper part of the vessel structure when “*Hattiya*” is made. The lower part of the body gets a spherical shape with a big volume. When the bend point moves to the lower part of the vessel structure the mouth of the pot becomes wider and height becomes lesser than the “*Muttiya*”. That profile is identified as a “*Hattiya*”. This is shown from the drawings. Changing the bend point has an effect on the use of the product and product functionally.

The structure of the “*Hattiya*” can be divided in to two parts as the upper part and the lower part. A vertical view of the exterior can be divided in to four parts. $\frac{1}{4}$ of the height (from the bottom) can be identified as the lower part while the upper part accounts for $\frac{3}{4}$ (three quarters). The upper part consists of an orifice, belly and the lower part consists of a base.

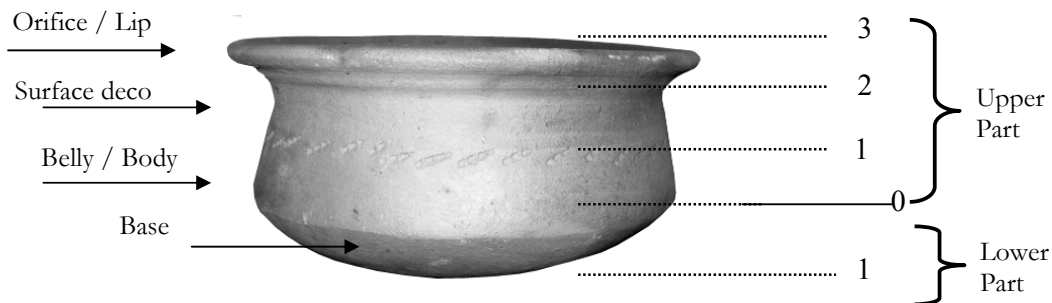


Figure 6: Upper Part & Lower Part of the “*Hattiya*”

The upper part of the vessel needs more functional characteristics than the lower part of the vessel. Mostly upper part of the vessel indicates the functional and stylistic characteristic of a pottery vessel (De Silva & Dissanayake, 2008). The orifice, the belly and the base are important for product functionality. A structure of a vessel might look simple but it consists of angles, curves, and corners. All body shapes need to address functional requirements. Ceramic products have numerous limitations. They cannot be created in several shapes. When developing vessel shapes, much attention has to be paid to the wall thickness and the product weight. The weight of the clay vessel is important to handle the object easily and thickness has an effect on water and heat absorption of the clay vessels. All body shapes and forms have to be created according to the usage of a product. These facts can be identified as main considerable factors when manufacturing clay vessels.

4.1.4 Importance of Body, Base and Stability of the “Hattiya”

Body and base are the other important elements of the vessel structure. The area of a vessel body can be identified as the area of orifice to base, and also it can be termed as belly. “Hattiya” has different types of body shapes but they all look alike. Vessel body has a volume. Traditionally outside surface is used to do decorations. In the past there were valuable decorations and designs created on top of the surface. When it is compared with present situations, design had been used for the surface decorations, which did not have any value. However there was a precious tradition. People did not pay much attention to the aesthetical pleasing of the products. It is one of the main features of clay cooking pots. There are six sizes of “Hattiya” used in current situation. Potters pay less attention to finish and decorate to small “Hattiya”, because they can be sold faster than the large “Hattiya”, with a short period. Therefore they do not bother to finish and create designs on them. They spend much time to finish and decorate large “Hattiya” consequently large pots are rich with design qualities and aesthetical values. People have the talent to create good products but they do not consider these factors.

Surface decoration gives the first impression of the product, because the aesthetical appearance is also important as the product functionality. Earthenware clay pots can have smooth or rough textured surfaces. There is a possibility of cracking the pots which have smooth surface during the process of firing. Thickness of the clay body (clay compound) provides a cooling effect for the inside surface, as it is an important aspect of the clay vessels. It facilitates the quality of warmth and the coolness of the product.

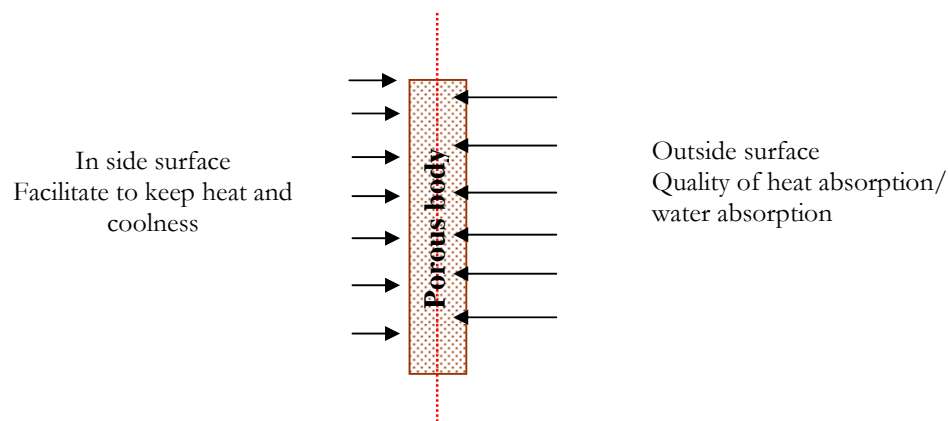


Figure 7: Section of a clay body

Body of the “Hattiya” is always fixed with the orifice and the base. Base is also an important part of the clay vessel. Wheel throwing product mostly gets a round base because the bottom part of the object is done manually. Base directly affects the product stability. The shape of the bottom and the thickness are important for handling and staking the object. Body thickness is important for cooking purpose and should not be a thin surface. Different parts of the body need to have

different thicknesses. Center of gravity of the “*Hattiya*” is an important factor for staking objects and keeping them on the hearth. It helps to handle the product in a proper manner, with ample confidence.

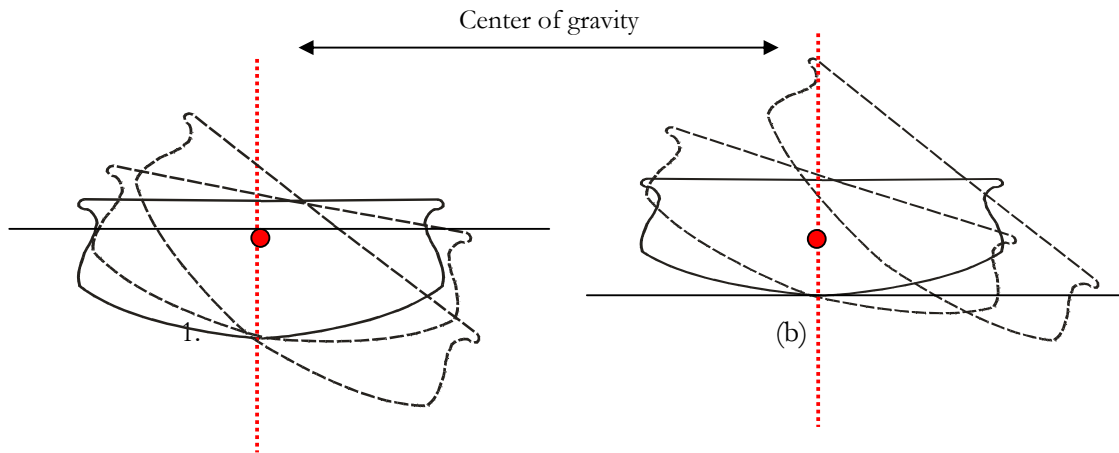


Figure 8: Stability of the “*Hattiya*” (a/b)

“*Hattiya*” cannot be kept on a flat surface as it has a curved base. De Silva and Dissanayake (2008) stated that the majority of cooking vessels are sphere shaped. These vessels have a large basal surface that helps to transfer heat to a greater extent. They are short and squat. Most of the earthenware cooking pots consist of a round base. A round base is good as it absorbs heat gradually.

Heat absorption is faster than the round base but makes the food dried easily.

Round base is important for

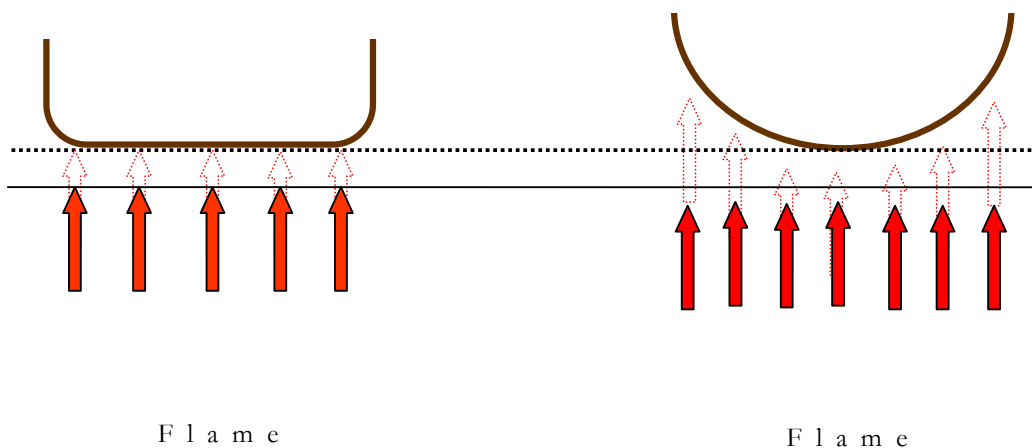


Figure 9: Variety of Base Shapes and heat absorption

Round base has an advantage, as the round surface is movable or rotatable unlike the flat base. Flat base can be damaged easily when rotating the object, because of straight angles of the base. It is an advantage of the “*Hattiya*”. The round base is difficult to be kept on a flat base. Although it is a disadvantage, people have overcome these difficulties as they have developed and found innovative solutions to them. They use a “*Daranuwa*” which should be less harder than the clay body to obtain the product stability

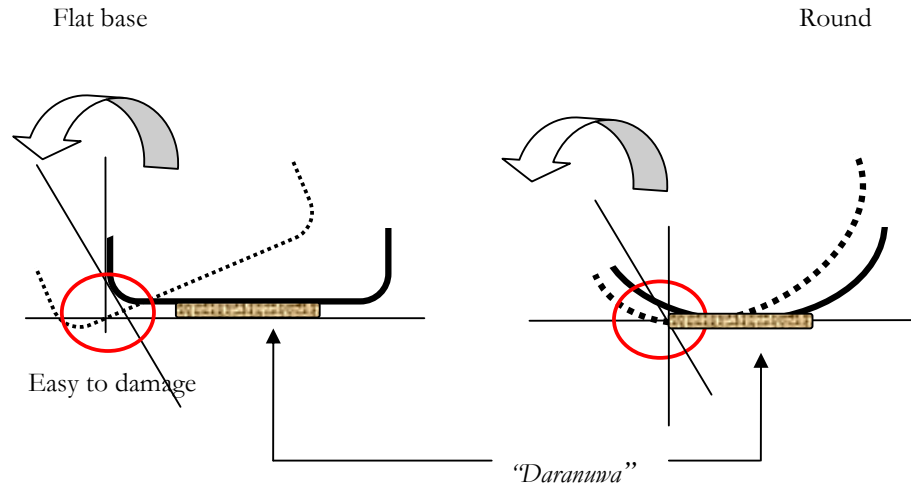


Figure 10 : Use of “*Daranuwa*”

Cleanliness and maintenance are very important for culinary products, as they should be kept clean and hygienic. Therefore, shape and form of the product should get more attention as those two factors are very important in cleaning products. “*Hattiya*” has a round base and the round base is easy to clean. There have been some textured which gets corner points and get the restricted form with deep curve it makes a space to deposit food particles and cleaning difficulties. Thus, it is a considerable point when designing the clay cooking pots.

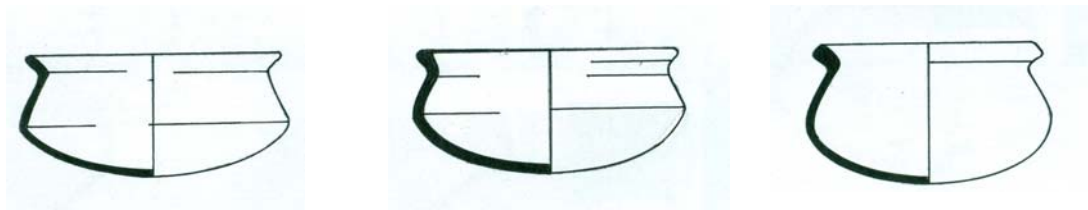


Figure 11: Variety of Base Shapes of the “*Hattiya*”

Several types of base shapes can be identified in the present “*Hattiya*”. Most of the base shapes do not consider the usage of the product. If the product has an angular shape, it cannot be kept on the gas hearth. It can be identified as a disadvantage of the product.

Base is also important to the product stability. When staking, “*Hattiya*” has to be kept upside down, as the orifice can easily rests on the round base. It helps to remove the extra water inside the surface and also the product transportation. It is easy to stack one by one. When transporting “*Hattiya*” people use rush and reed in between the products to protect them from damages.

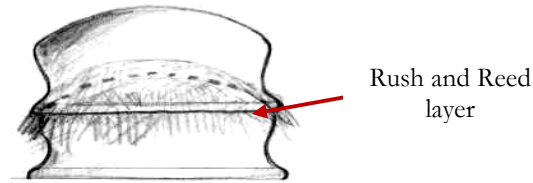


Figure 12: Product Stacking when Transporting

Collecting data about design, techniques, manufacturing processes, current situation and value of the clay pots are investigations for the pottery tradition and earthenware industry. It will be helpful to upgrade the pottery community and clay products in Sri Lanka. Identification and analysis about the “*Hattiya*” is a need of the society. It will help to understand the key considerations when designing the clay pot, because it is needed to carry out for the future generation to keep product standards.

4.2 Results and discussion of the Questionnaire survey

For the questionnaire survey five key factors were mainly considered and these factors have been identified by the case study. The questionnaire was designed to collect data about consumers’ opinion with concerning texture, value, proportion, shape and form and balance of the currently using products.

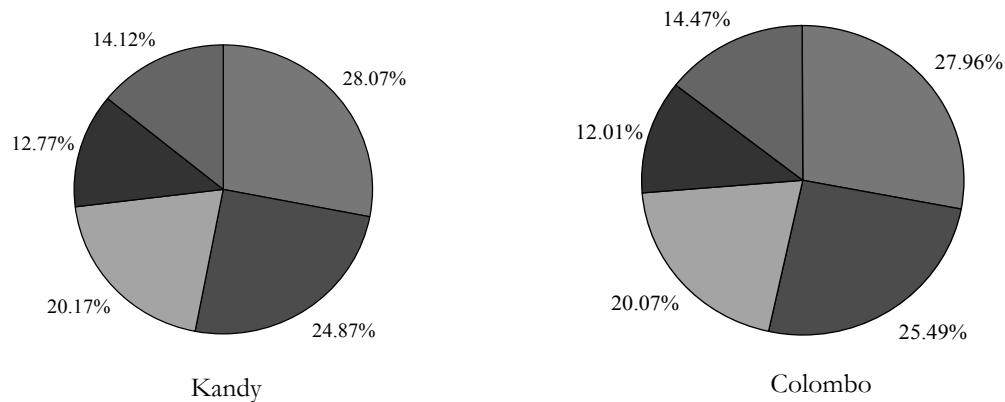


Figure 13: Data of Key Factors of the Survey Kandy & Colombo

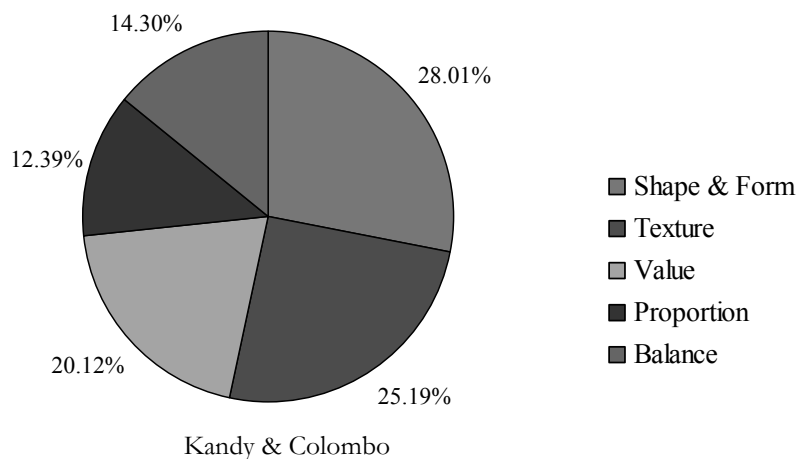


Figure 14: Data of Key Factors of the Survey

Above pie-chart shows the importance of the factors with regard to the selected sample (*"Hattiya"*). In the rating, people of Kandy and Colombo have given similar ratings. Throughout the research, several types of vital facts could be identified to develop the current clay pot (*"Hattiya"*). There are much more limitations and technical obstacles behind that processes. Five key factors discriminate as the major findings of the research in order to develop shape and form, texture, value, balance and proportion.

0.5 Conclusions and Recommendations

"Earthenware clay cooking pots" have been used as the main cooking utensils in traditional ways of cooking in Sri Lanka. Therefore, they played a huge role in conventional methods of cooking. As clay is an eco friendly material, it is undisputable that clay pots are good for preparing food. They are well known for their hygienic quality, too. However, it is understood that present clay products are not in the position to cater to needs of the people due to several drawbacks. This situation has made the people use alternative products for preparation of food particularly. It has been further revealed that these factors play a vital role and if they are not considered much there will be a failure of the earthenware vessels in the modern society. Despite the attraction for other alternative products people still prefer clay products, as they are good for health and also can be used for a prolonged period. However, people always expect high quality clay products which come in good shape and form in order to use them with ease.

Hence, this research has made an attempt to identify the prevailing situation of clay cooking pots and possible ways of developing the industry. The specific features of selected product that have to be developed to achieve the aim have been identified. It has been proved through this research that shape, form, texture, balance and value are the most considerable aspects of a product. Although *"Hattiya"* is in much use, it needs further improvements, taking shape, form, texture, balance and value as its key considerations to achieve design efficiency. The shape, form, texture, value and the balance are considerable key factors for a designer who needs to make a marketable earthenware cooking product. It has been proved that these key considerations are common to all the earthenware cooking pots and need much attention in developing the product further. These criteria can be used to improve the quality of earthenware clay cooking pots. It will make people appreciate and adore clay products immensely.

0.6 Future research

In this research, key components which are required to develop clay cooking pots according to the function of them have been identified. Nevertheless, future studies are necessary to identify how these key factors can be developed to increase product's functionality. Apart from this, further studies can be continued on body composition, manufacturing methods and technological development of clay products. They are invaluable in developing earthenware clay cooking pots and also to reestablish the earthenware industry in Sri Lanka.

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A Model for evacuation Risk Assessment on Transportation Networks

E. J. Warusavitharana

Department of Town & Country Planning, University of Moratuwa
eme_jayani@yahoo.com

J.M.S.J. Bandara

Transport Engineering Division, Department of Civil Engineering, University of Moratuwa
bandaras@sltnet.lk

Abstract

Cities around the world are vulnerable to many kinds of disasters. Although the disaster risk reduction is widely spoken and attempted, the complex layout of cities makes the risk reduction impossible most of the times. The rescuers cannot always reach out the victims during emergencies due to the congested and concentrated network of city systems. This leads to greater vulnerability of cities and the potential increase of casualties as the hazardous consequences.

The traditional transportation demand related analyses generally focus on analyzing peak travel demands on weekday morning journey to work and evening journey from work trips and provide solutions for acceptable level of service. However, it is also important to give special consideration on analyzing demand and assessing transportation system capabilities during the special events or circumstances. One of these special circumstances involves emergency evacuation. Modeling the complex spatial interactions between people and the environment that occur during an evacuation is an important need in developing a successful emergency plan.

Tsunami is one of the major uncertain disasters which created a severe loss to Sri Lanka in terms of loss of life, damages to infrastructure, and decline to the economic assets in year 2004. When the Tsunami warning is given, the road network has to play a crucial role in responding to city's emergency evacuation. Therefore, it is essential to determine the spatial distribution of transportation difficulties and the most critical locations during the Tsunami pre-disaster situation. Hence, the evacuation risk assessment model presented in this research helps the city emergency planners to identify the most critical road segments and nodes that may hinder the efficient evacuation process because of their deficient configuration.

1.0 Introduction

The spectrum of possible emergency events ranges from natural events like floods, epidemics and earthquakes to human activity-based disasters like terrorism, accidents and nuclear power plant failures. Yet during an uncertain events like radioactive release from a nuclear power plant, Tsunami or hurricanes, the transportation system's response is inadequate. Therefore, the ability for the transportation system to perform under adverse conditions and recover to acceptable levels of service is fundamental to the livability of cities and its people. The advanced planning methods and modeling can help to reduce the likelihood of inadequate response to an emergency.

Hence, this research presents an approach for identifying neighborhoods that may face transportation difficulties during an evacuation. The approach presented here is subjected to the hazards with high degree of uncertainty in its spatial impact. It can also be used to identify small neighborhoods at a given node that have potentially risky combinations of high population and low exit road capacity.

The approach presented in this research is based upon a model integrated with a Geographical Information System (GIS)'s network based approaches. Using the network based approaches it is possible to model risk scenarios by considering pre-disaster factors, rather than largely depending on post-disaster factors which sometimes unreliable to collect such as the realistic traffic conditions during evacuations. In this approach, the evacuation difficulty has measured in terms of bulk lane demand which gives ratio between evacuation demand (in passengers) to exit capacity (in numbers of exit lanes leaving the neighborhood). Accordingly, higher the value of bulk lane demand, the longer it will take to clear the neighborhood in the event of an evacuation. Based on this assumption, the model has prepared using road network data and demographic data to find neighborhoods that have high levels of bulk lane demand.

In most of the cases, even in Sri Lanka, the evacuation planning is more centered on personnel training and resource planning. For an example, in Sri Lanka, many communities have special program task forces for disaster planning that conduct mock drills involving many agencies and organizations to test communication systems, coordination and personnel skills in dealing especially with natural disasters. But less or no concern is pay on determining the critical nodes and links of a transportation network. Hence pre determination of such locations in a network is essential to mitigate the losses from an uncertain disaster. Indian Ocean Tsunami which occurred on December 2004 was taken as the case study for this research as it was one of the worst natural disasters faced by Sri Lanka in terms of loss of lives and devastation to infrastructure especially railway and the road network. From the lessons learnt from such a massive tragedy, the relevant government institutions have taken necessary steps to issue Tsunami warnings, conduct mock drills for coastal community groups, and establish Tsunami evacuation centers and evacuation routes. But it seems that less or no attention is paid on understanding the reliability of a transportation network on transferring evacuees from emergency zones to safer zones once the Tsunami warning has issued.....

2.1 Objective

The main objective of this research is to develop a model to that could map out the most critical nodes and links in a transportation network during an urgent evacuation.

3.0 Literature Review

3.1 Emergency evacuation

Emergency evacuation can be a life or death situation where the lack of safe exit routes and the time that it might take to safely exit can be directly related to lives lost. The significance of a transport system's utility and value in a support role become more apparent in emergency response and evacuation situations because of the higher demand placed upon them.

Emergency Management activities can be grouped into four tasks: risk reduction, readiness, response, and recovery. These terms capture the types of activities society must undertake in an effort to coexist with a variety of natural and man-made hazards (Lindell& Perry, 1992). The tasks can be described as follows:

Risk reduction: Activities that actually eliminate or reduce the probability of a disaster, such as preventative land-use zoning and the establishment of comprehensive emergency management programs.

Readiness: Development of plans to save lives and minimize the effects of the emergency, such as evacuation plans, and the creation and maintenance of up-to-date spatially referenced data such as property boundaries, utility lines and emergency headquarters locations.

Response: Activities immediately following the emergency. These activities provide assistance to those in need, to stabilize the situation and speed recovery.

Recovery: Activities needed to return all systems to normal or better. These include short-term recovery to provide vital life-support systems (e.g. shelter, food, water), and long term recovery that may continue for many years.

Each of these phases needs careful identification probable risk areas in order to prepare optimum disaster management plan. However, in most of the cases related to disaster management is more concern on assessing the risk or vulnerabilities of hazard prone areas which are also referred to as Emergency Planning Zones (EPZ). But it seems less attention is paid on assessing the risk and vulnerabilities of transportation network which plays a major role in transferring people from risky areas to safer ones as an attempt to alleviate loss of life and property.

3.2 Modeling

In the simplest construct, a model is a simplified version of a real world process, system, phenomenon, or entity. When there exist a multitude of issues and competing needs for resources, models can be a significant aid to decision makers before, during, and after an emergency. Modeling the complex spatial interactions between people and their environment that occur during an evacuation is an important step in developing a successful emergency plan.

The movement of people during a disaster event is happening at spatial and temporal scales. Spatial scale is important in accounting for the location and characteristics of populations that must evacuate the layout of the transportation network, and the area affected by a hazard when formulating an evacuation plan. Temporal scale is crucial as well, as event speed of onset largely dictates the start and end times of an evacuation.

Again the scale-based approach can further divide into two types as, large-scale evacuation that can be occurred due to disasters like nuclear power plant accidents & Tsunami and the small-scale evacuation of a building. Building evacuation is of great importance even in transportation as techniques developed first for building evacuation, now form the basis for most evacuation models in transportation. Some of the earliest research on building evacuation was done by Chamlet, Francis and Saunders (1982). Their paper describes three models they developed to analyze clearing time, bottleneck locations, and general performance of a building in the event of an evacuation.

To model the small scale evacuation of a building each person should be individually represented in the model. This technique is known as agent-based modeling or microsimulation, and is best suited to problems of limited size due to the computational complexity of representing individual people and their interactions. Microsimulation can also refer to the modeling of individual vehicles on a transportation network. These models are most suitable for neighborhood evacuation which could occur at a small spatial and temporal scale.

Microsimulation is less feasible in large-scale evacuation models which can be applied for large scale events like accident at a nuclear power plant, Tsunami, etc. Here the goal is to move thousands of people away from the disastrous area as quickly as possible, thus, need to utilize Macro scale models. These models group population into larger units, which can then be moved through the transportation network under different starting conditions producing a generalized evacuation plan. The benefit of such an approach is that it can simplify the complex interactions of large groups and thus be solved quickly. These models are most suited in deciding strategic disaster management decisions which is made at a large temporal and spatial scales. The major limitation of this model is the probability of unaccounting individuals or groups of individuals who take different evacuation behaviors that are not addressed in the model.

Between these two approaches is the meso-scale model which is neither microscopic nor macroscopic but rather borrows elements from each. A meso-scale model will not represent people individually but may aggregate them into relatively small population units, unlike the macro-scale model, which seeks the largest feasible unit. The spatial extent of meso-modeling can be at the neighborhood or community level, or the entire area affected. These models are often used for location-routing problems at a medium temporal scale.

Many evacuation modeling approaches rely on the delimitation of an emergency planning zone (EPZ). This focus was initially motivated by the perceived threat imposed by nuclear power plants during the 1970s and the accidents at Pennsylvania's Three Mile Island in 1979 and Chernobyl in 1986. The general approach involved predefining a circular EPZ around each nuclear site using a 10 mile radius (NRC 1980, Urbanik et al. 1980) and subsequently estimating the time it might take to clear the zone. Cova and Church (1997) point out that defining an EPZ in advance is problematic for fast moving hazards where the population that will need to evacuate is unknown in advance. They have called such models as "Indeterminable EPZ" (IEPZ) problems. In such situations, it is impossible to apply contemporary evacuation simulation models.

3.3 Modeling Evacuation Risk

Risk is understood as the potential inability to find accessible routes, the difficulty of transferring rescue resources, and transporting victims to safety and it is also a static measurement of the vulnerability of the road networks in a certain area in terms of the possibility of experiencing traffic congestion (Chen et al, 2011).

A number of factors can affect the safety of an evacuation. These factors include the number of people needing evacuation (i.e. demand), the transportation capacity provided for evacuation, the rate at which the demand is exerted, the rate at which capacity is actually provided, the differences between these rates, human behavior (Lindell and Perry, 1991), and accidents.

Total demand and transport capacity are the major factors which influence for risk of a transportation network. Previous works have proposed a simple formula to measure the evacuation risk of transportation networks considering the bulk lane demand.

$$\text{Bulk Lane Demand} = \frac{P}{C}$$

Where;

P = Number of people within a specific region or cluster / Total vehicle demand leaving a neighborhood

C = Number of lanes of roadway leaving a neighborhood

According to the above formula the neighborhoods with high bulk lane demand might have greater problems in evacuation than areas with low levels of bulk lane demand. (Church & Cova, 2000).

Cova and Church (1997) have presented a map of evacuation difficulty using an optimization model that can be used in conjunction with road network data and demographic data to find neighborhoods that have high levels of bulk lane demand. Their model delineates the neighborhood about a point (e.g. an intersection) that maximizes bulk lane demand. The model finds the worst case neighborhood about a point that has the highest bulk lane demand. By applying this model for selected intersections across a road network, it is possible to classify each street segment in terms of worst case bulk lane demand values.

Scholars have used different quantitative approaches in understanding the transporting behavior of evacuees during emergency evacuations. Dial (1971) found that the drivers will often choose routes that are not the shortest distance to their destinations. His approach clearly reflects the dynamic and unpredictable flow of traffic during an evacuation. Other researchers have built on this framework and introduced an element of random route assignment that represents driver behavioral decisions under conditions of distance and network topology uncertainty (Daganzo and Sheffi 1977).

People's decisions and behaviors always have a huge effect on disastrous situation. Chen et al (2011) has developed a model while also considering the factors such as evacuees routing behaviors and spatial impact of the disaster.

In recent years the awareness of the need for tools that assist with the facilitation of mass evacuation modeling for disasters has increased. Advances in computer systems over the past 25 years have provided an excellent opportunity to provide databases which give the sort of information required. In particular Geographic Information Systems (GIS) is one of the valuable tools in evacuation modeling which allow ready access to both spatial and attribute data, on a national or local scale, and provide the opportunity to overlay information for ease of interpretations.

3.4 Application of Geographical Information System (GIS) in emergency planning

GIS is a system of hardware, software and procedures designed to support the capture, management, manipulation, sophisticated analysis and modeling and display of spatially-referenced data suitable for solving complex planning and management problems. It is now a maturing mix of technology and is being a widely applying tool in the fields of government, emergency services, environmental, business, industry, education and transportation.

The four emergency planning tasks identified by Lindell & Perry (1992) can benefit from the application of Geographical Information System (GIS). The GIS technology provides a mechanism to centralize and visually display critical information during an emergency. In an emergency, it is critical to have the right data, at the right time, displayed logically, to respond and take appropriate action.

With regard to *risk reduction*, GIS can be used to identify and model hazards and begin to evaluate the consequences of potential emergencies. It can initially be used for land-use planning as a tool for consultation, zone delineation etc. The relative safety of routes, structures and populations can then be evaluated with respect to potential natural hazards.

Readiness is concerned with activities that prepare for actual emergencies. Here network analysis tools in GIS are used to provide answers to questions such as the optimum location for fire stations if a 10-minute response time is required, the safest location for new hospitals, emergency facilities and headquarters, what evacuation routes should be selected?, will the road networks handle the anticipated traffic?, etc.

The Network Analysis tools in GIS can also aid the *response* phase by determining the closest emergency vehicles to the incident and assigning them to the area using the optimum or shortest path. This is increasingly possible if the emergency vehicles have GPS units enabling them to be accurately located. In a complex emergency, GIS can help manage the overall status and provide timely information updates.

Recovery phase begin when the emergency is over, and are often in two phases, short- and long-term. Short-term recovery restores vital services and systems. GIS can play a role in damage assessment and information management. Using GPS and telecommunication devices, locations and assessments of damage can be geo-referenced and transmitted back to the emergency

headquarters for real-time update of the recovery. For long-term efforts, such as reconstruction of utilities, GIS can be used to locate new services and to track the construction and rebuilding.

4.0 Case study and Methodology

4.1 Case study

The evacuation risk assessment model presented in this research is subject to the hazards with a high degree of uncertainty in terms of its spatial impact. Tsunami is a uncertain disaster during which the road network plays a crucial role in responding to city pre-disaster evacuation. Therefore, it is worthwhile to evaluate the evacuation difficulty associated during the Tsunami pre-disaster situation to better identify the vulnerability of certain road segments.

Sri Lanka has been extremely hard-hit in terms of loss of life, infrastructure, and economic assets; the 2004 tsunami is widely acknowledged as the largest, most devastating natural catastrophe in the history of the country. Two hours after the first earthquake occurred, the Tsunami waves struck an extremely long (more than 1,000 km, or two-thirds of the coastline) coastal area of Sri Lanka across thirteen districts, including Jaffna in the north, the eastern and southern coast, and parts of the west coast as far north as Chilaw.

In Southern Province of Sri Lanka approximately 20% of the coastal population was affected by the Tsunami. Many of the village industries located along the southern coastlines were destroyed which also caused disruptions to livelihood activities of a large number of people.

Among the coastal cities of Southern Province, the city of Galle is one of the most hardly affected (Figure 1). According to the Department of Census and Statistics records, 497 residents were killed, 89 residents were disappeared, 996 residents were injured, 1588 houses were damaged and 8114 residents were affected due to the Tsunami disaster.

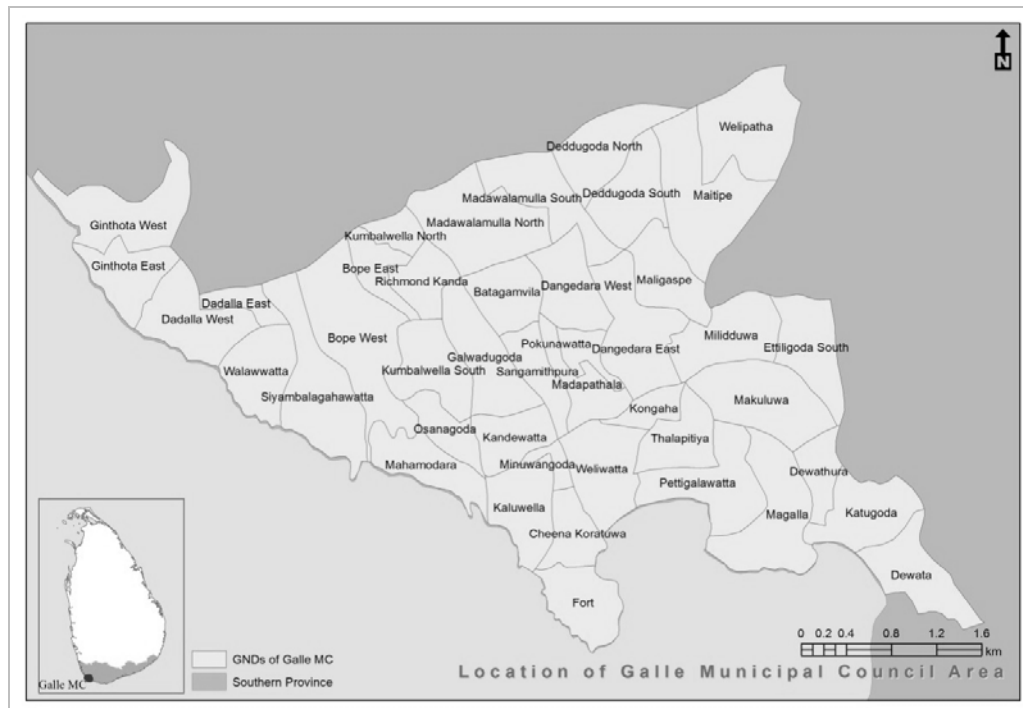


Figure 1: Location of Galle Municipal Council Area

Source: Survey Department

4.2 Planar Network Dataset

The spatial data model for the transportation problem was prepared as a planar network (Figure 2) where the arcs represents the road segments and the nodes represent street intersections.

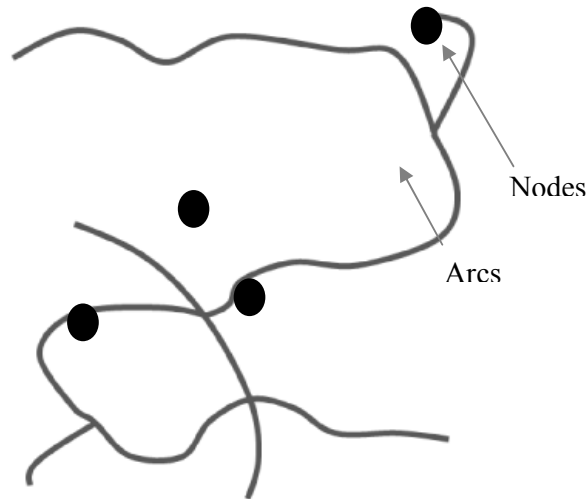


Figure 2: Representation of Planar Network

4.3 Generating Thiessen Polygons

One approach to aggregating population in GIS network analysis studies is to assign and aggregate residents to their nearest street intersection using Thiessen polygons (Flowerdrew and Green, 1992), centered on the street intersections as shown in the Figure 3.

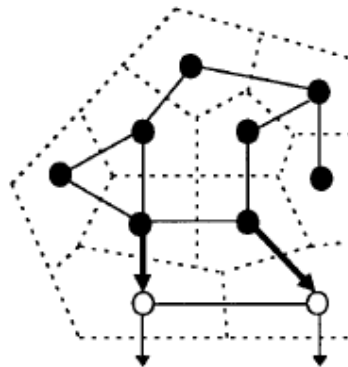


Figure 1: Thiessen polygons centered on the street intersections

A Thiessen polygon is a Voronoi Diagram that is also referred to as the Dirichlet Tessellation. Given a set of points, it defines a region around each point. A Thiessen polygon divides a plane such that each point is enclosed within a polygon and assigns the area to a point in the point set. Any location within a particular Thiessen polygon is nearer to that polygon's point than to any other point. Mathematically, a Thiessen is constructed by intersecting perpendicular bisector lines between all points.

The following diagrams illustrate how Thiessen polygons would be generated manually.

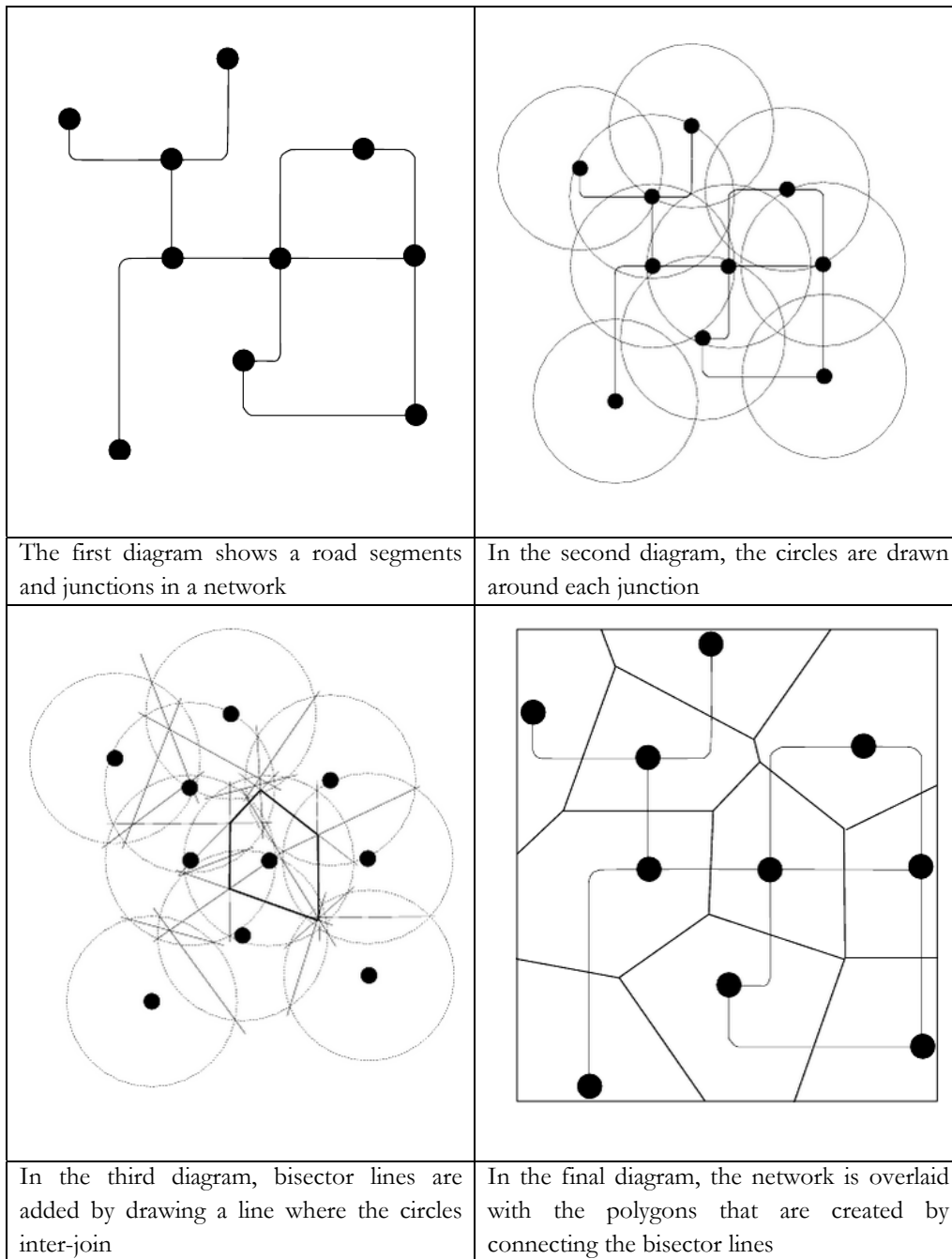


Figure 2: The process of generating Thiessen polygons

4.4 Dijkstra's Algorithm

The optimum routing of the evacuees were determined by the Dijkstra's Algorithm, which is a fundamental shortest path algorithm. It was discovered by Dutch computer scientist Edsger Dijkstra in 1956 and published in 1959. The algorithm computes the shortest path from one node to all other nodes in the network. It assumes that the link lengths are always non-negative.

In this method, every node is assigned a label with two components (x, y). A label could either be temporary or permanent. The algorithm stops when all labels are permanent. As will soon become apparent, after completion, the labels give information on the shortest distances as well as the shortest paths from a particular node to all the other nodes. Also a node is referred to being in the open state if its associated label is temporary; it is to be in the closed state if the label is permanent.

5.0 Analysis & Results

5.1 Identification of Emergency Planning Zone (EPZ)

Many evacuation modeling approaches rely on the delimitation of an emergency planning zone (EPZ). The EPZ for this model was demarcated by considering the Tsunami risk boundary.

The information pertaining to demarcation of Tsunami risk areas were taken from the hazard maps developed by Wijayaratna, et.al in 2010 (Figure 5). They have identified High, Moderate and Low hazard prone areas by considering flow directions, inundation levels, run-up distances, number of casualties and extent of damages during the Indian Ocean tsunami on December 26th 2004.

Accordingly the entire boundary comprised with high, medium and low Tsunami hazard prone areas were taken as the EPZ boundary to develop the model.

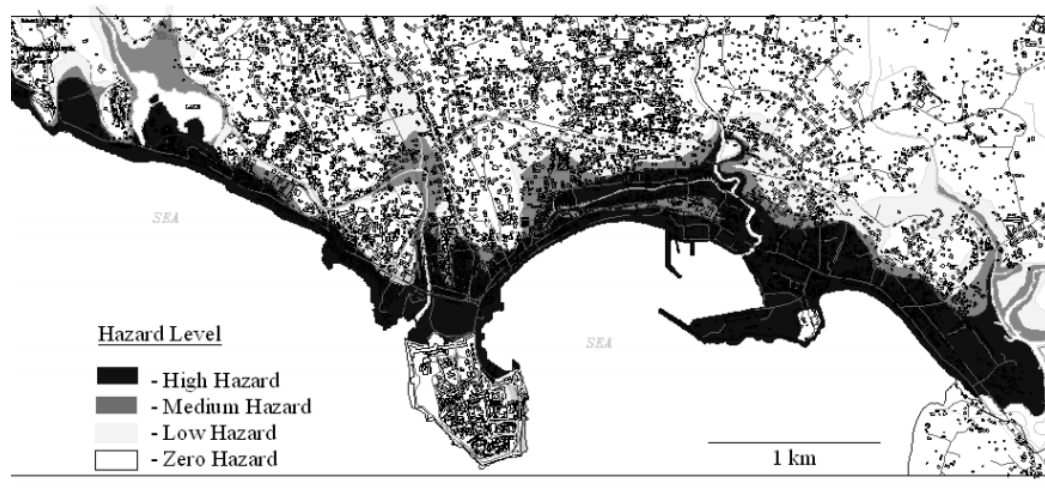


Figure 5: Tsunami Hazard Levels of Galle MC
Source: Tsunami Risk Assessment for Port City of Galle

When developing the model, the road based transportation network which consists of major and minor roads was simplified into nodes and edges. The railway network which is running through the area was not taken into consideration when developing the model. The transportation nodalities within the EPZ was considered as the origins of the evacuees and the nodes located immediate after the EPZ were considered as the destinations of the evacuees (Figure 6).

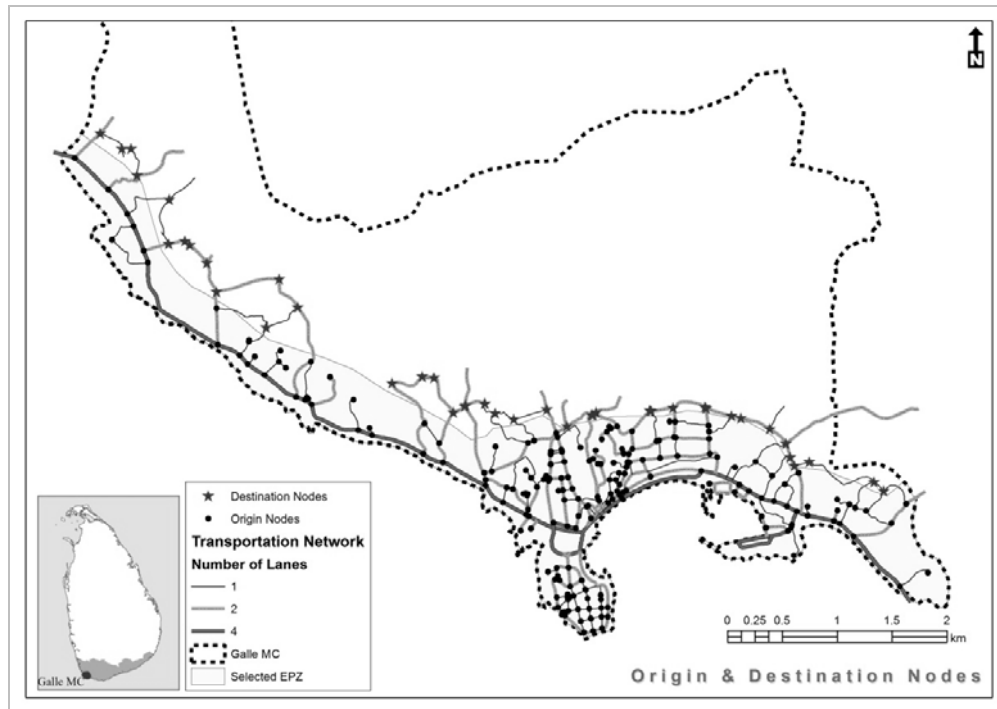


Figure 6: Tsunami Hazard Levels of Galle MC

Source: Compiled by Authors

5.2 Aggregation of population into Origin Nodes

To aggregate the total population of the area onto its closest intersection, the spatial multiplication method of Thiessen polygon method was applied. Figure 7 shows the Thiessen polygons generated for Galle MC area in this manner.

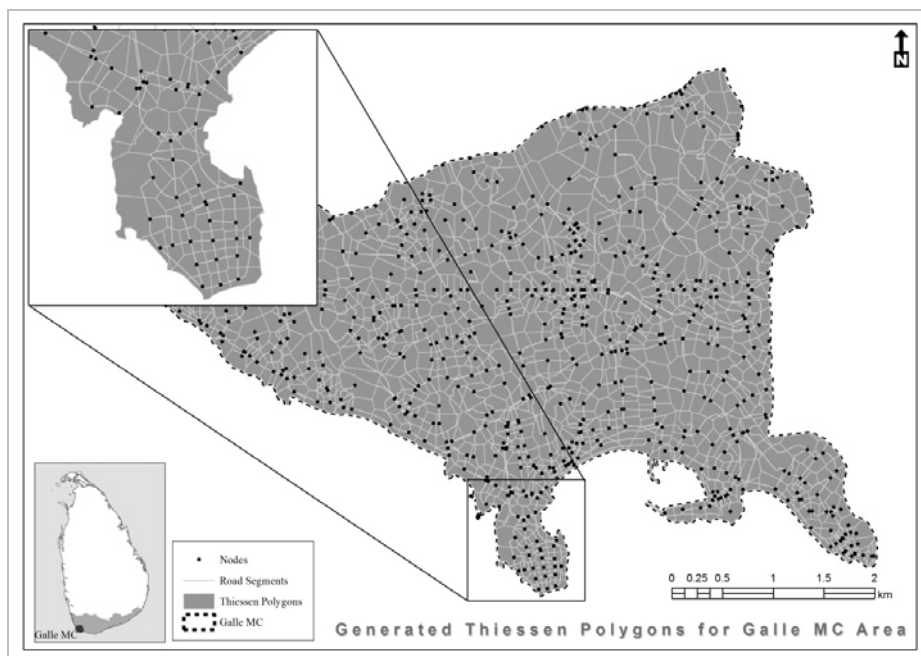


Figure 7: Thiessen polygons generated for Galle MC Area

Source: Compiled by the Authors

Due to unavailability of data pertaining to floating population and population working at commercial and industrial areas, the model applied in this research is best suited for emergency evacuation during the night time. Hence, in order to calculate the night time population, the buildings of the area were classified according to the land use of the area and only the residential buildings were selected. Then it was assumed that the average household size of the Galle MC area as four and each household occupies one residential building. Based on these assumptions number of residential population comes under each Thiessen polygon was calculated. Then the population value of each Thiessen polygon was assigned in to its respective node. The Figure 8 shows the estimated population for each transportation node. Hence the nodes with high number of aggregated population are the most critical origins located within the EPZ area.

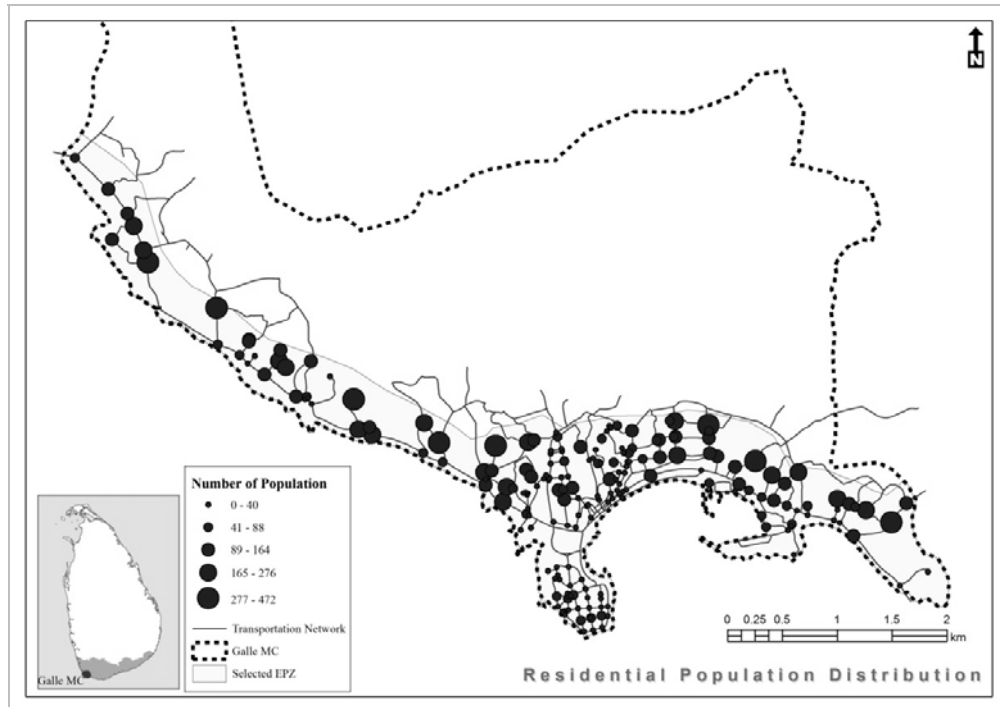


Figure 8: Residential Population Distribution

Source: Compiled by the Authors

5.3 Application of Dijkstra's Algorithm

When deciding the optimal routing of the evacuee, it was considered the nodes located inside the EPZ as the origin of the evacuee and the nearest node outside the EPZ as the destination of the evacuee. The optimal routing procedure can be viewed as a two-step decision-making process. First, evacuees target a shelter as a destination. Second, they move toward the destination by adopting the most efficient route in terms of the shortest distance or the least time expenditure. Dijkstra's Algorithm was applied to find the optimum path in terms of shortest distance, and the nearest destinations. The Dijkstra algorithm finds the shortest path from a given node to all the other nodes in the network. It solves an O-D assignment problem with one origin and several destinations (1-to-n).

Figure 9 shows the nearest destinations identified for each origin by applying the Dijkstra's Algorithm. Then the optimum route from each origin to destination was identified and population at each origin was accommodated to each road segment comes under that optimum route. In this manner cumulative population (evacuees) was calculated for each road segment of the EPZ area.

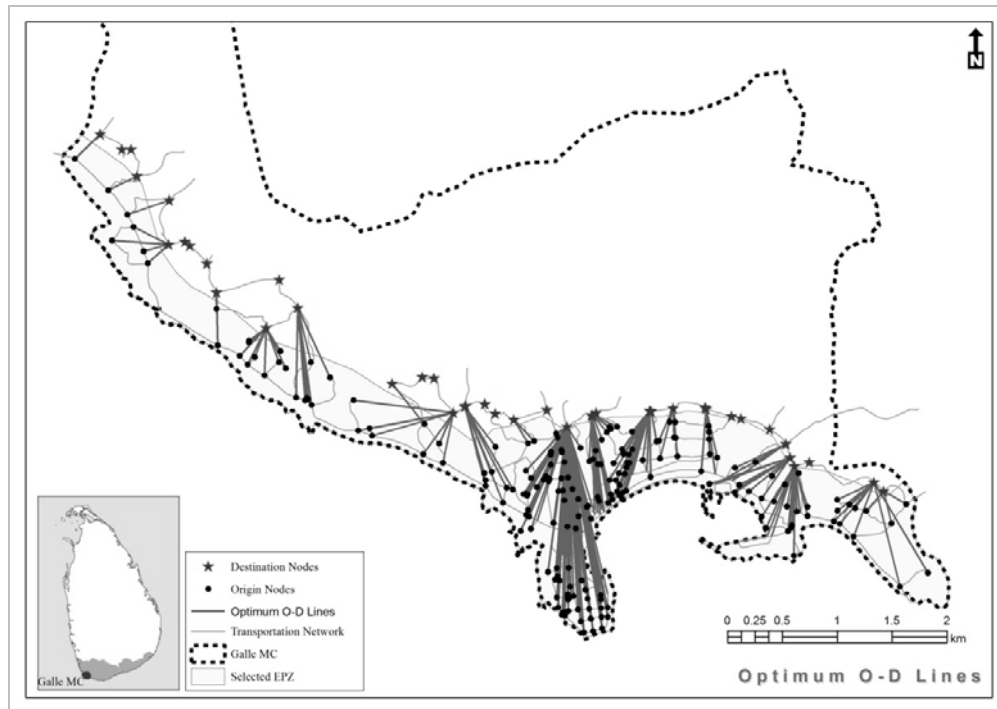


Figure 9: Optimum Origin - Destination Lines

Source: Compiled by the Authors

The critical destinations in terms of number of population, were created from the result obtained from the O-D assignment problem. Accordingly the critical destination map shown in Figure 10 demonstrates the cumulative population at each destination.

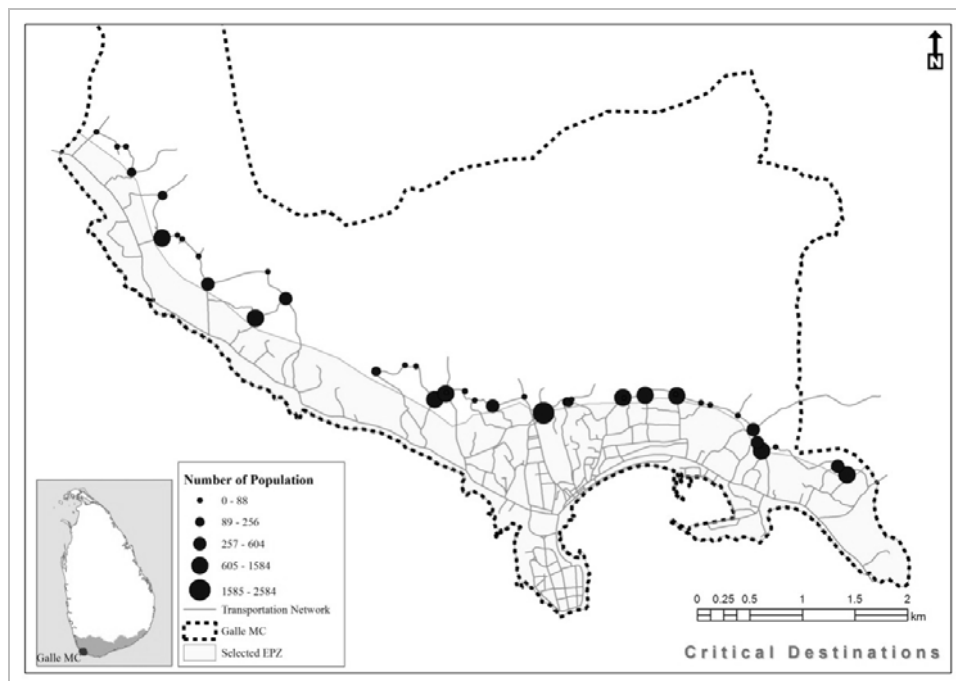


Figure 10: Critical Destinations

Source: Compiled by the Authors

The second objective of identification of spatial distribution of evacuation difficulties that might arise during an urgent evacuation was measured according to the formula given below:

$$\text{Evacuation difficulty} = \text{population} / \text{number of exit lanes}$$

Accordingly cumulative population (evacuees) at each road segment was divided by its number of lanes, to determine the evacuation difficulty at each road segment. Figure 11 shows the number of lanes of transportation network located at EPZ area of Galle MC.

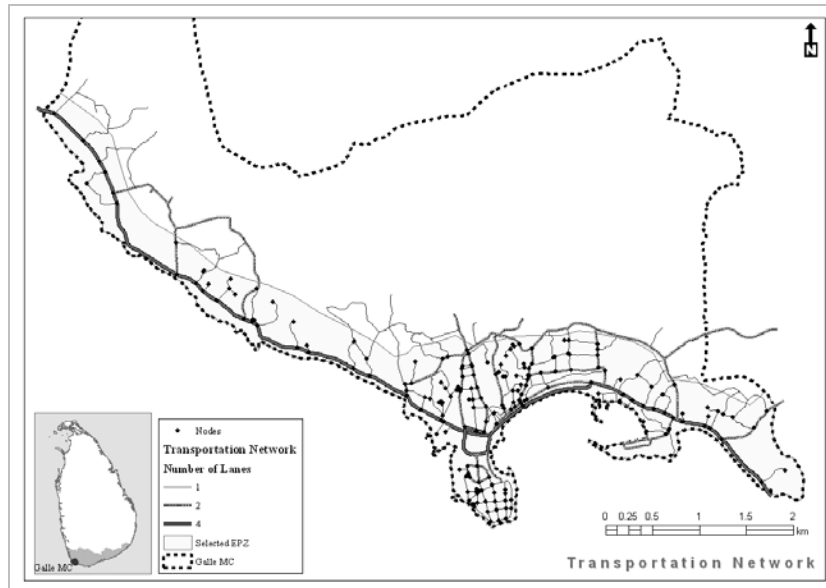


Figure 113: Transportation Network with number of lanes

Source: Compiled by the Authors

Figure 12 shows the result of the evacuation risk map produced according to the evacuation difficulty measuring according to the aforementioned formula. The unit of the map shows the number of people per lane that a road can sustain.

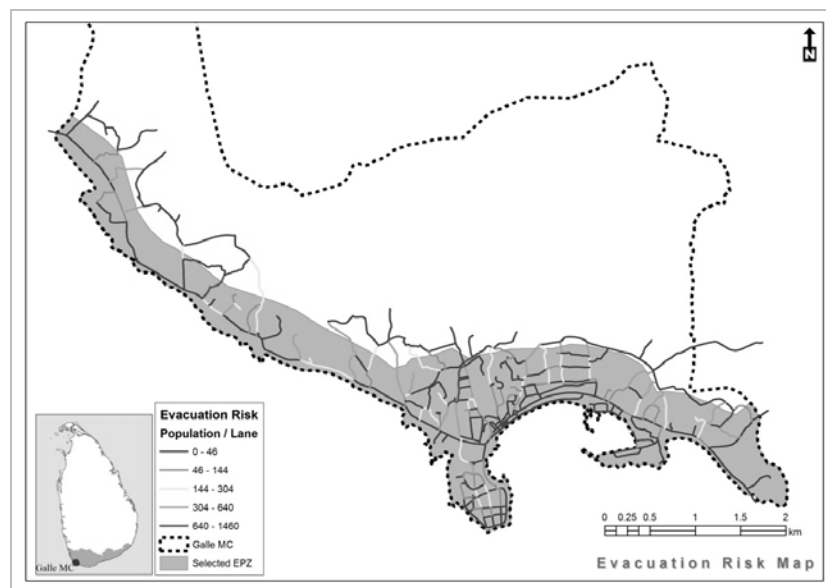


Figure 12: Evacuation Risk *Source:* Compiled by the Authors

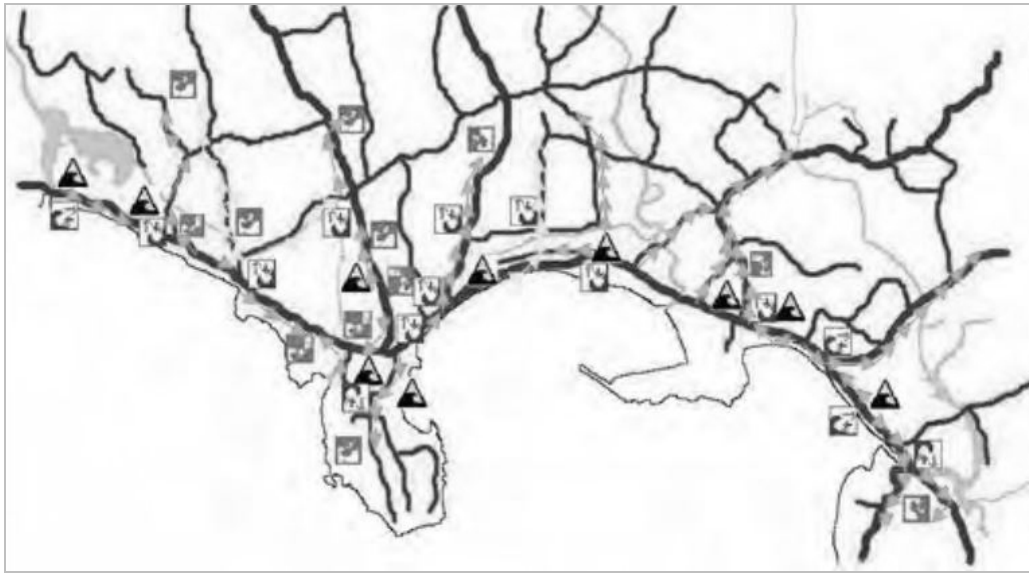


Figure 134: Existing Evacuation Routes and Places
Source: Tsunami Risk Assessment for Port City of Galle

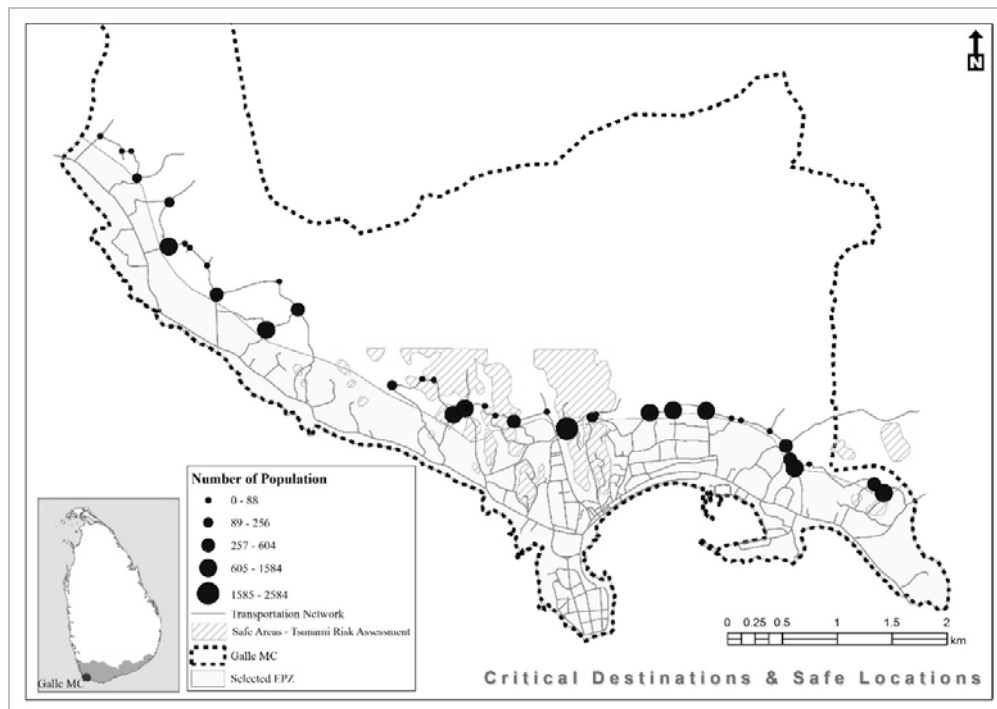


Figure 14: Safe Areas of Tsunami Risk Assessment & Critical Destinations
Source: Compiled by the Authors

Figure 13 and 14 show the evacuation routes, places and safe areas established in Galle city according to the Tsunami Risk Assessment. When comparing Figure 13 with Figure 12 it seems that most of the proposed evacuation routes are located on the road segments with high evacuation risk. Therefore, considerable attention must be paid in planning the evacuation activities in an effective manner on the evacuation routes where the risk is high. On the other hand, it is also possible to re-plan the evacuation routes by avoiding the high risk areas.

As shown in Figure 14, it seems most of the safe areas of the Galle City, as suggested in the Tsunami Risk Assessment, are located within the middle part of the EPZ area where the highly critical destinations are located. Therefore, it is vital to rethink the capability of those safe locations in handling the evacuees who have much probability in travelling across those areas.

5.0 Conclusions and Recommendations

There are various kinds of evacuations. The evacuations that the authors of this paper were concerned are related to major man-made or natural disasters in large geographic scales such as radioactive release from a nuclear power plant, hazardous material spills, fires, terrorist attacks, Tsunami and hurricane.

In this paper, a model has been developed to assess the risk associated with evacuating the affected population during a Tsunami disaster situation by also visualizing the risk. Most of the time evacuation risk is perceived as an abstract concept on the national level and it is not properly visualized on the scale of neighborhoods in a city. Thus, by examining the maps generated by the model, the roads with a higher likelihood of suffering evacuation difficulty in emergencies can be identified. This visualization is of great use for city emergency planners to identify urban infrastructures with deficient configuration that may hinder an efficient evacuation process.

The results presented in the model are also useful in re-planning and managing the existing tsunami evacuation routes and safe areas by also considering the road segments and nodes with high evacuation risk.

Also there are several limitations in the model. The model developed in this research is more applicable for disaster events that can arise at the night time, due to unavailability of data pertaining to floating population and prevailing traffic at the roads. Evacuation difficulty is at each road segment is highly time dependent. The number of evacuees travelling at each road segment varies with the time. However the model developed here is a meso-scale model that does not represent people individually but may aggregate them into relatively small population units using Thiessen polygon method. Hence delays occur at each road segment due to individual travelling speeds, mode of travel, turning movements at intersections were not incorporated when developing the model.

Also during an emergency, evacuees not always select the shortest path, rather they choose least congested routes or roads with which they are most acquainted or have previously used or sometimes they tend to follow the actions of the masses and move away with others. In such a case the shortest path method applied in finding the optimum route may not be sufficient.

The evacuation risk assessment model presented in this research is not applicable for certain events like seasonal floods in which the evacuation paths of the road network cannot be justified when the roads get flooded and when the community takes adaptation measures to live with the flood.

However, by using more accurate data such as floating population, number of vehicles that each Thiessen polygon contains and prevailing traffic conditions at road, more realistic model can be developed to evaluate evacuation risk at road based transportation network during an uncertain circumstance. The composite evacuation risk map shows the number of people per lane that a road segment can sustain. By incorporating such missing information it is possible to measure the evacuation difficulty in terms of passenger car units.

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A Study on the Factors Affecting Safety Behavior of Construction Workers

N.H.C. Manjula,

Department of Building Economics, University of Moratuwa, Sri Lanka
chathuri9m@gmail.com

Nayanthara De Silva

Department of Building Economics, University of Moratuwa, Sri Lanka
endds@uom.lk

Abstract

Construction industry, being one of the most injury-prone industries worldwide in terms of serious injuries, lost work time, hospitalization, disability, and mortality, is in a great need to improve occupational safety. Behavior Based Safety (BBS) is an approach that can be applied successfully in managing occupational safety; it is gaining more interest across industry sectors globally and has the great advantage of needing the involvement of the individual employee. This paper, therefore, aimed to investigate the factors governing construction workers' safety behavior. The factors which affect construction workers' safety behavior were identified through a comprehensive literature survey. Expert interviews were conducted in order to validate and generalize the factors found in literature to the Sri Lankan context.

Two categories of factors were basically identified which affect the safety behavior of construction workers, namely personal and organizational. The personal factors included age, marital status, education level, working experience, having dependents, and safety knowledge. Study indicated that personal factors such as habits and social life might also have an impact on a workers safety behavior yet need longitudinal research before generalizing to a particular context. Organizational factors identified were management commitment, OSH systems and feedback mechanisms, continuous monitoring of these systems, training and awareness for workers, accidents reporting, and workforce empowerment. The findings of this research were modeled in a model of construction workers' safety behavior.

The findings of this study can be used in enhancing the safety performance of the construction industry.

Keywords: *Safety behavior, Construction Industry, Occupational Safety, Construction Workers*

1.0 Introduction

Construction is a very accident prone industry worldwide. The poor safety performance of the construction industry continues to give international cause for concern (Li and Xiang, 2011). Further, Sri Lanka is considered to be one of the most vulnerable countries and is ranked at a low level for safety performance due to lack of improvement measures (Gunawardena and Priyangika, 2005). Workforce productivity, quality, and safety are the most important performance indicators at worker level. However, the construction industry is still striving to improve the performance in these areas (Gatti and Migliaccio, 2013). This fact was further affirmed by Jannadi and Bu-Khamsin (2002) as they clarified that worldwide, construction is one of the most hazardous industries due to its unique nature. Firstly, the industry is highly fragmented, which marginalizes efforts to safeguard safety and health (S&H) standards. Secondly, construction site activities are physically dispersed across various locations; thus, supervising and monitoring S&H issues in the workplace is much more challenging. Compared with other industries, construction is often classified as high risk because historically it is plagued with higher and unacceptable injury rates. Partly, this results from the fact that construction is historically

accepted to be one of the most “poorly performing” and hazardous of work sectors (Haupt, 2003; Loosemore and Lam, 2004), as confirmed by some relevant statistics.

For instance, in 2003-2004, there were 3,760 major injuries in construction in the UK, the majority of which resulted from falling from a height; while injuries causing a loss of three days or more from work stood at 7,509 of which 38 per cent involved manual handling (Health and Safety Executive (HSE), 2010). More alarmingly, during 2004-2005, there were 69 fatalities in the sector, this representing one-third of all worker deaths in that period (HSE, 2006). The poor safety performance of the construction industry continues to give international cause for concern (Li and Xiang, 2011). While there has been a modest decline in fatalities over recent years (rate of 4 per 100,000 workers), when collated with those in all industries, construction accounted for 31% of all work related deaths in 2002/03 in UK (HSE, 2010). The majority of construction fatalities in this year resulted from falls from height (46%) and struck by a moving vehicle (15%). Further, although the construction output is less in Sri Lanka, compared to developed countries in general, the magnitude of the accident rate in the construction industry is still significantly high as reported in other countries such as the USA (Chauet *et al.*, 2004), the UK (Health and Safety Executive, 2010, Sacks *et al.*, 2009), Hong Kong (Siu *et al.*, 2004) and Singapore (Chau and Goh, 2004). It was reported that annual accidents in the construction sites were 750-900 and among them 50-60 were fatal (Amarasinghe, 2011). Further, this annual figure was represented a more than 30 percent of accidents which was about 13 times higher than in the other industries in Sri Lanka (Rameezdeen *et al.*, 2003; Amarasinghe, 2009).

Thus, Construction industry, being one of the most injury-prone industries in Sri Lanka and worldwide in terms of serious injuries, lost work time, hospitalization, disability, and mortality, is in a great need to improve worker safety (Ahmed *et al.* 2000; Teo *et al.* 2005; Kines *et al.* 2010). Discussed in the literature are safety culture (Hale, 2000; Glendon and Stanton, 2000; Cooper, 2000; Fang *et al.*, 2006), regulatory frameworks governing safety (Langford *et al.*, 2007), BBS (Dedobbeleer & Beland, 1991; Burton, 2012, French and Geller, 2012) to make an impact in the industry to boost safety. However, due to the fact that more than 80% of accidents are down to employee behavior or the human factor, in the form of acts or omissions, among the above strategies, BBS could play a vital role (Burton, 2012). Thus, it is important to study BBS and its applicability for the construction industry to safeguard construction worker.

1.2 Safety behavior

Safety culture relates to the humanitarian aspects as well as safety as an integral component. The interactive relationships between people's behaviour, their attitudes and perceptions they hold, and the situation or environment in work place should be taken into account (Dedobbeleer & Beland, 1991). Creating a robust safety culture is about more than removing hazards and institutionalizing safety procedures. It is about working with people to change their attitudes, behaviors and thoughts, and improve their situational awareness — all within the dynamics of today's world. Further, French and Geller (2012) asserted that a total safety culture can only be achieved with a systems approach, including balanced attention to all aspects of the corporate culture. Three basic domains, for example, need attention when designing and evaluating safety processes: namely, Environment factors (such as equipment, tools, machines, housekeeping, engineering, management systems); Person factors (employees' knowledge, skills, abilities, intelligence, motives, and personality); Behavior factors (employees complying, recognizing, communicating, and actively caring). These researchers suggest that people factor is as important as, or more so, in promoting OSH in an organizational context. According to French and Geller (2012), to encourage employee engagement in safety, the safety infrastructure must invite employees to become actively engaged. When people choose to change their behavior, they adjust their attitudes and beliefs to be consistent with their actions. Change in attitude can influence more behavior change and then more attitude change – a spiraling, reciprocal interdependency between our outward actions and our inward feelings. This is how small changes in behavior and attitude can eventually lead to personal commitment and total involvement.

Thus, studying behavioural safety management is seemingly promising in improving safety performance with in an organizational context.

The emphasis of the behavior based approach to safety is on employees' behavior. Through influencing behavior, this system can reduce injury rates. The behavioral based approach to safety is focused exclusively on the observable, measurable behaviors critical to safety at a particular facility (Burton, 2012). The application of behavioral research to the solution of human problems is building and demonstrating the first effective and reliable technology of behavior change in human history (Cambridge Centre for Behavioural Studies, n.d.). In workplaces with troublesome rates of unsafe performance, safety behavior programs, properly implemented, produce significant improvements in safe performance and major reductions in workplace injuries and illnesses (Cambridge Centre for Behavioural Studies, n.d.). Thus, it is important to recognize safety behavior of workers in improving the overall safety performance of an organization. By identifying the factors that affect safety behavior of workers, how safe behaviors can be reinforced can be examined. Thus, the objective of this research is to identify the factors affecting safety behavior of construction workers in Sri Lanka.

2.0 Research Method

The study was structured in several steps. Initially in-depth knowledge gained regarding the research stream which was sorted upon the degree of relevance to the study. Based on knowledge gained from literature, a comprehensive interview guideline was developed. The guideline consisted of two stages. As the first step, a brief introduction to the study was provided to the interviewees with the purpose of explaining the background and the objective of the research. Secondly, a number of factors were introduced to the interviewees under two categories as personal and organizational to attain their views on how those factors would affect safety behavior of workers. Experts were selected from the fields of occupational safety and health as well as construction, based on their years of experience in the respective industries. Five professionals, each having more than ten years of industry experience, were interviewed in the purpose of validating the literature findings. Three district factory inspecting engineers, from the 31 professionals, available island wide, were selected based on the availability and proximity. Other two experts were project managers from two different construction projects. Each expert interview was conducted for 40 to 50 minutes. Experts affirmed most of the literature findings while they clarified that some of the factors need longitudinal research before they could be generalized in to a particular context. Further, they added 'accidents reporting' as an organizational factor that could positively affect safety behavior of construction workers. The next section will discuss the literature findings and the views of experts regarding those.

3.0 Research Findings and Discussion

The findings suggest that factors affecting construction workers' behavioural safety mainly fall under two categories as personal and organizational. The following sections discuss these in detail.

3.1. Personal Factors

The study identified that substantial influence has been determined for demographic factors as personal characteristics as age, gender, marital status, education level, working experience in the industry, and other personal information can influence individual safety behaviour. Seven personal factors are listed under the research findings as age, marital status, having dependants, educational level, knowledge on safety, industry experience, gender, and habits those may have an impact on individuals' safety behavior (Table 1).

Table 1: Personal Factors affecting safety behavior of construction workers

Factors	Findings
Age	Experts have observed that the workers who are older in age are more cautious about work safety than youngsters in the industry. With age the daringness of workers tame and they tend to behave more safely for their own protection (Hinze, 1997).
Marital Status & Dependants	Workers also tend to be more careful in what they do when their social responsibilities are higher (Fang <i>et al.</i> , 2006). Experts did clarify that those workers who are married and have more dependants in their families tend to follow safety instructions and guidelines onsite than others.
Educational Level	Educational level does have a positive impact on behavioural safety of workers (Hinze, 1997). They stated that it is easier to maintain safety standards when the workforce consists of individuals with a sound educational background. According to the experts, individuals with good education see the importance of following safety guidelines in work. A project manager explained that people with secondary or higher education are easier to handle and to get complied with safety practices than those with an education level of primary or lower.
Knowledge on Safety	Knowledge on safety also plays a major role in enhancing safe behaviors of employees (Fang <i>et al.</i> , 2006). Experts clarified that, if the workers don't, or even worse, don't want to understand why or how safety matters in construction, there is a bigger chance of them behaving unsafely during their work hours. So, knowledge in safety matters very much to develop behavioural safety.
Experience	More experienced workers in the industry are less likely to be behaving unsafe manner while they work (Siu <i>et al.</i> , 2003). Experts suggest that, experience let the workers know what sort of danger they are dealing with and what would the consequences be of work related accidents in construction. Thus, workers with more years of experience in the industry would naturally accustomed to safe behaviors than those with less experience, as per the experts.
Gender	Experts clarified that 'gender' as a personal factor cannot be stated with certainty, because, construction industry in Sri Lanka is male dominated. Although this fact is common to other countries, literature has highlighted gender as a governing factor of behavioural safety (Hinze, 1997).
Habits	Personal factors such as smoking habits and drinking habits can also affect the safety behaviour of workers (Fang <i>et al.</i> , 2006; Masood <i>et al.</i> , 2012). However, according to the experts, such information needs longitudinal research before it can be generalized in to a particular context.

Fleming and Lardner (1999) have discovered the personal factors contribute to 80 – 90% of all industrial accidents. Hinze (1997), in his study, identified that substantial influence has been determined for demographic factors as personal characteristics as age, gender, marital status, education level, working experience in the industry, and other personal information can influence individual safety behaviour. Siu *et al.* (2003) investigated age difference in safety attitudes and safety performance in Hong Kong construction workers with data from 374 Chinese construction workers from 27 construction sites. The study found that the older workers exhibited more positive attitudes toward safety. Fang *et al.* (2006) used logistic regression to

explore the relationship between safety climate and personal characteristics. Statistically, eight personal characteristics namely age, marital status, the presence of dependent family members, education level, safety knowledge, drinking habits, direct or indirect employer, and breaking safety procedures or not, were found to be related to safety behaviour of workers. Choudhry *et al.* (2009) found positive effects upon perceptions of older workers, who are married, and have more family members to support yet have little impact upon those who are in the youngest age, single, or have no family member to support. Workers with educational levels below primary had less perception of the safety climate. Respondents revealed that subcontractors' employees had a less positive safety climate as compared to the direct employees of the company. These findings suggest that personal factors such as age, marital status, having dependants, educational level, and knowledge on safety, experience, gender and habits may have an impact on individuals' safety behavior.

3.2 Organizational Factors

Not only personal and demographic factor, but also the organizational factors play a vital role in affecting safety behaviors of the workers. The study identified six organizational factors those may affect the safety behaviors of construction workers. Table 2 briefs the elaboration of these factors, supported by the literature references.

Table 2: Organizational factors affecting safety behavior of construction workers

Factors	Findings
Management commitment	Management commitment to safety is vital if an organization wants to promote safe behaviors among the workers (Choudhry <i>et al.</i> , 2007). According to experts, there is so little that can be expected from workers regarding safety if the top management's attitude to safety is dull. A project manager viewed that, people want to get the work done one way or another. So if they see no commitment from the top management to anything let along safety, the management cannot expect much from them. So, top management commitment is vital to safety if a firm is to assure workers' behavioural safety.
Proper OSH systems and feedback mechanisms	All the experts interviewed affirmed that proper OSH systems and feedback mechanisms must be there to monitor employee behaviour towards safety. They clarified that if these systems are well design to capture every error and rectify them, employees automatically adhere to these systems.
Continuous monitoring	Continuous monitoring of OSH systems was regarded as vital in affecting behavioural safety of workers by experts. They viewed that without continuous monitoring any good system can fail eventually. Also, monitoring process will give the workers a sense of been watched over and that will definitely lead to safe behaviors of them.
Training and awareness for workers	Experts identified training and awareness programmes for workers is also important. They will be a guide to proper and safe way of behaving while work and will clarify the need of safety while work.
Empowering the workforce	They also pointed out that empowering the workforce with necessary equipment, resources and authority is also important to enhance workers' behavioural safety. According to the experts, no matter how careful the worker/individual is or how cautious he is, if he is not provided with the right personal protective equipment, if he has no authority to act appropriately in a situation, they might hinder his safety performance.

Reporting of occupational accidents	Apart from these discussed above, the empirical data revealed that reporting of occupational accidents is also important. According to a district factory inspecting engineer, if the workers are certain that their every wrong move is been reported and recorded, they are more likely to adhere to safety behaviors. These experts pointed out that because of the major case of under-reporting of construction accidents, people have no accurate idea about how accident-prone the industry really is. But there was a 100% accident reporting system in existence, the behavioural safety could be enhanced.
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Literature viewed that promoting a positive safety culture is the best way to influence behavioural safety of the workers. Individuals who work in a strong safety culture are likely to adapt safety behaviors than others who are not under the influence of such culture because safety culture is an organizational atmosphere where safety and health is understood to be, and is accepted as, the number one priority (Flin *et al.*, 2000). Moreover, Choudhry *et al.* (2007) asserted that management commitment to safety; management concerns for the workforce; mutual trust and credibility between management and employees; workforce empowerment; and lastly continuous monitoring, corrective action, review of system and continual improvements to reflect the safety at the organization will strengthen the safety culture which will lead to positively affect the behavioural safety of the workers of the organization. In another research conducted by Pidgeon and O'Leary (2000), the authors argued that a good safety culture may be promoted by four factors: (1) Senior management commitment to safety; (2) Realistic and flexible customs and practices for handling both well-defined and ill-defined hazards; (3) Continuous organizational learning through practices such as feedback systems, monitoring and analyzing; and a (4) Care and concern for hazards which is shared across the workforce.

When comparing these factors identified by different authors, it can be observed that they, with slight overlaps among them, do point at the same direction. Management commitment to OSH, employee involvement and empowerment, proper OSH systems and feedback mechanisms, continuous monitoring of OSH systems can be identified as the most important factors that help to strengthen the safety culture within an organization and hence enhance the safety behaviors of its employees.

3.3 Conceptual Framework

A model is established from the identified personal and organizational factors (Figure 1). The model illustrates how individuals are exposed to construction hazards and that individual workers' behavioural safety may affect overall safety performance of the organization. The two categories of factors that affect construction workers are depicted in the model under the topics, 'personal' and 'organizational'. Personal factors those might affect individual behavioural safety, yet need more longitudinal research are indicated in the Framework as well.

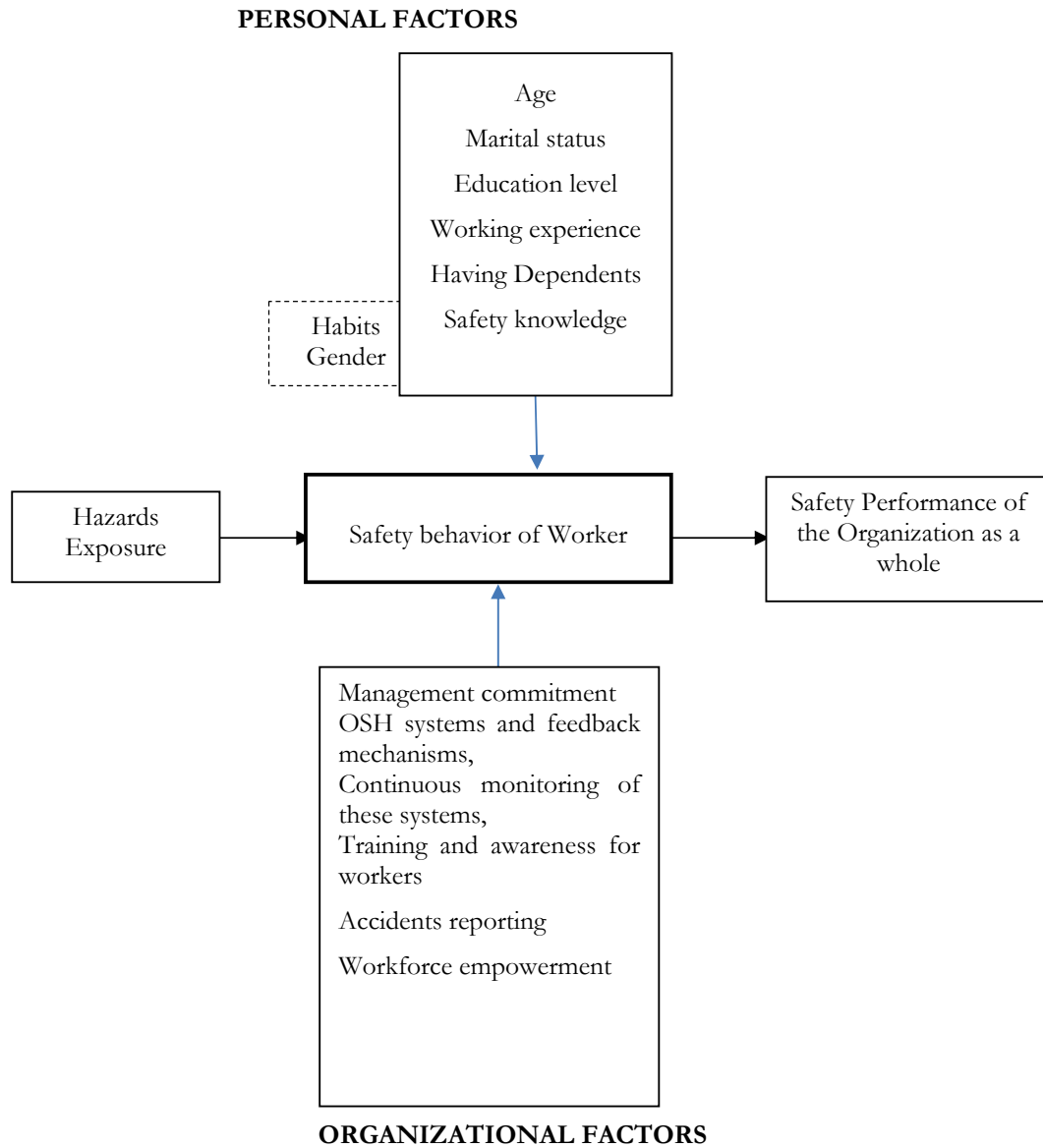


Figure 1: Conceptual Framework for Safety performance of an organization

Conclusion

This paper presents the findings on factors affecting construction workers' safety behavior, validated by the industry experts. First, the abstract of the paper together with the methodology adapted are presented. Next, existing concepts, theories, and literature from numerous disciplines reviewed to provide the theoretical grounding for the research are discussed. Then, the main research findings, those been the factors affecting construction workers' safety behavior, from literature and as validated by the experts are presented under two categories; namely, personal and organizational. Under personal category, study identified seven factors, namely, age, marital status, having dependents, educational level, and knowledge on safety, industry experience, gender, and habits. Management commitment, proper OSH systems and feedback mechanisms, continuous monitoring, training and awareness for workers, empowering the workforce, and reporting of occupational accidents are the six factors identified under organizational category. Finally, a model is been developed to illustrate how the safety behavior is affected by various factors and how it ultimately affect the whole organization's safety performance.

However, as it appears, numerous other influencing factors have to be considered to obtain a comprehensive understanding about the Sri Lankan context, because the factors affecting safety behaviors may differ from country to country and region to region. Thus, the authors plan to develop the model in the future contributions. Furthermore, the same research approach may be successfully applied outside the construction industry. For example, it could be applied to other labor-intensive industries, such as manufacturing.

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The Role of Socio-Spatial Relationships in Sustaining Communities: Case Study of Low Income Settlements in Colombo

Kasunjali Mahamudalige

Department of Architecture, University of Moratuwa.
kjmrocks@yahoo.com

Shaleeni B A Coorey

Department of Architecture, University of Moratuwa.
sbacoorey@gmail.com

Abstract

Low income settlements in Colombo represent communities that have high interdependence and social ties. Such communities are observed to be significantly linked and dependents on their public and semi public spaces where social activities and ties are reinforced and sustained. But it is observed that when such communities are resettled in other vertical or horizontal neighbourhoods such socio-spatial relationships are ignored and hence results in disruption of communities and loss of social ties. Therefore the existing socio-spatial relationships in such settlements can be considered as an asset to the settlement that urban designers and Architects must recognize in future resettlement programmes.

This paper examines the levels of physical integration or segregation of public – private spaces within such settlements and explores the impact on social integration. The importance and role of such spaces for enhancing social integration among the community is highlighted. Spatially integrated and segregated spaces within the settlement are analyzed via axial maps and their social integration is explored through activity maps, photographic surveys, observations and semi structured interviews. The study sheds light on the success of highly integrated spaces as oppose to the segregated spaces and highlights that spatial integration, the integration of private to public space in the form of space, form, activity and function plays a vital role in creating and sustaining socially integrated communities.

Keywords: *Low Income Settlements; Socio-Spatial Relationships; Spatial Integration, Colombo.*

1.0 Social space and spatial configuration in low income housing

Housing should not be restricted to its physical or economic characteristics rather the aspirations and concerns of the residents need to be considered (Galal Ahmed, K, 2012). Sanoff (in Galal Ahmed, K, 2012) argues that the success of designed environments depends on its ability to satisfy and support particular functional, spiritual and socio-cultural human needs. Rapoport (in Galal Ahmed, K, 2012) states that the socio cultural values of a community include the community's religious beliefs, family and clan structure, social organizations, ways of gaining a livelihood, and social relations between individuals and the survival and continuation of cultures are highly dependent on the form of housing capable of supporting the cultural core.

Dayaratne, R and Kellett, P (2008) in their research on home making in urban low income settlements identifies the desire for community as an important characteristic among the urban poor. The lifestyles and survival is highly dependent on sharing and such settlements are found to be not a collection of houses of separate families but groups of families that are closely related in many ways. Having common friends, response to each others outdoor spaces, creating informal paths across gardens and even through houses 'crossing homes' are factor identified as ways of establishing closer social relations. They further state that the forces behind the layout of settlements, houses, orientations, and spatial linkages are community – oriented and encourage

social interactions which enhance sense of home among the urban poor. The urban networks that connect home to its surroundings are discussed as extremely important in such low income settlements; the networks become as important as the house itself. These networks offer opportunities to construct the urban community. Places such as temples and religious places are identified as significant places in Colombo's low income communities offering a network to be established as a broader 'home range', a sense of orientation and also a way of 'connecting' to and 'becoming' a part of the larger community (Dayaratne, R and Kellett, P, 2008).

The spatial arrangement of a housing settlement contributes to and supports human activities, relationships, interactions which are important in building communities. In such communities the social spaces both indoors and outdoors play an important role in tying the physical and social networks. The social space can be interpreted as a collection of activities or behaviour patterns of different groups in a particular space. Brown and Moore (as cited in Rapoport, 1977) discuss this space as behavioral space or action space which has the ability to move and activate often. Further Hurst states (as cited in Rapoport, 1977) this space can vary according to several factors of its groups such as age, sex, ethnic group etc. and it reflects their perceptions, behaviours and relations. Madanipor (2000) explains that behavior patterns and social norms affect personal space and behavior in social space. Further he states about the group space where the people shared private space in the middle of public space. It determines that group space can be considered as social space and further describes the city as a social world where the individuals established socially and physically.

The important fact is that physical spaces need to be compatible to the social spaces. These social spaces facilitate social integration of a community and its distribution within the physical settlement can further enhance the levels of social integrations that are established in low income housing. Therefore an understanding of how the physical spaces enhance the social spaces is important and factors such as the spatial integration of spaces within settlement and also the quality of such spaces should be explored to understand its contribution to social relationships in communities. The links, distribution and composition of public to private space will affect the flow of pedestrian activity, its intensities and interactions among activities (Hillier and Hanson 1984). Research discuss that when high intensities of necessary and optional activity takes place in satisfactory conditions of public spaces, more social activities will be encouraged (Gehl 1996; Moirongo 2002).

Hillier (1996) as cited in Prayitno, B (2013) states that a space can be used for any activity such as walking, chatting, studying or sleeping but what is termed as spatial configuration is the order of space arrangements on spatial pattern. It explains how the inter-spatial connections work, the connections among elements and connection of the space itself. It explains the connections among units of space – not based on distance but topographic values. It is a measurement of depth rather than a distance between spaces which explains the connection among spaces. Hillier and Hanson (1984) establishes the Space syntax method to identify and read the spatial configuration of urban spaces. Spatial configuration describes the patterns of space in more complex terms rather than a general description. It is a theory of space and a set of analytical quantitative and descriptive tools for analyzing the spatial formation in different forms: buildings, cities, interior spaces and landscapes. It is a relation between human beings and their inhabited spaces and is structured according to a specific social logic. It is able to express the social meaning and social consequences of space and read space objectively while maintaining associations between physical and social structure of space. As stated by Hiller and Hanson (1984) it expresses the potential for people to get together and explore the relations or logic behind people and space. Hillier and Vaughan (2007) discuss that with space syntax theory it is possible to detect the forces or influences of social factors which construct the spatial patterns of social life.

The following figure 1.1 shows the spatial theories developed by the various planners and architects (Nolli, 1984; Cullen, 1961; Alexander, 1977; Krier, 1979; Hiller, 1996) within the passage of time.

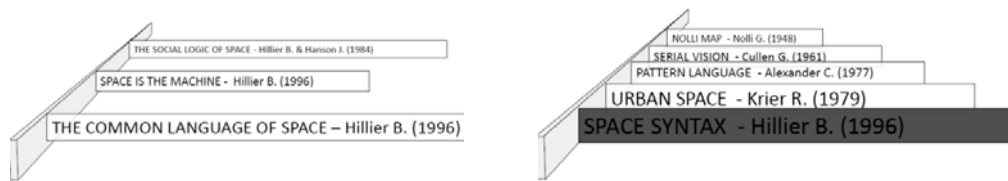


Figure 1.1: The conceptual diagram shows the spatial theories developed by the various planners and architects (Nolli, 1984; Cullen, 1961; Alexander, 1977; Krier, 1979; Hiller, 1996) with the passage of time.

Source: Retrieved from <http://spacesyntax.com>

In space syntax theory, there are two basic formal ideas of space described as follows: ‘Space not as the background to human activity, as we think of it as the background to objects, but as an intrinsic aspect of everything human being’s movement through space, interacting with other people in space, or even just seeing ambient space from a point in it, all have a natural and necessary spatial geometry.....’(Benedikt, 1979, Chapter 1(as cited in Hillier and Vaughan, 2007).

The ideas of space describe some aspect of how we use or experience space and how buildings or cities are arranged according to these ideas. Benedikt (as cited in Hillier and Vaughan,2007) explains that movement is always linear and the spaces are arranged according to that movement, such as streets, boulevards, avenues, alleys etc. and interactions need more spaces like public spaces, squares which are called convex spaces. The second idea about space as stated by Benedikt, (as cited in Hillier and Vaughan, 2007) is that human space is not just about the properties of individual spaces, but about the inter-relations between the many spaces that makes up the spatial layouts of buildings or cities. This is called the configuration of space. Space is further emphasized not as individual one but a collection of spaces which creates spatial patterns or language and has social meaning. The configuration of space expresses the meaning of spaces rather than a typical description of the physical space and it is able to express the property of space by which space both acquires social meaning and has social consequences (Hillier and Vaughan, 2007).

Space syntax method can be used to analyze the integration of urban spaces in cities and housing settlement. The links or connectivity between social and spatial structures are called “integration” and less connectivity is called “segregation”. “Providing a measurable scale for segregation and integration, enables a statistical comparison of different spatial forms across cultures, and hence provision of a platform from which social origins and consequences might be investigated.” Hiller B, Hanson.J, (1984), (as cited in Hillier and Vaughan, 2007). Axial maps are used in syntax theory as the straight lines which pass through the spaces representing the maximum visual distance from one space to another. There may be several axial lines in a particular settlement which pass through the spaces. Longest lines and the shortest lines are interpreted by a statistical value to identify the integration and segregation of spaces.

Palframan (2005) has researched on the socio-spatial spatial characteristics in low –income housing settlement in South Africa. He identified the appropriate typologies for redesign of the spatial linkages of the housing settlement. The space syntax method was used to explore the spatial configuration typology to study the functional relevance and appropriateness of several housing settlements. Finally he concludes his research result through the syntax configuration analysis identifying the cases with healthy environment and well-functioning spatial layouts. Study by Prayitno, B (2013) in his research uses space syntax for exploring the consolidation patterns of the use of alley spaces in Kampung housing in Indonesia. He establishes that such alley spaces are used not only for circulation and as dwelling unit connectors but also as spaces for

interaction. Pocket spaces in alleys in residential clusters with high integration values were identified to have high social interaction.

2.0 Research objectives:

This study explores the spatial integration levels of public - private spaces within a selected low income settlement and examines the impact of integrated and segregated spaces on social interactions and levels of activity among its residents. Results shed light on the importance and characteristics of such spaces in order to sustain communities of similar nature. However, it must be stated that apart from the integration of public – private spaces within a community many other factors such as the social harmony among its members, social and economic interdependency, sense of belonging, identity, political and economical factors also have impact on the social ties within a community.

3.0 Method:

The physical integration and segregation of the settlement layout is examined via Space syntax method. Axial maps were produced for exploring the spatially integrated and segregated spaces within the settlement. Following which activity maps, photographic survey, observations and Semi structured interviews among 10 residents are done to explore the activity in the identified integrated or segregated spaces and examine the residents' social integrations in such spaces.

Finally the objective of how spatial integration levels impact on social integration is explored. If it facilitated better social integration or segregation and the factors and reasons for such observations are discussed.

3.1 Identifying the spatial integration and segregation in housing via axial maps:

The standard quantitative approach of space syntax method (Hiller .B, Hanson .J, 1984) has been chosen to study the first objective of spatial integration in housing settlement. An axial map was constructed for the housing layout with manual calculations. The output confirmed the high integration and low integration (segregated) spaces within the settlement.

3.2 Socio-spatial relations through activity maps:

Having considering the axial calculations of highly integrated and low integrated spaces, casual observations were done to verify the locations of activities that people visited the most. The levels of activity within the settlements' outdoor spaces were also identified. In addition a random sample of 10 residents was asked to identify the places they visited the most and indicated on the layout map.

The activity map verified the socio-spatial relations of integrated spaces within the housing settlement at a particular time. This supports to identify the spaces linked to the human activities and the reasons for people to gather in such spaces. Therefore the activity maps were ideal for understanding and verifying the activity levels and functions in space.

3.3 Spatial connectivity through photographic survey:

Casual observations are done to further study the integrated and segregated spaces using a photographic survey. Further it verifies the calculation result of the axial maps and observations made with the activity map. It further observed the factors and characteristics or qualities of the spaces that were found to be of high or low integration value. A comparison was made to establish the physical differences between the integrated and segregated spaces.

3.4 Social relations of integrated spaces through interviews:

Factors influencing social integration apart from the method of axial calculation, activity map and, photographic survey was explored via in depth interviews. The semi structured interview questionnaire aims to gather the data of social integration among the communal spaces, neighborhood spaces and the physical environment they live in and how often they integrate, the

purpose and its implications on their social ties in the community is also explored. Interviews explored the places where meetings took place, type of meetings – optional, necessary or social (reasons), frequency of meetings, places where social events takes place and their participation and role in such activity, spaces for social gathering, availability of communal spaces, ideal places for meeting neighbours and interactions and their attitudes towards same, etc. Questions were all open ended in order to facilitate further discussion.

4.0 Analysis and Discussions:

4.1 Axial maps & spatial integration - Spatial integration and segregation in Harbor and Pettah fish market community housing at Mattakkuliya

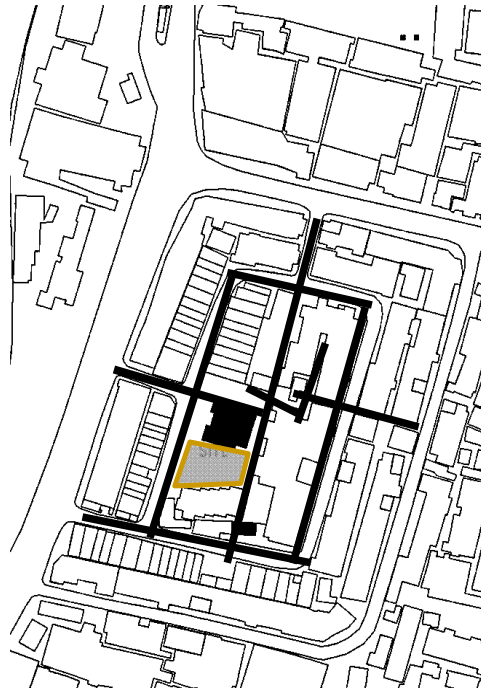


Figure 4.1: Maximum visual distance in settlement
Source: Author

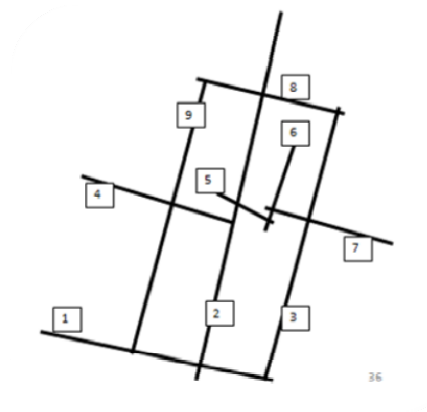


Figure 4.2: numbered axial line
Source: Author

The axial lines that interpret the maximum visible distance of Newham Square were constructed. These axial lines run through the streets and alley ways of the neighborhood. There were 9 axial lines constructed for the layout as shown in figures 4.1 and 4.2.

Table 4.4: shows the final calculation of spatial integration. Red shows the high value of which has high spatial integration. Yellow shows less value which has less spatial integration.

A	$\Sigma = A / \Sigma A$		$1/(\Sigma = A / \Sigma A)$	
1	1.15	1	1 / 1.15	0.86
2	0.76	2	1 / 0.76	1.31
3	1.06	3	1 / 1.06	0.94
4	0.93	4	1 / 0.93	1.07
5	0.84	5	1 / 0.84	1.19
6	1.15	6	1 / 1.15	0.86
7	1.04	7	1 / 1.04	0.96
8	1.05	8	1 / 1.05	0.95
9	0.84	9	1 / 0.84	1.19

Source: Author

The high integration and low integration lines were identified as shown in table 4.1. The line number 2 show high connectivity and therefore high integration and line numbers 1 and 6 shows less connectivity and therefore low integration. When considering the layout pattern of this neighborhood, line number 2 has more integration since it is the main central alley way of the neighborhood. Number 1 line shows another road entrance to the square and 6 shows the narrow alleyway among the houses. Line No 9 also shows a high level of integration.

- High value shows the high integration (more connectivity) – 1.13
- Low value shows the less integration (Less connectivity) – 0.86

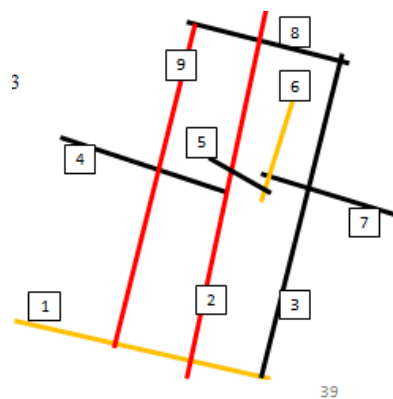


Figure 4.3: Value added axial lines
Source: Author

4.2 Location of activities – Layout map

The axial map results show the high spatial integration in line number 2 which is main alleyway of the neighborhood. The next step is to check the accuracy of the actual situation whether they integrate or not. This method shows the spatial integration theoretically but the activity map focus on the layouts potential spaces where people integrate and segregate and the factors that encourage same.

Location map was done by asking the question from people where they visit the most. Ten people described the places they visit most and this map was marked out according to their answers. The numbers indicates the most visit place relevant to the person. Considering the answers the findings show that most people visit the St' Anthony's church and high spatial integration which is not limited to the neighborhood is seen in outer boundary of the settlement. The playground and the community center are also major nodes for children and young people while other alleyways only act as circulation paths for daily use.

As shown in figure 4.4 it shows that the spatially high integrated spaces were identified by the residents as places and areas that they visit the most. Also figure 4.4 show that the spatially less integrated spaces also reflect less activity and choice of residents to visit these areas. Results show that the spatial integration is in line with the actual choice of activity and meeting places of residents.

Location of activities – Layout map

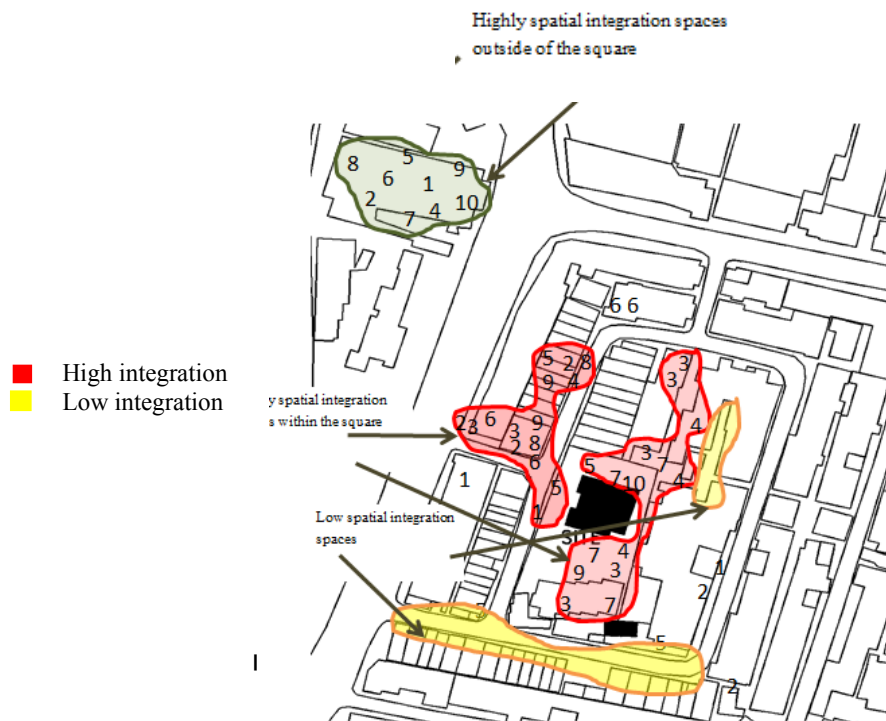
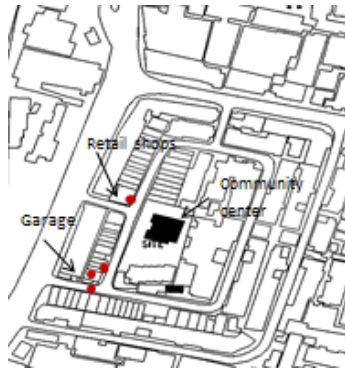
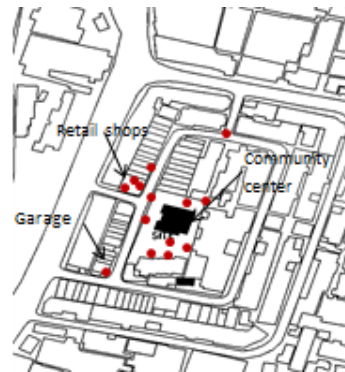


Figure 4.4: layout map of residents' answers
 Source: Author

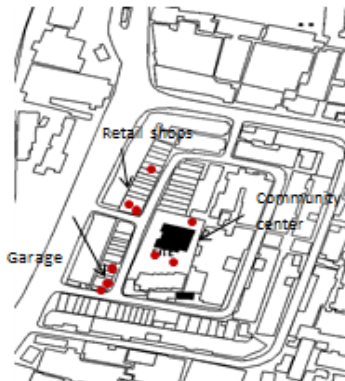
a) Activity map on highly integrated spaces



Activities - 8 to 10 a.m.



Activities -12 to 2 p.m.



Activities -3 to 5 p.m.

Figure 4.5: Activity Map of High Integration Spaces
Source: Author

Observed area map of the integrated spaces (Fig 4.5) mainly include the commercial activities and playing activities near the community center and basketball court. Therefore it can be classified into two types of activity,

Commercial activities – the garage, retail shop

Considering the 8 to 10 map the people integration on this spaces shows much higher amount than the 12 to 2 p.m map, during the day time it shows the less amount of people and the evening 3 to 5 p.m map shows the high people integration in retail shop area than the garage. But these two shops functions the whole day with activities.

Playing activities – the basketball court and open space

The playing activities on 8 to 10 p.m map shows the number of people were participated in basketball court and the shaded open spaces for play. During the day time 12 to 2 p.m map shows no playing activities.

Compared to the morning map, evening map shows much higher integration in areas with playing activities such as the basketball court and open area and some street nodes. The axial map findings were also verified by the activities of the integrated space. Therefore these public spaces such as the basketball court shaded open area, integrated spatially as well as functionally bringing people together.

4.3 Spatial connectivity through photographic survey

4.3.1 Photographic Survey on highly integrated spaces

Integration of living and commercial spaces: The marked red colored area shown in figure 4.4 consists of houses and small outlets and tea room which are very well-known/popular places in that area. Considering the arrangement of building, and building facades of every two or three story building consist of three foot wide balconies and these balconies face the narrow street (Fig 4.6). People engage in domestic activities within these balconies and they even talk to other neighbors while engaging in these activities.

(a) Photographic Survey on highly integrated spaces



Figure 4.6: Through the alleyway (left) Tea room (right)
Source: Author

The street shown in figure 4.7 provides the parking space for them and all the vehicles are parked at the door step and this arrangement of private spaces facilitates to secure their privacy.



Figure 4.7: The main alleyway
Source: Author

Mix of private and public spaces: The alleyway ends with the huge mango tree which was located at the rear space of the community center considering this narrow space all the household spaces (private spaces) provides a boundary for the public space which is the street shown in figure 4.7. Within this narrow space there is an interesting activity pocket which is 'Rahumaniya's tea room'. This is a well patronised space which was a very public space amidst the private dwellings. Therefore the mix of private and public spaces facilitates more integration.



Figure 4.8: The street vendor (left) the basketball court (right)
Source: Author

The special trading activities can be seen at this street. Variety of pedestrian vendors was highlighted at the neighborhood. This public space is a good opportunity for them to sell the products. Textiles and all the household items are sold by pedestrian vendors every weekday. The basketball court is located in between the mosque and the community center and act as a public space of the neighborhood as shown in figure 4.8. The open space (fig 4.9) next to the community center and other houses function with younger members of the community. Though they have the basketball court next to the community center there is much integration observed within this open space where the shaded areas encourages various forms of play such as cricket. This space was observed as the only open spaces with sufficient shading due to greenery.



Figure 4.9: The open space
Source: Author

The axial map results of high spatial integration (shown in figure 4.3) and the people's location map in figure 4.4 and activity maps in figure 4.5 correspond well with each other in terms of its physical spatial integration within the settlements, its activity, use and function. The combination of private and public spaces creating activity pockets amidst the habitable spaces reflects the close ties between private and public functions.

4.3.2 Photographic Survey of less integrated spaces



Figure 4.10: Entrance to the square (left) arrangement of private spaces (right)
Source: Author

Public space boundaries: The yellow lines of axial map in figure 4.3 and the yellow coloured area in figure 4.4 represent the low spatial integration areas. Although this area has similar character of building masses of the main alleyway the activities are not integrated. The private spaces and the mosque boundary define the road as public space but this space is for circulation purpose only as shown in figure 4.10 and 4.11. These spaces do not function as alleyways because priority is given to the mosque and it limits other types of informal activities in order to respect the religious activity of the Mosque.



Figure 4.11: The road
Source: Author

4.4 Social relations of integrated spaces through interviews

The interview was carried out among 8 out of the 10 people and the answers were categorized as follows. The interviews were done in a very informal manner to avoid the reluctance of the residents to discuss their neighbourhoods in an official manner. The residents were also more comfortable with informal conversations rather than a questionnaire survey due to their previous experiences on surveys done for relocation of their housing etc. The relevant data of socio-spatial relations was collected focusing on the residents' integration across private to public spaces.

Integration of living and commercial spaces: House is a primary unit of the social system and it is the place where integration begins. The domestic spaces and their social behavior reflect the different personal attitudes towards the domestic spaces. Most of the people are satisfied with

their domestic spaces and they have done many additions and alteration to the houses during the last 20 years. These domestic spaces are categorized according to the living purpose and commercial purpose as well. The fishing business man Mr. Weerawardana said,

'We stay in upper floor, it's easier for us. My ground floor has been rented out to the electrical shop and we get paid monthly by them, I think most of our neighbors do that'.

Weerawardana (Personal communication, March 2, 2013)

'First we had the ground floor only, after my son got married they developed the upstairs for us to live also and the ground floor became the retail shop. It belongs to him now and it's his side business.' T. Krishna.

(Personal communication, March 2, 2013)

Commercial activities were part and parcel of their domestic spaces. There was no major concern for privacy in domestic space rather the income generated from letting out part of their domestic spaces seems important. Household activities and business activities were easily managed. Mr. Selvam the tailor and the Mr. rahumaniya tea room owner gave the similar answers relevant to this topic. Other interesting factor is that they arrange their special functions at home while neighbours also share facilities with them.

Extension of domestic space – converted as intermediate public spaces: The arrangement of domestic spaces such as the balconies, act as extensions to the living room and the street became the intermediate public space within the domestic spaces. It's related to every resident in every culture. However they managed to conduct their social activities within their own private spaces.

'We arrange in our own house, if there's not enough space, we hired the tents and chairs and do it in street as well. There were so many funeral functions celebrate like that. Otherwise, where else to go?' Weerawardana

(Personal communication, March 2, 2013)

'My son has many friends and he often comes with his institute friends to dine here. They play cards in the balcony during the afternoon' Mrs. Farook

(Personal communication, March 2, 2013)

The residents also reflect a sense of belonging to their environment and rely on the functions and facilities around their home. Their lives are very much embedded in the immediate environment.

'Of course yes, this was my father's house; it's hard to live elsewhere without leaving this place. These noises are very familiar to us, I'll tell you one thing, last week I went to Ragama for my private work I couldn't stay one hour there and I was in a big hurry to come home, that day. And there is no place like this; if someone couldn't make food in a situation, the Church provides the lunch packets every day. It's a unique item specific to this context, and there are many facilities to live here'.

Weerawardana (Personal communication, March 2, 2013)

Private space arrangements: Residents also show satisfaction with face to face housing arrangement as a form of better interaction and mutual support among residents while maintaining a sense of security.

Mrs. Nilufer's statement further explains,

'Yes, it works a lot I think, the reason is no one can get to the house without authorization, there is less chance for that to happen because other neighbours keep an eye on that, very few robberies happens here. If someone comes to our house my neighbours tell me, and we have good support'.

Nilufer (Personal communication, March 2, 2013)

Landmark spaces for social integration: The community center and the basketball court play a significant role as an activity node and is part of the resident's memory of their neighbourhood. This was a main gathering point of the context. Most residents identified these spaces as a well-functioning public space within the context.

*'I have played there since I was in primary. Now I'm 25'
'We also have played the basketball there, there are so many children selected for national team also.'*

Weerawardana and Dilshani (Personal communication, March 2, 2013).

Social events and the celebrations were also major factors for social integration. The differences in religion and culture didn't segregate the community and instead was a factor for integration. The Sinhala Tamil New Year was celebrated by all residents and they participated in every festival of the St' Anthony's church.

'Yes, we celebrate every Sinhala Tamil New Year, Tamil people also same as that, they celebrate their functions Deepawali and Thaipongal and Christmas as well. I'm Buddhist but I go to Kotchchikade church also.'

Weerawardana (Personal communication, March 2, 2013)

'well yes, there are basic facilities to live here and this is the place we grow up, and it's easier to everything to our business, living conditions etc... we have good mutual support which is not seen in other housing settlements and without that support we feel very uncomfortable and we become strangers. There are less social issues such as heroin business and drugs. But that is also less than 10 cases. It happens everywhere as I know compared to the other housing settlement this one can be ranked in high position.'

Mr.Weerawardana (Personal communication, March 2, 2013)

The neighbours and neighbourhood activities made an impact on their social relations. This indicates the public space cannot be limited to the physical context and spaces but also their shared values, interdependence and cultural beliefs etc. had an impact on the levels of interaction among the residents.

5.0 Conclusion

The study shows that the physical configuration of spaces in terms of integration and segregation is very much reflected in the activity, use and function of spaces within the settlement. Highly integrated spaces reflect high activity levels as observed in activity maps and low integrated spaces show low activity levels. Photographic observations and interviews further show that the built environment surrounding the highly integrated areas plays a role in enhancing the levels of activity and interactions made in these spaces, and vice versa. Factors such as integration of living and commercial spaces, mix of private and public spaces, public space boundaries, and extension of domestic space – converted as intermediate public spaces, private space arrangements, landmark spaces play an important role in enhancing these integrated spaces for sustaining interaction and communities were found to be important in enhancing the social interactions in physically integrated spaces.

The arrangement of private spaces ensures the protection layer or a buffer and the uses of private spaces for multifunctional purposes further enhance the activity levels and social integration. Every well-functioning or active space has to have a social purpose as well. The streets, alleyways, internal pathways, playground, community centers, social centers can be considered as encouraging public spaces. The more application of these public spaces will provide social and cultural benefits. Organization of these spatial structures facilitates the opportunity for residents'

interaction. The well integrated private-public space arrangements will avoid the isolation or segregation of groups in community housing. Study finally highlights that in addition to a spatially integrated layout the private to public integration of space, form, functions and activity can play a major role in building a socially interactive and a cohesive living environment. But it must be noted that in addition to the spatial integration and the built factors the shared values, interdependence and cultural values play a major role in the social integration of these communities.

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The Effect of Visual Stimuli of Planned Residential Streetscapes on Way Finding Behavior of First Time Visitors

G.M.W.L. Gunawardena, KUBOTA Yoichi & KIYOTAKA Fukahori

Department of Environmental Science and Infrastructure Engineering
Graduate School of Science and Engineering, Saitama University, Japan
w.lakpriya@gmail.com

Abstract

This paper is concerned the streetscape visual stimuli making streetscape confusions as well as the visual stimuli making trouble-free bidirectional movements of first time visitors to an area. Pedestrian/vehicle streets around Saitama University, Japan were selected for the study. One forward movement movie along a streetscape with 5 movies of backward movements from different streetscapes were displayed to a group of subjects. Subjects were asked to select the correct backward movement analogous to the forward movement and a questionnaire was given to fill with the answers for individual's selection. This method was repeated by changing the forward and backward movies along streetscapes and the group of subjects. A significant variation could be identified in the backward path selection corresponding to the forward movement. Visual stimuli which caused streetscape confusions and the visual stimuli that helpful for correct path selection were identified. The visual stimuli that made streetscape confusions and that made correct selection were significantly similar among different planned streetscape groups.

Keywords: planned streetscapes, visual stimuli, bidirectional travelling

Introduction

This article is concerned about how people confuse in bidirectional travelling along planned streetscapes for the first time. The research study is aimed at contributing to knowledge about the relative roles of layout of the streetscape environment and local visual stimuli in bidirectional travelling.

Travelling along an environment is a progressive movement. It makes serial visions on the pedestrian's cognitive memory and these serial visions are perspective. The structure of the streetscape is developed on pedestrian's cognitive memory through the experience gained from the serial vision of the streetscape. Gordon Cullen (1961) in his book, Concise Townscape, proposed a serial approach to the design of public space in recognition of the constantly moving pedestrian vantage point. A visitor doesn't have any prior knowledge when he travels along the streetscape to a destination first time. In the absence of previous experience of the setting, information about arrangement, content and the opportunities will be acquired while navigating the places and spaces of the setting. How such information is sorted and stored in cognitive memory is dependent on the nature and specificity of individual purpose. The picture developed in cognitive memory through serial vision is helpful in returning along same path or in bidirectional travelling. Generally pedestrians remember a path with the help of visual elements present in both sides of streets. If the visual elements present in the streetscape are unique or has a quantity of distinctive qualities, then the pedestrian can easily create a good cognitive memory which will be useful in returning along the same path. However, in most of the time, first time visitors are misled by the streetscape views and they are unable to find the correct path to return. This is very prominent in planned residential areas with very similar streetscapes views. The picture created in the cognitive memory will not be helpful in most of the cases for finding the correct returning path due to the similarities among streetscapes in the to the similarities among streetscapes in the planned landscape areas.

Objective

1. To find out whether the planned streetscape views cause confusions in bidirectional travelling

2. To find out the visual stimuli that are helpful in bidirectional travelling and the visual stimuli that cause confusions in bidirectional travelling for the first time visitors to an area.

A special consideration is given to the planned residential areas in Saitama Prefecture.

Overview of the Present Study

This article addressed the problems faced by the pedestrians in planned landscape areas. This study was attempting to find out the reason behind the misleading in bidirectional travelling of planned landscapes. The visual stimuli in the visual environment that cause confusions in the cognitive memory of the pedestrian as well as the visual stimuli that helpful for correct path selection in planned residential areas were identified in this research. It will be helpful in landscape designing and planning to make the landscape areas with unique qualities to have much more friendly environment to the residents of the area and to the visitors to the area.

Very little prior studies are available on pedestrians' behavior on streetscapes. Most of the past research studies were about path choice and the exploratory behavior of pedestrians along streetscapes. Studies on serial vision on bidirectional travelling are very much lacking in the scientific literature. Further the researches on planned landscapes are very much lacking. Ambition of landscape planners is to get the utmost benefit from the available land area, however, they could not recognize the problem behind making very similar structures on landscapes. High similarity in the streetscapes of planned landscapes causes confusions in the travelling along landscapes. This is very problematic in bidirectional travelling when the pedestrian wants to find the returning path. Past researches have not addressed this issue yet. Thus, this study shows a new arena of research on streetscapes especially the confusions occur in bidirectional travelling along planned streetscapes.

Wrong path selection happens in any type of streetscapes such as vehicle dominant streetscapes, pedestrians/vehicle streetscapes or pedestrian dominant streetscapes. For this study, pedestrian/vehicle streetscapes of planned residential areas were selected. Well planned landscapes could be seen in all most all urbanized areas in Japan. Since the amount of usable flat land area is less in Japan, the landscape planning is essential for the best use of the available flat land area. The landscape planners design the landscapes according to the regulations of the landscape authorities of the relevant prefectures of Japan. Within one prefecture, all the landscapes shows similar patterns, for example, all the residential areas within one prefecture shows similar way of arranging landscape elements. The study is focused on the streetscapes in residential areas around the Saitama University in Japan at the Saitama Prefecture. The streetscapes around Saitama University are pedestrian/vehicle streetscapes and the area is highly dense with residential units. When the streetscapes were subjectively observed, one can easily states that the structure of all most all streetscapes are similar to each other with similar patterns of housing units and other elements in the streetscape. Therefore it is obvious that a new pedestrian to the area will be misleading by the streetscape views. New pedestrians most of the time complaint about the difficulties they faced while travelling along streetscapes in this area. However, these complaints are just subjective. Thus, through this research, the main aim was to verify whether difficulties that pedestrians faced along streetscapes in bidirectional travelling are truly occurred due to shortcomings in the planned streetscape views.

Physical Attributes Relevant for the Study

In this study two physical attributes were considered; architectural variation and streetscape complexity.

Complexity has been defined variously as the number of elements present in a scene (Herzog; Kaplan & Kaplan, 1982) and more particularly as the "noticeable difference" between elements (Rapoport & Hawkes, 1970, p. 109). In their analysis of environmental preferences, Kaplan and Kaplan (1982) propose that people have an innate need to be involved in the environment, meaning that they gather information which they can then make sense of and integrate into

mental representations that support effective functioning. In their framework, the complexity perceived in a scene is considered an important determinant of preference because it encourages exploration and offers immediate involvement with the environment.

Researchers have long considered the number of turns in a form's silhouette, or the number of points that construct a geometric shape, to be predictive of subjective responses (Attneave, 1957). Studies have shown that perceived complexity is strongly positively associated with the number of turns in skyline silhouettes (Heath *et al.*, 2000; Nasar & Terzano, 2010; Stamps, 2002; Stamps, 2003). Stamps (1999a) compared preferences for building façades with different shapes and concluded that façades with five turns were preferred over those with four turns. Stamps (1999b) argued that the physical determinants of surface complexity can be represented in a clear and objective way by utilizing the theory of visual perception developed by Van der Laan (1983). Accordingly, he proposed that elements with lengths of $1/7 \times 1/49$ of the façade length would be perceived as surface details. He also claimed that increasing the amount of the area of the building façade covered by elements within the length of $1/7 \times 1/49$ of the façade length would increase the perceived surface complexity (Stamps, 1999a). He found that perceived surface complexity increased with increased window and door trims and ornaments that fit within these size ranges (Stamps, 1999b). Therefore architectural variation included the building shapes and the ornaments presented on the buildings in streetscapes.

A considerable complexity and a good architectural variation make a place lively. This is applicable to streetscapes as well. If a streetscape has good architectural variation and a complexity, the pedestrians feel lively and feel enthusiastic in travelling along the street. Further such streets will create memorable picture in the cognitive memory to help the traveler in bidirectional travelling.

Study Area

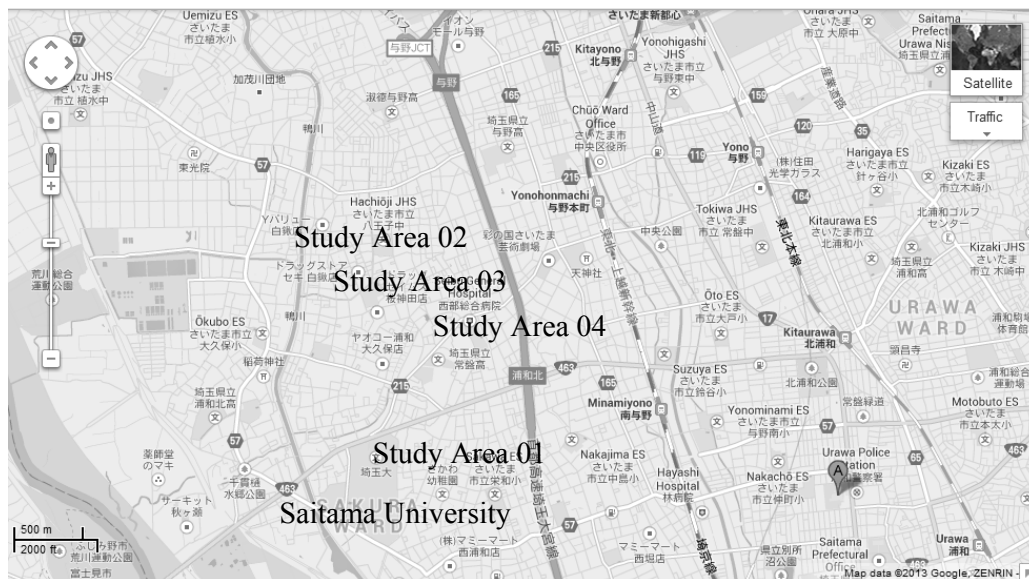


Figure 1: Selected Study Areas around the Saitama University

The study focused on 4 main planned residential areas around Saitama University. From each selected study area, 7-8 residential/vehicle streets were selected randomly for the study. Thus, altogether 30 streets were included in the study. Street network shows a grid pattern in the study area. The width of a selected street is averagely between 12-15 feet. The length varies according to the selected starting point and the ending point of the street. The streets were selected from one node to another node of the grid network. The same criteria were applied in the process of

selecting the streets for the study. The Figure 2 illustrates the grid pattern of the street network and the parameters of the selected streets.



Figure 2: Layout of Selected Streets

- ↔ : Road Length – length between two nodes of street network
- : Forward movement direction
- 1-7 : Selected streets

The streetscapes consisted of one to three stories residential units. The retail shops could rarely be observed on some of the streets. Figure 3 displays a typical residential/vehicle streetscape in the study area.



Figure 3: A Typical Residential/vehicle Streetscape around Saitama University

Methodology

Methodology consisted of selecting visual stimuli for the analysis, selecting participants for the analysis, conducting questionnaire survey and the analysis of data. Sections of methodology have explained below.

Selection of visual stimuli

Visual stimuli

Visual stimuli are the streetscape elements that act as stimuli for the pedestrians to remember their travelling path. These visual stimuli are important for creating a good picture in the cognitive memory of the traveler.

After conducting a preliminary subjective investigation of the study area, ten visual stimuli representing the two physical attributes explained above, were selected in streetscape views for further subjective analysis through an intensive questionnaire survey.

These visual stimuli are

- a. shapes of houses
- b. heights of houses
- c. roof styles
- d. color and texture of houses
- e. orientation of houses
- f. windows, doors or any other physical elements on houses
- g. positions of windows and doors
- h. front fences, walls and their appearances
- i. street junctions and
- j. street trees

Selection of participants

The participants in the questionnaire survey were entirely on voluntarily. The sample consisted of 60 participants representing countries like Japan, India, Sri Lanka, Nepal, Bangladesh, Vietnam, China and Pakistan. The degree of familiarity with the kind of planned urban environment presented in the images was low-to-moderate among the participants from other countries except Japan and China. However, before starting the questionnaire survey, a common question was asked from everyone that whether they have misplaced in streetscapes in any day of life they spent here. The answer from everybody was yes. Therefore, a prior conclusion was set that everyone participated in the survey had this confusion in bidirectional travelling along streets. It doesn't confine only to foreigners in Japan.

Conduction of the survey

Data collection was carried out via personal interviews with participants and via the internet. The purpose of the study and other necessary information (e.g., regarding informed consent) were presented at the "drop box" website, along with a link to start running the survey. When started, each participant was presented with series of streetscape movies from 30 selected streets of the study area. The movies were grouped with one forward streetscape movie with 5 backward

streetscape movies. One participant had to watch ten such streetscape groups and responded to ten questionnaire sheets. 60 participants were divided into 3 groups and the 10 streetscapes views for each participant group was given for the survey. Thus, there were 600 answers sheets for 30 different streets. The participants were instructed to find the correct backward movie for the given forward movie by watching the movies provided. He/she was instructed to watch movies one or two times only. In the questionnaire, the participant was requested to answer whether he/she could identify the correct backward movie and the visual stimuli that helpful for his/her selection. Participants were asked to rank visual stimuli according to the importance. Ranking scale was 1 to 10. Rank 1 is given for the most important visual stimuli that is helpful for correct backward movement selection or the visual stimuli that mislead the backward movie selection. Rank 10 is given for the least important visual stimuli. If the participant was unable to identify the correct backward movie, he or she has to give the reason for misleading by expressing what they observed in different streetscape views causing misidentification. In other words, participants were asked to point out the similarities they observed in streetscape visual stimuli among different streetscape views given to them.

Statistical Analysis

The data analysis was conducted in three ways.

1. Simple counting of ranks obtained by visual stimuli

The data were simply counted according to the given ranks to find out which visual stimuli got high number of priority level 1. Counting was done separately for each streetscape in each streetscape group.

2. Probability calculation of priority ranking

In this method probability of choosing each visual stimulus by the participants was calculated for each road separately by adding the priority ranks obtained by each visual stimulus.

3. Weighted probability calculation of priority ranking

In this method weights were given for the ranks and weighted probabilities were calculated for each visual stimulus ranking.

Three statistical analysis methods were used to find out the best method of analyzing the 600 survey sheets results.

Results and Discussion

Analysis of questionnaire survey results

The questionnaire survey produced a total of 600 answer sheets. The participants had given the priority ranks for the 10 visual stimuli for each road separately. The ranks were recorded for correctly identified streetscapes as well as for incorrectly identified streetscapes.

Streetscape groups

There were 3 streetscape groups. Each streetscape group had 20 participants. These 20 participants were asked to watch 10 streetscape movies containing forward and backward movies of streetscapes. Streetscape group 1 consisted of views from long streetscapes with irregular topography. Streetscape group 2 consisted of views from long streetscapes. Streetscape group 3 consisted of views from short streetscapes.

Table 1 displays the percentages of incorrect identification of streetscapes by the subjects in each streetscape group.

Table 1: Percentage of Incorrect Identification of Backward Movement along Streetscapes by the Subjects

Streetscape No.	Streetscape Group 1(%)	Streetscape Group 2 (%)	Streetscape Group 3 (%)
1	25	15	40
2	10	65	10
3	20	60	35
4	60	75	10
5	55	15	20
6	25	15	10
7	50	70	45
8	70	25	15
9	80	20	20
10	55	25	25

According to the results, from the given 10 streetscapes in streetscape group 01, the ninth streetscape was the most difficult one in remembering for bidirectional travelling. 80% of subjects incorrectly identified its backward movement view. There were 5 streetscapes with more than 50% of misidentifications of backward movement views in the streetscape group 01. In streetscape group 02, 4 streetscapes had more than 50% incorrect identifications and in streetscape group 03 there is no significant incorrect identifications of backward movement movies.

However, all most all streetscapes were misidentified in bidirectional travelling at least by one subject. Thus, the evaluated streetscapes as well as most of the planned residential/vehicle streetscapes in Japan show very similar characteristics causing identification problems in travelling. This is very ordinary among first time visitors to an area.

Figure 4 and 5 display the streetscape that most of subjects could not identify correctly in the survey. Figure 04 has taken from the starting point of the forward movement along residential/vehicle street. Figure 05 has taken from the starting point of the backward movement of the same street.



Figure 4: Starting Point View of Forward Movement along Residential/Vehicle Streetscape



Figure 5: Starting Point View of Backward Movement along the Same Streetscape

The street has very monotonous characteristics from beginning to the end. There were no any unique visual stimuli to make a good picture on the cognitive memory of the pedestrian. The architectural variation along streetscape is very low. All residential units are very similar in shapes, such as roof shapes, heights, shapes of windows and doors. Further the complexity along the streetscape is also not in a good composition. All most all residential units have same color, even in windows and doors. Windows and doors are similar in sizes and shapes and there were no significant ornaments on walls except windows, doors or any ordinary opening. There were no

significant vegetation patches along street. Generally speaking from the beginning to the end of the streetscape, the architectural variation and complexity were not in a good condition to create a memorable picture in the cognitive memory of the pedestrians. Further the length of the streetscape was comparatively longer, thus, pedestrian could not remember the visual stimuli they observed at the beginning of the road when they watch the return views. Thus, the pedestrian could not identify the streetscape when he wanted to return on the same pathway. Thus, this streetscape became the most mystifying streetscape among evaluated 30 streetscapes.

Figure 6 and 7 display the streetscape views that the subjects could identify easily in bidirectional travelling. This streetscape has some unique characters such as it starts from a residential area and it ends from a commercial area. Thus, the pedestrian has many visual stimuli along the streetscape to remember the pathway correctly in the cognitive memory. The architectural variation is in a considerable condition since the street occupied with residential units as well as commercial units. The shapes and sizes of buildings are different. Further the complexity along street is varied along streetscape. Therefore all subjects in the survey could easily identify the streetscape. Further the length of the streetscape is comparatively low facilitating the pedestrian to remember the visual stimuli along streetscape.



Figure 6: Beginning of the Forward Movement along Streetscape



Figure 7: Beginning of the Backward Movement along Same Streetscape

After evaluating streetscape identification, the next step was to identify the visual stimuli that helpful in the backward movement identification and the visual stimuli that made confusions in the identification. It was done using 3 statistical methods explained under Methodology section.

After analysis of 600 survey sheets results using 3 statistical methods, the method, weighted probability calculation of priority ranking gave the best results. Thus, the results of weighted probability calculations were explained below.

Weighted Probability Calculation of Priority Ranking

In this method weights were given to each level of priority. The weighting procedure is given below.

Priority Rank:	1	2	3	4	5	6	7	8	9	10
Weight:	10	9	8	7	6	5	4	3	2	1

For each streetscape for each visual stimuli, 20 participants of each streetscape group had given different priority levels. All these priority levels were multiplied by the respective weights and the weighted sum for each visual element for 30 streetscapes were calculated. Further the calculation was undertaken for correctly selected streetscapes and incorrectly selected streetscapes separately. Figure 08 and Figure 09 display the outcomes of weighted probability calculations.

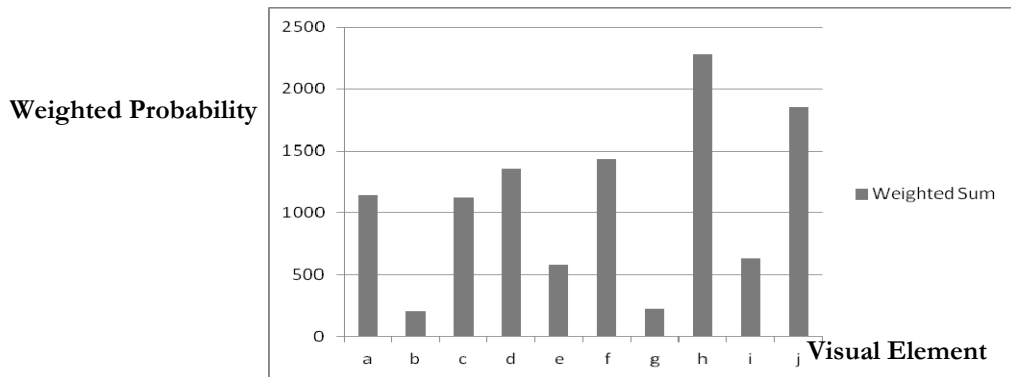


Figure 08: Weighted Probability vs. Visual Elements for Correctly Selected Streetscapes

The front fences or walls and their appearance are the most important visual stimulus in a streetscape for the pedestrians to find out their returning path in bidirectional travelling. This visual stimulus showed many variations causing a substantial complexity to the streetscape. Second most important visual stimulus is the trees along streetscapes. Street trees make the streetscape lively with the different tree cutting patterns. If a house has enough space, Japanese people use that space for gardening. Japanese gardens are very unique and attractive. Thus, if a streetscape has gardens with differ pruning patterns, then the pedestrians could easily remember the streetscape view. Further it contributes to increase the complexity along street. Thirdly, windows, doors or any other elements on houses along streetscapes were important for the pedestrians to keep the streetscape view in their cognitive memory.

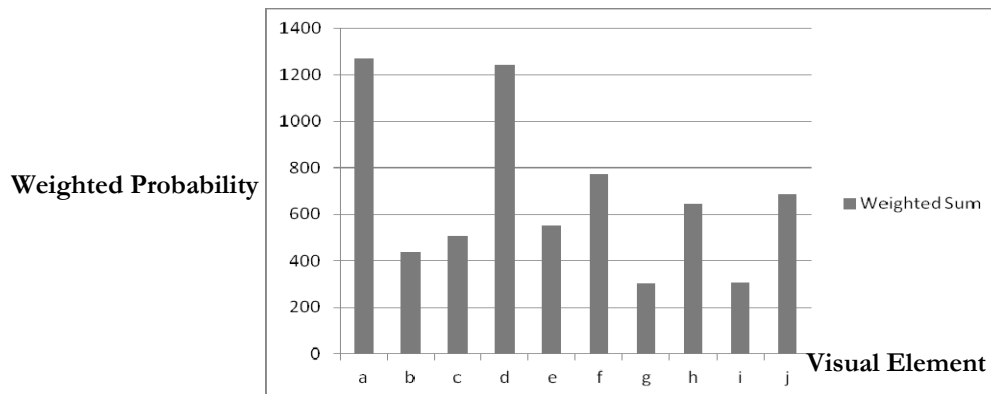


Figure 09: Weighted Probability vs. Visual Elements for Incorrectly Selected Streetscapes

Based on the weighted probability calculations for incorrectly selected streetscapes, shapes of houses were the mostly misleading visual character along streetscapes. Either sides of street have residential units with similar characters such as size, shape, roof pattern, etc. It is basically due to the landscape planning regulations of Saitama Prefecture. For each residential unit there is a fixed plot size, for single houses, for two story houses, for 3 or more story houses separately. Thus, the sizes of houses and shapes became similar to each other. Therefore, if a pedestrian tries to remember the street by just watching the houses along the street, it will practically be very unsuccessful. Secondly, color and texture of houses along streetscapes caused confusions in selecting correct returning path for pedestrians. Windows, doors or any other elements on houses were also misleading the subjects in bidirectional travelling.

The Summary of the Analysis

According to the weighted probability calculation of survey results, front fences or walls and their appearances were the most important streetscape visual stimuli for the first time visitors to the study area for easy identification of returning path. Secondly street trees were helpful for them in bidirectional travelling.

First time visitors to the study area were misled by the shapes of the houses along streetscapes. Secondly due to color and texture of houses, the pedestrians could not create a unique cognitive memory for each streetscape to find out the correct returning path in bidirectional travelling. If the streetscapes were observed, one can agree with the above results since all most all houses were painted in dull colors with nearly similar tones. Further Japanese houses have very unique architecture giving similar shapes to all houses. In other words, the architectural variation along a streetscape and among streetscapes is very low in evaluated residential/vehicle streets. It causes the low complexity among streetscapes as well.

Further, sternly use of landscape regulations in landscape planning of residential areas in Saitama Prefecture caused such similarities along streetscapes.

Weighted analysis resulted same third level of priority for windows, doors or any other elements for correctly selected views and for incorrectly selected views. Thus, these visual stimuli could not be highlighted under any event.

Conclusions

This study was an attempt to analyze the pedestrians' behavior in bidirectional travelling along residential/vehicle streetscapes. The main objective was to find out whether the planned streetscape views cause confusions in bidirectional travelling. The objective was comparable with the study results of evaluated residential/vehicle streetscapes. Building shapes, sizes, color, texture and the ornaments presented on the buildings in streetscapes caused architectural variations. In the evaluated streetscapes, the variations among these characters were very stumpy. Thus, the architectural variation along and among streetscapes were low, causing to have an unclear picture of the streetscape in the cognitive memory of the pedestrians. Visual complexity occurs with the good variations among the visual stimuli along streetscapes. However due to strictly confine to the landscape regulations in Saitama Prefecture, all most all residential areas have similar landscape patterns. It causes to have similar streetscape patterns to the streets as well. Thus, the first time visitors to the study area get confused in bidirectional travelling due to high similarities in streetscape in streetscape views within and among different streets in the study area.

The results shows that the importance of planning and designing streetscapes with some unique architectural qualities for the differentiation of one streetscape from another. It will be very helpful for the residents of the area as well as for the visitors to the area for trouble free travelling and for interesting travelling for their destinations.

This research addressed a problem occurring with the planned landscapes. Although many visual elements exist along planned streetscapes, they could not act as visual stimuli for the travelers along these streets. It is basically due to monotonous planning designs applied to the landscapes. In this research most of the pedestrians remember their returning path based on the appearances of the front fences and walls. Thus, the results prove the lack of good land marks along streets for easy and interesting travelling along streetscapes in the planned residential areas. Therefore, in landscape planning, although the planners have to follow the landscape planning rules, they can think about new designing methods of landscape to have unique architectural characteristics within the planning regulation boundaries. Then the people who use these planned landscapes will have to face minimum difficulties in their day today activities. Further, the travelers will feel

interesting in walking along such varied streetscapes. Thus, this research shows the need of such unique landscape plans for residential landscape areas in future.

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Future Directions for Fashion Design Education in Sri Lanka

Ruwandika Senanayake

Department of Integrated Design, Faculty of Architecture, University of Moratuwa
ruwandikasen@gmail.com

Abstract

The paper tries to address the key question: 'what is the role of the fashion designer in the emerging creative economy of Sri Lanka?' The answer rests upon the tasks of the Sri Lankan fashion design education and the readiness of the fashion designer qualifies via its training. Data collection was undertaken through a questionnaire in 2012. The participants were the locally qualified fashion designers who have completed their preliminary fashion design studies between 2004 and 2011. Data analysis was carried to discuss the young fashion designers' educational experience, work experience, personal goals and achievements, and consciousness about the local fashion industry. The research concludes that the fashion business and marketing knowledge, entrepreneurial skills and know global perceptions of fashion design practice are knowledge gaps within the questionnaire participants. If fashion design education adapts to the future directions of the fashion industry, Sri Lanka too can expect much advantage via its practices.

Keywords: Fashion designer, Fashion design education, Sri Lanka

Introduction

'Fashion' is a highly creative industry in the global context. Many nations enjoy economic benefits for being a participant in the global fashion industry system. Sri Lanka exposed to the system from export-oriented manufacturing end, at a time when apparel manufacturing was considered as a significant contributor for national development. Since the initiation, Sri Lanka moved up the apparel value-chain in manufacturing and today, it is renowned for quality and ethical production. At present, the industry's challenge is to achieve a sustainable economic development. In order to achieve that, both government and the private sectors have identified the potential need for fashion design to be developed into current systems. Identifying this need, fashion design education was introduced in the country to adequately prepare the fashion designers in 2000.

The fashion designer careers differ from other fashion industry career positions due to the significance of its creative practice. From the company's perspective, fashion designers are bringing economic advantage by meeting the buyer options and/or fulfilling the changing consumer demands. Designers are generally major decision makers, trend creators and inventors of new experiences. But in Sri Lanka's current situation, designers who have not reached manager level have not got the chance of making decisions that could introduce major changes to manufacturing and production.

Sri Lanka can expect much social, economic and environmental advantage via fashion design practice and the fashion designer is the identified key figure in this venture. Sri Lanka's fashion education so far has succeeded in meeting the prime need of the country, namely, filling the creative class gap within the fashion industry. The first generation of fashion graduates has taken the initial creative job vacancies in the context. They have succeeded within the system and the industry too welcomes the benefits.

The research is an attempt to examine how young fashion design talents in Sri Lanka are being shaped under the local higher education system to face the challenges and, how they are being

given an opportunity to participate in the creative economy to enhance a sustainable local fashion industry for the country. In doing so, the paper tries to address the key research question of 'What is the role of the fashion designer in the emerging creative economy of Sri Lanka?'

Data was collected through a questionnaire. It was prepared using Qualtrics web-based survey software to be answered online. It was carried out as an anonymous survey where the participants were given the freedom not to answer any question as they desired. Both open-ended and close-ended questions were included. However, online questionnaires are not very popular in Sri Lanka. Yet, the participants belong to the group those who are very familiar with global networking and have individual access to the Internet.

Identification of the sample

Since the fashion design education is introduced in Sri Lanka in year 2000, not more than 700 have qualified from all the fashion institutions up until year 2011. A sample of fifty participants from those who qualified from three selected fashion design courses were sought to take part in answering the questionnaire. The three initiatives are namely, (i) Fashion and Textile Design (BDes) – Department of Integrated Design, University of Moratuwa (UoM), (ii) Fashion Design and Product Development (BFDPD) – Department of Textiles and Clothing Technology, UoM and (iii) Fashion Design – Academy of Design. At the time of the sample identification stage, these three fashion education providers were selected deliberately as sub-groups because they were identified as the frontiers in creative fashion education in the island. However, it was identified that this specific target group is approximately 500 out of the total of 700 mentioned above. The variables in the selected category are the age from 20 to 34 years and the year of preliminary fashion education completion from 2002 to 2011.

Preparation and distribution of the questionnaire

The questionnaire was prepared under six sections; (i) personal details, (ii) educational experience, (iii) personal goals, (iv) work experience / personal achievements, (v) government collaborations and (vi) fashion industry awareness. Other than the personal details section, other five carries one open-ended question each to let them express their views at will. Yet, they were given the option not to answer any question as they wished. The main focus was to do a qualitative analysis at this exploratory research. When analysing data these sections were considered separately to get a more in-depth sense of their ideas.

To distribute the questionnaire, a snowball sampling¹ technique was used. Primarily, social-media was used to send the online questionnaire. It was only open for three months. Within the time duration the questionnaire had to reach more than fifty to be able to collect a minimum of fifty results. Through the channels the questionnaire reached approximately eighty and at the end of the given time period it was completed by fifty-six participants. Out of that there were two incomplete answers where a total of fifty-four carries useful data for the analysis.

Data analysis

As the participants are from three different courses and from different batches there can be contradictory views about their experiences. Without projecting any bias towards the course they have studied, the analysis is particularly done to discuss the common opinions of the majority. Out of the six sections that were used to prepare the questionnaire, four sections were considered to analyse data. They are: (i) *educational experience*, (ii) *work experience*, (iii) *personal goals and achievements* and (iv) *consciousness about the local fashion industry*.

Educational experience

In discussing the educational experience, main analysis is done based on the satisfaction level each claimed on the question being asked in the questionnaire, which is; '*how satisfied are you with your fashion design education?*' Apart from one participant even having 'no particular reason' saying he or she is 'very dissatisfied' with the local fashion design education received, all the others are in the views from 'neutral' to 'very satisfied'.

Table 1: Questionnaire responses to the question: 'How satisfied are you with your fashion design education?'

#	Answer	Response	%
1	Very Dissatisfied	1	2%
2	Dissatisfied	0	0%
3	Somewhat Dissatisfied	0	0%
4	Neutral	5	9%
5	Somewhat Satisfied	8	15%
6	Satisfied	24	44%
7	Very Satisfied	16	30%
	Total	54	100%

The reasoned out comments for their answers can be categorised mainly under six areas. They being due to;

- (a) the quality and the facilities of the education,
- (b) how the education helped at personal achievements and desires
- (c) suggestions, and
- (d) negative aspects

The main positive comments that highlighted *the quality and the facilities of the education* are for having 'enough resources', simple teaching methods and training under an educated local and international teaching staff. Fashion design teaching resources are very limited in the country. Therefore, it is very clear the respondent have carefully used the term 'enough resources' at the explanation. Other comments of saying the participants are satisfied due to gaining a 'very competitive' knowledge which is enough to start on own or to work for a company, having a practical education throughout and having a very supportive staff to help understand the vision while develop their creativity, also describe the quality of the education they had.

The next most noticeable factor is that majority of the positive comments are on how much has the education they had *guided them at their personal achievements and desires*. As individual achievements, the most common answer given is that they have been able to get a good job in the local export oriented textiles and apparel industry because they have qualified in fashion design. Among other reasons, the highlighted explanation that placed the education in higher position is,

'the things and the subject matters I have learnt always helped me to polish my knowledge and sharpen my skills. It helped me to climb the ladder to my dream job.'

Other interesting comments regarding personal desires are of saying, 'I really enjoy my life for what I learnt', 'as a fashion design student I never felt bored about studies' and,

'Fashion design was my passion. I define everything as fashion. Fashion...its limit-less. No barriers. And the way I learnt fashion is not just theory. I got an exposure to do what I love to do through my education.'

Some are happy for being able to apply what they have learnt, and some as well for being able to work head-to-head with other designers of world famous brands. Apart from all this, one intriguing answer was mentioning that he/she is thankful to the local free education system where he/she got the chance to become a fashion designer. All these responses, which are all positive aspects, show how much they enjoy of studying a creative field, which is specifically fashion within the local context.

The next important comment, which carries *as a suggestion*, is that,

‘if the fashion market was more developed (in Sri Lanka) it would have been so much easier to understand cycles of the fashion world.’

There is always a starting point for everything in this world. It is clear by this comment that the person specifically a fashion designer who thinks that there should be a ‘fashion industry’ in Sri Lanka but at the same time has not realised that the starting point could be initiated through him/her.

There are few *negative aspects* about the fashion training as well, and they can be useful when revising the curricula in due course. Such negative comments are mentioning of not having much resource such as, material, equipment, technical knowledge and teachers and, learning about fashion as a general design field which did not cover the important aspects that specifically relates to fashion. And these knowledge gaps have been identified only after starting working in the industry. Because fashion is a globalized subject, on the basis of considerable working experience, one respondent claimed that the education was not sufficient to achieve success internationally. And another says, the possibility of becoming a ‘real fashion designer is rare’. Use of the word ‘real’ may denote he/she is comparing the work they have to do within Sri Lanka with the renowned fashion designer’s practices of a fashion city in the Western world. Another descriptive negative comment was, ‘I was in the first batch of the (design) course. There was no fashion tutors to guide us and I mostly learnt Fashion from books.’

Within the negative comments, one positively says ‘even though it was not the perfect syllabus, the design education that I had, shaped me to who I am today’. Another similar answer was,

‘When we joined the fashion design – course – it was really new to the faculty..., with lack of resources (lecturers etc.) for us to learn. Mostly we were – guided through – experimental education – which – was so exciting for us (being all new to us). – But when we entered the industry, we realised that we have missed many things –’

According to the research findings, the above negative issues are justifiable. These fashion design courses are new to the education system in the country. Therefore teaching resources are limited; most of all, the teaching staff. If any study program does not find any subject experts locally either do not have foreign university collaborations, they are sure to have faced this situation. But in the present day, these types of replies should not be expected by any fashion education provider in the country as they are now more than a decade old in the system.

Work experience

Work experiences differ immensely with the year of completion of the fashion design education. As was expected, the questionnaire respondents are from the years 2004 to 2011. Each respondent has worked for a different length of time up to the day they answer the questionnaire since graduation. Different categories of answers show how far they have come in a career which they must have thought about greatly as a fashion design student. All those who are employed at present are generally satisfied with their careers. In analysing the work experience the data is considered in three sub categories based on the year of their fashion design training completion. They are; (1) 2004 – 2005, (2) 2006 – 2008 and (3) 2009 – 2011 [refer to table 2].

Table 2: The year of fashion design training completion and the age group, the Questionnaire participants' belong to

Year of fashion design training completion	Number of respondents	%	Age group
2004 – 2005	11	20%	32 – 34 years
2006 – 2008	19	35%	27 – 31 years
2009 – 2011	24	45%	22 – 27 years

Those who finished fashion design studies in 2004 – 2005 have passed many milestones in their career life than the rest. Starting the careers from junior positions, some have even come to manager positions having five to seven years of working experience up the ladder. Though some have held fashion merchandiser and design developer positions as well, at present all the respondents are employed in either, designing or management duties or involved in fashion design education. These positions are either fashion related or connected with self-employment. Those who mentioned as 'self-employed' are calling themselves freelance designers or entrepreneurs. This identification of being entrepreneurs is a very positive aspect in the research.

One respondent from all the questionnaire respondents who was also from this '2004-2005' category has been involved in fashion journalism as well. It is a fascinating trend to realise that a person with much fashion design knowledge, can consider a role in journalism. This is a neglected area in Sri Lanka. Fashion was never brought to life in written format with a proper fashion vocabulary. Without having the adequate fashion knowledge some journalists have tried to talk about fashion in an amateurish way that has become very annoying even to the present day.

The respondents' justifications on the question of how satisfied are they with their present employment suggest that they have secured exciting creative careers. One says, he created his dream job, which did not exist, and now he sees himself as an entrepreneur. Others say, they enjoy for having a chance to practice design and/or fashion development, being able to work for a reputable company and to work for an international brand is exciting. They do not particularly mention the income which other two categories have done.

However, many of the 2004-2005 graduates are married and seem satisfied with the careers as it is, because of personal life commitments. Marriage is a social norm in Sri Lanka where it is considered in the present day at least to get married before the age of thirty. Therefore changing careers or finding a different path even though it directs towards achieving their goals they may have had as students, seems an idle mission in their lives.

The next group consists of participants who graduated between 2006 – 2008. Those that fall in to this category have also worked in creative careers starting from junior designer positions to design manager positions at present. They exactly have followed the same fashion design related careers as the previous category did. However, being able to solve problems and showing leadership qualities, some have become design managers in the buyer accounts in the export oriented apparel companies within much shorter period of time than the previous group. Apart from one who is unemployed, all the other respondents are involved in fashion related employment where two entrepreneurs stand in the crowd as well.

Studying a fashion design course makes everyone want to practice only design anywhere in the world. But people change careers according to the context all the time. A similar descriptions given by one participant to the question how much satisfied are they with their present employment;

‘I always wanted to work as a fashion designer. But I still couldn’t and now working as a development merchandiser. However, as it is a fashion related job, I am somewhat satisfied about it.’

But whenever they get the chance to practice what they have been learning for several years they talk about it with much satisfaction. Though they learnt many other fashion industry related subjects or practiced skills within their tertiary education, they all talk mainly about wanting to do only ‘designing’. A contradictory answer is given by another who has changed her local context focus job to an export oriented job;

‘.... I was first started (working) as a fashion designer in the local industry, but thinking of going forward with the export market ... to learn more on international designing, trade and trends, – I joined the export oriented apparel industry as a product developer’

The fashion design graduates have pride when they know their design-involved products are bought by overseas customers. Therefore, the majority enjoy working in the export apparel industry. Today, some companies have moved forward with design departments where fashion design graduates are assigned to do designing using their knowledge and talents. Another mentioned, ‘They (the company) give good opportunities for hard work’. These opportunities usually have relationships with promotions and salary increases. Having mentioned that, the graduates are satisfied with the salaries they were given as well. In contrast, an entrepreneur who is also very satisfied with what she does says, ‘I am engaged in what I truly enjoy (doing). I have the authority to decide on the entire designing and manufacturing of my garments’. This explanation shows that there are some who want to do things on their own in spite of what they earn.

The third sub group of questionnaire participants of 2009 – 2011 graduates are the most recent to have entered the industry. Although they have only graduated recently few claim to have never worked in fashion related industry yet. Somehow, others are involved in fashion related design, development and merchandising jobs where they are still young in the field to get managerial positions. No any respondent mentioned they are into fashion journalism or fashion photography. But in recent times, a huge trend is seen in the country for photography, which will be another potential creative path for the fashion design graduates to consider of practicing in the future.

Having a considerable number of graduates employed in the industry at the time when the 2009-2011 cohorts entered the job market perhaps made them uncertain of securing in the field of fashion design. In that case if they get the slightest chance of employing at any fashion related job they are more than satisfied. Therefore most of the explanations for their employment satisfaction are about being able to get any job in relation to fashion design. A very simple explanation given by one respondent; ‘Now I am a fashion designer’ shows how enthusiastic it is for him/her to be recognised as a ‘fashion designer’. Apart from this type of comments, it is significant to see few commenting on having a satisfactory income, which other previous two categories have not paid much attention to.

Personal goals and achievements

Education always directs people towards achieving goals. As graduates of an emerging creative economy, the questionnaire participants too must have had many goals as students. The questionnaire asked respondents to select one of three answers or select ‘other’ to give their own explanation as to their goal as a fashion design student. The choices were; i) create my own fashion label in Sri Lanka, ii) work for a famous international fashion brand and iii) work for the export oriented garment industry in Sri Lanka.

Table 3: Responses on the question, ‘What was your goal as a fashion design student?’

#	Answer	Response	%
1	Create my own label in Sri Lanka	25	46%
2	Work for a famous international fashion brand	11	20%
3	Work for the export oriented garment industry in Sri Lanka	6	11%
4	Other	12	22%
	Total	54	100%

Majority selected the first choice and those who answered ‘other’ have also mentioned ‘*creating their own label in Sri Lanka*’ with an additional idea, such as wanting to create their own label and extend it to the international level, create their own label while working in the export industry and create their own label after getting some experience working in the industry. Those who have equalled or exceeded the expectations in achieving this goal have somehow managed to start a clothing-line under a self-owned label. But they are still at the very beginner level. Financial instability is a challenge they face. Those who have not met with the expectations do not talk about it as a failure yet. But they comment; ‘still planning to start my own business’, ‘still gathering knowledge to achieve the goal’, ‘still didn’t get the required experience to achieve the goal’ and ‘still work in process’. Another response embellishes these comments;

‘As a fashion design student I was dreaming to work with an international famous fashion brand to see and feel how a fashion designer really describes (him or herself). And (then) go for the goal of (creating) my own label. Learnt many things at implant training and when working in the industry. Working for the export industry provided me the technical and managerial skills that will be needed when creating my own label. Therefore now I have stepped a little forward with much knowledge and skill towards my own brand creation.’

All these explanations show that they are also still holding to their main goal, even though they know they have many challenges in the path. However, it is very interesting to find out that there is a good number of fashion graduates scattered all over with common expectations and beliefs, with a need to place their stamp at least in the Sri Lankan fashion industry.

The next most selected personal goal they had, as a fashion design student is to ‘*work for a famous international fashion brand*’. More than half of those who selected this claims they equalled their expectations. Some of them are satisfied by being able to work in the export apparel industry where they get the chance to work in the buyer accounts of reputed international brands. The comment which proves this is; ‘I am working for Victoria-Secret – USA brand as a regional design consultant’. Another who is short of expectations holds an opposing comment;

‘though we get to work for international fashion brands (in the export apparel industry) it’s not up to the same level (of satisfaction) as working directly to those brands.’

Another respondent has pointed out a very common issue in the job market. It is, requiring of industry experience to get a job while you need somebody to offer a job at the first place to gain experience. The related response was about the difficulty of finding an employment with a famous fashion brand where they require at least three years of industry experience. And to gain experience the most possible place is to work in the Sri Lankan apparel industry. As a recently graduated person now it is difficult to get a job in the local industry either.

‘*Working for the export-oriented garment industry in Sri Lanka*’ has not been a key goal of a majority. And even those few who selected it are satisfied at being able to get employment in such a company. This has been the choice of the minority as a goal, but when analysing data it is clear

that this is what the majority is involved in at present. And as analysed in the previous section of *Work experience*, they are basically satisfied with what they had to do by getting employed in the local export-oriented apparel industry.

Consciousness about the local fashion industry

The primary focus of the research is based on the future fashion industry of Sri Lanka. In this setup when analysing the fashion design graduates' transition to the industry, it is vital to understand their views about the current and future aspects of the fashion industry in the country. 'Fashion' is not a 'basic-need' for any country. But it can be a 'social-need'. On top of every aspect, at present the global fashion industry is a multi-billion dollar business. In the global context, Sri Lanka is only one jigsaw piece in this business as a quality apparel manufacturer.

Therefore, the question 'how do you see the present fashion industry in Sri Lanka?' was posed to the participants, who belong to the creative class in the country, specifically the group of 'Fashion designers'. The answer options were, 'as a business', 'as an art or craft', 'as a social need' and another option was placed for open explanations. This was a question which expected diverse explanations. However, only three of the total respondents have given a different explanation. One comments, 'It's a mess'. Another sees it as 'an art and craft oriented business', while the third sees, 'fashion as a small business opportunity, but apparel as a social and economic need'. Other than these three answers 67% of the participants sees fashion industry in Sri Lanka as a business opportunity [refer to table 4]. Some identified it as a social need where a very few select it as an art or craft. The participants were not asked a follow-up question to justify the selected answer. Since this questionnaire was initial research conducted in the selected context, this question was included to understand the local fashion designers' perspective about the current situation in the country. However, this question and answers could direct to further research studies.

Table 4: Responses on the question, 'According to your understanding how do you see the present fashion industry in Sri Lanka?'

#	Answer	Response	%
1	As a business	36	67%
2	As an art or craft	4	7%
3	As a social need	11	20%
4	Other	3	6%
	Total	54	100%

The majority of the participants who have seen the fashion industry in Sri Lanka as a business also see that fashion has a better future than what the country is experiencing today. If the participants, the fashion designers, were given an opportunity to create their own clothing line, the majority's selection was to do 'better fashion for moderate price'. A slightly lesser number selected 'branded clothing for a higher price' while very few chose 'branded high fashion for a very high price' [refer to table 5]. Because Sri Lanka is a developing country, 'price' is a major deciding factor for consumer buying patterns. Therefore the majority's selection is the most realistic within that context. Then again 'better fashion' means there has to be a design involvement. There is a niche market for branded clothing as well, if the brand personality carries a value for the marked price.

Table 5: Responses on the question, ‘Considering the present local consumer demands and if you were given the opportunity to have your own clothing line, what would be your target group?’

#	Answer	Response	%
1	Basic and commodity apparel for low price	1	2%
2	Better fashion for moderate price	26	48%
3	Branded clothing for a higher price	17	31%
4	Branded high fashion for a very high price	6	11%
5	Other	4	7%
	Total	54	100%

More than 80% of the respondents see fashion as a promising field in future Sri Lanka. This is a very positive answer and the justifications provide evidence for the development of plausible fashion industry in the country. The questionnaire respondents have already experienced the changes and identified several norms of the current industry that they believe are providing the basis for building a better future for fashion within the country. They are:

- i) having a developing fashion industry in the country
- ii) lot of new young designers emerging with a knowledge in fashion
- iii) having many young designers now in the industry who are trying to provide better fashion but for a common target group therefore creating a competition among them
- iv) by stepping in to the field of fashion, there exist many career paths, such as creative, technical and business

In addition another respondent claims,

‘there are potential designers who can understand the spirit of the country and can act accordingly. They will be able to do significant changes in the industry’.

These ideas all together are the existing strengths in the industry that can be advantages for a better fashion industry for the country.

Apart from that, most of the respondents have identified the demand in the market for fashion goods and the changing trends of buying patterns. The respondents identified main trends in the current local market are:

- i) people becoming more fashion conscious every day and fashion becoming a very basic statement of individuals
- ii) growing demand for unique designer wear and branded clothing
- iii) people being more cautious of design and quality rather than just price
- iv) people wanting to follow latest international trends and want to see a diversity in the market
- v) developing of different lifestyles around the fashion industry in the country

Apart from these, another very descriptive comment provides a comprehensive explanation;

‘People in Sri Lanka are now much interested in fashion and branded clothing. People see fashion as an icon in their lives. That view is gradually developing. (Therefore) there would be a better future for (those who involved) in the field (of Fashion). However, it is only happening in the major cities of the country, such as Colombo and Kandy. The reason behind this is only the people of upper middle and high (income) are interested in fashion, since they love it and can afford it.’

These give a clear identification that there are opportunities for industry development if appropriate strategies and policy settings are adopted.

However, one respondent claims,

‘I do not think we have a fashion industry in Sri Lanka yet. It’s still an apparel industry which has the monopoly among few manufacturers. People are not yet aware of fashion and only very few among them are following real fashion in each and every season. They will take few years to understand what fashion is and then they will start following it.’

The first two sentences describe the reality as seen by another fashion designer. But then again having mentioned ‘following real fashion in each and every season’ leads to many more questions. Why is it that people need to ‘follow’ what another does? And what is ‘real fashion’? In Sri Lanka what are the ‘seasons’? If a fashion designer is aware of the context more realistically he/she can answer these with a good design solution. This type of an answer again draws us back to the starting point of questioning his/her design training.

Few commented on the current strengths and some on the opportunities while few have brought explanations as suggestions. One who claimed that currently many new young designers are emerging with fashion knowledge suggests that ‘if the target markets are identified by them wisely’, there would definitely be a good future for the fashion industry in the country. Similarly another mentioned:

‘With the war ending, Sri Lanka is now an emerging market just waiting to be developed. Do believe we need to develop it wisely so that it does not become the stereotypical commercial fashion arenas we see around the world. We have a chance to combine Sri Lankan culture into our perception of fashion and market it that way to the consumer. Give the consumer a new kind of edge to their fashion experience in Sri Lanka. Make our own stamp on fashion the same way that Japan is doing.’

This explanation shows how aware some fashion designers in the current industry are about the future potential of the industry.

However, there is another set of respondents which is less than 20% of the total who do not see fashion as a promising field in future Sri Lanka. Their main concern is the economic condition of the country. They consider that the image of ‘fashion’ as very luxurious and expensive products is not suitable to a developing economy like Sri Lanka. This group of respondents suggest that the people who can afford fashion goods are only a very small fraction of the total population. And due to a low consumer base, they suggest that there will not be a successful future for fashion in Sri Lanka. This is a very narrow minded view of a minority. If the fashion design graduates are not being trained to think out of the box without just following the existing trails, there has to be loop-holes in the education they received.

Conclusion

Creative education and creative industries do not have a long history in the Sri Lankan context. It is being introduced and people are getting used to it many years after they were introduced and practiced in many other western countries. However, the questionnaire participants who belong to this new creative class of the country having been educated in the field of fashion design are a pioneering qualified creative group in the Sri Lankan fashion industry. Data collection through this type of a questionnaire among this group has not been done previously in Sri Lanka. Therefore, this attempt can be considered as a good start for the industry creative practitioners and the education providers to think beyond their usual practices and link what they have been doing with the outer world.

However, a decade old fashion design education system has provided a good number of fashion design graduates to the industry. As it is a very new experience for the youth and the industry, a lot of graduates face many problems in breaking the existing industry systems. Almost all the fashion design graduates try to enter the prevailing export oriented apparel industry in search of a job as it is the very realistic job that has been projected in front of them. Fashion design graduates have had different goals as students other than working in the apparel manufacturing industry, as example, wanting to see their own fashion label in the market. However, satisfactory conditions of the current employment opportunities do not encourage them to search for different career paths.

For those who want to break from the prevailing job system, there are many challenges in front of them in achieving their goals. Only very few have tried to step out of the usual system in search of achieving their goals. However, in the present day, there are industry collaborations of fashion designers uplifting programs around the country. Therefore, there are some realistic opportunities in front of them which could act as stepping stones. Yet, most of the designers' goals are couched in terms of economic advantage.

The reality is that the young designers, who want to have a label, are also aware of not having a customer group to market their products to. In that case, their business and marketing knowledge seems very rudimentary. Other than fashion business knowledge, entrepreneurial skills and know global perceptions of fashion design practice to succeed in the future are also their lacking areas. Lack of such knowledge has been identified as a gap in the curriculum. Within the emerging fashion industry of the country, these subjects seem highly relevant teaching areas for design students. However, these subjects have to be well thought ahead and should be merged with current world trends along with local social, environmental and economic advancements. Then the fashion designer can create new business opportunities in order to develop a designer focus industry beside the mass production for export focus that currently exists.

As the questionnaire reached the participants through social networks and further via the snowball technique, the unpublished personal feedback were very positive. Some respondents have not even realised that they do belong to a rising creative class in the country and that there is a whole group of people within that category who could do a change in the current practices. Now that a first group of fashion designers is in the industry, it is high time for the fashion design education providers to rethink the national development pattern and revise their curriculums appropriately. The national fashion industry bosses; the export oriented apparel manufacturing companies are well aware of the sustainable practices. Therefore, there is increasing awareness in the current Sri Lankan fashion industry for sustainable systems to be adopted and developed. Yet, it is not well incorporated in the education systems. This again brings back the same conclusion of the need for significant curriculum revision to take account of global fashion trends, the potential of a creative economy to drive Sri Lanka to achieve national development for the future.

Endnote

¹Snowball sampling: In this method, participants or informants with whom contact has already been made use their social networks to refer the researcher to other people who could potentially participate in or contribute to the study. Snowball sampling is often used to find and recruit "hidden populations," that is, groups not easily accessible to researchers through other sampling strategies. (Qualitative Research Methods: A Data Collector's Field Guide)

People's Perception of Revitalized Public Spaces: The Case of Independence Square, Colombo, Sri Lanka

L.P.Gangabada,

Department of Town & Country Planning, University of Moratuwa
lahirutcp@gmail.com

P.K.S.Mahanama

Faculty of Architecture, University of Moratuwa

G.Ranasinghe

Department of Town & Country Planning University of Moratuwa

Abstract

The increasing tendency of enhancing the quality of public spaces in developing countries, for example by promoting strong visual identity, is a crucial government policy instrument in economic and urban revitalization, while generating threats against the 'inclusive' qualities of these public spaces. Concerning that matter this study was designed to fulfill two main objectives: Identify the different community perceptions regarding current public space revitalization actions that are going on in Colombo and to find out how it vary with different social levels in order to discover the social inclusive/exclusive nature of those particular projects selecting Independence Square as the case study.

This paper concludes with the following results: The revitalization activities leads to further shrink the limited city space that has been used by the marginal groups while diminishing the 'inclusive' character of the public space and the city. Further, it challenges several current government policy assumptions concerning public space and give clues for urban planners and policy makers about the need of broad definition to the term "community" recognizing the so called marginal or problem groups are also a part of the community.

Keywords: Public Spaces, Urban revitalization, People Perceptions, Social Inclusion

1. Introduction

The establishment of truly 'vital and viable public spaces' which can guarantee the creation of inclusive cities has been the focus of many developed countries and more recently of developing countries too (WangP., 2002). Revitalization of public spaces is comparably new and is presently a popular phenomenon in Sri Lanka subsequent to the end of 30-years of civil conflicts. Until year 2009 during which the war came to end, the government's first priority was war rather than city development. With the end of the war, political establishments and the government have focused on developing the cities through revitalization programmes. This is to drive economic growth, improve quality of life (including health status) and images of cities, mainly in Colombo. Hence, currently, revitalization of public spaces is the central concern of most urban planners. One can witness workers being busy making roads, pavements, gardens etc, to give Colombo a much needed face lift under the city improvement and beatification programme led by the Ministry of Defense and Urban Development. Many kinds of resources have been allocated for these programmes which are top down; often led by political leaders. A question often asked is "Whether current urban revitalization programmes in Colombo fulfill the objectives and needs of all city users?".

However, it is well understood that revitalization of public spaces should be carefully considered to cater to all the urban dwellers of its use. It is also believed that only careful planning can ensure reasonable and efficient use of public spaces by all city users and avoid the negative impacts which may come about. The challenge for local authorities, planners, architects and others involved in revitalization initiatives is to take into consideration everyday people's needs, and the wider civic functions of public spaces in cities (Akkar, 2006). Thus, it is useful to have information of the community's point of view regarding public space revitalization projects.

Cities are no more homogeneous entities and have become dynamic due to diverse inhabitants. In Sri Lanka, current government urban revitalization priority is to improve the urban landscape quality by city beautification actions as a strategy for urban development. Yet different social groups have different opinions regarding these projects in the context of benefits which they perceive. Thus, this study poses the question, "What are the different community perceptions of current public space revitalization attempts in Colombo city in the context of perceived benefits to their quality of life?" It thereby raises the question 'how inclusive these projects are?'. The paper aims to address these questions by examining the public open spaces in Colombo. The main objective of the study is to identify the community perceptions regarding current public space revitalization actions in Colombo in terms of benefits which they perceived and to find out, how they vary at different social levels. This is expected to discover the inclusive/exclusive nature of those particular projects.

This research study focused only on the urban revitalization attempts in Colombo (urban landscaping and city beautification programmes). The study is based on a single case study with a limited sample. It does not deal with other stakeholder perceptions beyond the project boundary.

2. Background Studies

Identification of Community impacts of public space revitalization

Different countries have adapted urban revitalization processes with a variety of objectives. According to reviewed literature, successful urban revitalization should incorporate social and environmental policies and it should facilitate better physical change and urban development (Waever, 1973 as cited in Dayaratne 1981). Further, urban revitalization can have many positive effects. It might have economic, social and environmental benefits and improve quality of public spaces of the city. Although it has been recognized as a city development strategy, many opinions were emerged contradictory due to its bias performances favoring special social groups (Wang, 2002). Through the literature review on the impacts of similar kind of projects, following impacts can be summarized:

Table 1: List of potential impacts of PSRP

Dimensions	Positive	Negative
Socio cultural	<ul style="list-style-type: none"> • Entertainment and social opportunities for local residents • Increase in the level of local interest in the activity associated with the project • Increasing social cohesion 	<ul style="list-style-type: none"> • Dissatisfaction especially where the theme of the project does not fit the socio-cultural level of the community • Benefits are more bias towards one social group ex: elite • Exclusion of some social groups
Physical	<ul style="list-style-type: none"> • Regeneration and beautification of public areas • Construction of new facilities and infrastructure • Improving city image 	<ul style="list-style-type: none"> • the extent of this benefit depends on the long term usefulness of these facilities to the community • neglecting lower socioeconomic groups during the creation of new 'desirable middle/high class environments'
Psychological	<ul style="list-style-type: none"> • Bring a sense of belonging and sharing to the community 	<ul style="list-style-type: none"> • Rapid development may bring disruptions which may lead to feelings of alienation, and the loss of a sense of belonging or attachment to the community
Economic	<ul style="list-style-type: none"> • Increased local authority revenue • Increased demand for local goods and services • Creation of direct and indirect employment 	<ul style="list-style-type: none"> • Affordability issues
Environment	<ul style="list-style-type: none"> • Improving & managing city environmental resources 	<ul style="list-style-type: none"> • Environmental damage due to over use

Source: Compiled by Author based on literature

All together these underlying principles, objectives and criticisms suggested that any PSRP should consider the aspirations regarding the quality of life of all citizens to become a successful or sustainable public space revitalization programme. The research is designed to identify different perceptions of community on current public space revitalization projects based on these theoretical findings.

3.0 Research Methodology

3.1. Selection of the Case Study

City of Colombo is the capital of Sri Lanka and famed by neglected, deteriorating but potentially magnificent resource in terms of national development. Therefore, several attempts were taken in the recent years through massive development programs to modernize Colombo city and its surrounding. In a study of this nature Colombo will become an obvious choice in terms of above reasons as well as population, population density, multi ethnic, multi-cultural, and multi income nature in the society. Such variation leads to the diverse socio economic requirements, perceptions and ultimately distributes a heterogeneous character in Colombo. Hence public space revitalization attempts under the Metro Colombo Urban Development Project (MCUDP) were selected for study.

Selection of the case study project from Colombo city – Public space revitalization Project

Under the programme of Urban Landscaping for Recreation and City Beautification (for which the government has given priority) several revitalization projects including development of Independence Square, refurbishment of Old Dutch Hospital building at Colombo Fort, revitalization of Beira Lake and its surroundings, and development of Pettah bus terminal have been assessed with the objective of selection of case study. Finally based on below mentioned criteria, Independent / Torrington Square public space revitalization project was selected for further study.

Table 2: Case study selection Criteria & specifications

Criteria	Specification
Project type, objective and impact	Public open space regeneration projects , which were implemented with a purpose of improve the quality of life promoting diverse uses
Nature Project impacted area	Part of an urban area which is having enormous community heterogeneity
Type of access	Since the objective is to investigate community perceptions, priority was given to the common access projects which are not purposely exclusive part of community using it
Level of completion	Action project should have been completed to usable level.

3.2. Revitalization of the Independence Square Project (Project description and location)

This project is being carried out by the UDA with the aim of enhancing the stature and protecting the nobility of the Independence hall and establishing a green zone. Project is planned to be carried out over 12 stages, is anticipated to cost of Rs 350 million. Consequently work has been accelerated on the third and fourth stages of this project, which are a proposed Cultural Avenue from Bauddhaloka Mawatha to the Independence Square Development area and work in connection with the Ceremonial Entrance to the Independence Square and different kind of walking tracks.

3.3. Selection of Study Area

Based on the rationale of "Everything is related to everything else, but near things are more related than distant things" (Kolb L. W. 1954) which is known as first law of geography, the study area has been expanded to one kilometer radius towards different settlements from the independent square for the purpose of getting public perceptions.

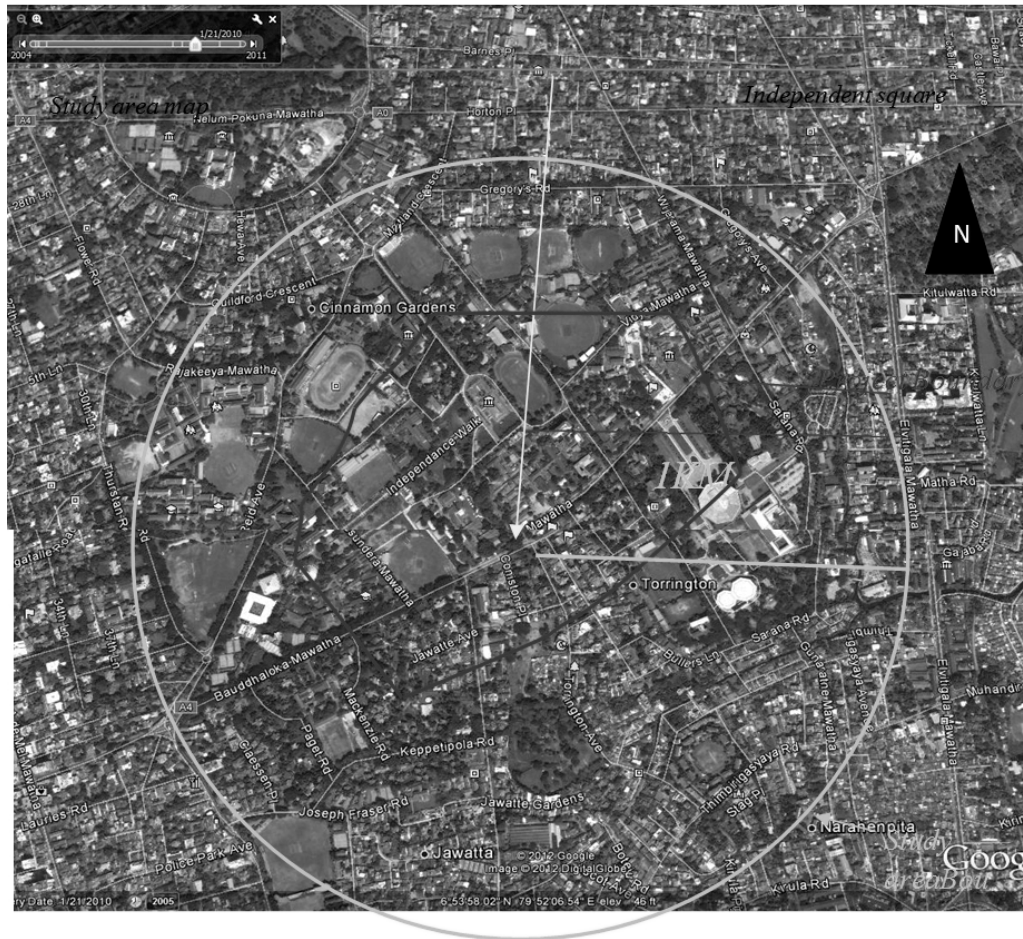


Figure1: Location of the study area

3.4. Systematic identification of deferent social groups in study area

The main objective of this research was identification of different user perceptions on selected PSRP especially from different socio economic groups. Therefore, major communities within 1km study area boundary have been selected as participants shown as in table 3.

Table 3: Specification and location of target group for study

Target group	specification	Selected area
On site participants	from people who are using project site	Independent square project site
Off site participant - City users	People who are working & gathering around study area	Torrington place, Maitland place and surrounding
Off site participant- city inhabitants	Areas selected according to the income status	Low income – 60 watta Middle income- Gunarathne rd, jawatta rd High income- Gregory rd, Torrington

Above mentioned community groups were selected to obtain true sample to get perceptions by all diverse city owners. Those community groups were identified as target group after preliminary visits to the project site and surrounding areas and according to the consultation of project maintenance team, GND officer and officers of UDA.

3.5. Survey Methods and Sampling

Observations

There are two main purposes for conducting observations in this study: one is to identify users and user behaviours and investigate the use pattern around square and observation was conducted on square site from 6:00am to 10:00pm on weekdays and weekends. The information recorded on the site includes who use the squares (i.e. age, gender, social class and tourists or local), the purpose (i.e. how do they use it), and the use density. Here the term 'use density' is describe the volume of use of squares. A 10-point scale was adapted to measure use density by the researcher, from 0.5 to 5 (every 0.5 point), in which 0.5 means that there are few people (<40) on the square, while 5 means that it is full (>400) of people.

Questionnaire survey

By considering the circumstances of this particular research, especially neediness of the identification of different perceptions on public space revitalization project, questionnaire survey adopted as main technique to collect data. Furthermore, observations and semi structured interviews were used to fill the gap creating by the questioner survey. Table 4 shows the sample method, sample size and the targeted group for experimental study.

Table 4: Specification of target group for study

Type of group	Method used for survey	Method of sampling
On site participants project users	QA, Observations & Interview, temporal basis within a weak	Stratified random sample survey
Off site participant-city inhabitants	QA & Interview	Stratified random sample survey
Offsite participant - City users (workers & consumers)	QA & Interview	Non probabilistic random sample survey

Source: Compiled by Author

Overall sample size is 104 and it consists with 38 people of high income respondents (monthly income is above Rs. 50,000), 34 and 32 samples of middle (Rs. 15,000- 50,000) and low income (monthly income is below Rs. 15,000) respondents respectively. Since perceptions of respondents of different income groups were decided to take for comparison, sample also mainly based on this categorical variable.

Preparation of Questionnaire

The questionnaire was structured with many close ended and few open ended questions to get perception of three main sections (Questionnaire is attached in Appendix B). The first was intended to get respondents profile. The second section was intended to gather perception on the particular project according to the criterions which were collected through the literature survey. And the third section mainly focused to get the overall idea about the revitalization project implementing in Colombo.

3.6. Identification of Perceptions

Criteria selection for identify community perceptions on public space revitalization projects

Perception regarding the project has been identified through predefined set of statements/questions covering objectives of public space revitalization, common issues and expectations of urban revitalization& characteristics of inclusive city which were obtained from the literature review. Based on below criterion develop the questionnaire which was used to identify the different perceptions of different social groups on particular project.

Table 5: Criteria and indicators for identify project impacts



Base of the Criteria	Dimension	Criteria	Indicator
<ul style="list-style-type: none"> Principles of Public spaces Town planning Urban design and sustainable urban regeneration Objectives of regeneration projects, Common impacts, issues and expectations of regeneration projects Nature of the selected project 	Economic	Local economic growth Affordability, economic incentives	Provision of Employment opportunities, local revenue External benefits to neighboring communities
	Social & cultural	Accessibility (for any social group) Social cohesion social exclusion Safety & comfort Effectiveness	Can everybody in-out-use (in any time) Everyone feel friendly-familiar- safe and comfortable Provision of Varsity of benefits social, economic, health
	Psychological	Belongingness Alienation	Free of fear to access Sense of belongings
	Physical	Accessibility Conviviality Usability/suitability Flexibility Connectivity Efficiency	Maintenance & management Do the elements of the projects satisfy the different community needs Opportunities for varied activities
	Environment	Environmental quality	Community satisfaction on existing natural elements Enhance natural resources

Source: By Author using literature

Identify Overall perceptions of impacts

Adopting the methods of Fredline (2000), the main dependent variables, (residents' perceptions) were measured using 32 impact statements, and participants were first asked to assess whether they believed if there were changed in particular statement due to the project and to identify the "direction of the change". If residents did perceive a change, they were subsequently asked to assess the "effect on their personal quality of life", and also the "effect on the community as a whole". Those personal and community effects were measured using a seven point scale ranging from -3 (very negative) to +3 (very positive).

Part A of each questionnaire asked whether something has changed because of the project and which direction. For example,

1a Social cohesion	Statement	Decreased 
	Because of the project many and varied opportunities for social interaction and social cohesion have	Increased 
		No change
		Don't know

Part B of the questionnaire asked participants to rate how he/she is affected personally. This reflected the effect of project on their personal quality of life. For example,

1b	Statement	-3	-2	-1	0	+1	+2	+3
	How has this affected your personal quality of life?	High negative	negative	Week negative	No effect	Week positive	positive	High positive

Part C asked to rate how it affected the community as a whole. This will reflect the overall effect on the community. For example,

1c	Statement	-3	-2	-1	0	+1	+2	+3
	How has this affected the community as a whole?							

3.7. Analytical Approach

The analysis of data of the QA survey was done by using integrated statistical method due to the nature of the questionnaire (most questions are close ended). According to the nature of answers for the first section of the questionnaire differentiated the socio-economic status of the respondents and second and third sections of the questionnaire provide different perception regarding the project which could be used as a tool for measuring the dimensions of social inclusion of the particular project and it was designed to compare perception with their socio economic conditions based on the identified category of different social groups.

Selection of technique

Respondent's answers and ratings were analyzed using integrated statistical methods in order to identify their perception on project respective to their social groups. Collected raw data were imported into the Statistics Package for the Social Sciences (SPSS) and been analyzed using SPSS techniques of ANOVA, Chi-square test and Post-Hoc analysis.

4. Analysis Results

The following section initially presents description about project users and their nature of use of the project site.

4.1 Identify the project users

In the following table 6, Results indicate that, 70% from total respondents have been used the revitalized project site (at least once) for diverse purposes. Out of them 51% are high income people (97% within high income) and 30% and 19% is middle (65% within middle income) and low income respectively

Table 6:Percentage of project use by different social groups

Project User	Social group			Total
	Low income	Middle income	High income	
% of Non use within social group	56%	35%	3%	
% of Non use within all non-users	58%	39%	3%	100%
% of Use within social group	44%	65%	97%	
% of Use within all Project Users	19.2%	30.1%	50.7%	100%

Source: Questionnaire survey

4.2. Reasons for use & non use

Through the questionnaires it was found that the project participants, non-participants and reason behind use or nonuse. Those reasons are differ according to their social levels. The descriptive analysis of the motivations of local residents to go to squares is shown in figure 2 below.

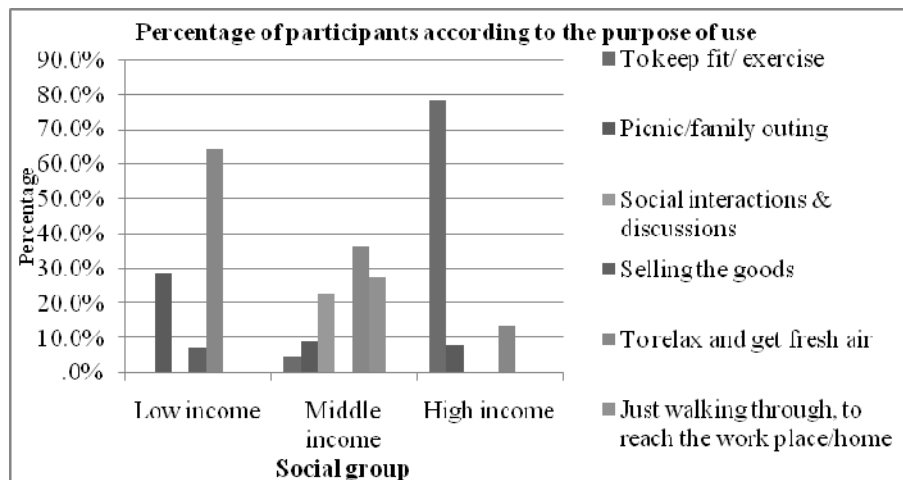


Figure 2: Purposes of use (motivation) the project site by different social groups

Source: Questionnaire survey

4.3. Social group & their nature (frequency & stay time) of use

According to the statistics, frequency of use and the duration of stay of high income group are significantly higher than the low income group.

According to the following Table 7, out of the sample of high income community, 95% is using the project site more than once a month while 24% of middle income and only 16% of low income people are using the site.

Further, a relatively large proportion of high income people (81%) use project site regularly (more than once a week) while only 14% and 7% of the middle and low income local residents.

Table 7: Frequency of use the project site by different social groups

Type of project user (participants)		Frequency of visit				Total
		less than once a month	Monthly	More than once a month	More than once a week	
Low income	% within Type of user	50%	14%	29%	7%	100%
	% within Frequency of visit	39%	29%	29%	3%	
Middle income	% within Type of user	46%	23%	18%	14%	100%
	% within Frequency of visit	56%	71%	29%	9%	
High income	% within Type of user	3%	0%	16%	81%	100%
	% within Frequency of visit	6%	0%	43%	88%	
Total	% within Type of user	25%	10%	19%	47%	100%
	% within Frequency of visit	100%	100%	100%	100%	

Result regarding stay time indicates that most of the high income participants stay on the site for 1-2 hours (46%) followed by more than 2 hours (22%). Yet usual stay time for middle and low income participants is less than 1hour (Appendix C, Table 9, 9.1). Yet it shows slight increase of stay time of those two gropes in weekends. Percentage of people who are staying more than two hours is increased by 29% of low income and 54% of middle income.

High positive correlation between frequency of visiting and duration of stay with monthly personal income (0.613 and 0.606 significant levels respectively) show the use of project site by high income groups more conveniently than other social groups. The relationships between frequency of visiting and length of stay, and monthly personal income, type of participants (social class), age group, travel mode and sex, are explored by the application of Chi-square tests.

The results shown in Table 8 reveals that there is a significant difference between use patterns and demographic and socioeconomic characteristics of local residents, except for frequency of visiting and sex (gender), frequency of visiting and age.

Table 8:Chi-Square Tests: Use Pattern

Use pattern	Characteristic	Value	df	Sig.
Frequency of visiting	Age	9.319	12	0.676
	Type of respondent	69.634	8	0.000
	Gender	5.998	3	0.725
	Monthly Income	46.459	8	0.000
	Travel mode	74.260	10	0.000
Duration of stay	Age	47.993	12	0.000
	Type of respondent	91.223	6	0.000
	Gender	43.352	3	0.23
	Monthly Income	170.857	8	0.000
	Travel mode	112.453	10	0.000

Results indicates that the dominant project user is the high income social group while very few of others groups are using the site. That has been clearly demonstrated by the results of analyses regarding to the Composition of the projects participants, frequency of use and duration of stay.

Use pattern

The observation was conducted from 6:00am to 10:00pm continuously. The use density, characteristics of users (their social status, age, and whether they are tourists or local residents), and their major activities were recorded every hour.

From the data concerning the use pattern of project site, it can be found that 7:00-8:00 and 17:00-21:00 are the most preferred periods for people to be on the Independence Square during both weekdays and weekends.

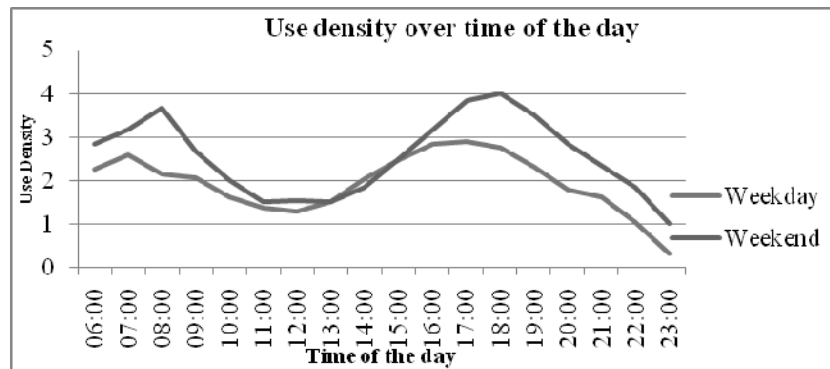


Figure 3: Use pattern of project site weekday & weekend

The changes in use density at different times for weekdays and weekends also differ according to the income level (below figure 4).

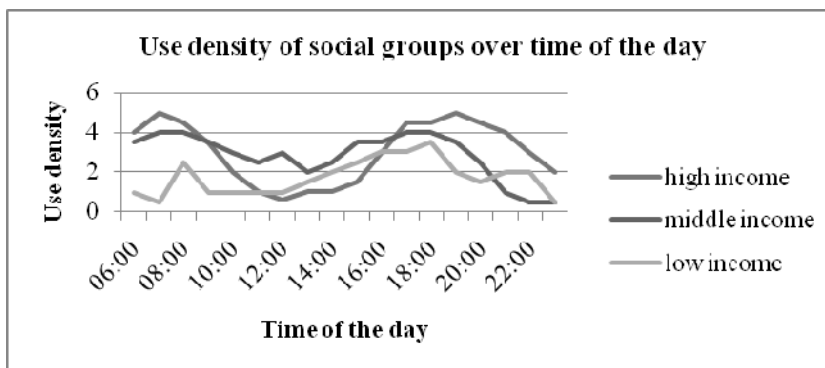


Figure 4: Use pattern of project site respect to the social groups

Source: Field observation

The site has two crests on the use density graph. Although for this revitalized Square the crests occur between 6:00-8:00 and 11:00-21:00 in weekdays, low and middle income people are mostly visiting during weekends.

4.2. Perception on Independence Square Revitalization Project

Perception on fulfilment of lacking requirements

Below table shows the perception regarding to the fulfillment of specific needs by the regenerated project site.

Table 9: Perception on fulfilment of lacking requirements

Type of respondent		Lacking requirements			Total
		health related activities (exercise)	Increasing mobility	Aesthetic & environment needs	
Low	% within Type of respondent	0%	67%	33%	100%
Middle	% within Type of respondent	36%	44%	20%	100%
High	% within Type of respondent	76%	0%	24%	100%
Total	% within Type of respondent	53%	24%	24%	100%

Overall satisfaction on results & nature

The descriptive analysis on the satisfaction level of different social groups on revitalization project is shown in belowtable10.

Table 10: Satisfaction level on project results and nature by different social groups

Type of respondent		Satisfaction results					Total
		Strongly not satisfied	Not satisfied	No opinion	satisfied	Strongly satisfied	
Low income	% within Type of respondent	69%	25%	6%	0%	0%	100%
	% within Satisfaction results	76%	62%	15%	0%	0%	31%
Middle income	% within Type of respondent	15%	15%	32%	27%	12%	100%
	% within Satisfaction results	17%	39%	85%	53%	13%	33%
High income	% within Type of respondent	5%	0%	0%	21%	74%	100%
	% within Satisfaction results	7%	0%	0%	47%	88%	37%
Total	% within Type of respondent	28%	13%	13%	16%	31%	100%
	% within Satisfaction results	100%	100%	100%	100%	100%	100 %

Although 31% of the total respondents have strongly satisfied with the project results, that differs according to the income levels. 74% of the high income respondents are strongly satisfied with the project while 76% of the low income respondents are strongly unsatisfied with the project.

Overall perceptions on impacts

Different patterns in perceptions can be observed. In the case of low income community groups, the majority (64%) indicated ‘no effect’ at the personal level, and the proportions indicating a negative impact outweighed those indicating a positive impact, resulting in a negative mean score. It is interesting to note that although the 6% of low income indicate very negative impacts at community level, no one of high income indicating a very negative impact at community level. Behalf of that 60% of high income and 74% of them indicated “very positive impacts” at personal and community levels respectively.

Table 11: Overall perceptions of personal and community impacts by each social group

Statement	Social group	very negative (-3)	-2	-1	no effect	1	2	Very positive (3)	MEAN
Overall, how does the project affect your personal quality of life	Low income	12%	11%	5%	64%	6%	2 %	0.2%	-0.5224
	Middle income	2%	2%	2%	56%	7 %	8%	23%	0.7876
	High income	0%	0%	0.2%	27%	5%	8%	60%	2.0124
Overall, how does the project affect community as a whole	Low income	6%	8%	4%	28%	15%	23%	16%	0.7373
	Middle income	5%	6%	3%	20%	13%	14%	40%	1.3262
	High income	0%	0%	0.2%	16%	4%	6%	74%	2.3733

When tested using ANOVA (impact level \times different groups), the significant variance was observed for different social groups and also between personal and community effects.

Perceptions on specific impacts

Frequency analysis was performed comparing the relationship between the perception of different social groups and the perceived direction of change of the impacts. In an effort to simplify these results, Table 14 shows only the direction of change perceived by the largest proportion of the respective sample.

High income respondents have been always indicated the direction of impacts towards positive track (by giving answers as agree, increased or better) while low income respondents have indicated their perception regarding change towards negative direction. For the statements regarding social impacts majority of low income and two third of middle income respondents have been indicated negative responds, statements such as “Comfortably at the site” (91%, 62% - disagreed), “Promotion of better community balance and integration” (Decreased- 91%,79%), “Promotion of equal opportunity to access” (Disagree - 91%, 65%).

Table 12: Perceptions on direction of change for specific project impacts

No.	Project Impacts	Low income		Middle income		High income	
		Direction	%	Direction	%	Direction	%
1	Appearance of the area around the site	Better	81.3%	Better	85.3%	Better	97.4%
2	Quiet and peaceful atmosphere of the site	Decreased	59.4%	Increased	70.6%	Increased	97.4%
3	Pride of residents have, on their city	Increased	65.6%	Increased	85.3%	Increased	92.1%
4	Comfortably at the site	Disagree	90.6%	Agree	61.8%	Agree	100.0%
5	Maintenance of public facilities	Better	53.1%	Better	82.4%	Better	86.8%
6	Cleanness of the vicinity	Better	100.0%	Better	100.0%	Better	100.0%
7	Safety & management of environment	Better	96.9%	Better	94.1%	Better	94.7%
8	Employment opportunities	No change	75.0%	No change	50.0%	No change	52.6%
9	Property values of the vicinity of the site	Don't know	53.1%	Don't know	55.9%	Don't know	60.5%
10	Decrease expenditure to some services (ex: payment to gym)	Agree	50.0%	Agree	47.1%	Agree	36.8%
11	Opportunities for local business	No change	56.3%	No change	35.3%	No change	55.3%
12	Promotion of better community balance and integration	Decreased	90.6%	Decreased	79.4%	Increased	94.7%
13	Promotion of equal opportunity to access	Disagree	90.6%	Disagree	35.3%	Agree	97.4%
14	Encouragement of different people for different Activities	Disagree	75.0%	Agree	64.7%	Agree	92.1%
15	Equal chance to access and enjoy with family and friends	Decreased	93.8%	Increased	55.9%	Increased	97.4%
16	Opportunities to meet new people	No change	81.3%	Increased	67.6%	Increased	92.1%
17	Friendly behavior of society	No change	56.3%	Increased	67.6%	Increased	88.2%

18	Facilities available to local residents have.....	No change	65.6%	Increased	47.1%	Increased	92.1%
19	Number of people around the site	Increased	96.9%	Increased	100.0%	Increased	100.0%
20	Identification of needs by Project priority elements	Disagree	93.8%	Agree	67.6%	Agree	94.7%
21	Placement of elements orderly for requirements	Agree	84.4%	Agree	73.5%	Agree	81.6%
22	Ability of use project at any time during day	Agree	65.6%	Agree	76.5%	Agree	76.3%
23	Improvement of physical health & mental health	No change	68.8%	Increased	61.8%	Increased	100.0%
24	Pleasant feelings in daily life	No change	59.4%	Increased	73.5%	Increased	97.4%
25	Collective enjoyment of life and sense of belongings	Decreased	87.5%	Increased	67.6%	Increased	100.0%
26	Opportunities for entertainment and other various activities	Increased	78.1%	Increased	88.2%	Increased	84.2%
27	Social, moral values and self confidence	No change	68.8%	Increased	52.9%	Increased	97.4%
28	Parking availability in the vicinity	Increased	78.1%	Increased	94.1%	Increased	81.6%
29	Interactions between locals and tourists	Increased	84.4%	Increased	73.5%	Increased	78.9%
30	Priority for local community rather than tourists	Disagree	78.1%	Agree	64.7%	Agree	94.7%
31	Stimulation of local the economy by Income of the site	Disagree	68.8%	Not change	47.1%	Not change	50.0%
32	Getting the maximum return for invested public money	Disagree	93.8%	Disagree	52.9%	Agree	92.1%

Table 13 presents the mean scores of residents' perceptions of each impact on personal quality of life and overall community well-being (that is, Parts B and C of the dependent measure).

Table 13: Perceptions of specific project impacts on personal and community quality of life

No.	Project Impacts	Mean personal value rating			Mean community value rating		
		Low	Middle	High	Low	Middle	High
1	Appearance of the area around the site	.3125	1.2059	2.6842	1.5000	1.9118	2.8421
2	Quiet and peaceful atmosphere of the site	-.1563	1.2353	2.6579	.5000	1.4412	3.0000
3	Pride of residents have, on their city	.0313	.6765	2.0789	1.5313	2.2647	2.7632
4	Comfortably at the site	-1.6875	.2941	2.8947	-.2188	.5294	3.0000
5	Maintenance of public facilities	-.0625	1.1471	2.1622	1.7188	2.5294	2.6053
6	Cleanness of the vicinity	.5625	2.0000	2.7632	2.0938	2.4412	3.0000
7	Safety & management of environment	.3438	2.2059	2.8421	2.0625	2.5588	2.8421
8	Employment opportunities	-.0625	-.0588	.0000	.0000	.0000	.2632
9	Property values of the vicinity of the site	.0000	.0000	.0000	.3125	.2353	.3947
10	Decrease expenditure to some services (ex: payment to gym)	-.0313	.5588	.0526	.9375	.9412	.7105
11	Opportunities for local business	-.2188	-.0294	.0000	.1563	.6176	.7105
12	Promotion of better community balance and integration	-2.2188	-.4412	2.8421	-2.7500	-1.5588	2.8421
13	Promotion of equal opportunity to access	-2.5313	.3529	2.5526	-1.8750	-.3529	2.8947
14	Encouragement of different people for different Activities	-1.7188	.5294	2.7632	.6875	1.9118	2.7632
15	Equal chance to access and enjoy with family and friends	-1.8750	-.5294	2.0789	1.0000	1.0000	2.8158
16	Opportunities to meet new people	.1250	1.6471	1.9211	1.0313	2.3824	2.7211
17	Friendly behavior of society	.1250	.7353	2.3421	.8438	1.7059	2.6053

18	Improvement of facilities available to local residents	-.0313	.6176	2.6579	2.0938	2.1176	2.7368
19	Number of people around the site	-.6563	.5588	1.0000	.8438	1.6765	2.4474
20	Identification of needs by Project priority elements	-2.0313	.7941	2.7632	-.1250	.8824	2.7632
21	Placement of elements orderly for requirements	.2188	1.3529	2.1842	1.8125	2.1176	2.4474
22	Ability of use project at any time during day	.1250	1.2941	2.6053	1.6563	2.2353	2.9211
23	Improvement of physical health & mental health	.2188	1.2353	2.3684	2.4375	2.8824	2.8421
24	Pleasant feelings in daily life	.3438	1.8235	2.8421	.7188	1.1471	2.8421
25	Collective enjoyment of life and sense of belongings	-1.8125	.6765	2.8421	1.4688	1.7647	3.0000
26	Opportunities for entertainment and other various activities	.0000	1.2941	2.7632	1.2813	1.7353	3.0000
27	Social, moral values and self confidence	-.5625	.5882	2.3684	.9688	.8235	2.2632
28	Parking availability in the vicinity	.1563	1.2647	2.2105	1.4688	2.0294	2.3158
29	Interactions between locals and tourists	.0000	.4530	.0000	.3750	1.3235	2.2632
30	Priority for local community rather than tourists	-1.0938	1.4118	2.8421	-.7813	.9706	2.6842
31	Stimulation of local the economy by Income of the site	.0000	.0000	.0000	.0938	.2059	.4737
32	Getting the maximum ,return for invested public money	-2.5313	.7647	2.3158	-.2500	-.0294	2.4737

An ANOVA (one way) with the Post hoc test was used to examine the variance of the mean scores between different social groups. The significance of the mean difference has been varied according to the statement. According to the findings, perceptions regarding specific impacts were differed according to the income levels. According to the perception of high income respondents, they indicated that they are having positive impact regarding all impacts at personal as well as community levels. Although low income respondents indicated positive impacts at community levels, regarding some impacts they indicated they are having negative impacts at personal level.

For statement such as “number of people around the site” and “social, moral values and self-confidence”, low income perception resulted negative value (-.5625, -.6563 respectively) while high income respondents resulted positive values (2.4474, 2.2632 respectively). According to the total mean values as shown below, there is negative mean value regarding impact at personal for low income respondents, while mean values regarding impacts at community level for three groups have been gradually increased (low to high income).

Table 14: Means of specific project impacts on personal and community quality of life

Personal(Total)				Community(Total)			
Low	Middle	High	Total mean	Low	Middle	High	Total mean
-0.5224	0.7876	2.0124	0.8317	0.7373	1.3262	2.3733	1.5276

Since middle and high income respondents have resulted positive mean score though low income indicated negative value, resulting in a positive mean score as personal total mean. For all three social groups, the perceived benefit at the community level is significantly higher than at the personal level. According to the high income respondent's perception, most perceived impacts by the project at personal level and community level are "improvement of physical health and mental health" and "improving quiet and peaceful atmosphere" respectively while "safety and management of environment" and "improvement of physical health and mental health" were resulted by middle income as most perceived impacts by the project at personal level and community level. According to the low income perception "improvement of the cleanness of the vicinity" was resulted as most perceived impact at personal level and "improvement of physical health and mental health" as at community level.

Below Table 15 shows the resulted impacts as "most perceived benefits" by the project, according to the overall perception of all respondents.

Table 15: The most strongly perceived benefits of the project according to the perception of respondents

Personal benefits	Mean	Community benefits	Mean
Safety & management of environment	1.8654	Improvement of physical health & mental health	2.7308
Cleanness of the vicinity	1.8365	Cleanness of the vicinity	2.5385
Pleasant feelings in daily life	1.7404	Safety & management of environment	2.5096
Appearance of the area around the site	1.4712	Improvement of Facilities available to local	2.3365
Opportunities for entertainment and other various activities	1.4327	Maintenance of public facilities	2.3077
Ability of use project at any time during day	1.4135	Ability of use project at any time during day	2.3077
Improvement of physical health & mental health	1.3365	Pride of residents have, on their city	2.2212
Quiet and peaceful atmosphere of the site	1.3269	Placement of elements orderly for requirements	2.1442
Opportunities to meet new people	1.3077	Appearance of the area around the site	2.1250
Placement of elements orderly for requirements	1.2788	Collective enjoyment of life and sense of belongings	2.1250

According to the perception of all respondents, the environmental and physical benefits are the mostly perceived benefits by the project while social and economic benefits are ranked as least

perceived benefits. Table 16 shows the resulted impacts as “least perceived benefits” by the project according to the overall perception of all respondents.

Table 16: The least perceived impacts of the project according to the perception of respondents

Personal benefits	Mean	Community benefits	Mean
Opportunities for local business	-.0769	Promotion of better community balance and integration	-.3173
Employment opportunities	-.0385	Employment opportunities	.0962
Property values of the vicinity of the site	.0000	Stimulation of local the economy by Income of the site	.2692
Interactions between locals and tourists	.0000	Property values of the vicinity of the site	.3173
Stimulation of local the economy by Income of the site	.0000	Promotion of equal opportunity to access	.3654
Equal chance to access and enjoy with family and friends	.0096	Opportunities for local business	.5096

According to the perception regarding benefits some benefits were resulted as least perceived. Yet it also differs according to the income levels. Particularly, low income respondents have been ranked “Promotion of equal opportunity to access”, “Getting the maximum, return for invested public money”, “Promotion of better community balance and integration” as least perceived benefits at personal level while “Increase Employment opportunities”, “Property values of the vicinity of the site” and “Opportunities for local business” have ranked as least perceives according to the high income’s perceptions.

Overall mean values revealed that high income respondents have fully agreed with the project due to delivered benefits to their personal quality of life as well as for the community while other two groups have respectively less agreement about project and its benefits.

4.0 Conclusion

Public space revitalization projects are concerned on the benefits of the city and its users. Therefore, they should be appreciated and used by the people. The importance of urban squares in urban public life has been addressed by many scholars and other professionals. However, this particular study reveals the significant variance of the perceptions between different social groups regarding their quality of life, further it reveals that high income group’s perception extensively favored for current revitalization projects whereas low and middle income groups raise criticisms against it, since not considering their requirements in such projects. Subsequently, several conclusions can be drawn from the findings of this study on the significance of variance of the perceptions regarding current public space revitalization projects.

According to the research hypothesis most of PSRPs are often achieving preferences of elite groups only. Partially align with that hypothesis, results revealed that perceptions and satisfaction levels were differed according to the social classes and most benefited and satisfied group is the high income community (positive perception regarding project benefits gradually diminishing with social levels, high to low income). Perceptions regarding most of community level impacts on quality of life are approximately common to all groups while recording significant variance in personal level impacts. There was huge difference regarding perception of social benefits of the project rather than Physical and environmental achievements (more similar in different social groups perspective) of the project.

It is quite clear that urban public open spaces are vital element in urban daily life and study found that revitalized public open spaces are rarely used by the entire public. The examination of the PSRP discovered that, with its diminishing variety of users and strict control measures, it is presently serving a more 'homogeneous' public for homogeneous activities than it used to do. And it is increasingly characterized more towards enhancing social exclusion and stratification. Yet, as a public space, it is still accessible to whole society. Otherwise revitalization attempts will reason to further shrink the limited city spaces which have been used by the marginal social groups.

The construction / revitalization of public spaces in the city area is not a waste of money or land resources, it can generate more social benefits and has become a productive strategy for city environment and social quality improvement, yet since these projects use public money, opportunities should equally transfer to the each income level. Therefore, elements which cater the needs of each social group should be included into the project. Otherwise public spaces will be only for high income groups while excluding majority.

The research challenges several current government policy assumptions concerning public space. The 'urban revitalization' agenda appears too concerned with matters of urban design and city beautification and become playing field of elite avoiding the marginal groups using the public space who are key actors in contemporary cities. Therefore, it is important for policy makers and practitioners to recognize that so-called marginal or problem groups such as poor communities are also a part of the community.

List of Abbreviation

PSRP	Public Space Revitalization Projects/Programs
UR	Urban Revitalization
URP	Urban Revitalization Project
CMC	Colombo Municipal Council
MI	Monthly Income
UDA	Urban Development Authority
UD	Urban Development
GN	Grama Niladahri
MCUDP	Metro Colombo Urban Development Plan
SL	Sri Lanka

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Colour associated thermal perception (CTP): Evidence from an experimental research design implemented in Sri Lanka.

Anishka Hettiarachchi,

Department of Architecture, University of Moratuwa, Sri Lanka
anishka_h@yahoo.com

Nimal de Silva,

Professor Emeritus, Faculty of Architecture, University of Moratuwa, Sri Lanka
tknpdesilva@gmail.com

Abstract

Colours have been hypothetically recognized to alter perceived temperature and thus differentiated as warm colours and cool colours, even though not satisfactorily supported via scientific inquiry. Given that this association could be generalized, the current investigation proposes its integration to create the optimal perceived thermal milieu demanded by human activities in built environment eventually working as a potential hybrid approach for energy conservation. In order to comprehend the logic behind warm-cool dichotomy of colour perception and to provide scientific explanation on its nature, emergence and significant factors, an experimental research design was adopted with reference to red and blue associated thermal perception (RTP and BTP).

It was affirmed that a warm RTP and a cool BTP can be generalized. Colour blind subjects were found to perceive the same suggesting possibilities of CTP beyond visual perception. Colour associated thermal perception was found to be more of a psychological response. One's psychological state triggered by colour stimuli, preference to exposed coloured environment and the preconceived, learnt ideologies molded by educational background were found to have a significant impact on both RTP and BTP. Further, BTP was found to have relationship with subject's age, and the surface temperature of blue work station while subjects' favorite colour was significant for RTP. Accordingly, CTP was found to emerge as a subtle, complex combination of several layers; psychological, learnt, external as well as certain un-revealed factors.

Keywords: Warm colours, Cool colours, Colour perception, Thermal perception, Colour associated thermal perception

1) Introduction

The meaningful integration of colour to create optimum built spaces transcending its typical aesthetic and beautification value has been identified in the current study as a vital necessity in the contemporary field of architecture, landscape and interior design. Careful integration of the fixed psychophysiological effects of colour to manipulate human thoughts, feelings and behavioral responses in built environment to set the milieu demanded by the activities, have been increasingly attempted in this regard. For instance, use of red in restaurants to increase table turnover (Singh, 2006), pink in detention centers to suppress aggressive behavior of inmates (Schauss, 1981), blue street lights to prevent street crimes and suicides McClatchy (2008) and Shimbun (2008), are few such attempts. Colour is further distinguished for its ability to alter perceived dimensions and properties of space; height, width, depth, scale, proportion, weight, and temperature. A long – favored hypothesis maintains that colour has the power to suggest warmth or coolness (Mahnke & Mahnke, R. H, 1996). This investigation is focused on the said unique ability of colours to alter human thermal perception (CTP).

Colours have been hypothetically recognized to alter human thermal perception. Theory of colour distinguishing this relationship, clearly differentiates between “warm colours”; red, yellow

and orange and “cool colours”; blue, green, purple. This warm/cool dichotomy of CTP has been recognized by the author as a vital yet a barely utilized potential in designing built spaces. Lack of ample scientific evidence to comprehend on the nature, emergence and potentials of CTP has been identified as the main problem, which is the sole driving force of this investigation. Principally, it was attempted to obtain a comprehensive understanding on the logic behind CTP with reference to a warm colour (red) and a cool colour (blue) i.e RTP –Thermal Perception triggered by red colour and BTP – Thermal Perception triggered by blue colour.

The study further attempted in,

- a. Providing scientific justification for dual nature of CTP; revealing the nature and emergence; whether it is a psychological response, a biological response, a response which transcend beyond visual perception (via examining colour blind subjects), a property of the colour (surface colour) which contributes to room temperature enabling a warm/cool TP, or a combination between several of or all these suppositions.
- b. Identifying significant predictors contributing to CTP and their relationships.

Given that CTP could be generalized among all humans, it could contribute to architects, interior designers, landscape designers etc to integrate colour to aid the perceived optimal thermal ambience/milieu demanded by human activities in built environment. With further R&D, the above strategy has greater potential to be integrated as an effective hybrid method of energy conservation where colour becomes an energy conservation tool; application of warm colours in cool climatic region will contribute to energy conservation and vice versa. Accordingly colour will be a decisive factor that needs to be considered in developing effective energy saving applications in future.

2) Background

The basic theory under consideration is the principle of duality in human existence and the dual nature of human activities; stimulated vs pacified. Identifying a parallelism in dual impacts of colour on human existence based on wavelength and frequency as the basis for the theory of warm/cool distinction has been recognised; warm colours (high wave length colours) to have a stimulating, arousing effect and cool colours (low wave length colours) to have a pacifying, sedating, relaxing effect on humans (Plack & Shick, 1974, Wineman, 1979, Walters et al 1982, Whitfield & Wiltshire, 1990, Stone, 2001 and Ballast, 2002). Accordingly, the study suggests a parallelism between duality of human activities and TCP and is supposed to be integrated effectively to support human activity in built environment via setting the corresponding arousal, emotional and thermal ambiances;

Warm colours: To create warm, simulative, energetic ambience facilitating active and energetic activities; e.g. - eating, playing, shopping, and exercising.

Cool colours: To create sedative, pacifying or contemplative ambience facilitating calm and concentrated activities; studying, reading, drawing, and contemplating.

CTP was considered as unification between two significant paradigms of perception; colour perception and thermal perception where two different processes are involved. As a main assumption, the parameters pertaining to human thermal comfort (Fanger, 1970, Wilson and Belshe, 2001) was considered as applicable to CTP as based on the logic that thermal comfort is

an outcome of thermal perception. On the other hand factors contributing to colour perception was identified via a thorough literature review of which Mahnke's (1996) colour experience pyramid that explains the subtle psychological layers of colour perception was significant. The research was designed to control the predictors of thermal perception and colour perception supposedly pertaining to CTP as best as possible.

3) Hypothetical research questions

Principally it was hypothesized that CTP can be generalized among all humans. Accordingly it was assumed that RTP will be warm and BTP will be cool to a majority of the subjects.

Four hypothetical research sub questions were considered in exploring the nature of the CTP

a. **A fixed biological reaction?**

It was assumed that an actual change in the body temperature is taking place enabling warm vs cool CTP. Temporal Artery Temperature (TAT) was considered to represent body temperature (Hebbar et al, 2005, Lawson et al, 2007, Hegner, Acello and Caldwell, 2012).

b. **A Psychological reaction?**

Possibility of CTP to be a subjective/learned psychological reaction molded with socio, cultural, religious influences and mannerisms (Mahnke, 1996).

c. **A change in the external thermal environment?**

Caused by colour leading to altered CTP due to properties of each colour applied ; colour reflective value, colour absorption coefficient will alter the applied surface temperature and consequently effecting CTP.

d. **CTP beyond vision?**

Possibility of CTP to be a combination of both visual and skin perception, a union of two sensory pathways suggesting synesthesia; triggering one sensory path leading to the processing of another sensory organ; a cross link between the visual sense and the thermal sense (Mahnki, 1996) was considered via studying colour blind subjects in this regard.

4) Research Design

4.1) Output variable / Dependent Variable (DV) – RTP and BTP

Three identical workstations painted in White (WWS), Red (RWS) and Blue (BWS) were located in a controlled lab environment and the thermal perception in the RWS (RTP) and thermal perception in BWS (BTP) were tested while using the WWS as a control.

4.2) Predictors /Independent Variables (IVs)

The following tables summarise all the predictor variables suspected to have an impact on the DV based on literature, and how such variables were controlled during the experiment. Since the investigation is on colour associated thermal perception, predictors pertaining to both colour perception and thermal perception were considered.

4.2.1) Participant IVs having an impact on Colour Perception

Variable	Controlling measures/ Data
Condition of eye sight	Couldn't control as participants were selected via simple random sampling. (Blind/colour blind subjects avoided). Vision was identified as a confounder (Normal vs Impaired) and included in the regression model.
Age	Included in the regression model in three categories.
Gender	Restricted only to a <u>male sample</u> to assure more accuracy in data.
Personal variations of perception molded by socio, cultural, religious, topographical, climatic and experiential constructs	Cannot be controlled- Included as a confounder. (Psy)
Sensitivity towards external stimuli ;warm /cool conditions (Dermal perception – Conditions of the skin)	Cannot be controlled- Included as a confounder. (Sen_cool and Sen_warm)
Health condition (e.g. Increased blood sugar levels will decrease vision)	Controlled via a vigorous screening process; Medical checkup.
Colour preferences/ favorite or least favorite colours	Cannot control. Included in the model (Pre and FVC)

Table 1: Participant Variables of Colour perception

4.2.2) Control - Situational IVs having an impact on Colour Perception Properties of the applied colour in workstations

<ul style="list-style-type: none"> ▪ Colour reflectance value (Could have a bearing on the thermal environment in WSs contributing to TP.) 	<p>Cannot fix as it is a property of colour- Differ from colour to colour (black 0% and white 100%) (DATA –SFT) Surface temperature readings to capture any possible change of WS temperature due to reflectance of colour radiation.</p>
<ul style="list-style-type: none"> ▪ Colour absorption, (Could have a bearing on the thermal environment in WSs contributing to TP.) 	<p>Cannot fix as it is a property of colour - Differs from colour to colour. (DATA –SFT) Surface temperature readings to capture any possible change of WS temperature due to absorption of colour.</p>
<ul style="list-style-type: none"> ▪ Emissivity (Could have a bearing on the thermal environment in WSs contributing to TP.) 	<p>Cannot fix as it is a property of colour - Differs from colour to colour. (DATA –SFT) Surface temperature readings to capture any possible change of WS temperature due to absorption of colour.</p>
Area applied,	Controlled – Applied on the walls of WSs of identical dimensions in equal amounts.
Thickness of the paint coat,	Controlled – Applied 2 coats in all three WSs.
Finish (Texture; mat, gloss, semi gloss),	Controlled – Maintained the same matt finish.
Colour combination (Effects of single colour, two colours, three colours) ,	Controlled by applying a flat single colour.
Pattern	Controlled by applying a flat single colour.
Colour selection method. Additives colour method was used to generate colour. Criteria for colour selection was based on available theory; Red to be the warmest colour, blue to be the coolest colour representing the two opposite polarities of colour perception and response. White was selected to	<p>Colour selection was done based on the RGB colour model; Require Pure Hue</p> <div style="display: flex; align-items: center; margin-top: 10px;"> <div style="border: 1px solid black; width: 100px; height: 20px; background-color: white; margin-right: 10px;"></div> <div>White - RGB 255,255,255</div> </div> <div style="display: flex; align-items: center; margin-top: 10px;"> <div style="background-color: blue; width: 100px; height: 20px; margin-right: 10px;"></div> <div>Blue – RGB 0, 0,255</div> </div>





<p>represent the neutral state. Colour specification based on the RGB colour model; Also it was attempted to obtain the purest hue (Red – 255, 0, 0, Blue – 0, 0,255, White - 255,255,255) with the assistance of Causeway Paints. Due to the impossibility of mixing paint to create the exact RGB values, Causeway Paints research team at Holland head office was consulted for advice. The RGB values of closest purest hues to be mixed via the Colour box as specified by the specialists from Netherlands were as follows. (Jolanda de Jong, Technical Sales Tinting Systems, Ralston Colour & Coatings B.V. Russenweg 2-4, P.O. Box 205, NL-8000 AE Zwolle, The Netherlands)</p> <p><u>White – 255,255,255</u> This is pure white: Base white with additional AQ40 colorant (for 1 litre base white, add 150 shot AQ40).</p> <p><u>Blue – 0, 0,255</u> Most bright blue in colour fan is H03810, but RGB is 10, 111, 175</p> <p><u>Red – 255,0,0</u> Most bright red in colour fan is H00820, but RGB is 193, 57, 48</p>	 Red – RGB 255, 0, 0 The closest purest hue which could be obtained by Causeway paints are as follows.  White - RGB 255,255,255 (1litre base white, add 150 shot AQ40).  Blue – RGB 0, 0,255 Most bright blue in colour fan is H03810, but RGB is 10, 111, 175  Most bright red in colour fan is H00820, but RGB is 193, 57, 48 (Even though the above samples appear to be pale on computer screen the applied colours came very close to the proposed colours)
Lighting level	(The level of lighting received by each WS will have an impact on the dependant variable.) It was controlled by maintaining a uniform lux level (350 lux) in each workstation.
Time of exposure to coloured surface / environment	Was fixed to 15minutes in RWS and BWS and 10 minutes in WW's.

Table 2: Situational Variables of Colour perception

4.2.3) IVs having an impact on - Human Thermal Perception- Situational Variables

Being an empirical research, a thorough literature review was done and extensive discussions were taken with renowned medical practitioners and scholars. This helped in identifying and controlling the predominant factors (Internal and external or personal) pertaining to human thermal perception.

Considering the fact that thermal comfort is an outcome of thermal perception, already established factors pertaining to human thermal comfort were considered. (Fanger 1970, Parsons 1993, Wilson and Belshe 2001, Zhang et al., 2004).Further additions were done based on the review of literature.

Variable	Controlling measures
Air temperature	Controlled in a laboratory condition. Temperature was maintained at a constant level (26°C).
Radiant temperature	Controlled in a laboratory condition
Humidity	Controlled in a laboratory condition
Air movement	Controlled in a laboratory condition

Table 3: Situational Variables of Thermal perception

4.2.4) IVs having an impact on - Human Thermal perception- Participant Variables

Metabolic heat production Most essential personal variable of the perception of thermal comfort).	Cannot control as the subjects were selected via simple random sampling. BMI value was included as data in the regression model. (Asian average BMI= 19-23 Kg/m ²)
Clothing insulation	Controlled by making the subjects wear a fixed dress with <ul style="list-style-type: none"> ○ The same material - Cotton ○ Same colour - Black ○ Same body coverage
Natural body responses- (thermo regulation process that constantly balances both heat gain and heat loss from the body)	This was supposed to be controlled automatically when all the external parameters are fixed and maintained at a constant level.
Activity level (The body generates heat at widely varying levels depending on activity contributing to TP)	Controlled by allowing the participants to get involved in identical activities in each WS; comfortably seated and filling the questionnaire. (Participants were given guidelines to refrain from any hard physical activity prior to the trial)
Reactions to CO and other chemicals	Controlled by making the laboratory environment free from chemical stimuli.
Conduction from body	Direct contact with cold surfaces was avoided in WSs; The worktop and the chair to be seated made of timber. Specially designed identical slippers to avoid direct contact with the floor.

Table 4: Participant Variables of Colour perception

4.2.5) Factors leading to core body temperature resulting a change in Thermal Perception (DATA - Temporal Artery Temperature)

Ambient Temperature – (DATA – WS temperature)	Controlled via conducting the study in a controlled lab environment (26 °C).
Time of the day; Circadian rhythm	Test time zone (TTZ) included as a data in the model.
Individual variations	This was included in the model as Temporal Artery Temperature values. (TAT)
Age	Included in the regression model as a discrete ordinal variable.
Gender (Female: ovulation, pregnancy)	Controlled by selecting only a male sample to assure more accuracy in data.
Body Mass Index	BMI value included in the regression model.
Metabolic rate	BMI value included in the regression model.
Consumption of food	Controlled by instructing the subjects to have a specified balanced meal 2 hours prior to entering the WS.
Consumption of alcoholic drinks	Controlled via initial guidelines and the screening interview before entering the lab.
Physical activities	Controlled via initial guidelines and the screening interview before entering the lab.
Fasting	Controlled via initial guidelines and the screening interview before entering the lab.
Sleep deprivation	Controlled via initial guidelines and screening at the medical test and interview before entering the lab.
Sicknesses	Controlled via initial guidelines and screening at the medical test and interview before entering the lab.

Exposure to light	Will be controlled by providing the same lighting level within each work station (350 lux).
Regions of the body - Temperature can be varied in different regions of a body	Controlled by taking the body temperature measurement only from the forehead area (TAT). (Since the human body regulates skin temperature to balance the heat gain and heat loss, the use of skin temperature has significant potential as an index to the thermal sensation)
Topographical/ regional adaptation/Homeostasis to thermal conditions.	This was included in the model by including the average temperature of the region/home town (HT_Temp) in to the regression model.

Table 5: Core body temperature variables

4.3) Methodology

4.3.1) Population: The population tested under the study was undergraduate male students (age 20-30) of Faculty of Architecture, University of Moratuwa, Sri Lanka (n=321). The population was restricted only to males purposely as gender is suspected to be contributing to thermal perception due to the established correlation with core body temperature. The student population of Faculty of Architecture, having four diverse affiliated departments (Architecture, Integrated Design, Town and Country Planning and Quantity Surveying) was selected to draw the sample due to its rich mix of students representing a fair cross-section of the whole country; all the racial, religious, regional, climatic, socio, cultural, economic, and educational difference (*art, science, math and commerce based*), so that the findings could be generalized to a greater extent.

4.3.2) Sampling technique – Stratified Simple Random Sampling

To obtain a statistically valid outcome, a random sample (n=111) from the male student population of Faculty of Architecture (n=321), University of Moratuwa with a 95% confidence level and 7.5% margin of error was proposed to undergo the final trial as mentioned below.

Population Size : 321 Margin of error : 7.5%

Confidence Level	Sample Size
80%	59
90%	87
95%	111
99%	154
99.9%	193
99.99%	217

Table 6: Justification for Sampling.

It was attempted to obtain a representative and statistically valid sample from the varying subpopulations (stratums; four departments) independently to represent the overall population; faculty of architecture as a whole via adopting a stratified sampling technique. During the stratification process the subjects per stratum were allocated considering the sample fraction; ratio of sample size to population size (Dodge, 2003) (Arch- 28, Des-22, QS-52 and TCP-10).

Once the numbers were decided the subjects within each department was selected via simple random sampling. A preliminary sample consisting of 155 students were drawn initially via simple random sampling, keeping tolerance for possible dropouts due to absenteeism, withdrawals, unforeseen circumstances, and holidays and not meeting the set eligibility criteria during the screening process. After going through three rigorous screening processes the 111 most eligible subjects to face the trial were selected out of the preliminary sample.

Ethical clearance: Using humans as subjects vitally needs ethical clearance. A letter of consent was distributed among the randomly selected male subjects (n=155) explicating the details of the investigation; objectives, procedures, impacts and contact persons.

Eligibility criteria: The randomly selected initial sample (n=155) was screened via three rigorous screening processes done based on a fixed eligibility criteria setup, referring to literature within the process of selecting the best suiting subjects and further to collect a database with most accurate data from the subjects;

A) First screening via self report: A preliminary screening of the subjects was done based on the set eligibility criteria by means of a questionnaire survey. It was attempted to select subjects with normal health via self-reporting to proceed with the next level of screening.

Note: 21 subjects withdrew due to personal, health, absenteeism and reasons and 9 subjects were identified to have long term illnesses. Out of the 155 subjects, only 125 proceeded to the 2nd screening.



Fig: 1 – Medical Checkup

B) Second screening- Medical check-up: The participants selected for the second screening (n=125) had to go through a general health check up (as specified by the eligibility criteria) done by an experienced medical practitioners.

Medical Examination Criteria:

- a) Height, Weight, BMI.
- b) Vision; Normal / Impaired/Colour Blind.
General health condition of each subject; heartbeat, pulse rate, respiration rate, blood pressure...etc.
- c) Health conditions leading to high/low body temperature; Hyperthyroidism, hypothyroidism, endocrine issues, infections, hormone /chemical imbalances, skin problems, cardio vascular problems, swellings, kidney disorders.

Note: 5 subjects were detected to be colour-blind (The colour blind subjects were sent to the final trial and studied separately in order to explore possibilities of CTP beyond vision. The other subjects who got through the second screening were given a set of guidelines to be followed, (designed based on literature review) before coming to the trial.

C) Third Screening: Personal interview before the trial: Took place just before entering the lab for the trial. Each subject was interviewed to identify his medical/health/psychological

condition to determine the eligibility. It was inquired whether the subjects have adhered to the set guidelines provided duly to them to become eligible for the trial.

The best fitting ($n=111$) were selected through the aforementioned 3 staged screening process.

Clothing: Specially designed lab kit: The subject's were dressed in a specially designed black coloured comfortable linen lab kit and comfortable lab slippers (black) ensuring identical body coverage with identical materials and colour. The lab suit design was done using the standard measurements used for lab kit in the theaters of Durdans Hospital, Sri Lanka.



Fig: 2 – Especially Designed Lab Kit

Lab Design: The laboratory was designed by converting an existing studio of Faculty of Architecture (20' x 12' x 11'), in to a controlled environment where colour Workstations (WS) were installed. It was designed to control all the external factors pertaining to thermal/colour perception as established via literature.



Fig 3; Colour Lab

Work Station Design: The WSs were identical in every aspect other than its applied colour. 4'x4'x5' WSs were made with 2mm thick timber planks fixed on to a frame of 1'x 1/2' thick timber members. Each WS is three sided and includes a simple work top (1 1/2'x 4') done with the same method of construction placed at a height of 2 1/2' from the ground level. Each WS was initially coated by filler with an identical thickness and the two paint coats were applied on top (Matt finish). Colour selection was done based on the RGB colour model. Three identical timber chairs were kept in each WS for the subject to sit comfortably and engage in the task given.

4.3.3) Experimental research design; A Randomized, crossover experiment

The study adopted an experimental research design to investigate the impact of colour red and blue on human thermal perception. In doing so, a crossover design was integrated. A crossover trial allocates subjects randomly to study arms where each arm consists of a sequence of two or more treatments/exposure given consecutively (Sibbald, 1998).

BR/ RB Crossover trial: In the current investigation the colour of workstations was manipulated by the experimenter to test its impact on the dependant variable; (CTP) while controlling all the predictor variables. Thermal perception of randomly selected 111 healthy male subjects was tested under two different colour treatments; Red (R) and Blue (B). The simplest crossover model was adopted in the trial; BR/ RB. Explicitly, subjects in BR study arm were exposed to blue colour first followed by red colour and vice versa in the RB study arm.

Drawback: Carryover effects: The principal drawback of the crossover trial is that the effects of one treatment may “carryover” and alter the responses to subsequent treatments.

Usual approach to preventing this is to introduce a washout period; no treatment period between consecutive treatments which is long enough to allow the effects of the initial treatment to wear off (Sibbald, 1998).

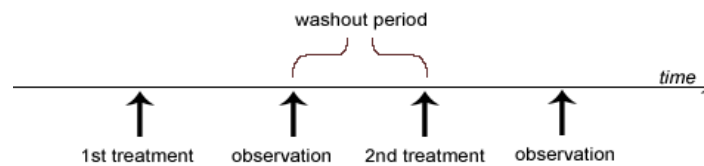


Figure.4. washout period Source: Sibbald, 1998

White workstation (WWS): To overcome the carryover effects, a white work station was introduced to the research design. While providing a washout period for the subject, the WWS provides a control environment for the trial as well. It was expected that being a neutral colour, a white environment will control, neutralize and settle the subject to reach his normal/basal psychophysiological level, especially core body temperature (CBD). Prior to entering the colour WS for the first treatment each subject was kept inside the white WS for 10 minutes until he reached his basal temperature level. Then, in case of the RB study arm he was first exposed to the red WS for 15 minutes. In order to washout carry over effects from the first treatment he was sent back to the white WS for another 10 minutes. Once the subject reached a constant/basal temperature level again he was sent to the next treatment; blue work station for another 15 minutes.



Fig 5: White workstation to neutralize and washout carryover affects

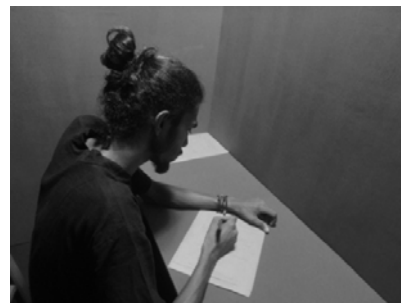


Fig 6: A subject in BWS



Fig 7: A subject in RWS



Fig: 8 - Questionnaires and the pens were of selected with the corresponding colour
Source: Author

Laboratory was maintained in controlled conditions; fixed room temperature (26°C), lighting level (350 lux) and fixed interior finishes (matt) and colour (black). Around 10 research subjects were tested per day and equal numbers of subjects were allocated to both study arms (RB study arm = 5 and BR study arm = 5)

The temperature readings were taken via non invasive thermal monitoring system using a Temporal Artery Thermometer (TAT). Forehead temperature readings were taken in 2 minutes intervals until the subject reached none fluctuating /constant reading while in the WWS. When it comes to temporal artery temperature readings, the base line is identified as 99.6 °F (Hegner, Acello and Caldwell, E. 2012) where the normal range is established to be 97.4°F – 100.1 °F (Exergen,2006). Temperature readings were taken at 5 min intervals in the Red and Blue WSs. To facilitate the same activity/metabolic level in each WS, the subjects were guided to fill an identical questionnaire while they were seated and exposed to each colour. Papers on which the questionnaire was printed and the pens placed in each WS were of the same corresponding colour.

The subjects rated their thermal perception in a 5-point likert scale provided to them in the questionnaire. Meanwhile they reported their psychological condition triggered by exposure to each colour WS (thoughts, feelings, emotions and memories related to the colour of the workstation) and suggested activities they would prefer to perform within each WS.

Outdoor temperature was monitored per research unit with the use of two digital thermometers (Testo 174 T-). The surface temperature of WS was measured using non invasive infra red thermal monitoring system via FLIR i60 infra red industrial camera.

5) Data Analysis Protocols.

The investigation involved both both quantitative and qualitative data.. Some of the data were collected during the screening process via self report questionnaire, medical checkup and the interview just before the trial, namely level of practical and theoretical exposure to colour (Loe), vision (Vis), religion (Rlgn), race (Rce), study stream followed for A/L s (A/L_SS), favorite colour (Fvc), sensitivity to warm conditions (Sen_Warm), sensitivity to cool conditions (Sen_Cool), rate of sweating (Ros), average temperature of the home town (temp HT_Temp), body mass index (BMI), age.

The rest of data collected during the trial were,

Quantitative data: Temporal artery temperature in RWS and BWS (RTAT, BTAT), surface temperature of RWS and BWS (R_SFT / B_SFT), outdoor temperature (OT), test time zone (TTZ).

Qualitative data: Thermal perception in RWS and BWS (RTP and BTP) were recorded in a 5-point likert scale. Thoughts, feelings, emotions associated with RWS and BWS (R_Psy/ B_Psy) and preference of being in RWS and BWS (R_Pre, B_Pre) were recorded in the questionnaire.

5.1) Data collection method and tools

5.1.1) Temporal artery temperature - Forehead temperature; Temporal Artery Temperature (TAT) in°F (to represent core body temperature)

a) Method: Thermographic Measurement Technique - Non-Invasive Infra red thermal monitoring system.

b) Tool/ Equipment: Exergen Temporal Artery Thermometer (Temporal Scanner)
This thermometer obtains accurate infrared readings of temporal artery blood flow.



Figure: 9– Obtaining temporal artery temperature readings

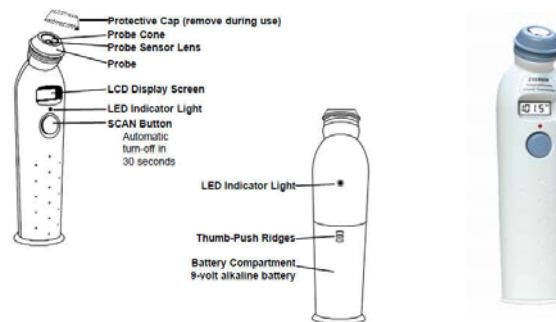


Figure 10: Temporal Scanner
2006 –User guide Source: Exergen,

5.1.2) Outdoor temperature (OT)- Testo 174T - Mini Data Logger Temperature

a) Method: The outdoor temperature was monitored at the information desk located just outside the lab where the 3rd screening interview took place.

b) Tool/Equipment: Testo 174T - Mini Data Logger was placed at the reception desk to measure OT. This digital thermometer possess a factory calibration;

Reference value of 25.0oC is measured as 24.9oC.

Measuring range -30 to +70oC
Accuracy $\pm 0.5\text{oC}$ (-30 to +70oC)
Operating Temperature -30 to +70oC
Storage temperature - 40 to +70oC
Resolution 0.1oC



Figure 11: Testo 174T-Mini Data Logger

5.1.3) Surface temperature of WSS (RSFT/BSFT)- FLIR i60: infrared thermal imaging camera

a) **Method:** Surface temperature of each WS monitored for any possible changes every time a subject enters the WS.

b) **Equipmet:** FLIR i60 non invasive infra red camera

Temperature Range	- 4°F to 662°F (-20°C to 350°C)
Temperature Accuracy	$\pm 2^{\circ}\text{C}$ or $\pm 2\%$ of Reading
Emissivity Table	0.1 To 1.0 (Adjustable)
Thermal Sensitivity	(N.E.T.D) $< 0.1^{\circ}\text{C}$ at 25°C



Figure12: FLIR i60: High-Temperature Thermal Imaging camera
Source: <http://www.tequipment.net/Fliri60.html>

5.1.4) Perceived Temperature (RTP and BTP)

a) **Method :** The participants were requested to rate their thermal perception inside each of the three WSs (warmness/ coolness).

b) **Tool/Equipment:** A 5 – Point likert scale used for the subjects to rate the TP following the ASHRAE thermal sensation scale (5 hot (Very warm), 4 warm, 3 neutral, 2 cool,1 cold (very cool)).

5.1.5) Time

a) **Method:** The trial took place as per a fixed time schedule. Accordingly the test time; the time which the subjects entered the lab as well as the time intervals the temperature reading were taken (2 minutes/5 minutes) were recorded in the data sheet.

b) **Tool/Equipment:** A digital clock was used in taking down the time.

5.1.6) Thoughts, feelings, emotions associated with each colour : ‘Psy’-Factor

The subjects were requested to write down their thoughts, feelings, emotional and memories triggered via each colour in the identical questionnaire given in each workstation.

5.1.7) Activities preferred to perform in each workstation: In order to identify the suspected relationship between perceived thermal environment and human activities, the subjects were requested to suggest activities they wish to perform in each workstation on the same questionnaire where they had to rate their thermal perception. **(Pre factor)**

6) Results and Discussion:

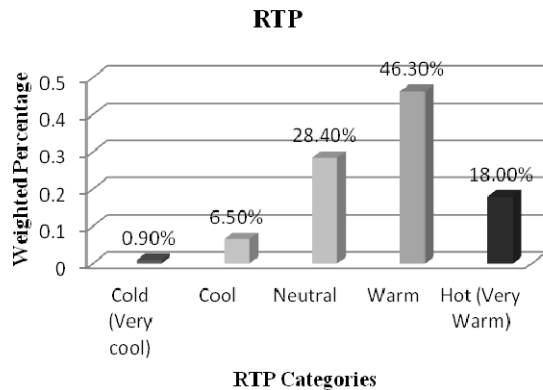


Chart 1- RTP weighted percentages

Data was initially entered on to Microsoft Excel and then transferred into SPSS software. The complete database of 111 subjects was weighted to be valid for the total population of Faculty of Architecture (n=321). All the qualitative data was interpreted, coded and transferred into quantitative data in the form of categorical variables.

6.1) Thermal Perception RTP/BTP

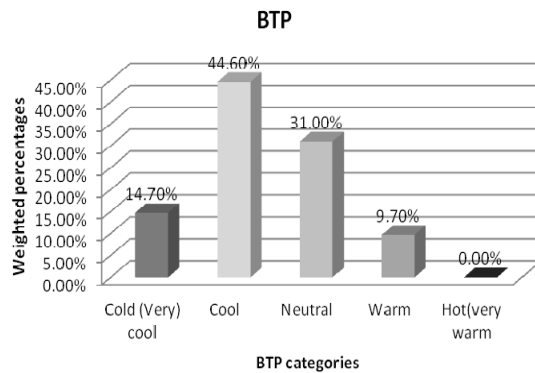


Chart 2- BTP weighted percentages

Supporting the theory of warm colours, 64.20% perceived RWS to be warm (46.3%) / hot (18%).

Only 7.4% subjects perceived red to be cool. However 28.4% subjects perceived red to be neutral. So it can be seen that a majority has perceived RWS as warm. On the other hand supporting the theory of cool colours 59.30% were found to witness a cool (44.6%) / cold (14.7%) BTP. Significantly none has

rated BTP to be very hot and only 9.7 % has perceived BWS to be warm. Anyhow another 31% have rate BTP to be neutral.

Comparing RTP against BTP of all the subjects tested, the theory of warm cool dichotomy was re affirmed.

RTP was found to be warmer than BTP. The graph clearly demonstrates the trend line of RTP values lying on a higher level than BTP. As hypothesized, BTP is found to be cooler and RTP to be warmer. Therefore the study supports the hypothesis that the perception of red as warm and blue as cool can be generalized.

Eventhough it was expected to observe a different behavior, the above finding was in parallel with the reseponses of colourblind subjects.

80% of the colourblind subjects repotrtrd to perceive a warm TP and 0% cool RTP. 20% rated it to be neutral. But contrastingly, BTP has been neutral for the majority of colourblind's (60%) while only 40% has perceived BWS to be cool. No one perceived BWS to be warm. Colourblind subjects, though theoritically cannot see colour, has experienced a thermal perception similar to normal subjects. But they seem more responsive to red then blue. This finding suggests that colour associated thermal perception has linkages beyond visual pereception.

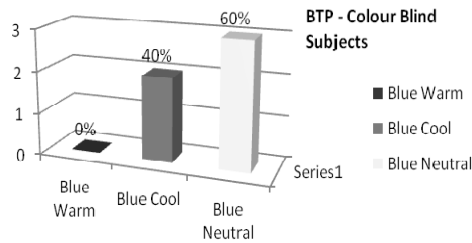


Chart 3- BTP Colour Blind Subjects

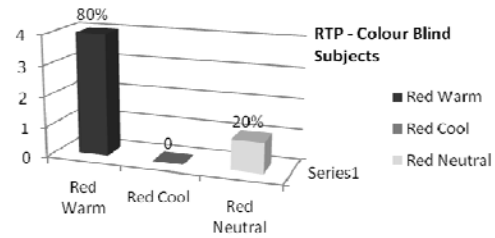


Chart 4- RTP Colour Blind Subjects

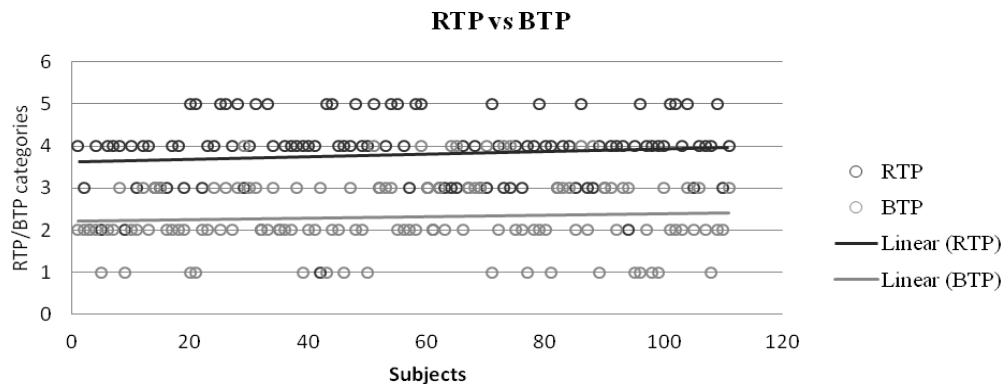
6.2 Significant findings associated with IVs.

6.2.1) Comparison between RTAT and BTAT:

It was hypothesised that RTP/BTP could be a repercussion of a variation of a biological reaction. It was suspected that there can be a variation in body temperature (which was measured by TAT) triggered by color stimuli. The study witnessed that the change of RTAT or BTAT caused by colour stimuli is insignificant. The difference between the basal TAT in WWS and the average temperature reading in RWS;RTAT and BWS;BTAT was graphed in ascending order.

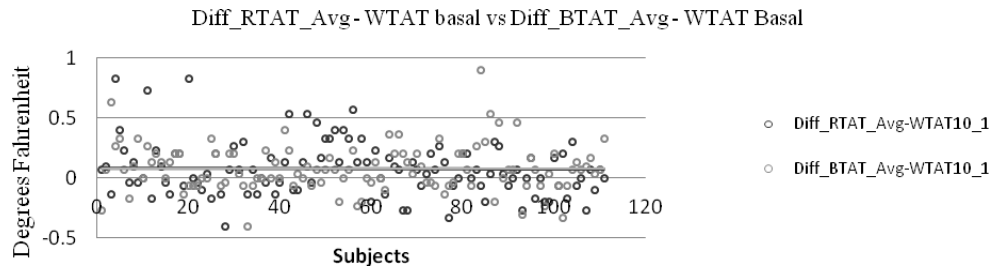
The range of increase or decrease of RTAT was : - 0.4 °F – 0.8 °F, Average: 0.083 °F.

The range of increase or decrease of BTAT was: - 0.4 °F – 0.9 °F , Avg: 0.08 °F.



Scatter Plot 1- RTP Vs BTP

Eventhough it was hypothetically explicated that red could trigger a drastic increase in RTAT' and blue could decrease BTAT', it was revealed that the increase/decrease of body temperature (TAT) due to colour stimuli was insignificant. This suggests that the warm/cool diachotomy of colour is not a consequence due to a body temperature variation. As per the scatter polt both trend lines overlap and run horizontally suggesting no relationship between RTP/BTP and TAT. Accordingly it is suggestive that body temperature variation is not significant for CTP as suspected.

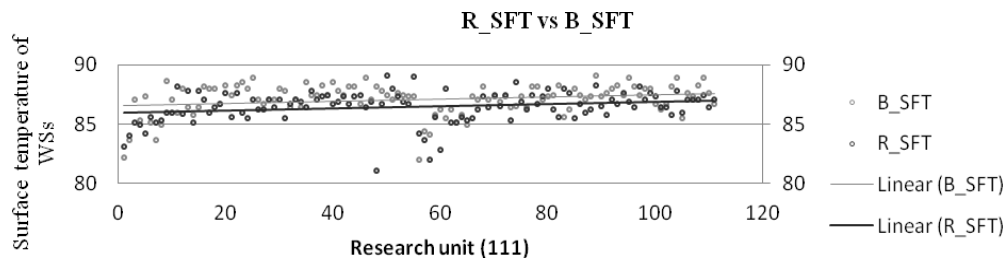


Scatter Plot 2 - Diff_RTAT_Avg- WTAT basal Vs Diff_BTAT_Avg – WTAT basal

6.2.2) Impact of surface temperature on CTP:

Significantly B_SFT was found to be higher than R_SFT, witnessing the potential of colour to contribute to the external thermal milieu.

Average of R_SFT = 86.46 °F, Average of B_SFT= 87.17 °F, Diff = 0.71 °F



Scatter Plot 3: Comparision between B_SFT' and R_SFT'

6.2.3) Psychological Predictors: a) 'Psy' factor (R_Psy /B_Psy): Psychological condition

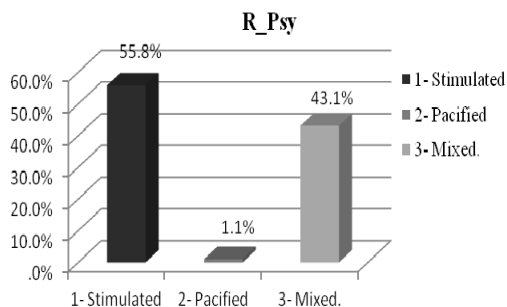


Chart 5- R_Psy weighted Percentages

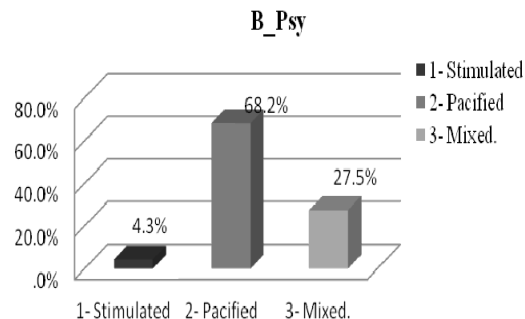


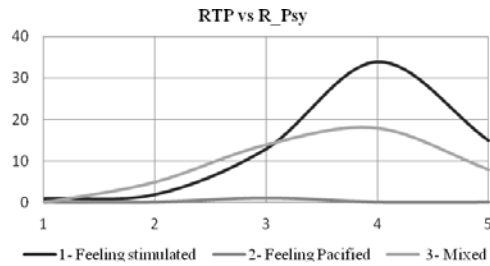
Chart 6- B_Psy weight percentages

R_Psy: For instance 55.8% subjects experienced stimulated psychological level while only 1.1% was found to be pacified. Another 43.1% demonstrated a mixed psychological.

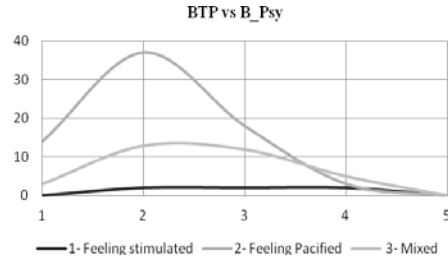
B_Psy: 68.2% (majority) was found to be pacified in BWS and only 4.3% witnessed to be stimulated. Another 27.5% experienced a mixed level. Parallel to the duality of RTP and BTP, dual psychological reactions against exposure to red and blue was demonstrated.

It was found that the 'Psy' factor plays a significant role for both RTP and BTP.

B) Preference; R_Pre/B_Pre: As per the graph, it was seen that having a stimulated



Graph 1- RTP vs R_Psy



Graph 2- BTP vs. B_Psy

Psychological level has contributed to a warm RTP and a pacified state for a cool BTP

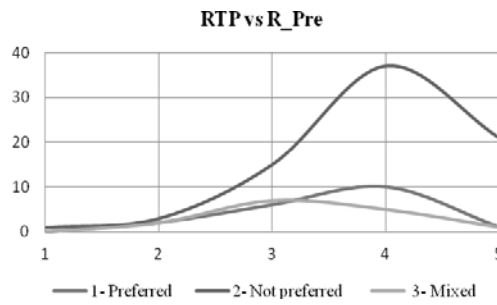
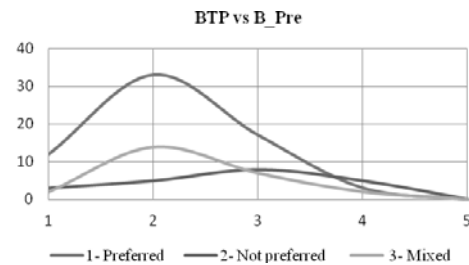


Chart 4- BTP vs B_Psy



Graph 3- RTP vs R_Pre

A majority (66.6%) did not prefer exposure to RWS. Only 20.8% was found to prefer being in RWS and 12.6% had mixed thoughts in terms of preference. Contrastingly, a majority (60.9%) preferred exposure to BWS while only 17.3% did not prefer. 21.8% were found to have mixed thoughts.

R_Pre /B_Pre; Preference associated with RWS/BWS too were found to have a bearing on RTP and BTP

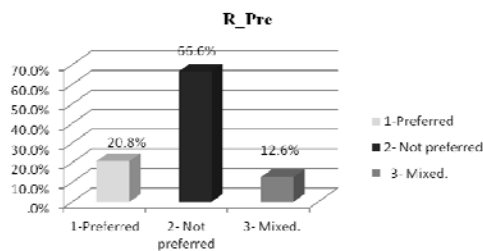


Chart 7- R_Pre weighted

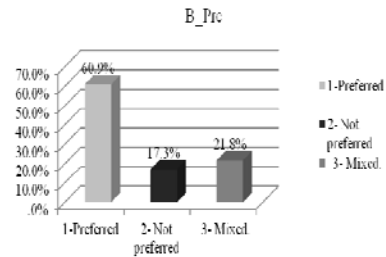


Chart 8- B_Pre weighted

It can be seen that the subjects who have not preferred the exposure to RWS has a tendency to perceive a warm RTP. Conversely the subjects who preferred exposure to BWS has propensity to perceive a cool BTP.

c) Favorite colour

55.7% subjects' favorite colour was found to be a cool colour and only 22.9% and 21.4% had warm colours and neutral colours respectively as their favorite colour. The subjects having cool / neutral favorite colours demonstrated tendency to rate RWS to be warm and BWS to be cool equally. Deviating from above, subjects having warm favorite colours showed a probability of perceiving a neutral RTP. Accordingly, it was clearly evident that the probability of CTP to be a psychological response is high.

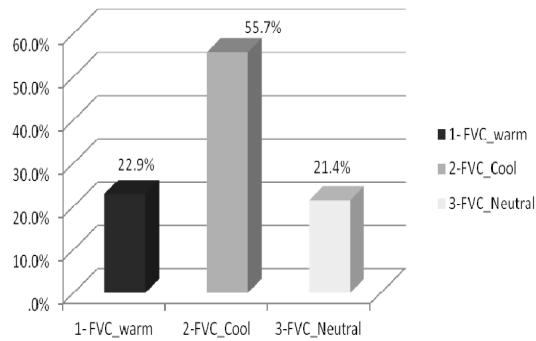
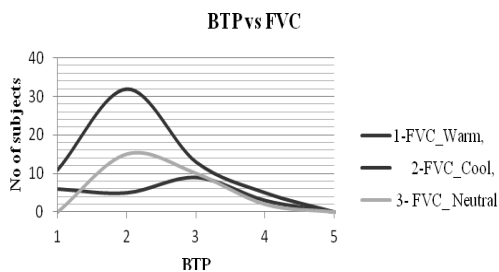
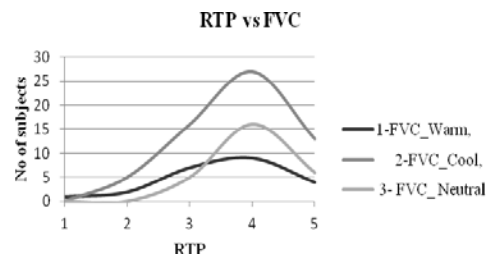


Chart 9- Favorite colour weighted Percentages



Graph 5- BTP vs FVC



Graph 6- RTP vs FVC

6.3) Complex Sample Ordinal Logistic Regression Model (CSOLRM)

In order to provide a statistically significant explanation for RTP and BTP, especially to understand the most powerful predictors of RTP and BTP, a literature review was conducted to find a best fitting regression model. As per literature, considering the fact that the output variable is a discrete variable having 5 ordinal categories (Lunsford, 1993 and Pasta, 2013) an ordinal logit regression model was adopted. Since stratification was done in sampling to represent the total population of 4 departments in a fair and reasonable manner the model was further specified in to a Complex Sample Ordinal Logistic Regression (Liu and Koirala(2013). CSOLR model was run for both RTP and BTP separately considering all the predictors as summarized below.

RTP-AL_Streme, FVC, LoE, Vis, RoS, Sen_Warm, Sen_Cool, Rlgn,,Rce, TTZ, R_Psy , R_Pre, BMI, R_SFT, OT, HT_Temp, Diff_RTAT_AvgWTAT10_1and Age

BTP - AL_Streme, FVC, LoE, Vis, RoS, Sen_Warm, Sen_Cool, Rlgn,,Rce, TTZ, B_Psy , B_Pre, BMI, B_SFT, OT, HT_Temp, Diff_BTAT_AvgWTAT10_1and Age

6.3.1) Classification of Dependant Variable – RTP and BTP

DV	Variable label	Value label	Variable type and level of measurement
RTP	Thermal Perception in Red Workstation	1- Cold (<i>Very cool</i>), 2 - Cool , 3 - Neutral, 4 - Warm, 5- Hot (<i>Very Warm</i>)	Discrete – Ordinal scale
BTP	Thermal Perception in Red Workstation	1- Cold (Very cool), 2 - Cool , 3 - Neutral, 4 - Warm, 5- Hot (Very Warm)	Discrete – Ordinal scale

Table 7: Classification of Dependant Variable – RTP and BTP

6.3.2) Classification of Independent Variables - Discrete variables— Ordinal Scale

IVs	Variable label	Value label
LoE	Level practical and theoretical exposure to colour (Pre conceived ideas)	1-Good, 2-Moderate, 3-Poor
Ros	Rate of Sweating	1- -High 2- Normal, 3- Low
Age_M	Age	1- (20-22), 2- (23-24), 3- (25-30)
Sen_Warm	Sensitivity to warm conditions	1 Very high to warm, 2 High to warm, 3 Normal to warm
Sen_Cool	Sensitivity to cool conditions	1 Very high to warm, 2 High to warm, 3 Normal to warm
LoE	Level of practical and theoretical exposure to colour	1-Good, 2-moderate, 3-less
R_Psy B_Psy	Psychological state associated with RWS/BWS	1- Feeling stimulated, 2- Feeling Pacified, 3- Mixed.
TTZ	Test Time Zone	1- 8 .30 -9.30 a.m/ 2 - 9.30-10.30 a.m/ 3-10.30-11.30 a.m / 4-11.30 a.m - 12.30 pm/ 5 - 12.30-1.30 p.m / 6- 1.30 - 2.30 p.m/ 7- 2.30 p.m - 3.30 p.m/ 8 - 3.30 p.m-4.30 p.m/ 9- 4.30-5.30 p.m/ 10 - 5.30 - 6.30 p.m

Table 8: Classification of Independent Variables - Discrete variables – Ordinal Scale

6.3.3) Classification of Independent Variables - Discrete -- Nominal Scale

IVs	Variable label	Value label
Vis	Vision	1- Normal, 2- Impaired, 3- Colour Blind
Rlgn	Religion	1-Buddhist, 2-Chatholic/Christian, 3-Islam, 4-Hindu
Rce	Race	1-Sinhalese 2-Tamil 3- Muslim/ Moor
A/L_SS	Subject streams followed for A/Ls	1-Maths, 2-Arts, 3-Bio, 4- Commerce
Dept	Department	1-QS, 2-Archi, 3-Design, 4- TCP
FVC	Categorization of favorite colours in to warm, cool and neutral colours	1- FVC_Warm, 2-FVC_Cool, 3- FVC_Neutral
R_Pre B_Pre	Preference associated with RWS/BWS	Preferred 2- Not preferred 3- Mixed.

Table 9: Classification of Independent Variables - Discrete — Nominal Scale

6.3.4) Classification of Independent Variables - Continuous – Interval scale

IVs	Variable label	Value label
BMI	Body Mass Index	Value in Kg/M2
Diff_RTAT _ Avg / Diff_BTAT _ Avg	Difference between the basal WTAT value and RTAT/BTAT average value: Total increase of decrease of RTAT/BTAT in °F.	Value in °F
R_SFT/ B_SFT	Surface Temperature of RWS/BWS	Value in °F
OT	Outdoor temperature	Value in °F
HT_Temp	Average temperature of Hometown (In year 2012)	Value in °F

Table10 : Classification of Independent Variables - Continuous – Interval scale

The predictor variables pertaining to the dependant variable were investigated based on a 95% confidence interval considered in sampling process. A null hypothesis (H_0) and an alternative hypothesis (H_A) were tested. H_0 hypothesized that none of the predictors will have a correlation to the outcome variable. β explains the coefficient for the fitted line. Accordingly the hypothesis can be defined as follows.

(H_0): $\beta_i = 0$ for all i. (H_A): $\beta_i \neq 0$ for at least one coefficient.

The following parameters were used to decide on the goodness-of-fit and the strength of the model.

Test of Model effects table: Explains the significance (P value) of each predictor variable to the dependant variable (RTP/BTP). A predictor is considered as significant if the p value is less the 0.05.

"pseudo-R" statistic describes the strength of the model. It is designed to explain something similar to what R-squared tells in ordinary least-squares regression, that of the proportion of variance accounted for in the dependent variable based on the predictive power of the independent variables (predictors) in the model (Denis,2010). R^2 in ordinary least square regression is a fraction between 0.0 – 1.0 where 0.0 explains that no linear relationship between variables. Anyhow pseudo-R values cannot be interpreted exactly as one would interpret R-squared in ordinary least-squares regression (Denis, 2010). As clarified by Cohen, Cohen, West & Aiken (2003 as cited in Denis, 2010), and “. . . we caution that all these indices are not goodness of fit indices in the sense of proportion of variance accounted for, in contrast to R-squared in OLS regression”.

Correct Classification Rate (CCR): A parameter used to test model fit. CCR is a percentage value and higher the value, better the model fit will be. For instance 50% CCR describes that 50% of the predictors are explained by the model. As per literature a good model should achieve a CCR higher than 50% CCR.

Initially a full model was run for both RTP and BTP including all the predictor variables mentioned above in order to test the significance with the outcome variable. Secondly excluding the insignificant predictors suggested the model was re –run to identify the most significant predictors pertaining to RTP/BTP.

6.4) Significant CSOLR Model – RTP

Tests of Model Effects

Source	df1	df2	Wald F	Sig.
AL_Streme	3.000	105.000	2.872	.040
FVC	2.000	106.000	5.779	.004
Rlgn	3.000	105.000	3.201	.026
R_Psy	2.000	106.000	7.105	.001
R_Pre	2.000	106.000	7.873	.001

Dependent Variable: RTP (Ascending)

Model: (Threshold), AL_Streme, FVC, Rlgn, R_Psy, R_Pre

Link function: Logit

Pseudo R Squares

Cox and Snell	.334
Nagelkerke	.364
McFadden	.164

Dependent Variable: RTP (Ascending)

Model: (Threshold), AL_Streme, FVC, Rlgn, R_Psy, R_Pre

Link function: Logit

Classification

Observed	Predicted					
	1	2	3	4	5	Percent Correct
1	.000	.000	.000	2.900	.000	.0%
2	.000	3.400	8.700	8.700	.000	16.3%
3	.000	.000	39.300	49.900	1.900	43.1%
4	.000	.000	14.000	125.500	9.100	84.5%
5	.000	.000	.000	48.600	9.100	15.8%
Overall Percent	.0%	1.1%	19.3%	73.4%	6.3%	55.2%

Dependent Variable: RTP (Ascending)

Model: (Threshold), AL_Streme, FVC, Rlgn, R_Psy, R_Pre

Link function: Logit

6.5) Significant CSOLR Model – BTP

Tests of Model Effects- BTP Significant Model

Source	df1	df2	Wald F	Sig.
AL_Streme	3.000	105.000	9.483	.000
B_Psy	2.000	106.000	4.032	.021
B_Pre	2.000	106.000	3.694	.028
Age_M	1.000	107.000	8.435	.004
B_SFT	1.000	107.000	6.820	.010

Dependent Variable: BTP (Ascending)

Model: (Threshold), AL_Streme, B_Psy, B_Pre, Age_M, B_SFT

Link function: Logit

Pseudo R Squares

Cox and Snell	.371
Nagelkerke	.405
McFadden	.188

Dependent Variable: BTP (Ascending)

Model: (Threshold), AL_Streme, B_Psy, B_Pre, Age_M, B_SFT

Link function: Logit

Classification

Observed	Predicted				Percent Correct
	1	2	3	4	
1	18.900	23.500	4.800	.000	40.0%
2	7.600	113.500	22.200	.000	79.2%
3	1.900	48.300	46.000	3.400	46.2%
4	.000	1.900	20.400	8.700	28.1%
Overall Percent	8.8%	58.3%	29.1%	3.8%	58.3%

Dependent Variable: BTP (Ascending)

Model: (Threshold), AL_Streme, Age_M, B_Psy, B_Pre, B_SFT

Link function: Logit

6.6) Output Summary:

RTP significant predictors: R_Psy, R_Pre, AL_Streme, FVC, Rlgn,

BTP significant predictors: B_Psy, B_Pre, AL_Streme, Age_M, B_SFT.

Revealing the outputs of the CSOLR model, it was found that the significance of the predictors differ from RTP to BTP, while certain factors remain common. A major finding of the study is the common significance of psychological factors (Psy and Pre) for both RTP and BTP. Further the preconceived learnt ideas due to prior exposure and education (AL_Stream) dominate as common. Apart from that, favorite colour has become as significant parameter only for RTP, which is another psychological response. BTP was found to be affected by the subject's age. Affirming the hunch that SFT could have an impact of RTP/BTP, it was found that B_SFT is significant for BTP. The supposition of a possible increase/decrease of human body temperature due to colour stimuli was not revealed.

RTP models gave correct classification for 55.2% of the predictors studied. BTP provided classification for 58.3% suggesting a good model fit.

RTP Model - $R^2 = .334$ (Cox and Snell); .364 (Nagelkerke).

BTP Model - $R^2 = .371$ (Cox and Snell); .405 (Nagelkerke).

7) Concluding Remarks

To recapitulate, the findings of this experimental research supports the warm cool dichotomy of colour perception. In general terms it can be explained that red is perceived as warm and blue as cool. The findings further demonstrate dual psychological reactions against exposure to red and blue. The supposition of CTP as a consequence of body temperature difference is non-valid. Unexpectedly, it was found that the B_SFT was higher than R_SFT witnessing impact on CTP. B_SFT is found to be highly significant on a cool BTP compared to the significance of R_SFT on a warm RTP. Colour-blind subjects too demonstrated a warm RTP, suggesting CTP's links beyond vision. It was found that psychological factor plays a significant role amidst all the predictors considered on CTP.

The study in a nutshell supports the hypothesis that the perception of red as warm and blue as cool can be generalized. The emergence of colour associated thermal perception was found to be a complex combination of several layers; learnt, psychological, external as well as certain un-revealed factors. Considering the revealed nature of CTP, conducting further research on the

possibility of colour to manipulate perceived thermal as well as psychological milieu demanded by human activities intended in built environment and for energy conservation is highly recommended.

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Sri Lankan Children's Independent Mobility

Julie Rudner

Community Planning and Development, School of Social Sciences,
La Trobe University
J.Rudner@latrobe.edu.au

Naduni Wickramaarachchi

Community Planning and Development, School of Social Sciences,
La Trobe University

Abstract

Children's and young people's independent mobility has decreased significantly in industrialised countries, and these trends could be replicated in Sri Lanka as standards of living increase alongside changes in urban form. This paper presents data from a questionnaire conducted in 2011 with children aged 7-15 years about their mobility behavior which was conducted as part of a larger international study coordinated by the Policy Studies Institute, UK. The questionnaire was completed in five different settlement types in Sri Lanka. The research found that children in inner urban and suburban areas had less independent school travel than children in large and small towns and rural areas. In contrast, more urban and suburban children could go more places on their own, but this is likely due to more options than parental permission. Secondary school children have greater independent mobility than primary school children. The dominant mode of transport changed depending on settlement size. The data is interpreted and discussed in the context of increased standard of living as expressed through urbanisation processes as represented through urban form, density, transport networks, and lifestyle preferences.

Keywords: Children, Mobility, Sri Lanka

Introduction

Sri Lanka's urbanising environments increasingly reflect a particular type of westernized development, materially, socially and symbolically. These changes are often expressed through the development of lower density suburban form, motorised-based transport networks, and box retail shopping. Increasing individual wealth and standard of living is facilitating aspirational desires, as car ownership and private vehicle use increases, alongside chauffeuring of children to and from school and other activities. Ironically, trends in industrialised countries means policy and urban redevelopment are redirecting away from car dominated urban design toward walkable city infrastructures with strong public transport networks. Sri Lanka is in an interesting position with regard to urban policy and transport decisions, especially if decision-makers want to consciously choose a development path that supports children's and young people's independent mobility (CIM).

CIM refers to the use of public space by children under 18 years of age who are not accompanied by an adult. In Sri Lanka children and young people tend to have greater independent mobility compared to their counterparts in industrialised countries, but not as much as those in less developed countries (Fyhri, Hjorthol, Mackett, Fotel, & Kyttä, 2011; Malone & Rudner, 2011). At the same time, the research data presented in this paper indicates Sri Lanka shares global trends in which there are geographical inequities and different levels of CIM depending on income and settlement type. It is likely that increasing engagement in market processes, as represented by the standard of living, is impacting on family decision-making to accompany, drive or pay for chauffeured travel to transport children and young people places.

This paper explores the potential impact of urbanisation processes on children's and young people's freedom to use public space on their own in Sri Lanka. To interrogate this idea further, the authors examine international trends and factors affecting children's and young people's independent mobility, then presents results from a survey conducted about CIM in 2011. The authors interpret the Sri Lankan context with regard to changing standard of living, and its impacts on urban form, social structure and behaviour change as expressed through modes and patterns of mobility. The tensions for Sri Lanka are centered on the potentially deep levels of economic, physical, social and cultural changes that occur in public space that may result from the impact of different mobility futures.

Changing spatial expression of economic choice and CIM

Globalization processes have transformed spatial relationships within countries, cities and between people. Sri Lankans, internationally connected through colonialism and post-colonial free-market reforms, have already experienced previous transformations. These changes simultaneously reveal and symbolise the evolving aspirations and lifestyles of 'westerners' and of Sri Lankans themselves through the expression of particular economies, settlement form, land use patterns, and transport networks (Asoka, Alam, & Coghill, 2008; Gunasekera, Anderson, & Lakshmanan, 2008). The effects of urbanisation and improved standard of living on family needs, values, priorities and abilities in relation to their physical, social and transport environments has the potential to significantly impact CIM.

Physical features of cities in Sri Lanka are becoming more similar to western landscape patterns and similar social and behaviour patterns of use may follow. Figure 1 shows examples of urbanized development in Colombo. Shopping malls, hypermarkets and gated communities are emerging across the urban landscape, competing with or even displacing more traditional forms of development. As a result, traditional retail shops and street markets, which encouraged widespread use of public spaces as meeting places are diminishing. These urban features provide new and different opportunities for Sri Lankans, as well as shifting current cultures of land use, activities and behaviors.



Figure 1 Examples of urbanised development in Colombo

These sorts of semi-private spaces can be implicated in the definition of appropriate places for children and young people. Enclosed areas that provide adult surveillance, such as youth centres, formalised sports and other activities are often viewed as providing a safer space for children and young people compared to public spaces, especially in places like the UK and Australia (Gill, 2007; Rudner, 2012). Alternatively, children and young people may experience practices of exclusion in spaces like malls due to their lack of economic ability or their age (Valentine, 2004).

On the residential front, gated communities can provide its inhabitants with a sense of security. However, researchers (Behrens, 2005; Spinks, 2001), reporting from the South African context, have commented that this form of development can also promote polarisation and distrust between different social groups. Mobility can also be hindered through the loss of urban connectivity for both private and public transport uses and pedestrians, the latter two of which has particular implications for children and young people.

Urban transformations extend to highway and road network development. As Gunasekera, Anderson, and Lakshmanan (Gunasekera, et al., 2008) observe, highway improvement works facilitate industrial growth, higher land prices, increased income and the transition of land use and employment from agriculture to non-agricultural production along the road corridor. While these improvements have been reported to lead to a positive shift from working to schooling for children, the intensity of traffic has significantly increased (Gunasekera, et al., 2008). International research has shown that traffic has a major negative impact on CIM and children's and young people's safety, regardless of wealth, country or settlement type (Behrens & Muchaka, 2011; Bwire, 2011; Driandra & Kinoshita, 2011; Fyhri, et al., 2011; Rudner, 2012). This is particularly an issue for children and young people who need to use active transport to go to work, attend school or help with family errands.

Much of the existing urban form in Sri Lankan settlements facilitates walking and casual interaction. Even with a lack of designated pathways and crossings and a chaotic transport environment, these environments generally encourage greater social interaction between pedestrians, cyclists and drivers due to the number of people on the street and low traffic speeds compared. Arguably, these aspects should be maintained in some form even as urbanisation occurs. While smooth, fast moving traffic may be a goal for many Sri Lankans, the mixed-use chaotic spaces of Sri Lanka are aspirational goals for many urban planners and community members in industrialised countries - especially when combined with a focus on public transport and integrated land uses (Curtis & Tiwari, 2008). In many places, including Oudehaske, The Netherlands and Poynton, UK strongly defined boundaries between pedestrian, cyclist and driver have been removed to encourage greater awareness and interaction, and speed limits lowered to promote people rather than car dominated environments. Figure 2 illustrates how current infrastructure in Trincomalee is similar to Amsterdam in The Netherlands, and Oslo in Norway with regard to shared multi-modal streets.

Current development trends indicate that choices based on lifestyle aspirations are becoming more common, and this includes associated motorised transport modes like the Southern Expressway in Sri Lanka that is likely to favour private vehicles. Although traditional stratification based on wealth, income, occupation and power retain some influence in forming social norms, the expression of individual lifestyles that reflect westernised patterns of consumption have become the prominent factor in determining individuals' prestige and social position. Co-option of westernised practices is not new, as many of the wealthy previously followed colonial examples, but development of the open market has made certain lifestyle choices more achievable for the middle classes. As decision-making about CIM is affected by family structure and culture, socio-economic status and associated ability to make choices, it is likely that CIM will be affected if more people choose to drive (Beck-Gernsheim, 1996; Tranter, 2006).



Figure 2 Streets showing shared multi-modal streets model

Greater consumption of semi-privatised and privatised residential, shopping, transport and educational options in Sri Lanka has implications for CIM. Levels of risk tolerance and risk acceptability, especially with regard to social trust, can change with regard concerns about safety for children and young people in public space. Numerous international studies have confirmed that parents and guardians from various economic and ethnic status cite concern about traffic and stranger danger as the most influential factors on their decision-making about whether they will allow their children and young people to go places on their own (Behrens & Muchaka, 2011; Bwire, 2011; Driandra & Kinoshita, 2011; Fyhri, et al., 2011; Porter & Blaufuss, 2002; Rudner, 2012). It appears that as more parents drive their offspring to school and other locations, whether due to concern, distance, convenience or spending time with them, concern about traffic and strangers are increased or validated through the driving experience. In addition, driving, rather than allowing CIM helps support negative socio-cultural considerations about children and young people's competencies to engage in CIM, which are often based on expert advice in relation to their age and gender.

A reading of this extensive research literature reveals that although these are priority concerns, there are differences levels of concern and different approaches to ensuring safety. There are also narratives about the level of concern, parental responsibilities and type of risk management behaviours that should be initiated in relation to 'appropriate' mobility patterns. These narrative serve to ensure children and young people conform with community expectations, many of which reflect class expectations (Valentine, 2004).

Different countries demonstrate cultural tendencies about their concerns and priorities. In countries like Australia and the UK, keeping children and young people safe in an overriding priority to their urban independence (Gill, 2007; Rudner, 2012). In Finland and Japan, children's and young people's independence tends to be prioritized, and there seems to be a greater emphasis on collectivise surveillance; community members are expected to watch over and help children and young people when they use public space on their own (Driandra & Kinoshita, 2011; Fyhri, et al., 2011). South African, Ghanaian and Tanzanian researchers have emphasised the need to support CIM so poorer children and young people can access education and participate in family responsibilities (Behrens, 2005; Bwire, 2011; Porter & Blaufuss, 2002).

Significance of the study

The presentation of data about CIM from Sri Lanka is significant as research on this topic has not been previously conducted in this country; it increases our knowledge about CIM in middle-developing countries, and provides a baseline data set for monitoring and future evaluation of development impacts. Importantly, Sri Lanka provides an interesting context for the study of CIM due to processes of urbanisation, economic and spatial development, as well as changing standards of living. It is likely that priorities for children's and young people's safety, independence and education will fluctuate depending on economic ability and settlement type and location. This will make it challenging for decision-makers to choose a development path, if CIM becomes a priority. They have an existing environment with relatively high CIM and number of examples from other countries to learn from. Interventions of denser residential development, mixed use streets and low speed limits that have been identified in industrialised countries as a way to support CIM, already exist in Sri Lanka. Finland and Japan have achieved high levels of development alongside high CIM. Australia and the UK have achieved high levels of development alongside low CIM. South Africa, while not as developed has both low and high levels of CIM depending on income, which is often associated with colour.

Sri Lankan Context

Sri Lanka is an Island of 65, 610 sq.km, located in the Indian Ocean, south-east of India. Politically the country uses the Westminster system, and administratively the country is divided into nine provinces. Sri Lanka's population of close to twenty million is ethnically, linguistically, religiously, spatially diverse. The majority of people are Sinhalese (74%), with a large proportion of Tamils (18%). The population is primarily Buddhist (76.7%), with a mix of Muslims (8.5%), Hindus (7.8%) and Christians (7%). Sri Lanka's urban population is 3.0 million; 16.3 million people live in rural areas and 1 million live in residential estate sectors (Household income and expenditure survey- 2009/10, 2010).

Sri Lanka is a lower middle-income developing nation with 8% of GDP growth rate in the year of 2010. From a micro economic standpoint country is divided into three main sectors: urban, rural, and estate. Income inequality in the country is severe, with striking differences between rural and urban areas. Mean household income per month is Rs,47,783 (£234.31; €283.77; AUD \$360.28) in the urban sector, Rs. 35,228 (£172.74; €209.22; AUD \$265.62) in the rural sector and Rs. 24,162 (£118.48; €143.50; AUD \$182.18) in the estate sector. Sri Lanka's poverty head count ratio is 8.9%. It is 5.3% in the urban sector, 9.4% in the rural sector and 11.4% in the estate sector (Household income and expenditure survey- 2009/10, 2010).

Sri Lanka has been using free market mechanisms since 1977 as part of International Monetary Fund supported economic restructuring (Asoka, et al., 2008). While there has been some oscillation between privatisation and reestablishment of the public sector that allows market forces to play a great role in allocating resources and determining the prices. Economic restructuring in response whole society has been changed. Lifestyles and aspirations of people of Sri Lanka have been changed according to the western developed countries.

Methods

This paper contributes to a multi-country research update about children's and young people's mobility conducted in 2010. The research design and methods used in the current study replicates the approach used in England in 1970, and England and Germany in 1990 to identify CIM trends, and facilitates a broader comparison of the cultural and other factors affecting CIM. Quantitative pen and paper surveys were conducted with children and young people aged 7-15 years old in five settlement types. The survey sought data about children's mobility behaviour, adult accompaniment and children's concerns if they go places on their own.

The Department of Town & Country Planning at the University of Moratuwa was commissioned by La Trobe University, Australia to conduct fieldwork for the research. Five different geographical areas for this survey were selected including: inner city, suburban, large town, small town, and rural area. One primary school and one secondary school in each of five different geographical areas participated in this survey. Participants included children aged 7-11 years and children aged 12-15 year olds.

Settlement types and schools were selected based on the feasibility of collecting data from mixed-gender schools (girls & boys) and areas that had co-located primary and secondary schools. Principals of each schools distributed the survey. Approximately 50 children from each grade level for children aged 7-11 years and children aged 12-15 year olds were asked to complete a questionnaire. Efforts were made to complete more than 50 questionnaires from each grade level.

The questionnaire asked children to indicate whether they could do things on their own like cross roads, cycle places (if they owned a bicycle) or take the bus, how they travelled to and from school on the day of the survey and how they would prefer to travel, time taken to travel to school, with whom they travelled, other places they went on the weekend prior to the survey.

All data was transcribed into pre-formatted excel worksheets and transferred to SPSS 20 for analyses. In addition to analysing frequency data, statistical tests were conducted on the data to identify significant differences between primary and secondary school children's mobility patterns, as well as differences between settlement type and gender. Statistical analyses were performed using IBM SPSS Statistics version 20. Independent t-tests were used to test the differences between means of mobility licenses for all settlement types, between the level of schooling. Logistic regression analysis was used to study the association between mobility licenses on the one hand and independent school travel and weekend activities on the other hand. In these analyses gender was controlled.

Limitations of the study

When reviewing the results, it is important to consider some limitations of this study. These results cannot be generalized, although they present important data for discussion. Borella, which is an inner urban area, is diverse as the population includes both very poor and very rich people, and will not reflect the mobility patterns of other inner urban children and young people with greater family incomes. In addition, due to terrain and other localized differences, there are various dominant modes of transport across the country depending on the particular settlement.

The questionnaire itself is westernised as it was originally developed in the UK in the 1970s, and its current version was amended to meet the survey needs of industrialised nations. While questions could be amended somewhat to meet the current conditions, the desire for international comparison means there are inherent assumptions motivating the study such as viewing CIM as a goal and assumptions within the research instrument like the types of activities provided as examples for children and young people.

The questionnaire was only conducted with Sinhalese speaking students and was not conducted in Tamil language dominant areas. It was difficult for many children to answer the questions; primary school children required substantial help, with questionnaires taking 40 minutes to complete. Secondary children had troubles answering whether they could take public transport and where they went on the weekend. Although parents were also invited to participate in the study, very few parents chose to respond, so the data could not be analysed and presented.

Study Sites

To help readers identify study site locations, a map of Sri Lanka and each settlement area surveyed is presented in Figure 3. As can be seen in the map, the study sites are located to the

south and east of the country. Surveying in the north and east of the country was not possible due to security concerns, time and distance.

Table 1 provides a brief overview of the study sites with regard to area, settlement type and population size. While there does not appear to be large population differences between the large town, small town and rural area, the population is spread over larger areas as the size of settlement decreases.

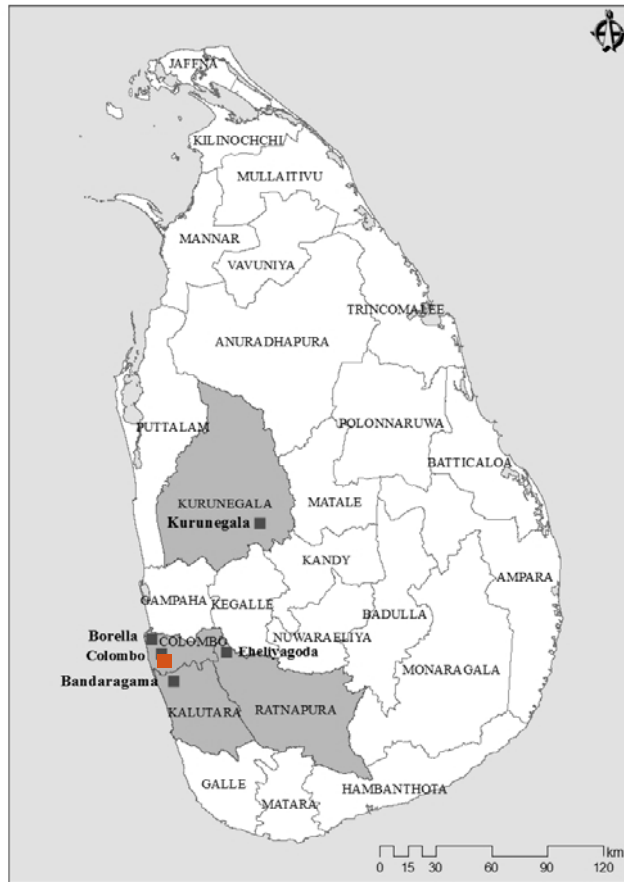


Figure 3 Map of study site locations

Table 1 Settlement type, area and population of study areas

District	Divisional Secretariat	Settlement type	Population
Colombo	Thimbirigasyaya	Inner city	(DS divisions)
Colombo	Maharagama	Sub Urban	195,355
Kurunegala	Kurunegala	Large town	80,395
Kalutara	Bandaragama	Small town	108, 889
Ratnapura	Eheliyagoda	Rural area	70,713

Participants

In total, 721 school children participated in the survey, as can be seen in Table 2. Around one quarter of the participants were based in each of the urban (23%), suburban (26%) and large town (24%) settlements. Participants from the small town and the rural area accounted for 15% and 12% of the survey sample, respectively. Just over half of the participants attended primary school (56%).

Table 2 Participants by settlement type

Location	Settlement Type	Primary <i>n</i>	Secondary <i>N</i>	Total <i>n</i>
Borella	Urban	82	81	163
Maharagama	Suburban	84	104	188
Kurunegala DS	Large town	81	94	175
Bandaragama	Small town	90	21	111
Eheliyagoda	Rural	66	19	85
Total				721

Table 3 shows the number of primary and secondary school boys and girls who completed the survey. In the urban settlement types, a noticeably larger percentage of primary and secondary school boys (80%) completed the survey compared to girls. Nearly equal proportions of primary school girls and boys completed the survey in the suburban area, but by secondary school, more boys (58%) participated. The dominance of male respondents was less pronounced in the large town where 57% of primary and secondary school boys completed the survey. In contrast, a higher proportion of girls completed surveys at both the primary (56%) and secondary (62%) levels in the small town. In an opposite trend, more primary school boys (58%) in the rural area completed the survey, but by secondary school the gender balance of participants was equal.

Table 3 Gender of participants by settlement type *

		Primary		Secondary		Total
		<i>n</i>	%	<i>n</i>	%	
Urban	Girl	16	20	15	19	31
	Boy	66	80	62	81	128
	Total	82	100	77	100	159
Suburban	Girl	42	52	44	42	86
	Boy	39	48	60	58	99
	Total	81	100	104	100	185
Large town	Girl	45	56	58	62	103
	Boy	35	44	36	38	71
	Total	80	100	94	100	174
Small town	Girl	38	43	9	43	47
	Boy	50	57	12	57	62
	Total	88	100	21	100	109
Rural	Girl	27	42	8	50	35
	Boy	37	58	8	50	45
	Total	64	100	16	100	80
Total Girls		168	43	134	43	302
Total Boys		227	57	178	57	405

* Results do not match total number of participants as some children did not answer this question.

Children's and Young People's Mobility

As a prerequisite for CIM, children and young people need to have permission or 'license' to do certain activities such as cross roads, ride a bicycle places and/or take public transport. Figure 2 shows secondary school children tend to have double the licenses than primary school children for crossing main roads(urban = 63% and 30%; suburban = 72% and 18%; large town = 56% and 22%); small town = 76% and 46%); rural = 72% and 47%). Between 27% and 41% of children from all settlement types are allowed to cycle places without an adult, with the exception of the slightly higher proportion of rural children who can do the same activity (54% and 60%). For primary school children, licenses to take public transport increases with smaller settlement size (rural area, 44%; small town, 29%; large town, 28%; suburban, 11%; urban, 10%), however, the proportion of secondary school children who can take public transport is similar across the settlement types, and ranges from 63%-71%, with the exception of the small town which is 95%. The results indicate that children's mobility licenses are affected by their level of schooling and where they live, with the exception of cycling which shows an overall similarity across the samples and settlement type.

Table 4 Licenses permitted to children

Licence	Cross main roads		Cycle places		Take public transport	
	Yes	%	Yes	%	Yes	%
Urban						
Primary	25 (n = 82)	30	26 (n = 73)	36	8 (n = 82)	10
Secondary	51 (n = 81)	63	19 (n = 51)	37	52 (n = 81)	64
Suburban						
Primary	15 (n = 84)	18	19 (n = 61)	31	9 (n = 84)	11
Secondary	74 (n = 103)	72	22 (n = 63)	35	66 (n = 104)	63
Large town						
Primary	18 (n = 81)	22	18 (n = 53)	34	17 (n = 61)	28
Secondary	53 (n = 94)	56	36 (n = 79)	46	64 (n = 93)	71
Small Town						
Primary	41 (n = 89)	46	20 (n = 74)	27	26 (n = 90)	29
Secondary	16 (n = 21)	76	7 (n = 17)	41	20 (n = 21)	95
Rural						
Primary	31 (n = 66)	47	22 (n = 41)	54	29 (n = 66)	44
Secondary	13 (n = 18)	72	3 (n = 5)	60	11 (n = 18)	61

Children's reported licenses to cycle on main roads may be affected by whether they own a bicycle or have access to a bicycle. Table 3 shows that bicycle ownership is highest among children from the large and small towns and lowest among children in the rural area. Bicycle ownership is somewhat similar between primary and secondary school children, however more primary than secondary school children have bicycles in the urban, small town and rural areas (urban = 82% and 62%; small town = 76% and 71; rural area = 45% and 28%, respectively). About one-third of children from urban and suburban areas, and primary school children from the large and small towns are allowed to go places on their bicycles. A greater proportion of primary (54%) and secondary (60%) school children from the rural area can go places on their bicycles compared to the other settlement types.

Dichotomous data (1= yes; 2 = no) representing children's responses as to whether they could cross main roads alone, cycle places and take public transport were summed to form a mobility license variable. Independent t-tests were conducted to identify if there were significant differences across the settlements with regard to mobility licenses. There were no significant differences between primary and secondary school children. Examining the means indicates that children in the inner urban area ($N = 163$; $M = 2.50$; $SD = 4.31$) had the highest level of mobility licenses followed by the small town ($N = 110$; $M = 3.14$; $SD = 3.64$), suburban area ($N = 187$; M

= 1.49; 4.75), large town ($N = 174$; $M = 1.32$; $SD = 5.97$) and lastly, the rural area ($N = 84$; $M = 0.18$; $SD = 4.81$). The standard deviations across each of the sites indicate high levels of variability.

There were significant differences in mobility licenses between the inner urban area and the suburban area ($t = 2.07$, $df = 347.47$, $p = 0.039$), large town ($t = 2.09$, $df = 315.5$, $p = 0.04$) and rural area ($t = 3.71$, $df = 152.48$, $p = 0.000$), respectively. Significant differences between the means were found between the suburban area and small town ($t = -3.34$, $df = 275.13$, $p = 0.001$) as well as the rural area ($t = 2.09$, $df = 269$, $p = 0.037$). In addition, the means of the large town and small town were significantly different ($t = -3.19$, $df = 281.71$, $p = 0.002$), as was the small town and rural area ($t = 4.70$, $df = 149.71$, $p = 0.00$). The data suggest that children in inner urban and small town areas have similar levels of mobility licenses, and that there are similarities between suburban areas and small towns.

The mobility license data needs to be considered with caution. While the data indicates that children in rural areas have lower mobility licenses, being able to cycle places may be affected by bicycle ownership. As Table 5 shows, nearly half as many children in the rural area own a bicycle compared to children located in the settlement types, yet, Pearson's product moment correlation test indicates there is a significant medium inverse relationship between bicycle ownership and cycling places ($r^2 = -0.586$, $p = 0.001$), suggesting that there is a relationship between children who noted they do not own a bicycle but are allowed to cycle places on their own. As children had some difficulty with the questionnaire, it is possible that children interpreted the question as: 'If you have a bicycle, do you (*rather than are you*) allowed to ride it to go to places (like the park or friend's houses) without any grownups?'

Table 5 Bicycle ownership

		Have bicycle	
		Yes	%
Urban	Primary (n = 82)	67	82
	Secondary (n = 81)	50	62
Suburban	Primary (n = 84)	46	55
	Secondary (n = 104)	64	62
Large town	Primary (n = 81)	58	72
	Secondary (n = 94)	76	81
Small town	Primary (n = 89)	68	76
	Secondary (n = 21)	15	71
Rural	Primary (n = 66)	30	45
	Secondary (n = 18)	5	28

Turning to the most common indicator of CIM, which is school travel, Figure 4 and Figure 5 show children's dominant mode of travel to and from school differed depending on settlement type, and varied between primary and secondary school. Half of the primary school children in the urban area travelled to school by 3-wheeler/motorcycle, with just over 10% walking or taking a school bus or public transport. The majority of urban secondary school children travelled to school by public transport (39%) followed by 3-wheeler/motorcycle (26%). Only 15% of urban school children walked or cycled to school.

The dominant forms of transport for children in the suburban area were similar to those used by children in the urban area, although there was a shifting in distribution. More primary school children walked (16%) to school, but fewer used school buses (21%), took public transport (21%) or used 3-wheeler/motorcycle (32%). Fewer secondary school children walked (11%) or used 3-wheeler/motorcycle (24%), but more used school buses (18%), took public transport (45%)

In the large town, nearly 60% of primary school children travelled to school by school bus, and the majority of secondary school children travelled by school bus (51%) or public transport (35%). The majority of primary school children in the small town travelled to school by school bus (40%) and 3-wheeler/motorbike, while most secondary school children travelled by public transport or by foot (38% for both modes). In the rural area, the majority of primary and secondary children walk to school (83% and 89%, respectively).

There were some noticeable differences in school to home travel for children and young people in the urban and suburban areas; more walked or took public transport home from school. However, school to home travel was fairly similar across the other settlement types.

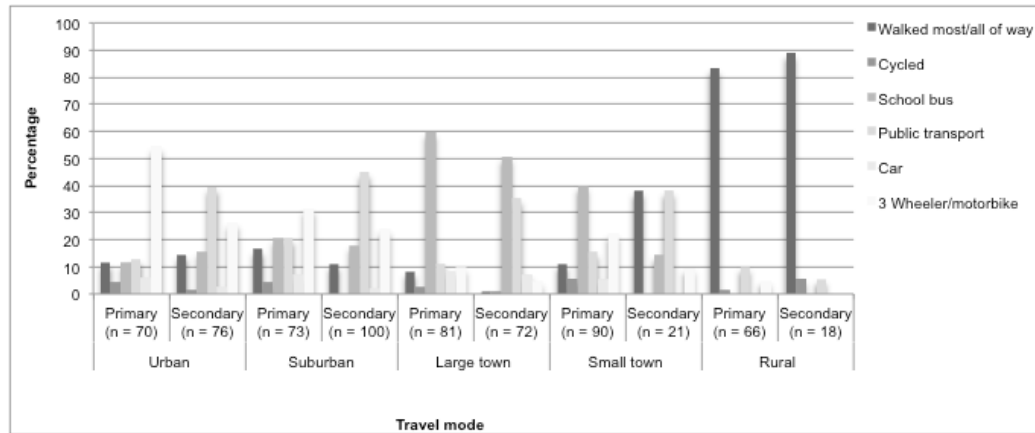


Figure 4 Travel mode to school

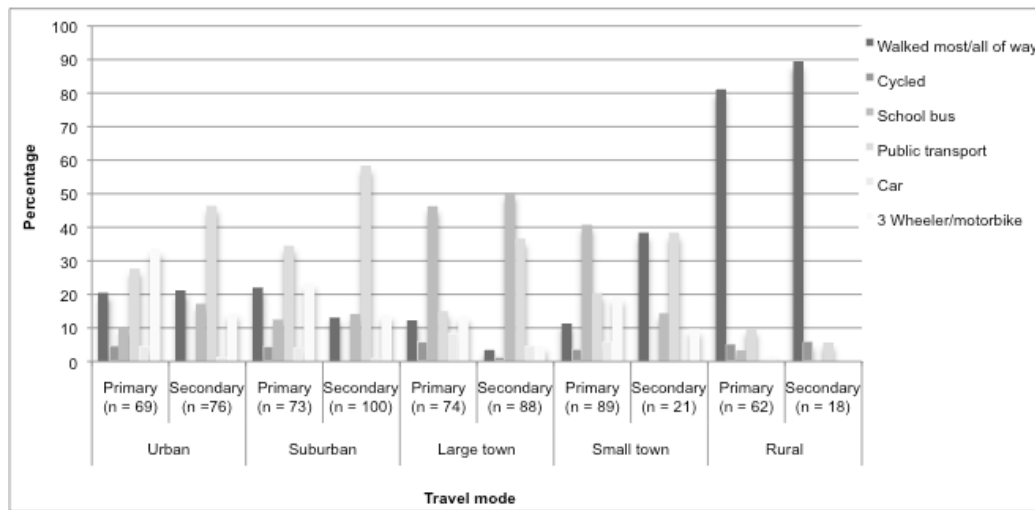


Figure 5 Travel mode from school

To identify level of independence, Figure 6 and Figure 7 summarises accompaniment on children's school journeys. Across all settlement types, a higher proportion of primary school children was accompanied by their parents or other adults compared to secondary school children. Children from the rural area had the most independent school journey for both primary and secondary school children. More primary and secondary school children in urban (82% and 34%) and suburban (77% and 38%) areas had adult accompaniment on their school journeys than in the large town (53% and 22%), small town (55% and 8%) and rural areas (24% and 6%).

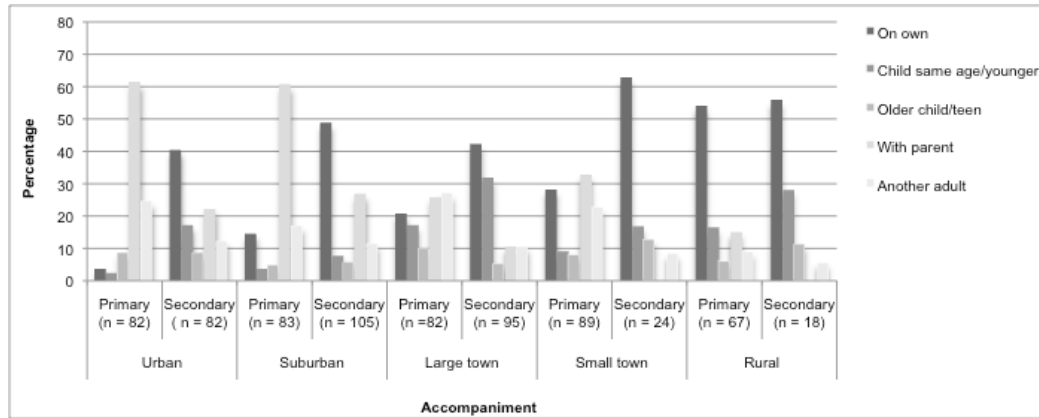


Figure 6 Accompaniment to school

Overall, there were not many substantial changes adult accompaniment of children on their school journey across most settlement types. However, there was an increase in the proportion of urban primary school children (11%) and small town secondary school children (23%) travelling home alone, and an increase in the proportion of rural secondary school children travelling with an older child or teenagers (11%).

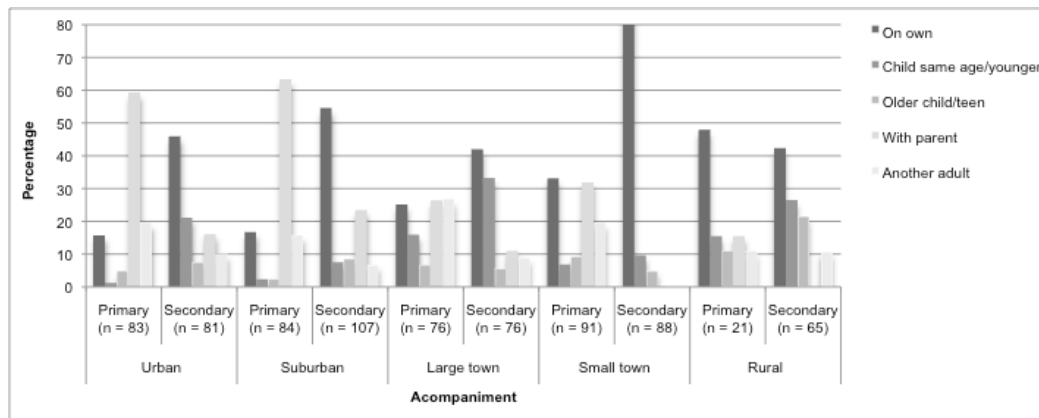


Figure 7 Accompaniment from school

Chi square tests were conducted to identify if children's mobility licenses were associated with adult accompaniment of children to and from school and to places other than school. In addition to the mobility license variable, a dichotomous variable representing children's travel was created from the data using 1 = travelled alone or with children the same age or younger and 2 = with an older child/teenager, a parent or adult.

The results indicate that there are significant relationships between mobility licenses and children's independent travel to school ($X^2= 7.20$, $df= 1$, $p = .007$) and from school ($X^2= 9.63$, $df=1$, $p = .002$), suggesting that children with more mobility licenses have a greater likelihood of travelling to and from school on their own.

Children were asked to report their preferred modes of school travel. Figure 8 illustrates that 48% of urban, 55% of suburban and 43% of small town primary school children indicated car or scooter was their most desired travel mode. There were also high proportions of both primary and secondary children preferring this mode across the other sites, with the exception of rural children. While a high proportion of rural primary (71%) and secondary (72%) school children

reported walking or cycling as their preferred mode, less than one-third selected these modes in the other settlement types; in particular, it was the least preferred mode amongst children in the small town. With the exception of the rural area, 43%-58% of secondary school children indicated that the school bus and public transport was their desired form of travel.

A dichotomous variable was created for travel mode to and from school and preferred travel mode with 1 = walking or cycling and 2 = school bus, public transport, car/scooter, and other modes. Pearson's product moment correlations were conducted to identify whether there were associations between active school travel and preferred travel modes. There were significant high positive correlations between active transport to and from school ($r^2 = 0.792$, $p = 0.0000$) and significant medium positive correlations between active school travel and active transport as a preferred mode (to school: $r^2 = 0.294$, $p = 0.0000$; from school: $r^2 = 0.302$, $p = 0.0000$). The data suggests that children are socialised to prefer certain modes through existing transport behaviours.

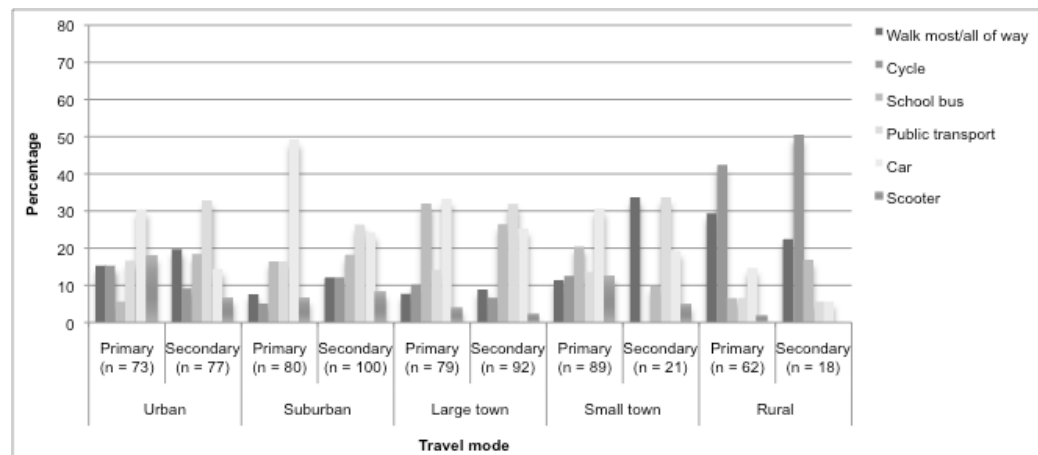


Figure 8 Desired travel modes

Mode of transport and independence of travel can be associated with travel distance; unfortunately data about distance was not requested, so time is used as a rather poor proxy indicator of distance. Children's reported school travel time is presented in Figure 8. With the exception of primary school students in the urban area (68%) and secondary school students in the large town (56%), more than 75% of children travel less than half an hour to school. Nearly two-thirds or more of primary and secondary school children travel less than 15 minutes on their school journeys (excluding secondary school children from the suburban and large town areas). However, for urban and large town areas, over 20% of primary and secondary school students travel more than half an hour on their school journeys.

The means for time taken to travel to school indicate that children in the rural area ($N = 84$; $M = 2.20$; $SD = 1.10$) and the small town ($N = 111$; $M = 2.29$; $SD = 1.00$) spent less time travelling to school on average, followed by children in the inner urban area ($N = 163$; $M = 2.55$; $SD = 1.16$) suburban area ($N = 188$; $M = 2.61$; $SD = 1.13$) and large town ($N = 175$; $M = 2.75$; $SD = 0.08$).

There were significant differences in the means of time travelled between the small town and inner urban area ($t = 1.99$, $df = 254.62$, $p = 0.047$), the suburban area ($t = 2.60$, $df = 258.88$, $p = 0.010$) and large town ($t = 3.71$, $df = 245.80$, $p = 0.000$), respectively. Significant differences between the mean time travelled by children in the rural area compared to the inner urban area ($t = 3.714$, $df = 152.48$, $p = 0.000$) and the large town ($t = 3.77$, $df = 158.19$, $p = 0.000$) were also found. The result may be due to more children walking to school in the smaller settlements; in the larger settlements a larger proportion of children take motorised transport and would experience traffic congestion.

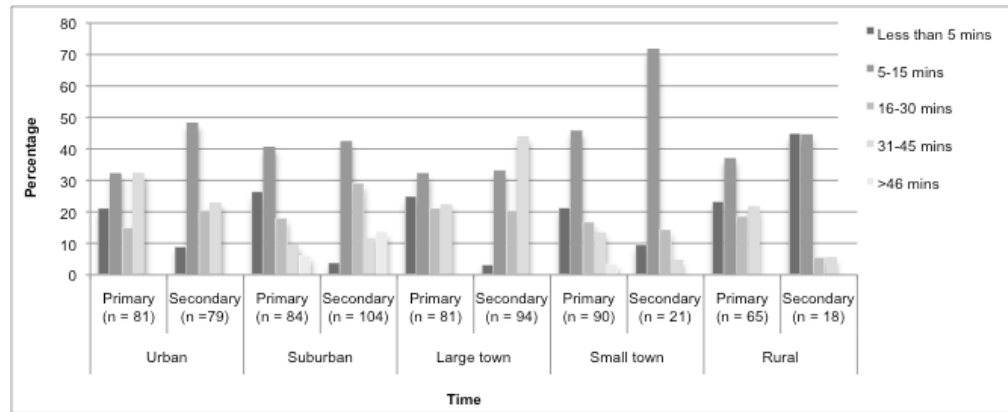


Figure 9 Travel time to school

To assess children's level of independent mobility to places other than school, children were asked to identify from a list of 12 items the places they visited on their own, with another child and with a parent or other adult during the weekend before the survey. Table 6 summarizes this data. A greater proportion of secondary school children could go places on their own compared to primary school children. More children from urban, suburban and small town environments reported they visited more places than the other settlement areas. Responses from rural children indicated fewer visited the listed places compared to children from other areas, however, children in this settlement type and those from the small and large town do not have the same activity opportunities.

The majority of primary school children visited friends with a parent or other adult, while the majority of secondary children visited friends with another child. Rural primary school children were an exception because they also visited friends with another child. Excluding the majority of rural secondary school children who indicated they visited relatives on their own, most primary and secondary children reported they visited relatives with parents or another adult. Across all settlement types, the majority of children indicated they went the shops and walked/cycled around with another child; most children also indicated they went to a place of worship, the cinema and concert/nightclub with their parents or other adult. With the exception of primary school children from suburban and large town areas, most children visited libraries and youth clubs with other children; for the youth clubs, primary school children also attended with their parents. The majority of children went to parks/playgrounds and sports/swimming with another child, but primary school children from urban and suburban areas, and secondary school children from the small town attended these places with adults.

Table 6 Places children visited

Activity	Urban n = 82				Suburban n = 84				Large town n = 81				Small town n = 90				Rural n = 66			
	Primary	Secondary	%	n = 81	Primary	Secondary	%	n = 104	Primary	Secondary	%	n = 94	Primary	Secondary	%	n = 21	Primary	Secondary	%	n = 18
Visited friend																				
Another young person	21	33	26	41	15	18	38	40	14	17	34	36	23	26	10	48	30	45	5	28
Parent/other adult	32	20	39	25	39	46	30	29	26	32	25	27	42	47	10	48	10	15	1	6
Visited relatives/grown ups																				
Another young person	5	11	6	14	10	12	14	13	4	5	10	11	12	13	5	24	7	11	10	56
Parent/other adult	53	47	65	58	52	62	63	61	47	58	64	68	55	61	11	52	23	35	3	17
Youth club																				
Another young person	20	24	20	25	18	21	32	31	6	7	42	45	18	20	5	24	10	15	5	28
Parent/other adult	16	20	11	14	31	37	8	21	26	9	10	19	19	21	4	19	6	9	1	6
Shops																				
Another young person	55	61	67	75	43	51	74	71	26	32	59	63	47	52	19	90	40	61	11	61
Parent/other adult	16	20	10	12	20	24	15	14	15	19	17	18	19	21	3	14	8	12	2	11
Library																				
Another young person	18	31	22	38	18	21	46	44	14	17	28	30	27	30	10	48	10	15	3	17
Parent/other adult	9	11	12	15	24	29	17	16	22	27	14	15	25	28	6	29	2	3	1	6
Cinema																				
Another young person	5	4	6	5	4	5	3	3	8	10	5	5	4	4	1	5	8	12	1	6
Parent/other adult	25	30	27	33	38	45	40	38	22	27	27	29	39	43	9	43	6	9	4	22
Friends after dark																				
Another young person	23	19	28	23	21	25	16	15	12	15	25	27	16	18	3	14	13	20	2	11
Parent/other adult	14	17	10	12	19	23	22	21	14	17	14	15	25	28	6	29	8	12	4	22
Playground/park/playing field																				
Another young person	15	32	18	40	24	29	41	39	20	25	37	39	24	27	13	62	14	21	5	28
Parent/other adult	18	22	17	21	31	37	27	26	14	17	12	13	29	32	0	0	6	9	0	0
Sport/swimming																				
Another young person	15	21	18	26	16	19	29	28	16	20	44	47	22	24	10	48	11	17	5	28
Parent/other adult	18	22	20	25	27	32	22	21	16	20	15	16	28	31	1	5	5	8	2	11
Walk/cycle around																				
Another young person	30	50	37	62	27	32	53	51	26	32	48	51	50	56	14	67	24	36	4	22
Parent/other adult	18	22	9	11	20	24	17	16	13	16	9	10	14	16	1	5	4	6	0	0
Concert/nightclub																				
Another young person	2	6	2	7	4	5	7	7	7	9	7	7	6	7	2	10	11	17	2	11
Parent/other adult	17	21	21	26	34	40	35	34	21	26	26	28	40	44	3	14	10	15	4	22
Place of worship																				
Another young person	10	12	10	12	10	12	11	11	4	5	12	13	9	10	7	33	10	15	4	22
Parent/other adult	28	34	40	49	45	54	54	52	32	40	51	54	47	52	9	43	13	20	4	22
Other																				
Another young person	9	11	10	12	2	2	5	5	4	5	13	14	9	10	4	19	3	5	6	33
Parent/other adult	19	23	21	26	23	27	18	17	20	25	9	10	8	9	2	10	9	14	2	11

A dichotomous variable was created with 1 = 3 or more activities and 2 = 1-2 activities. In addition, Boys were likely to have visited more places on their own than girls ($X^2= 27.13$, $df=1$, $p = .000$). These results reflect social norms about gender within Sri Lanka, and the greater freedom often experienced by males than females.

Mobility licenses did not affect whether children go to places other than school on their own. The lack of association between mobility licenses and where children go may be due to the fact there are fewer activities for children in smaller settlements, or the activities for children to select from did not adequately represent children's options, suggesting that their mobility may not be adequately reflected in the data.

Discussion

The results suggest that increased urbanisation may reduce CIM. As Sri Lanka becomes more urbanized there will be impacts on urban form, density, transport networks, and the types and speed of improvements to individual and family standards of living. These changes are likely to be spatially, economically and socially uneven. Economic choice in relation to the opportunities offered by the urban environment in terms of the schools children attend, the variety of places children can go, the ability to travel longer distances, and travel modes available and preferred will result in spatially specific levels of children's and young people's mobility. This can already be seen in the data presented above which indicates different levels of mobility and types of travel mode depending on settlement size. Importantly, there was a correlation between children's existing and preferred travel modes, suggesting a process of socialisation is occurring.

Children in Sri Lanka have medium levels of independent mobility. There are high levels of adult accompaniment for the majority of children and young people, with the exception of the rural area. Accompaniment was greater for primary than secondary school children. The use of motorised transport was more dominant in urban and suburban areas. Transport by school bus or public transport was higher for the large and small towns, and walking was more prominent in rural areas. The majority of children and young people spent less than half an hour travelling to school, however, time can be affected by distance, as well as urban density and form, mode choice, traffic and road speeds. Interestingly, while there were significant relationships between mobility licenses and independent school travel and places children and young people went on the weekend, these latter two were not significantly associated with each other.

As noted earlier in this paper, people living in more urbanized areas and along transport routes are more likely to have greater access to jobs and higher incomes than in less developed areas (Gunasekera, et al., 2008). For families in the inner urban, suburban and large town, proximity to this infrastructure would increase the ability for families to own a car and drive, pay for semi-private transport like the three-wheelers/motorbikes, select private schools and afford leisure activities. As such, adult accompaniment of children and young people in more urbanised areas now and/or in the future may reflect these lifestyle choices or concern about the safety of the urban environment (Beck-Gernsheim, 1996; Rudner, 2012; Valentine, 2004).

Families living in rural areas, further from urban infrastructure may have lower incomes, and greater necessity for children and young people to have independent mobility and to use less expensive forms of transport to school (Behrens & Muchaka, 2011; Bwire, 2011; Porter & Blaufuss, 2002). In the current research this may also be true for the inner urban area since access to existing infrastructures means more than its mere provision. For these groups, access to leisure activities may have the effect of reducing CIM as there are fewer accessible destinations to visit.

Children and young people's preferred transport mode choice may symbolize family and cultural socialization, in addition to a convergence of settlement type, experience and financial expectation. Greater proportions of children in more urban areas tended to indicate car travel as a preferred travel mode, while children in less urbanised areas preferred more public modes like school bus and private transport, or walking in the rural area. Alternatively, children in urban

areas may not like public transport. Preferred travel modes may also indicate preferences for independent travel for reasons of socialisation, especially for secondary school children. These modes permit children to travel with friends without adult accompaniment.

An important consideration in relation to this study is the problematic nature of cross-cultural comparisons and the inherent bias in the conception of CIM and the instruments used to measure it. It is assumed within the research and literature of industrialised that children and young people should have CIM, and assessments of CIM are essentially founded on the baseline data from the UK in 1970s. While cultural differences such economic status, community trust and expectation, and need have been used to explain differences levels of CIM between industrialised and lesser-developed countries, the authors have yet to come across research that examines this issue more closely. Within Sri Lankan and other countries, CIM may not be a goal to aspire to, and could conflict with family and community expectations for rearing children and young people and their independence in public space.

Conclusion

Decision-makers in Sri Lanka can choose whether they maintain current levels, experience a decrease, or create an increase of CIM depending on the development trajectory they pursue. Since emerging new landscapes will have a direct influence on the mobility patterns and behaviours of all people within Sri Lanka, it is important that decision-makers and the broader Sri Lankan community consider whether they value CIM what their goals are for CIM. This will take a wholistic approach to urban planning and design so the outcomes of economic development does not occur at the expense of these values, and associated impacts on children and young people, as well as adults.

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Factors Contributing towards establishing a Positive Safety Culture in Manufacturing Sector

D.M.P.P. Dissanayake

Department of Building Economics, University of Moratuwa, Sri Lanka
piumi2d@gmail.com

Nirodha Gayani Fernando

Department of Building Economics, University of Moratuwa, Sri Lanka
nirodhafernando@uom.lk

Abstract

A combination of large scale disasters and hazards has encouraged high risk industries to reduce the potential workplace incidents and accidents with routine tasks and to improve workplace safety. This idea encourages the promotion of a strong safety culture which has attracted much attention across a broad spectrum of industries such as manufacturing, shipping, nuclear, airports, mining and construction where manufacturing sector has one of the highest and continued incidence of fatal incidents, major injury, and reportable 'over 3-day' injuries and high overall numbers. In addition, the manufacturing sector accounts for the second largest number of major injuries when compare to the services. Therefore, promoting a positive safety culture in manufacturing sector creates an atmosphere in which employees are aware of the risk in their workplace, continually on guard against them, and avoid taking any unsafe actions. Establishing a positive safety culture is affected by many factors such as safety management systems occupied including reporting procedures, communication and feedback systems, auditing processes, attitudes and behaviours, work environment, management commitment, employee involvement and employee performance including training and development, incentives, reward systems etc. Thus, understanding such aspects is crucial to create and nurturing a safety culture that suits the organization and the individuals within it. This paper, therefore, aims to investigate factors which contribute towards establishing a positive safety culture in manufacturing sector.

A comprehensive literature review and preliminary study were conducted. Key words such as safety culture, definitions of safety culture, components of safety culture and way to establishing a positive safety culture were used to gather relevant literature. Further, semi structured interviews were carried out with the industrial experts who are in charge of the concerned areas to validate the factors identified from literature review. Research findings illustrated three key areas to be considered when developing a safety culture namely; organizational environment, individual and behaviour (human), and systems and processes. Each manufacturing organisation needs to consider all of these aspects in developing and strengthening the safety culture that suits the organisation and the individuals within it. Also, it was further disclosed that everybody needs to feel that safety is everyone's responsibility in order to create the safety culture in the organisation. The finding of this research will be a guideline to propose a better working condition so that the safety culture can be created.

Keywords: Safety Culture, Manufacturing Sector

1.0 Introduction

A safety culture is so much more than the “Safety First” sign hanging over the entrance door. Many industries around the world are increasingly showing interest in the concept of ‘safety culture’ as a means of reducing the potential for large scale disasters and accidents with routing tasks as disasters and accidents and their consequences continue to be a major public safety concern (Sukadarin et al., 2012). In addition, the Occupational Safety and Health Act (OSHA) 1994 states that the self regulation concept was promulgated based on the primary responsibility of ensuring safety, health and welfare of all persons at all places of work. Therefore, an

introduction of positive safety culture can be seen as a systematic solution towards the establishment of zero accidents in the workplace. Since manufacturing sector accounts for the second largest number of major injuries when compared with services (HSE United Kingdom Government estimate, 2008; Halim, Said and Said, 2012; Madugamuwa, 2012), creating and strengthening a positive safety culture in manufacturing sector creates an atmosphere in which employees are aware of the risk in their workplace, continually on guard against them, and avoid taking any unsafe actions. Further, establishing a positive safety culture is affected by many factors. Accordingly, this paper aims to investigate factors which contribute to develop a positive safety culture in the manufacturing sector.

2.0 Safety Culture

Safety culture is the way in which safety is managed in the workplace, and often reflects the attitudes, beliefs, perceptions and values that employees share in relation to safety (Cox and Cox, 1991). Further, safety culture is just one of many within an overall organisational culture. With this context, following sub section explores the relevant literature in the research arena with major focus is given to two areas such as organisational culture and safety culture in manufacturing sector.

2.1 Organisational Culture and Safety culture

A positive safety culture should be developed within the framework of an organisational culture to help ensure organisational consistency within safety culture programs (Clarke, 1998). Before continuing with a safety culture literature review, it is necessary to understand what organisational culture is in a broader context, and why researchers continue to focus on it. Organisational culture comes from the external environment and the integration of an internal framework (Schein, 1990). Organisational culture is defined in many ways in literature. Organisational culture encompasses the central beliefs, values and basic assumptions that are shared by members of an organisation (Schein, 1990; Denison, 1996). Schein's (1990, p.111) commonly held definition of culture is 'pattern of basic assumptions, invented, discovered, or developed by a given group, as it learns to cope with its problems of external adaptation and internal integration, that has worked well enough to be considered valid and, therefore is to be taught to new members as the correct way to perceive, think, and feel in relation to those problems'.

Safety culture, like organisational culture, does not have a universal definition. The concept of Safety Culture came into international usage following a report by the International Atomic Energy Agency (IAEA) in 1991, after the Chernobyl nuclear disaster in 1986 (Flin *et al.*, 2000) which led to safety culture being defined as an organisational atmosphere where safety and health is understood to be, and is accepted as, the number one priority. This definition highlights two major points: (1) while safety culture is about positive safety attitudes, it is also about positive safety management established by organisations; (2) good safety culture means assigning the highest priority to safety. Since then, a number of organisations and researchers have developed the concept, applying it more widely to non-nuclear industries and linking it to the need for preventative approaches to occupational safety health and to human and behavioural aspects of effective safety management (ILO, 2005).

2.1.1 Defining safety culture

A safety culture generally refers to the extent to which every individual and every group of the organisation is aware of the risks and unknown hazards induced by its activities; is continuously behaving so as to preserve and enhance safety; is willing and able to adapt itself when facing safety issues; is willing to communicate safety issues; and consistently evaluates safety related behaviour. The term is loosely used to describe the corporate atmosphere or culture in which safety is understood to be, and is accepted as, the number one priority (Cullen, 1990). Numerous

definitions of safety culture exist in the academic literature and examples of selected definitions are shown in Table 1.

Table 12: Definitions of Safety Culture

Reference	Definition
Kennedy and Kirwan (1998)	An abstract concept, which is underpinned by the amalgamation of individual and group perceptions, thought processes, feelings and behaviours, which in turn gives rise to the particular way of doing things in the organisation. It is a sub-element of the overall organisational culture
Hale (2000)	Refers to 'the attitudes, beliefs and perceptions shared by natural groups as defining norms and values, which determine how they act and react in relation to risks and risk control systems'
Glendon and Stanton (2000)	Comprises attitudes, behaviours, norms and values, personal responsibilities as well as human resources features such as training and development
Guldenmund (2000)	Those aspects of the organisational culture which will impact on attitudes and behaviour related to increasing or decreasing risk
Cooper (2000)	Culture is 'the product of multiple goal-directed interactions between people (psychological), jobs (behavioural) and the organisation (situational); while safety culture is 'that observable degree of effort by which all organisational members directs their attention and actions toward improving safety on a daily basis'
Mohamed (2003)	A sub facet of organisational culture, which affects workers' attitudes and behaviour in relation to an organisation's on-going safety performance
Richter and Koch (2004)	Shared and learned meanings, experiences and interpretations of work and safety - expressed partially symbolically – which guide people's actions towards risk, accidents and prevention
Fang <i>et al.</i> (2006)	A set of prevailing indicators, beliefs and values that the organisation owns in safety

Most of the definitions are relatively similar in the beliefs perspective, with each focusing to varying degrees, on the way people think and/or behave in relation to safety. The definitions (see Table 1) adopted by Hale (2000), Glendon and Stanton (2000) and Cooper (2000) are the most practical, as they clearly outline the contents of safety culture. Lee and Harrison (2000) reveal that basically, any safety management system is a social system, wholly reliant upon the employees who operate it. Its success depends on three things: its scope, whether employees have knowledge about it and whether they are committed to making it work. The concept of safety culture has evolved as a way of formulating and addressing this new focus. In line with this, the Advisory Committee on the Safety of Nuclear Installations (ACSNI, 1993) provides the definition that 'the safety culture of an organisation is the product of individual and group values, attitudes perceptions, competencies and patterns of behaviour that determine the commitment to and the style and proficiency of an organisation's health and safety management'.

The latest definition of safety culture is proposed by Fang and co-workers (2006): a set of prevailing indicators, beliefs and that the organisation owns in safety. In practice, creating or engineering a safety culture is due to the goal directed of various organisational characteristics by considering the impact upon safety management practices. The specific principles are reductions in number of accidents and incidents, ensuring that safety issues receive appropriate attention, ensuring that organisational members share the same ideas and beliefs about risks, accidents, and illness related to health and, determining the style and proficiency of an organisation's health and safety programs. Companies are being encouraged to adopt a positive organisational safety

culture in order to safeguard their operations against accidents and it is accepted as the number one priority (Clarke, 2003; Sukadarin et al., 2012). In high-risk industries, like aviation, nuclear power, manufacturing and fuel transportation this makes sense. The next section reviews the safety culture in manufacturing industry.

2.2 Safety Culture in Manufacturing Sector

According to the HSE United Kingdom Government estimates (as cited in Crime Risk and Incident Management e-Service, 2008), the manufacturing sector has one of the highest and continued incidence of fatal incidents, major injury, and reportable 'over 3-day' injuries and high overall numbers. They further emphasised that the rate of fatal injury in manufacturing was 1.27 per 100,000 employees in 2004/2005 and 1.39 per 100,000 in 2005/2006 where the manufacturing sector accounts for the second largest number of major injuries each year (6078 in 2003/2004) when compared with services. A recent study by Halim et al. (2012) revealed that among all sectors, the number of accidents reported for the manufacturing sector has been the highest in Malaysia. This reflects that the workers in the manufacturing sector are exposed to higher accidental risks. It is often the case that rapid expansion of manufacturing industries during economic expansion is associated with large employment of new workers and new technologies, machineries and equipments. While the application of new technologies would expose new hazards to the workers, hiring new worker might as well pose higher risk of accident as they are not accustomed to the hazard of workplace environment (Said et al., 2012). As stated by Allahakoon, Colombo District Factory Inspection Engineer (Madugamuwa, 2012), in Sri Lanka around 2,000 occupational accidents were reported annually and over 80 Sri Lankans lost their lives in work-related accidents every year where manufacturing sector has the second highest number of work place accidents. Thus, creating and strengthening of the safety culture is most critical in manufacturing environments with a high risk of accidents and safety-related incidents. Developing of a positive safety culture is affected by many factors. The next section discusses factors that contribute towards establishing a positive safety culture in manufacturing sector.

3.0 Research Method

The study is structured in several steps. A background study was carried out on a broader perspective with the purpose of getting familiarised with the subject areas of the research study while holding the focus on research problem. The background study took the attention of journal articles, online journals, e-books, web sites, electronic library data base and other publications. Based on knowledge gained, an interview guideline was developed, investigating the research question of what are the factors which contribute to develop a positive safety culture in manufacturing sector. The interview guideline consisted of five stages as Introduction to the research, Importance of safety culture for manufacturing industry, Involvement of organisational environment, Involvement of individual and behavioural (human) and Involvement of systems and processes for developing a positive safety culture in manufacturing sector.

Data collected from respondents who are in charge of the concerned areas of manufacturing sector. The respondents include industrial experts based on number of years of experience in the respective industries (see Table 02). Semi structured interviews were carried out with them to identify factors which contribute towards establishing a positive safety culture in manufacturing sector. Finally, collected data were analysed using code based- content analysis. The QSR.NVivo - version 10.0 produced by QSR (Qualitative Solutions and Research Private Limited); computer software was used.

Table 23: Interview Profile

Selected Industrial Experts (IE)	Designation	Nature of Manufacturing organisation (currently their working in)	No of years of experience in the respective industries
IE1	Senior Manager – Environmental Health and Safety (EHS)	Pharmaceutical	12
IE2	Manufacturing Manager	Pharmaceutical	15
IE3	Senior Manager – Compliance and EHS Systems	Apparel	10
IE4	Senior Compliance office	Apparel	8
IE5	Senior Safety Engineer	Fast Moving Consumer Goods (Dairy products)	11

4.0 Research findings and Discussion

It is not possible to graft a general safety culture onto manufacturing organisation as each manufacturing organisation is unique with their nature of business, processes, systems, etc. and the best safety systems in the world will fail without a supportive culture. The coding structure (see Figure 1) related to factors that contribute towards developing a positive safety culture in manufacturing sector is presented in this section which will be the basis of following discussion.

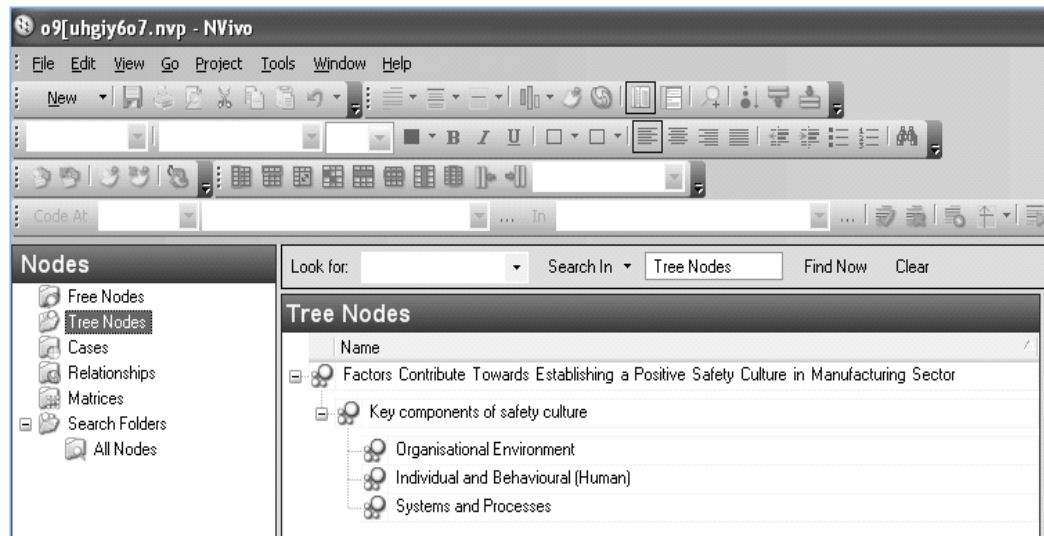


Figure 15: Coding structure for factors contribute to safety culture

Many industrial experts and results from the preliminary study revealed that the key factors such as *Management systems* such as integrated management systems for Environmental Health and Safety (EHS), risk management plan, EHS policies, standards (e.g. OSHAS 18000) and international EHS rating systems (e.g. Nike bronze rating) etc., *Workforce, Rules, Standard Operating*

Procedures (SOPs), and *Systems* including reporting procedures, communication and feedback systems, auditing processes, investigation processes, etc. are really needed in developing and nurturing a safety culture that suits the organisation and the individuals within it. This was more alike with the literature where many researchers believed that the key factors in developing an environment which is conducive to a positive safety culture include: (1) Management (Cox et al., 2000), (2) Individual and behavioural (workforce) (Cooper, 2000) and (3) Rules and procedures. These factors and their elements are summarised in Table 3.

Table 34: Factors that contribute to safety culture

Management <i>Source: Literature findings</i>	Management commitment	Rules <i>Source: Literature findings</i>	Clear
	Ability		Practical
	Leadership	Reporting procedure <i>Source: Literature findings; Preliminary findings</i>	Reporting near misses
	Communication		Open door policy
	Flexible culture		No blame culture
	Co-ordination		Analysis
Individual and behavioural (workforce – at all levels) <i>Source: Literature findings; Preliminary findings</i>	Attitude		Risk / incident analysis
	Behaviour	Supervisor subordinate relationship <i>Source: Literature findings; Preliminary findings</i>	Confidentiality
	Involvement		Feedback
	Training		Open door policy
	Competency		Participation
Communication <i>Source: Literature findings Preliminary findings</i>	Internal and external communication		Support correct behaviour
	Commitment		
	Internal and external communication		
	Visual aids		
	Newsletters		
	competitions		

MacDonald et al. (2000) (cited Sukadarin et al., 2012) claimed that the reason for many accidents is deeply linked in organisational and management factors. Also, preliminary findings disclosed that incompatibility management policies and practices may cause a fuzzy understanding about priorities. It stated that the safety communication, safety training and safety systems must be considered for developing and measuring an organisational safety culture. Further, many industrial experts believed that commitment at all levels as another important factor of safety culture. They further mentioned that organisation should adopt safety and health as a core value and actively cares for the workforce. The vision for the organisation is that the workplace will be free of incidents/injuries and safety and health is integrated into every aspect of the work process. This attitude is evident throughout the organisation from the managing director through to the newest and most inexperienced member of the workforce. However, literature finding shows that the commitment from the managerial level in order to create and promote safety culture is still weak. Putting more priority in making profit instead of workers, safety is not acceptable at all (Sukadarin et al., 2012). The industrial experts (IE1, IE2, IE3 and IE5) who are in charge of the concerned areas disagreed with this fact and they stated that “*some workers still not fully understand with the purpose of conducting accident investigations. They assumed that it is made to find who’s to be blame in any accident or incident rather than to focus on reoccurrence of accident or incident prevention.*”

Since the concept of safety culture developed, there has been comprehensive research that has been carried out to establish the model of safety culture. Geller (1994) presented a model that has discriminated three dynamic and interactive factors consist of Person, Behaviour and Environment. Cooper (2000) proposed the Reciprocal Safety Culture model by adopting the

Bandura's model of Reciprocal Determinism which derived from Social Cognitive Theory (SCT). This model suggested that the concept of safety culture to facilitate the measurement and quantification of safety culture. It constitutes of three dominant dimensions of safety culture such as Psychological (people; the values and beliefs that inspire their behaviour), Jobs (behavioural; brought to the surface through the observable practices) and Organisation (situational; an international organisation's environment reinforced the preferred behaviour and the adaptability on the safety).

IE5 (Senior Safety Engineer) highlighted that strong leadership is very much essential to drive the safety culture within manufacturing environment. This was more similar to the study by Reason (1998). However, he discovered few more factors apart from strong leadership, which include conditions, past events, and the overall attitude of the workplace. When it comes to the overall attitude of the workplace, IE3 (Manager – Compliance and EHS Systems) stated that *“Attitudes, both personal and organisational, affect development of a safety culture in a workplace. For an example, the wearing of protective clothing and the use of safety equipment is crucial in reducing the effects of accidents on production area. It is often the case that safety equipment is provided, but employees are reluctant, or neglect, to wear it. Consequently, the provision of safety equipment alone does not improve safety, there also needs to be a corporate culture that encourages its use”*. He further stated that management commitment is required to enforce the wearing of safety equipment and with that, Rules and procedures have become crucial factor in developing of safety culture in manufacturing sector. Also, everybody needs to feel that safety is everyone's responsibility in order to create the safety culture in the organisation.

A recent study by Sukadarin et al. (2012) stated that workmate's influence, safety knowledge and safety behaviour are also crucial factors in grafting the safety culture onto manufacturing sector. He further indicated that, most of the workers in the manufacturing sector have the knowledge to work safely for the example, they know about hazard in the specific job, the control measure that need to be taken in avoiding any accident to happen and any necessary information regarding to their job task. The definition (see Table 1) adopted by Glendon and Stanton (2000) stated that safety culture comprises with attitudes, behaviours, norms and values, personal responsibilities as well as human resources features such as training and development. Considering the effective safety training and development, IE1 (Senior Manager – EHS) stated that *“It is essential to provide proper Training and Safety information for everyone. People who are provided with regular information about safety and health at work are more likely to be mindful of safety and health issues and the ways in which their actions can affect themselves and others*. Further, Davies and Tomasin (1999) suggest that effective training in workplace is one means by which safety can be improved and company management must be active in order to reduce the number of injuries and fatalities. Nishgaki (1994) and Garza (1988) both recommended that educating and training of workers about all aspects of work safety and giving them the skill to look after themselves is the right thing to do. However,

Preliminary findings further revealed that posters, warning signs and policies are not enough and safety and health discussions and information distribution should be built into all aspects of the work process from board meetings to individual interactions. People who are properly trained in their jobs and are aware of the hazards associated with the role they, or those they supervise, perform are less likely to suffer or cause injury. Therefore, training can take a variety of forms and should be ongoing throughout an individual's time with the organisation.

According to the discussion had with IE3 (Senior Manager – Compliance and EHS Systems), External and internal reporting procedures on accidents, workplace monitoring and employee participation are other few components helpful in fostering a positive safety culture. Empirical data further revealed that employee participation includes EHS committee meetings, near miss promotional campaigns, rewarding and poster competitions, street drama, and quiz competitions as way of communicating the importance of safety culture to the organisation. Further, observations disclosed that safety communication can be many forms including internal and external communication, visual aids, newsletters and healthy communication etc. Workers' mental stability is crucial factor to be concerned with the complexity of manufacturing processes

carried out and especially when workers operate machines. Therefore, Counseling has become a key factor of safety culture in manufacturing environment which has not disused in literature yet. Safety evaluation is also another important factor in ensuring the positive safety culture and IE5 (Senior Compliance Officer) revealed that “Normally, we conduct comprehensive evaluation on Health and Safety (OSH) performance bi-annually which helps us to ensure that safety level is up to the required level”.

As mentioned in beginning of this section, all the above discussed factors can be divided into three key areas, namely, Organisational environment, Individual and behavioural (human) and finally Systems (see Figure 2). In conclusion, human (Individual and behavioural) factors including attitudes, both personal and organisational, strong leadership, supervisor subordinate relationship etc. affect development of a safety culture in a workplace. The organisational environment in which people work and the systems and processes in the organisation also influence the safety culture. Therefore, each manufacturing organisation needs to consider all of these aspects in developing and nurturing a safety culture that suits the organisation and the individuals within it.

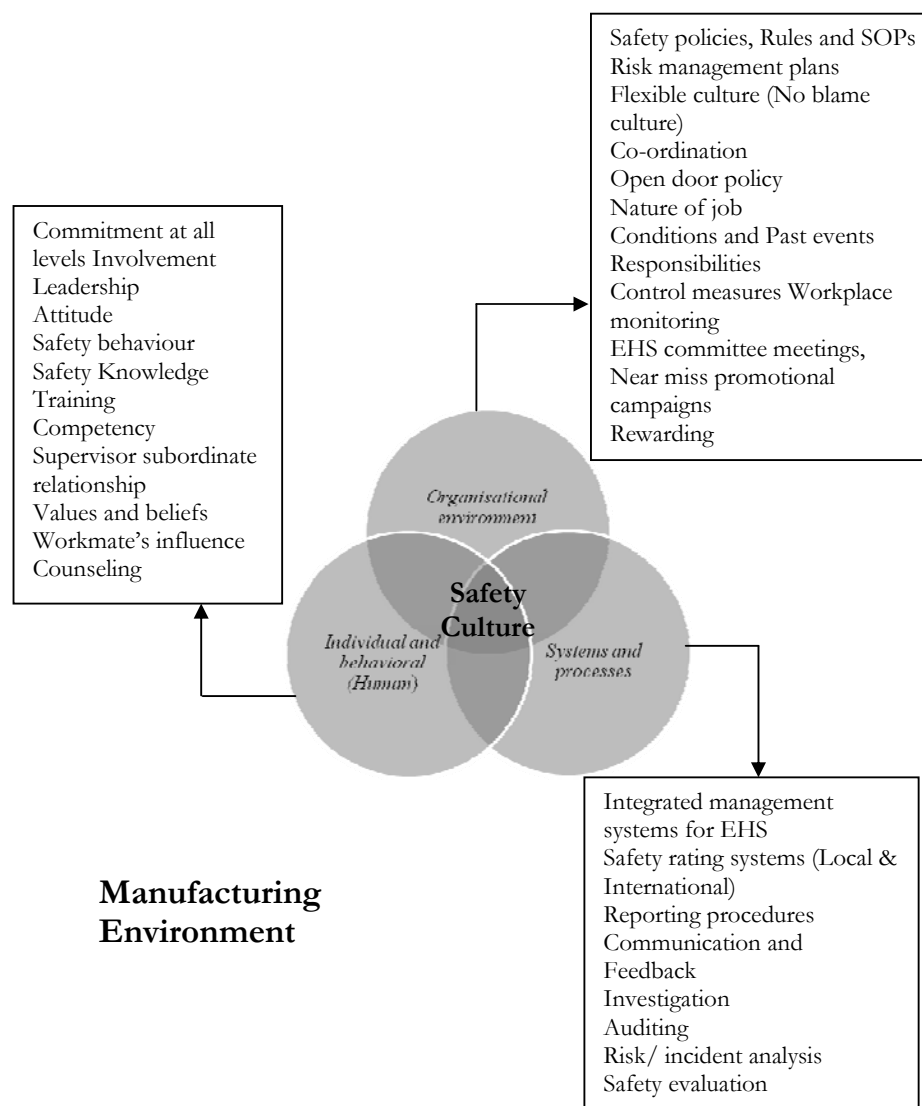


Figure 26: Factors contribute towards establishing a positive safety culture in manufacturing sector

4.0 Conclusion

This paper reviewed the existing literature and preliminary findings to investigate factors which contribute towards establishing a positive safety culture in manufacturing sector. Research findings revealed that creating a robust safety culture is about more than removing hazards and institutionalizing safety procedures. It is about working with people to change their attitudes, behaviours and thoughts, and improve their situational awareness within the dynamics of today's world. Safety culture is not a one day implementation; it is an on-going instillation to the work environment. The management must ensure all machinery and engineering and workplace related issues have been addressed first to create the safety culture. Sense of belonging must first been taken into consideration before any other aspect of safety culture being instilled. Both the management and employees need to play their own roles and responsibility in order to ensure the objective of safety culture is achieved. Research findings illustrated three areas to be considered when developing a safety culture namely; organisational environment, individual and behaviour (human), and systems and processes. Each manufacturing organisation needs to consider all of these aspects in developing and strengthening the safety culture that suits the organisation and the individuals within it. And also, everybody needs to feel that safety is everyone's responsibility in order to create the safety culture in the organisation.

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Factors Affecting the Accuracy of Pre-Tender Estimation of Road Construction in Sri Lanka

A.D. Britto

Department of Building Economics, University of Moratuwa, Sri Lanka
crazyadb@gmail.com

Perera B.A.K.S

Department of Building Economics, University of Moratuwa, Sri Lanka
pererabaks@yahoo.co.uk

Illankoon I.M.C.S.

Department of Building Economics, University of Moratuwa, Sri Lanka
cillankoon@gmail.com

Abstract

Within the sphere of construction, the “estimating process” is a significant element due to the lack of financial resources available, and out of the branches of estimating, pre-tender cost estimating of road construction projects requires extensive knowledge and expertise. The aim of this research is to assist clients and consultants in improving the predictive ability of the cost estimating of road construction in Sri Lanka. This research has been conducted through a literature review of topics related to the cost estimating process, followed by a questionnaire survey. The analyzing of 59 factors conclude that the main factors affecting the accuracy of pre-tender cost estimation of road construction are: accuracy and reliability of cost information, material (prices /availability /supply /quality /imports), clear and detailed drawings and specifications, completeness of cost information, designer’s experience level. “Spearman’s Rank Correlation Coefficient” test was used as a measure of agreement between the three groups of respondents with regard to factors ranking, and it appears that they are generally in strong agreement. Finally, 15 expert interviews were conducted to identify the existing practices of cost estimation of road construction in Sri Lanka. These conclude that the main existing practices are: comparison with past similar projects based on personal experience, established standards ex. HSR (Highway Schedule Rates) and comparison with similar past projects based on documented facts. The study recommended that both clients and consultants give more attention to the cost estimating process and to hire qualified technical staff in order to obtain the accurate estimate and to keep computerized historical data of completed projects.

Keywords: pre-tender cost estimation, accuracy, clients, consultants

Introduction

The success or failure of a project is dependent on the accuracy of several estimates done throughout the course of the project (Ahuja, Dozzi & Abou Rizk, 1994). Therefore, the preparation of a cost estimate of the project is one of the most difficult tasks in project management because it must be done before the work is accomplished (Oberlender, 1993). Pre-tender cost estimating is simply the final costing of the work carried out by a consultant (i.e., quantity surveyor or engineer) on behalf of a client (Odusami & Onukwube, 2008) before tenders are received. It sits somewhere between cost planning and post-contract cost control, provides an indication of the probable construction cost prior to contract-awarding and involves collecting, analyzing and summarizing all available data related to the construction of the project (Ashworth, A. & Skitmore, R. M. 1999). Thus, for a contractor to secure a job, his cost estimate must be as accurate and competitive as possible (Marjuki, 2006). Inadequate estimating invariably leads to misallocation of scarce resources.

An estimate can be accurate, low or high. An accurate estimate generally results in the most economical project cost, while either an underestimation or an overestimation often leads to greater actual expenditures. Inaccuracy in the estimate of a project may arise from two sources: bias associated with the project itself and bias associated with the estimating techniques used and the operating environment (Aibinu & Pasco, 2008).

An accurate estimation of construction costs heavily depend on the availability and quality of historical cost data and the level of professional expertise, when compared with many other factors. The limited information available at the early stages of a construction project may mean the quantity surveyor must make assumptions about the design details of a project, which may not eventuate as the project's design, planning and construction evolve (Liu & Zhu, 2007). Professional estimators have access to reliable cost and productivity references for estimating labor, material, equipment and other major work components. These major cost items have a high visibility factor and consequently receive adequate attention in the preparation of the pre-tender estimate. However, there are little-known low visibility factors affecting the estimate accuracy, such as procurement forms and contract arrangements, which should be considered in the preparation of pre-tender estimates. Unfortunately, these factors are either entirely overlooked or neglected by estimators in the Sri Lankan road Construction Industry. Identification of these low visibility factors is very important for improving the overall performance of the Construction Industry. Therefore this research aimed at assisting clients and consultants in improving the predictive ability of the cost estimating of road construction in Sri Lanka. Fulfilling above research aim was done by achieving five research objectives. These objectives are; (1) Identify the existing practices of preparing pre-tender cost estimating, (2) Identify the factors affecting to the accuracy of pre-tender cost estimate, (3) Identify the factors which are not considered enough by clients, consultants and contractors, (4) Investigate the perspective of clients', consultants' and contractors' of the essential factors, (5) Identify the relationship between the perspectives of clients, consultants and contractors about essential factors affecting accuracy of pre-tender cost estimate in Sri Lanka.

Factors influencing the accuracy of estimates: literature review

Various studies have focused on identifying the factors that have some influence on the accuracy of estimating the costs of construction work. Based on previous studies there are two types of factors that influence and contribute to the cost of a project, namely; control factors and idiosyncratic factors (Liu & Zhu, 2007). Further Control factors are the factors that can be controlled by estimators to improve the performance of estimation. Idiosyncratic factors are factors that influence cost estimation and these factors are outside the control of the estimators including market condition, project complexity, weather, size of contract, site constraints, resource availability, type of procurement system and contract work type

Elhag, Boussabaine, & Ballal (2005) stated that most of the significant factors affecting project costs are qualitative such as client priority on construction time, procurement methods and market conditions including the level of construction activity. Gunner and Skitmore (1999) reviewed previous studies and summarized the factors as follows: type of contract, conditions of the contract, contract sum, price intensity (consistency of price without fluctuating), contract period, number of bidders, good/bad years, procurement basis, project sector (public, private or joint), the number of priced items and the number of drawings. Gunner & Skitmore (1999) analysed the estimates of 181 projects in Singapore and they found that a majority of the factors influenced the accuracy of estimates. The study conducted by Ling & Boo (2001) in Singapore also found similar results when they compared five variables against Gunner & Skitmore's work. Skitmore & Picken (2000) studied the effect that four independent variables (road type, project size, sector and year) had on estimating accuracy and tested these variables against 217 projects from a Quantity Surveyor based in the USA. It was found that bias existed in project size and year, and consistency errors existed in project type, size and year. In a study of 67 process industry construction projects around the world, Oberlender & Trost (2001) identified 45 factors contributing to the accuracy of early stage estimates. They summarized the factors into 11

orthogonal elements. From those 11 factors, the five most important include: process design, team experience and cost information, time allowed to prepare estimates, site requirements, and bidding and labour climate. Al-Shanti (2003) summarized the factors that affect construction cost estimating as follows: project type, special construction (complexity), project accessibility, time of year, labour rates, and material costs. Iyer & Jha (2005) in their analysis of factors affecting cost performance of Indian construction projects state that conflict among project participants, presence of poor project specific attributes, hostile socio economic relations and climatic conditions, aggressive competition at tender stage and short bid preparation time, adversely affect construction costs. Further, it was indicated that coordination among project participants was the most significant of all factors having maximum positive influence on cost performance.

Dysert (2006) mentioned in his study that there are many factors which affect the estimate accuracy such as the level of project definition, the quality of reference cost estimating data (material pricing, labour hours, labour wage rates, etc.), the quality of the assumptions used in preparing the estimate, the state of new technology in the project, the experience and skill level of the estimator, the specific estimating techniques employed, the desired use of the estimate, the level of effort budgeted to prepare the estimate as well as extraneous market conditions (such as periods of rapid price escalation and labour climate factors).

In addition, other factors that affect the accuracy of the estimate are the capability of the project team to control the project, and the capability to adjust the estimate for changes in scope as the project develops. Akintoye (2000) worked on factors influencing project cost estimating and identified that the complexity of design and construction as the most important factor; this is followed by scale and scope of the construction. Odusami & Onukwube (2008) studied the factors that influence the accuracy of consultant pre-tender cost estimates. They indicated that the main factors are: expertise of consultants, quality of information and flow requirements, project team's experience of the construction type, tender period and market condition, extent of completion of pre-contract design, complexity of design and construction, availability and supplies of labour and materials.

Akintoye & Fitzgerald (2000) identified 20 causes of inaccurate cost estimates as insufficient time for estimating, poor tender documents, insufficient tender document analysis, lack of understanding of project requirements, poor communication between project team, low participation in estimating by site team, lack of review of cost estimate by management, poor comprehension of site requirements, poor feedback on accuracy previous estimates, pressure from management, removal of estimate padding by management, poor project cost feedback, lack of diligence by estimators, lack of adequate guidelines for estimating, inaccurate production data used in estimating, lack of historical data on past estimates, poor analysis of cost data for cost estimates, lack of performance reviews of estimators, estimators' lack of data processing techniques and frequent requests for changing of an estimate.

A great deal of research has been carried out on various aspects of estimation and several factors have been identified which effect to the impact to the accuracy of cost estimation worldwide with many country-specific models. These studies have contributed much, adequately covering the topic while orienting both researchers and practitioners towards accuracy of pre tender estimations. These studies were immense of value to those who wish to study the principles and practices of estimating in the Sri Lankan Construction Industry. Since the perception of estimation is subjective while also being affected by the unique political, economic, environmental and cultural conditions of a country, researchers have argued that paying attention to the manner in which these differences in thinking, value systems and living conditions affect the Construction Industry, especially the management cost. Thus, in the case of the Sri Lankan Construction Industry, the conditions affecting the Industry have to be understood as particular to the country's environment.

Research methodology

Sample and Response Rate

The targeted research population consisted of construction engineers, managers and quantity surveyors from public client, diverse contracting and consultancy organizations experienced in tendering and estimation in the road construction sector. Although this was carried out about pre-tender cost estimating, the contractors were also selected as a part of the sample and the reason for that is even though the contractors are not involved in the pre tender cost estimating process, they are involved in the tender estimating process. Therefore they have a very close rapport with pre-tender estimating techniques and factors because perhaps they would also have to suffer because of the inaccuracy of pre-tender estimates. Further, the other reason is to identify the perspectives of contractors about the factors affecting pre-tender cost estimating of road construction in Sri Lanka, with the aim of aiding the client and consultant. In total, 60 questionnaires were distributed to clients', 35 questionnaires to local consulting firms and 14 questionnaires to major contracting firms which have been dominating in NRCP projects in Northern and Northwestern Provinces. The sample of 14 contracting firms represented 70% of total population of major contracting firms in Northern and Northwestern Provinces

The response rate from consultancy firms was very high, (91%), whereas it was 75% and 71% from client' organizations and contracting firms respectively. 15% of the target population were non respondents. Hence, the obtained response rates should produce reliable results. On average, the respondents have an average of 20 years of experience in tendering and estimating.

Further the discrepancies between the samples size of the respondents group have prejudiced the ultimate outcome of the research in terms of their amount of respondents (32 consultants, 10 contractors and 9 clients). Therefore to avoid this partiality when comparing the group perceptions, the "*t-test and p-value*" was used to determine the significant and the reliability of the obtained result with the use of "*Spearman's Rank Correlation Coefficient*".

Questionnaire Design

A questionnaire survey was undertaken to determine the opinions of clients, contractors and consultants regarding factors affecting the accuracy of pre-tender cost estimation of road construction in Sri Lanka. The questionnaire was constructed based on a literature review and three face-to-face interviews with clients, contractor and consultants.

A total of 64 factors that were identified and reported in 12 previous studies (Al-Thunaiyan, 1996; Akintoye, 2000; Madi, 2003; Trost & Oberlender, 2003; Elhag et al., 2005; Shash and Ibrahim, 2005; Babalola and Mochtar, K., & Ardit, D. 2001; Dysert, 2006; Enshassi, A., Mohamed, S., and Madi, I. 2007; Liu & Zhu, 2007; Odusami & Onukwube, 2008) were considered in this research. These identified 64 factors were common for the estimating accuracy of all types of construction projects. In addition for better reflection of the nature of the local road construction industry, a preliminary survey (semi structured interviews) was conducted with 3 experts from the industry those who have more than 20 years of working experience in road construction. At the end of the preliminary survey 10 factors were deleted, 16 factors were modified and, 5 factors were newly added. In total, 59 factors were concluded and grouped into five groups as follows:

- Factors related to clients' characteristics (Group 01)
- Factors related to consultants, design parameters and information (Group 02)
- Factors related to project characteristics (Group 03)
- Factors related to contract requirement and procurement method (Group 04)
- External factors and market conditions (Group 05)

Data analysis technique

Relative Importance Index (RII)

The Relative Importance Index technique has been widely used in construction research for measuring attitudes with respect to surveyed variables. Likert scaling was used for ranking questions that have an agreement level. The respondents were required to rate the importance of each factor on a 5-point Likert scale using 1 for not important, 2 for of little importance, 3 for somewhat important, 4 for important and 5 for very important. Then, the relative importance index was computed using the following equation:

$$\text{Relative Importance Index} = \frac{\sum w}{AN} = \frac{5n_5 + 4n_4 + 3n_3 + 2n_2 + 1n_1}{5N}$$

Where W , which is the weight given to each factor by the respondent, ranges from 1 to 5; $n1$ = the number of respondents for very important; $n2$ = the number of respondents for of importance; $n3$ = the number of respondents for somewhat important; $n4$ = the number of respondents for less important; and $n5$ = the number of respondents for not important. A is the highest weight (i.e., 5 in the study) and N is the total number of samples. The Relative Importance Index ranges from 0 to 1 (Tam and Le, 2006).

“Spearman’s Rank Correlation Coefficient” test for degree of agreement between the clients, contractor and consultants

One of the research objectives is to study the relationship between the perspective of clients, consulting and contracting firms of the essential factors affecting the accuracy of pre-tender cost estimating of road construction in Sri Lanka. In order to reach the requirements, “*Spearman’s Rank Correlation Coefficient*” tests were used. To determine whether there is a significant degree of agreement among clients, consultants and contractors. “*Spearman’s Rank Correlation Coefficient*” is used as a measure of agreement among respondents.

Null Hypothesis: H_0 : There is an insignificant degree of agreement among the clients and consultants.

Alternative Hypothesis: H_1 : There is a significant degree of agreement among the clients and consultants.

Interpreting the Size of the Correlation Coefficient (rs)



1 – 0.9	Very Strong positive correlation
0.89 – 0.7	Strong positive correlation
0.69 – 0.5	Moderate correlation
0.49 – 0	Weak positive correlation
0 – (-0.49)	Weak negative correlation
(-0.5) – (-0.69)	Moderate negative correlation
(-0.7) – (-0.89)	Strong negative correlation
(-0.9) – (-1)	Very Strong negative correlation

The agreement is significant at a level of significant $\alpha = 0.05$

Results and Discussion

The first objective of this section is to identify existing practices of preparing pre-tender cost estimates in Sri Lanka. Fourteen numbers of existing estimating practices were revealed from the literature review and those methods are used for the small expert survey to identify the methods which exist as estimating practices in Sri Lanka.

Fifteen numbers of experts participated in the survey. All of the respondents have more than 15 years of experience in the pre-tender cost estimation of road construction. Out of these fifteen experts, five were further interviewed for the purpose of collecting information about these methods (refer table 1). Finally the survey concluded that in “Comparison with similar past projects based on personal experience”, “established standards (Highway Schedule Rates)” and “comparison with similar past projects based on documented facts” are the most popular existing pre-tender cost estimating methods for road construction in Sri Lanka. Whereas, “Range estimating” and “published price information” are mentioned as other existing practices.

Table 1: Existing practices of preparing pre-tender cost estimating in Sri Lanka

Existing Pre-Tender Estimating Practices for Road Construction in Sri Lanka	Frequency	%
Comparison with similar past projects based on personal experience	15	100%
Established standards (HSR)	15	100%
Comparison with similar past projects based on documented facts	13	87%
Published price information	10	67%
Range estimating	8	53%
Intuition	1	7%
Guessing	1	7%
Arithmetic formula	0	0%
Estimating software	0	0%
Capital estimating factors	0	0%
Shared information with subsidiary of the firm	0	0%
Estimating standard procedure	0	0%
Shared information from other firms	0	0%
Complex statistical formulas	0	0%

Most of the respondents were not satisfied with the accuracy level of existing estimating practices. They mentioned that the poor documentation of past records and lack of availability of cost data are the main causes. Further they added that the Srilankan road construction industry should maintain a proper cost database and document keeping of finished road projects to enhance the accuracy level of the existing estimating practices. Moreover, they mentioned that these existing estimating practices are not fully suitable for the future road developments and also disclosed that the modifications are required for future needs. Further they pointed out that enhancement of use of estimating software could be a better solution for the massive road construction projects in future.

Top ten factors affecting the accuracy of pre-tender estimating in road construction projects in Sri Lanka

With the use of questionnaire survey the top ten factors affecting the accuracy of pre-tender estimating in road construction projects in Sri Lanka (refer table 2). Relative Importance Index

(RII) was used to rank the factors. According to the respondents' ranking, the "Accuracy and reliability of cost information" ranked in the first position. "Material (prices/availability/supply/quality/ imports)" was ranked as the second important factor affecting the accuracy of pre-tender cost estimates.

Table 2: Top ten factors affecting the accuracy of pre-tender estimating in road construction projects in Sri Lanka

Factors	RII	Rank	Group
Accuracy and reliability of cost information	0.929	1	Group 2
Material (prices/availability/supply/quality/imports)	0.925	2	Group 5
Clear and detailed drawings and specifications	0.922	3	Group 2
Completeness of cost information	0.910	4	Group 2
Designer's experience level	0.902	5	Group 2
The experience and skill level of the consultant	0.875	6	Group 2
Applicability of cost information	0.871	7	Group 2
Availability of a data base of bids on similar projects (Historical cost data)	0.839	8	Group 2
Completeness of project documents	0.831	9	Group 2
Quality of information and flow requirements	0.820	10	Group 2

Factors which are not considered enough by client/ contractor/ consultant in the accuracy of pre-tender cost estimation of road construction in Sri Lanka.

This objective was achieved with the use of questionnaire survey and ranking was done with the use of Relative Importance Index (RII). Table 3 shows ten factors which are not considered enough in the accuracy of pre-tender cost estimates of road construction in Sri Lanka from the point view of clients, consultants and contractors.

Table 3: Poorly (are not considered enough) considered factors

Factors	RII	Rank	Group
Client experience level	0.318	1	Group 1
Type of project (residential, commercial, industrial, .etc.)	0.255	2	Group 3
Classification and level of competitors in the tendering	0.227	3	Group 5
Level of involvement of the project manager	0.212	4	Group 2
Tender selection method (open, selected, negotiation, etc.)	0.212	4	Group 4
Type of client (Government/ UN Agencies/ NGOs ...etc.)	0.165	6	Group 1
Number of estimating team members	0.165	6	Group 2
Client's method of payment	0.157	8	Group 1
Content of disputes resolution methods clause (litigation/ arbitration/ others)	0.149	9	Group 4
Financial capabilities of the client	0.129	10	Group 1

According to Table 3, the respondents ranked the "Client experience level" as the least considered factor. The "Type of project (residential, commercial, industrial, .etc.)" was also ranked as the second not considered enough factor affecting the accuracy of pre-tender cost estimates. Further, the results show that the clients, consultants and contractors agreed that the "classification and level of competitors in the tendering", "level of involvement of the project manager", "tender selection method (open, selected, negotiation, etc.)", "type of client", "number of estimating team members", "the client's method of payment", content of disputes resolution methods clause (litigation/ arbitration/ others)" and the "financial capabilities of the client" were the other very poorly considered factors affecting the accuracy of pre-tender cost estimating of road construction in Sri Lanka

Table 4: Overall perspective of respondents on the group of factors

Group of Factors	Client		Consultant		Contractor		Overall	
	RII	Rank	RII	Rank	RII	Rank	RII	Rank
Factors related to consultants, design parameters and information	0.753	1	0.756	1	0.748	1	0.754	1
Factors related to contract requirement and procurement methods	0.593	2	0.608	2	0.671	3	0.617	2
Factors related to external factors and market conditions	0.591	3	0.594	3	0.698	2	0.614	3
Factors related to project characteristics	0.586	4	0.582	4	0.653	5	0.597	4
Factors related to clients' characteristics	0.571	5	0.506	5	0.663	4	0.548	5

Table 5: The relationship between the perspectives of the respondents

Groups	Clients vs. Consultants		Clients vs. Contractor		Consultants vs. Contractors		Sig.
	Coefficient	t- value	Coefficient	t- value	Coefficient	t- value	
Factors related to clients' characteristics	0.786	2.840	0.723	2.342	0.741	2.468	$\alpha < 0.05$
Factors related to consultants, design parameters and information	0.956	14.516	0.953	14.135	0.937	11.970	$\alpha < 0.05$
Factors related to project characteristics	0.881	4.560	0.923	5.859	0.774	2.992	$\alpha < 0.05$
Factors related to contract requirements and procurement methods	0.871	4.687	0.738	2.889	0.717	2.719	$\alpha < 0.05$
Factors related to external factors and market conditions	0.773	4.046	0.721	3.452	0.643	2.783	$\alpha < 0.05$

Overall perspective of respondents on the group of factors

Table 4 shows that, “factors related to consultants, design parameters and information” was ranked in the first position by the respondents with an RII of (0.754). Further, the client, consultant and contractor separately ranked it in the first position with an RII of (0.753), (0.756) and (0.748) respectively. Nine factors out of the top 10 factors being related to this group emphasized that this is the most important group of factors affecting the accuracy of pre-tender cost estimates. It is also emphasized that, the consultants, design parameters and information are crucial in accurate estimation of construction costs at the pre-tender stage. Further, these findings indicated that construction project costs were more affected by architects and consultants than by others.

On the other hand, it is shown that, “factors related to contract requirement and procurement method” was ranked in the second position by the respondents with an RII of (0.617). The responding contractor ranked this group in the third position with an RII of (0.671) while the client and consultants ranked it in the second position with an RII of (0.593) and (0.608) respectively. Nine factors are included in this group. The top factor in this group is “clear contract conditions” which was ranked as the 19th overall.

Further, it is shown that, “factors related to external factors and market conditions” was ranked in the third position by the respondents with an RII of (0.614). The responding contractors ranked this group in the second position with an RII of (0.698) while the clients and consultants ranked it in the third position with an RII of (0.591) and (0.594) respectively. This group consists of thirteen factors, one factor out of the 10 top factors being related to this group. “Material (prices/ availability/ supply/ quality/ imports)” was ranked 2nd overall.

Moreover, it is shown that, “factors related to project characteristics” was ranked in the fourth position by the respondents with an RII of (0.597). The responding contractors ranked this group in the third position with an RII of (0.653). While the clients and consultants ranked it in the fourth position with an RII of (0.586) and (0.582) respectively. This group includes eight factors. The top ranked factors in this group are “location of project (town, village camp)” which was ranked 22nd overall and “site conditions and requirements” which was rank 25th overall.

Finally, it is clear that, the “factors related to clients characteristics” was ranked in the last position by the respondents with an RII of (0.548). The responding contractor ranked this group in the fourth position with an RII of (0.663) while the client and consultants ranked it in the fifth position with an RII of (0.571) and (0.506) respectively. This group contains seven factors. The top ranked factor in this group is “clear scope definition for the client” which was ranked 17th. All other factors of this group have a low importance index with respect to other factors in this research. Therefore, it is evident that factors related to this group have little influence in the preparation of construction estimates.

The relationship between the perspectives of the respondents

The results illustrated in Table 5 show that there is a “*very strong positive correlation*” between the client and consultant in the group of “factors related to consultants, design parameters and information” with (0.956 of r_s), whereas there are “*strong positive correlation*” between them in the other remain group of factors. Further, the results illustrated in Table 5 show that the p-values (Sig.) are less than the level of significance $\alpha = 0.05$, which lead to the rejection of the null hypothesis, H_0 . Therefore, it was concluded that there is sufficient evidence to support the alternative hypothesis, H_1 . Hence, there is a significant degree of agreement among the clients, and consultants.

Further, the results illustrated in Table 5 show that there is a “*very strong positive correlation*” between the client and contractor in the group of “factors related to consultants, design parameters and information” and “factors related to project characteristics” with (rs of 0.953) and (rs of 0.923) respectively, whereas there were “*strong positive correlation*” between them in the other remain group of factors. Further, the results illustrated in Table 4.20 shows that the p-values (Sig.) are less than the level of significance $\alpha = 0.05$, which lead to the rejection of the null hypothesis, H_0 . Therefore, it was concluded that there is sufficient evidence to support the alternative hypothesis, H_1 . Hence, there is a significant degree of agreement among the clients and contractors.

Moreover, the results illustrated in Table 5 show that the “*very strong positive correlation*” between the contractor and consultant in the group of “factors related to consultants, design parameters and information” with (rs of 0.937), while “*moderate correlation*” between them in the group of “factors related to external factors and market conditions” with (rs of 0.643). Also there were “*strong positive correlation*” between contractor and consultant in the other remains group of factors. Further, the results illustrated in Table 4.21 show that the p-values (Sig.) are less than the level of significance $\alpha = 0.05$, which lead to the rejection of the null hypothesis, H_0 . Therefore, it was concluded that there is sufficient evidence to support the alternative hypothesis, H_1 . Hence, there is a significant degree of agreement among the contractors and consultants.

Conclusions

An exploratory study of factors affecting the accuracy of pre-tender cost estimate was conducted in order to determine the relative level of influence for each factor. The ranking of 64 factors revealed that accuracy and reliability of cost information, material (prices/availability/supply/quality/imports) and clear and detailed drawings and specifications are the mostly influential factors affecting cost estimate accuracy.

Further, the least influential factors as evaluated by respondents are client experience level, type of project (residential, commercial, industrial, .etc.) and the classification and level of competitors in the tendering

From the above, it was concluded that clients, contractors and consultants generally agree on the ranking order of the factors affecting the cost estimate accuracy. This agreement confirms the influential effect of those factors on the accuracy of cost estimation which provides a level of validation for this research. This was confirmed by the high t-values obtained through the *Spearman's Rank Correlation Coefficient* achieved within each group. According to the p-value (sig) test, it was concluded that there is no difference of the opinions among clients, contractors and consultants in the factors affecting the accuracy of pre-tender cost estimates at a significance level of 0.05.

Further, this study revealed the existing practices of pre-tender estimation in Sri Lanka as the “comparison with past similar projects based on personal experience”, “Established Standards (HSR)” and “comparison with similar past projects based on documented facts” as the most popular existing pre-tender cost estimating methods. In addition to that, this study reviewed the future needs of pre-tender estimating practices for road construction in Sri Lanka.

It is recommended that clients and consultants give more attention to the most important factors that affect the accuracy of pre-tender cost estimates in order to achieve more reliable and realistic estimates. They should monitor the performance of their estimates in terms of accuracy and hire qualified technical staff to obtain accurate estimates. Clear identification of project requirements is essential before the start of the estimating process. Clients and consultants should make sure the accuracy and reliability of the cost information, also obtain information as accurately as possible from manufacturers and suppliers pertaining to the costs of procured materials and/or systems. If clients and consultants have a poor understanding of materials (prices/availability/

supply/ quality/ imports), this would undoubtedly affect the accuracy of cost estimates. Clients and consultants should make sure that contract conditions are very clear to both parties.

It is also recommended that training courses on factors affecting the accuracy of cost estimates should be conducted. These activities would improve the local practice of cost estimating and increase the capabilities of estimators by using estimating software packages. Further, the estimating practices must comply with the need and the type of the project and should also be compatible with changes and evolution of the Construction Industry. Therefore, the new estimating practices should be introduced for the intended future needs of Sri Lankan infrastructure development.

Finally, the findings of this study will help clients and consultants to focus on the main causes which directly affect the accuracy of pre-tender cost estimation and develop effective strategies to develop an accurate cost estimate.

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Model_isi; Developing a Model for Indigenous Knowledge Management

Dilina. J. Nawarathne

Department of Integrated Design, University of Moratuwa, Sri Lanka
dilinajanadith@gmail.com

Sithumini Ratnamalala

Department of Integrated Design, University of Moratuwa, Sri Lanka
sithuminir@gmail.com

Abstract

This article presents the initial development of a communication model (Model_isi) as a mean of gathering, preserving and transferring indigenous knowledge in knowledge management. The article first discusses the need for an appropriate complimentary model for indigenous knowledge management which differs from the existing methods and models. Then the paper suggests the newly developed model for indigenous knowledge management which can be implemented as a complementary approach for the existing scientific method. The paper further presents the effectiveness of the developed method in reflecting upon a pilot demonstration carried out on selected indigenous communities of Sri Lanka.

Keywords: *Indigenous Knowledge Management, Knowledge Transferring, Tacit Knowledge, Research Model, Asian centric philosophy*

BACKGROUND

There is an emerging requirement to preserve indigenous knowledge (IK), as indigenous communities around the world face threats in the survival of their traditional languages and cultures. Further this knowledge has a huge scientific value which can be used for the development of humans in their day to day life. Much of this recent interest has been generated by the fact that Indigenous communities worldwide possess an unsurpassed knowledge of their physical environment and that it is therefore of crucial importance this knowledge be preserved and shared. Although there is an evident growth of the demand for indigenous knowledge, still organizations have a smaller amount of facility to gather and preserve this knowledge. According to Amanda Stevens (2008), Indigenous knowledge, however, differs greatly from Western knowledge (In here Amanda Stevens refers to the practice of explicit knowledge majorly based on positivism) and so it ***must be managed in unique and sensitive ways that may challenge conventional knowledge management tools and processes***, as well as prevalent assumptions about knowledge and information.

AIMS AND OBJECTIVES OF THE STUDY

As stated above, the existing scientific approach and its paradigm/models have many issues related with the IKM. The intention of this paper is to suggest a complementary model for handling indigenous knowledge. The key objective of the study is to suggest a model which addresses the identified weaknesses of the existing IKM.

METHODOLOGY

Since the research has an action oriented approach, the newly suggested model has been demonstrated on scientifically selected indigenous communities of Sri Lanka. The demonstration was based on 9 persons of 7 different villages around the country which interviewed by a team of undergraduate students throughout two months from June to July 2013.

STATE OF KNOWLEDGE ON IKM

Understanding IKM

There are many sub tasks behind the terminology of IKM such as gathering, collecting, storing, accessing, transferring and conversion, etc. Yet for the comprehensiveness of research, all these actions are integrated in to three main tasks which depicts the entire process of IKM.

Identified three main tasks of IKM

- (1) Gather
- (2) Preserve
- (3) Transfer

However, Indigenous Knowledge is not confined to knowledge of the physical sciences. It is spiritual as well as ecological and embraces ways of knowing that are sometimes characterized as cultural or artistic. Viewing Indigenous Knowledge through categories such as art, science or culture, however, tends to fragment its inherent unity. As Greg Young-Ing describes it, the Traditional Knowledge of Indigenous peoples (Traditions; National gathering for IK 2005)

“... encompasses a broad range of Indigenous knowledge ranging from: ancient stories, songs and dances; traditional architecture and agricultural; biodiversity related and medicinal, herbal and plant knowledge; ancient motifs, crests and other artistic designs; various artistic mediums, styles, forms and techniques; spiritual and religious institutions and their symbols; and various other forms of Indigenous knowledge.”
(Heritage 2011)

Existing models/tools/systems

With the growing demand for IKM in knowledge generation, there is a necessity to develop many knowledge management systems / models / paradigms for this management process. The paper reviews three different existing models as the point of departure of the project which was carried out in different parts of the world.

Smithsonian National Museum of the American Indian

‘Distributed Systems Technology CRC (DSTC) at the University of Queensland in Australia has designed an open-source software system for indigenous knowledge management (IKM) to manage the process of virtual repatriation of objects by the Smithsonian National Museum of the American Indian to their original owners’ (Stevens 2008).

In this project, their key concern is to protect the intellectual property rights of the knowledge. Further they use ICT to preserve the gathered knowledge in order to provide access to the IK communities. But they do not suggest a proper guidance for the key action of gathering. It mainly focuses on the action of store and access. As discussed above, this tool does not provide an acceptable solution for the later key actions of preserving and transferring.

Indigenous Knowledge Management System Using Mobile Device Video Capture and Web 2.0 Protocols by Prof. Alexander G. Flor (Philippine)

This particular model/study attempted to answer the following research questions: How can mobile devices be used by rural communities to document indigenous knowledge? How can Web 2.0 protocols be employed in an indigenous knowledge management system? (Flor 2006). It has taken a different approach in the gathering process where it utilizes mobile video camera devices. Further they suggest web 2.0 as the main medium of storage. This approach of using mobile devices helps to preserve the tacit form of the practice which is hard to convert into the explicit documentation. But again this model does not cater to the very first obstacle of IKM which is awakening the knowledge from the communities. This occurs due to the unawareness of the community about their tacit form of knowledge. Further the project is only limited and oriented on managing agricultural practices.

Northern Territory Library (Australia)

This database allows the community to digitize objects that have been repatriated by museums and other institutions and record other cultural knowledge in audio, text, video, and photographic media to be accessed by the community or sold to universities and other researchers. Rights and responsibilities for Yolngu (the community) knowledge are divided between two different clans, and so the database was designed to reflect this (Steven 2008). One of the key constructive approaches of this model is adapting to the forms of society (the reflection of two clan diversity). Apart from this approach, the model further suggested and invented unique software called AraIritigia for access with better regulations.

NEED FOR A COMPLIMENTARY METHOD FOR “IKM”

As per the above models/tools, there are several identified main issues related to IKM and the existing methodologies used, which should provide proper solutions via the suggested new model. The identified main issues are as follows.

The threat of time

The critical state of IK is that communities and personalities associated with knowledge are under a threat of losing their identity and unique features due to globalization.

Tacit knowledge

Tacit knowledge is commonly referred to as the knowledge that is contained inside our heads and is therefore difficult to express. This knowledge should be experienced in first hand. Since **written information has a permanence that does not reflect the true nature of Indigenous Knowledge** (Traditions; National gathering for IK 2005) IK can be identified as a form of tacit knowledge. Therefore managing this form of knowledge remains a greater challenge in IKM.

Attributes of Tacit Knowledge

- Individual and often un-shared
- Being unaware of
- Time sensitive
- Expressible in action and difficult to express in words
- Un-scalable to Others
- Provides linkage

(What is Tacit Knowledge? 2008)

The challenge of knowledge transferring

Knowledge transfer (KT) is the practical process of transferring knowledge from one part of the organization to another. Like knowledge management, knowledge transfer seeks to organize, create, capture or distribute knowledge and **ensure its availability for future users**. It is considered to be more than just a communication process. Therefore KT models like Nonakas SECI model should be followed to generate a solution in IKM.

Limitations related to the Conventional practice of Western Scientific Method (WSM)

Commonly the western scientific model is used in knowledge management as an effective model, and it is common with IK management too. But this western scientific model which mostly based on positivism has limitations with its structure. These limitations should be carefully analyzed and the scope should be identified to overcome issues relating to the conventional mode of knowledge management.

Limitations of WSM

The extent of basic knowledge

The basis of Investigation

Our ability to interpret result

Limitation for accidental discoveries

Inability explain the existence of God super-natural powers and faith

Inability for appreciation of aesthetics

The philosophical contradiction

The knowledge that is based on this communication model is a completely different form of knowledge to the western form of knowledge (main stream knowledge). It is deeply rooted to the Sri Lankan (Asian-centric) philosophy. The epistemological assumption for an Asian-centric paradigm is that everyone and everything becomes meaningful in relation to others. The foregoing ontological assumption naturally leads to this epistemological assumption. Indian philosophers teach us that since all things, events, phenomena, and beings are united to one another at a higher ontological level, they can be meaningfully understood only in relation to one another (Dissanayake, 1983a). In Chinese epistemology, likewise, genuine knowledge is believed to result from interaction and interrelation between the individual mind and the world. It is not an isolated phenomenon totally independent of individual life and society, nor is it a construction related merely to the basic functioning of the mind (Cheng, 1983) (Miike, 2002).

THE NEW MODEL

The new development model, Model_isi is based upon four main approaches in managing indigenous knowledge.

The four premises of the model

(1) A personally and contextually based gathering and preserving

This approach suggests collecting information based upon personalities but not based upon subjects. As stated above, IK is deeply linked to people and the Asian philosophy believes knowledge to be an inter-related subjective phenomenon. Therefore the model gathers and preserves a personality instead of a subject like indigenous medicine or agriculture.

(2) Moving Image as the main medium

The model recommends utilizing moving images as the main documentation medium instead of the conventional writing format. This approach helps to preserve the tacit quality of IK and also avoid the knowledge slip which occurs in writing.

Strengthens of video as a documentation medium

- Video can present visual information that is difficult to convey in other ways.
- It provides a sense of 'being there'.
- Allow viewers to 'travel' to different places and different time period, as well.
- Videos can be used to demonstrate specific manual skills or physical processes, either at normal speed, in slow motion, or speeded up to reveal relationships, principles, or practices.
- It has the power to elicit emotional responses.

- Crosses the language barrier to a certain extend.
(Denning 2001)

(3) Interacting process to gather

Instead of interviewing these personalities via a third party (scholarly or any academic based party) the model creates the opportunity for them to interact with their peer communities. Recorded videos are re-projected to different communities and the reactions for videos are again recorded. This re-projecting and re-recording process is the major and unique approach of model_isi to effectively gather and moderate IK.

(4) Layered preservation

The preservation of collected footages is done in a layered manner. The information collected from indigenous communities will be store in a main layer where a secondary layer (which consists of scholars) operates for the conversion of knowledge for contemporary usage).

THE METHOD - The pilot experimentation of the model

A demonstration has been carried-out to analyze the effect of the suggested model and its approaches. The demonstration was based on 9 personalities of 7 different villages around the country which interviewed by a group undergraduate students throughout two months from June to July 2013.



Figure 17 Demonstration at Ritigala Village

Source : by author

Selected villages for the demonstration

Seven different villages were focused on in the demonstration and these villages are from two main geographic zones of the country. There were little sub cultural links within the two areas which were deliberately selected to experiment the maximum effectiveness of the model the villages are as followed.

Dry Zone Villages

Keeriyagaswewa
Galapitagala
Kaluobe

Wet Zone Villages

Karamidula
MandaramNuwara
Kothmale
Welampagoda

Interviewed personalities

9 persons were interviewed during the time period of the demonstration. The group was consisted of different types of personalities from Sri Lankan indigenous communities. There were people who were awarded by the government for their contribution to folk art and traditional medicine. These names were taken from the database from the Sri Lankan folk music library. Also there were people who are typical adult villagers who were well known among the villagers for their maturity and knowledge.

Demonstration Team

The demonstration team was consisted of 4 undergraduate students, who were intentionally selected from different disciplines to experiment the user friendliness of the model. These members were selected from diverse disciplines such as environmental studies, Art and Design and Engineering.

DISCUSSION

Effect analysis of the model

The demonstration trotted out many positive impacts and effects of the isi-model. As stated above, the demonstration took place with 9 different persons of 7 different villages. The demonstration indicates the following effective values of the model.

Overcoming the knowledge slip

As mentioned above, the model mainly concerns of avoiding knowledge slip. Since the model uses an inter-reaction approach in knowledge awakening, the potential of knowledge slip is in a minimal level.

A simple story became knowledge

Karunarathne from ritigala told a few stories of his past life. Among them there was a story of how he possessed knowledge from his father. While he was explaining his stories he sang many "*kavi*". These were just ignorable parts of his story. Yet Katakandure reacted to these videos and he responded to these "*kavi*". He explained those *kavi* and their designations (He explained it as "hath adiyakavi "). Then he sang some other versions of this *kavi*. Simply those "*kavi*" might be un-notable in a conventional model to a third party due to the way it placed in the karunarathnes story.

Easy to interview, awake hidden knowledge and make them more expressive

Generally, interviewing such a senior citizen requires professional knowledge and a special practice in the related field. Yet this structure helps to over-come these issues and allows the teams to easily carry out their task. Specially seeing visuals of an old man performing stimulates the viewer to act instantly.

"Son! bring that ola leaves book on the shelf "

After describing his daily routine Katakandure ran out of words, then he asked "what else do you want know?". At the time being he mentioned he is commonly engages with traditional dancing and traditional medicine. But after projecting the footages of Karunarathne from ritigala, he mentioned his knowledge on astrology. After seeing the "*nimithikulla*" ritual he asked his son to bring a "*ola leaves book*" from the shelf and then he started to conduct a different version of

“nimithi ritual” that is unique to the upcountry. The astrology knowledge of this person might have been missed in a conventional manner but not in this isi-model.

Helps to create complete and comprehensive knowledge

One of the important effects of the model is that it helps to gather complete and comprehensive knowledge deposited among the senior citizens of folk communities.

A series of poems by two different villages

Dissanayake from Kothmale narrated a folk story during his interview and then he sang a “kaviya” (a type of poem). At that time the story looked like a complete one, but the poem was un-completed. This story was re-projected to Heenbanda from Mandaramnuwara. Then he narrated the complete series of stories related to that previous story. Further he sang 4 sets of inter-linked “kavi”.



Figure 28 Demonstration at Keeriyagaswewa

Source : by Author

Awakening alternative version of practicing

In the case mentioned under overcoming the knowledge slip, Katakandure explained of an alternative version of practice after viewing the “Hathadiya” of Karunarathne. Further he sang all of the kavi related to that ritual. This provided the opportunity of gathering and preserving many linked alternative practices.

“I am an astrologer ... so I know things about it”

At the interview held in Kothmale, Heenbanda introduced himself as a traditional farmer. Yet during the re-projection session, the previous videos from the others stimulated him to state about his knowledge in astrology which has not been used from a long time. Further he explained astrology-based agricultural practices after seeing videos of Mr. Ranbanda from Galapitagala.

Awakening completely new subject streams

Providing further alternatives and links is one advantage of the model as stated above. Since tacit knowledge is an outstanding and eccentric human psychological phenomenon, it is difficult to predict how it will provide linkages to knowledge. Therefore, this isi-model has the potential of awakening completely new subject topics during the interviews and re-projections.

From agriculture practice to a language

Abeyasiri from Ritigala explains some of traditional agricultural practices which he was engaged in his youth. These descriptions were consisted of many diverse practices. After viewing these footages, Katakandure started to explain about a provincial language and its idioms instead of giving knowledge linkages to agricultural practices. This is an ideal proof that tacit knowledge cannot be scaled or predicted to a third party. These discover of new subjects is rare in the conventional linear practice.

Understanding and evaluating the potentials of the model

Apart from the above proven effects of the model, there are many potential strong suits of the model which can be identified by the further analysis. As mentioned under the “Need for a complimentary method for “IKM”, This particular subject area directly associate with deeper parts of the human psychology. Generally people from typical indigenous communities have a stereo type impression on the researchers/outsideers come to interview them, which ultimately guide them to purposely hold their knowledge. In other hand as explained in under the traits of tacit knowledge, they do not have an accurate sense to answer and react to the needs of IKM. Almost every time they start their conversation like “I don’t know what to tell sir”. But all of these blockades can be meritoriously over come through the re-projecting approach of the model.

One of the main and unique features of the model is that it has the ***self-growing potential*** without a major involvement/moderation of senior scholars. With this features the model can promptly cover and gather a larger area of IK possess by the communities. When it comes to the researching IK, The scholars/research team needs a thorough knowledge on diverse subjects as well as the sense on the particular society. Even a specialized scholar on particular subject stream might miss many other related clues on IK since IK does not exist in the subject/stream form. Yet with the approaches taken by the model allows to an average person to participate in the process. Diverse undergraduate students were participated during the experiment who are not directly linked/study the indigenous knowledge. According to the two students from IT and art stream, they did not face any difficulties while participating and carrying out the interviews. This particular approach further gives access to appoint a large number of people on IKM projects which generally limited and currently carrying out by high professional senior scholars.

As mentioned under the philosophical background of the IK, It is intensely attached to person and his/her context who possess it. Therefore the model adapted this feature and respond to it by gathering and preserving IK in personally and contextual based manner instead of conventional subject based approach. This approach supplementary address the intellectual property rights of IK.

Identifying Insubstantialities of the model

Some portion of the IK must unquestionably experience in first hand. Any third party involvement will not be able to provide an effective and accurate experience. As an example an application of an ointment or medicine by a traditional doctor (his finger pressure, unique movements) cannot be capture with the limitations of the model nor even the conventional approach. Further this model has a drawback when it comes to managing community based

group knowledge. But again this issue can be addressed at the preserve point by storing the knowledge as a collective set of individual experiences.

CONCLUSION AND FURTHER STUDIES

The model_{isi} is a complementary approach to the existing scientific method of IKM research paradigms. Prior to the conclusion, the analysis of the model and its effectiveness can be stated as follow. The existing practices in IKM have many issues as stated in the beginning of the paper. Especially, the act of preservation should take place within the process since IKM is under the threat of extinction. Further the rest of the actions in the process (gather, transfer) as well as the action of preservation should happen as per the factual traits and paradigms of the IK. The model is proven to have the capability of providing a better solution for identified issues related with IKM.

The model demonstrated mainly the first three phases of the approaches which were basically oriented on gathering, preserving and initial peer moderation. The 4th approach (the layered network and the knowledge moderation of scholars from mainstream) should be further analyzed and elaborated to understand its effectiveness in knowledge transferring by allowing main stream scholars to involve in the secondary knowledge moderation.

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¹¹Nonaka's SECI (Socialisation, Externalization, Combination, Internalisation) model is a widely accepted paradigmatic status related to knowledge transferring (Gourlay, 2006). This framework captures the dynamic character of knowledge and is based on sharing of subjectivity (Richter).

The Effects of Globalization on Multi-disciplinary consultancy Firms in Sri Lanka

Meegahakotuwa M.G.A.L.I.B.

Department of Building Economics, University of Moratuwa
lakshan.ibm@gmail.com

Perera B.A.K.S.

Department of Building Economics, University of Moratuwa
pererabaks@yahoo.co.uk

Illankoon I.M.C.S.

Department of Building Economics, University of Moratuwa
cillankoon@gmail.com

Abstract

'Globalization' is a phenomenon that describes the accelerated pace at which interaction and expansion in cross-border trade activities, open markets, migration and technology advancement take place in today's world. Though hardly any institution in the world has been able to escape the effects of globalization, its effects on multi-disciplinary consultancy firms in Sri Lanka remains a subject little analyzed despite the fact that firms that are global in nature play a dominant role within the domestic construction industry. This research aims at identifying the magnitude of globalization processes on Sri Lankan multi-disciplinary consultancy firms in order to help them withstand the negative effects while upgrading existing practices in order to be more in tune with the demands of the modern world. The principal methodology used in the study is a preliminary survey, followed by a comprehensive questionnaire survey administered to professionals from multi-disciplinary consultancy firms. The study identified both positive and negative effects of globalization on local multi-disciplinary consultancy firms. Based on these results, a framework has been developed to help local multi-disciplinary consultancy firms withstand the negative effects while modifying current practices to sustain themselves in the face of globalization, which would require that they focus continually on innovation and research.

Keywords: Globalization, Multi-disciplinary consultancy firms, Sustainable practices, Framework, Sri Lanka.

Background

Globalization remains the “buzzword” of the decade, a topic of inexhaustible interest to its proponents and defenders alike. According to the Levin Institute (2012), it is not a new concept, one famous example being the Silk Road across Central Asia that connected China and Europe during the Middle Ages and which made possible trade deals between people and corporations alike during this time. These investments by individuals/ enterprises in other countries had the effect of bringing nations closer together than before. However, with the passage of time, the earlier cross-border interactions have changed and the pace of interaction has accelerated leading to a new awareness today of a more globalized world.

The first person to define globalization, Robertson (1992), for instance, described it as the process of compression of the world and the intensification of the consciousness of the world as a whole by its inhabitants. Since then, different definitions have emerged providing a foundation to define globalization as the connectivity of different parts of the world (National Geographic Education, 2013).

The International Monetary Fund (IMF, 2008) has defined the four basic aspects of globalization as trade and transactions, capital and investment movements, migration and movement of people, and dissemination of knowledge. These definitions demonstrate how globalization has

captured the imagination of the global citizenry today and that it is not a single event but a continuously evolving phenomenon carrying within it a spectrum of events. The construction industry too has not spread its effects. As Cartledge (2006) has pointed out, the construction industry is significantly affected by market globalization along with other business sectors. Consultants who fall within this category are no exception.

Construction consulting is a particular form of business consultation that focuses on all forms of construction such as buildings and civil work (Consulting.co.uk, 2012). The website quoted above also defines a consultant's duty as the accomplishment of best value for money on behalf of his/her client. Project planning, construction and risk management, schedule delay analysis, cost estimates, construction claims, expert testimony and litigation support are some of the other services provided by these professionals. The Sri Lankan definition, as given by the Institute for Construction Training and Development (ICTAD, 2007), describes an Engineer as the person named in the Contract Data (or any other competent person appointed by the Employer and notified to the Contractor) who is responsible for administering and supervising the execution of the work. Such a person may be an engineer, architect or any other technical person.

It is important to understand the extent to which Sri Lankan consultancy firms are connected with the outside world as a dominant party in the construction industry. According to Thenuwara (2002), trade liberalization introduced from 1977 has made it easy for Sri Lanka to connect with the outer world and for Sri Lankan consultants to become familiar with the way business is conducted in the world. In addition, Thenuwara says that to reap the full benefits of globalization as a country, it is necessary to develop a range of supervisory and regulatory policies and to be mindful of factors that affect economic growth. This is applicable to Sri Lankan consultancy firms too. Hence, consultants have been able to serve internationally while protecting their businesses and self-interests.

According to Sandanayake and Senaratne (2012), given the global challenges taking place in the industry, there is a need for the construction industry to innovate in order to respond successfully to these challenges. They also state that continuous innovation and research are ways to do that. This requirement applies equally to local consultancy firms as well because the firms that are major stakeholders in the national economy is undoubtedly adversely affected by this phenomenon. However, irrespective of the importance of innovation and research, adequate attention has not been paid to the effects of globalization on consultancy firms in Sri Lanka. The present paper attempts to fill this lacuna in research by focusing on the ways that local consultancy firms understand the effects of globalization and respond to them in a way that ensures their sustainability. The study hence focuses on multi-disciplinary consultancy firms performing in Sri Lankan context.

Aim and objectives

The study aims at researching how Sri Lankan multi-disciplinary consultancy firms can become sustainable in the face of the globalization processes. It has the following four objectives:

- Identifying the concept of globalization;
- Understanding the current status of consultancy firms in Sri Lanka;
- Analyzing the effect of globalization on multi-disciplinary consultancy firms in Sri Lanka;
- Proposing a framework for multi-disciplinary consultancy firms in Sri Lanka in order to enable them to sustain themselves in the face of globalization

Research limitations

The study scoped multi-disciplinary construction consultancy firms in Sri Lanka that are engaged in providing building and civil construction consultancy services. These firms offer total

consultancy solutions to their clients on architecture, engineering and quantity surveying aspects. Since the study looked at the multi-disciplinary consultancy firms as a whole, it did not focus on individual disciplines which could be considered as a limitation of this research.

Research methodology

The research methodology involved a mixed approach constituting both qualitative and quantitative approaches (i.e., a preliminary survey and a questionnaire survey) followed by a literature synthesis. The literature synthesis helped to develop and refine the research problem using recently published literature such as books, journals, articles and electronic media. The views and thoughts expressed in which were reviewed, analyzed and critiqued with the intention of constructing the argument, which helped the researchers to accomplish the first objective and a portion of the second.

Subsequently, a preliminary survey was conducted with the use of semi-structured interviews to identify the contemporary consultancy practices that are aligned with globalization, thus fulfilling second objective. In addition, it helped to elicit opinions in the industry regarding multi-disciplinary consultancy practices that are already aligned with the processes of globalization while also enabling the researchers to identify the opportunities and threats incumbent upon such practices. Thus, it provided an entry point to the third objective, which is to analyze the effects of globalization on multi-disciplinary consultancy firms in Sri Lanka. As the next step, a questionnaire survey was carried out focusing on professionals employed at various multi-disciplinary consultancy firms in Sri Lanka. The collected data was analyzed with the help of one sample t-test. The results were helpful in developing a conceptual framework for multi-disciplinary consultancy firms in Sri Lanka on how to sustain themselves through the globalization process. These steps enabled the researchers to achieve the fourth objective, namely, to propose a framework for multi-disciplinary consultancy firms in Sri Lanka to sustain themselves in the face of globalization

The concept of globalization

Globalization, according to Schiffers (2007), is on everyone's lips, from politicians to businesspersons. Though the processes and activities that are associated with globalization, as previously mentioned, are many centuries old, sustained focus on the concept has a much more recent history (Robertson, 2000). As Larsson (2001) describes it, globalization describes a process through which the world appears to shrink, distances get shorter and things move closer. One could say it is a concept that is still evolving in time.

The IMF (2012) defines globalization as the growing economic interdependence of countries worldwide through the increased volume and variety of cross border trade in goods and services, freer international capital flow, and the more rapid and widespread diffusion of technology. The IMF definition crystallizes the multidimensional and complex nature of globalization, which is difficult to encompass within a single scope.

A more recent definition describes globalization as the connectivity of different parts of the world (National Geographic Education, 2013). In addition, it speaks of the expansion in international political, economical and cultural activities, making people around the world experience similar experiences due to fast moving ideas, knowledge, people and goods around the globe. As suggested by the above definitions, the globalizing processes have made nations across the globe dependent on each other with regard to their relationships and activities.

According to Crosthwaite (2000), the role that the construction sector plays in economic development is significant in both size and role. Accordingly, given below is a detailed list of the features that connects globalization with economic perspectives for a more meaningful understanding. Devereux (2007) listed the following features as characteristics of globalization:

- Interconnectedness
- Reduction of distance in terms of time and space
- Rapid transfer of ideas, goods and services powered by advances in ICT
- Increased awareness of the global phenomena in people's lives
- Globalization of culture and economic activities
- Migration of people
- Decrease in the significance of identities
- Anti-globalization movement to resist economic and cultural globalization

The above features reveal that globalization has left its imprimatur on the behaviour of people everywhere. Supporting this idea, Bhagwan (2009) saw globalization as being driven by a combination of economic, technological, socio-cultural, political and biological factors and stated that it is a complex set of processes rather than a single one. This multi-dimensional process of globalization exhibits unique facets, which distinguishes it from earlier phases of the world economy's internationalization (Economic Commission of Latin America [ECLAC], 2002).

Being a popular concept and a global phenomenon, globalization consists of its own set of advantages and disadvantages, which creates awareness in people of themselves as members of a global nation. Dubrin (2011) categorized these advantages and disadvantages as follows:

Table 5: Advantages and Disadvantages of Globalization

Advantages	Disadvantages
<ul style="list-style-type: none"> • Global outsourcing • Increase in productivity • Reduction in global poverty • Integrated economies • Open economy • International trade • Collateral R & D projects • Experienced work force • Revitalized economy • Inexpensive overseas investments 	<ul style="list-style-type: none"> • Unemployment • Competitive pressure • Reduced benefits to lower costs • Unfair increments in executive wages • Loss of national pride

Source: Essentials of Management, Dubrin A.J.

According to some authoritative sources, Sri Lanka as a nation has benefited from globalization in the recent past. International Labour Organization (ILO, 2008) has stated that Sri Lanka is marching towards development despite many challenges, attempting to reap the maximum benefits of globalization while minimizing costs. The Central Bank of Sri Lanka (CBSL, 2012) has asserted that the Sri Lankan economy, despite global and domestic challenges, has grown at a healthy rate of 6.4 in the year 2012. In addition, according to World Bank (2013) statistics, Sri Lanka has become a middle-income country, thereby giving access to the International Bank for Reconstruction and Development (IBRD).

The above information confirms that Sri Lanka is starting to face the challenges of development with an awareness of the strengths and weaknesses of globalization. Hence, first it is need to look at the nature and behaviour of Sri Lankan consultancy firms before proceeding further with the study of these firms' response to globalization.

The status of consultancy firms in Sri Lanka

The construction Industry is not an isolated sphere but consists of many other sub-sectors. Hillenbrandt (as cited in Ofori, 1990) professed that the construction process covers parties involved in it as well as suppliers of industry inputs to a certain extent. This view underlines the fact that the construction industry is not a stand-alone entity but is a combination of a few sectors.

Figure 1 below demonstrated that apart from the client and the professional consultants, civil and specialist engineers are dominant parties in the industry compared to building contractors, manufacturers and suppliers.

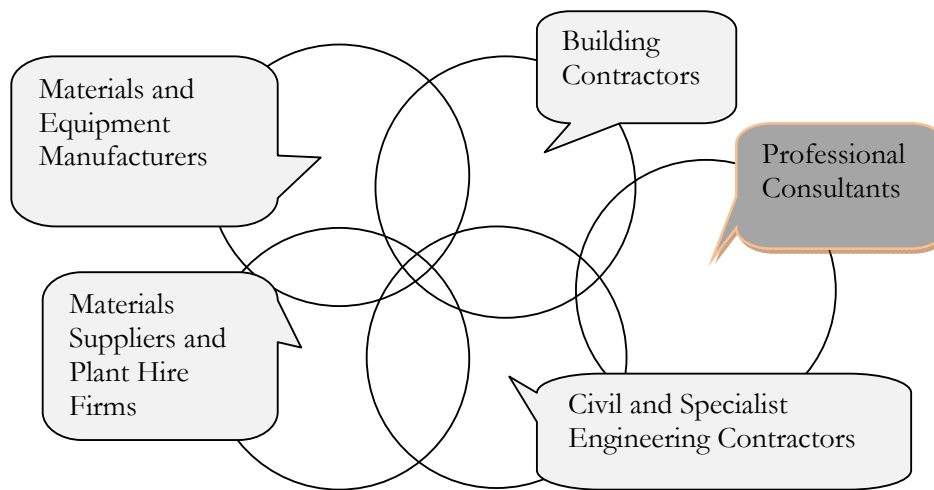


Figure 1: Parties Involved in the Construction Industry

Source: (The Construction Industry, Ofori, G.)

Among them, consultants have been identified as experts and strategists regardless of their specialization and they are hired by businesses to fix a problem that they have recognized but that they are unable to remedy internally (Consulting.co.uk, 1). The Royal Institute of British Architects (RIBA) (cited in Chinyio, & Olomolaiye 2009) defined 'consultants' as architects, geotechnical engineers, structural engineers, building services engineers and surveyors who are mainly contributing their professional knowledge to a project throughout the design, tendering, and construction stages. Ip (2008) stated that a 'consultant' is the administrator of the contract. Accordingly, construction consulting is a specialized form of business consultation that focuses on all forms of construction, most notably building construction.

The status of construction consultancy in Sri Lanka can be determined by the distinct publications illustrating the scope of consultancy services published by the ICTAD for the domestic. ICTAD (2002) has shown that the success of any project principally depends on consultants who plan, design and have a greater responsibility towards the client including a high standard of competency and a high degree of professionalism.

Orienting the discussion towards consortium/multi-disciplinary consultancy (MDC) firms, Clark (2008) has shown that firms that provide all construction associated disciplinary services for projects beneath one roof are recognized as MDC firms. However, for both MDC and non-MDC firms functioning in Sri Lanka, ICTAD as the regulatory body has published a set of regulations to be adhered to by such firms.

Accordingly, the different duties and responsibilities that consultants and MDC firms must shoulder vis-à-vis, construction related activities could be listed as follows as derived from ICTAD (2002):

- Skill, Care and Diligence
- Impartial advisor
- Provision of expertise, Technical advice and Skills
- Supervision or Inspection of work
- Alterations to design and Variation instructions
- Certificate of completion
- Issue of certificates and payments to contractors and suppliers

ICTAD (2002) has specified consortium consultancy services in fulfilling construction consultancy works as listed below. It has further dictated that firms should assign to clients a consortium of consultants who are able to undertake all the consultancy services required by a particular project.

- Feasibility phase
- Schematic design phase
- Design development phase
- Tender document phase
- Bidding and negotiating phase
- Construction phase
- Maintenance phase

In contrast to the role currently played by consultancy firms and multi-disciplinary consultancy firms, it is evident that they are a key party in the Sri Lankan Construction Industry. The performance of multi-disciplinary consultants that are identified by ICTAD as capable of better execution of services however seems traditional, working with outworn methods rather than experimenting with something new or adapting themselves to the demands of the new. Thus, in order to ready themselves to play their new roles, these firms would have to rethink their current roles in the construction industry and determine what their new roles might be in the increasingly more globalized world. Hence, the study aims to look at the connectivity between globalization and the construction industry in Sri Lanka.

Globalization of Sri Lankan consultancy firms through the construction industry

According to Thalagodapitiya (2010), the impact of globalization on the Sri Lankan construction industry has been significant in the past few decades. Sri Lanka's investment in infrastructure has opened up opportunities for its consultancy sector within the country, and its excellent connectivity via internet and telecommunication has opened doors for Sri Lankan consultants to engage in work overseas. Mendis (2009) has stated that Sri Lanka has made much progress in the consultancy sector, including the building of new roads, which has opened up opportunities for its consultants in the global arena. Confirming this, Ellis (2011) has stated that construction/consultancy is an export service of Sri Lanka.

The situation outlined above highlights the impact of globalization on MDC firms in the Sri Lankan construction industry. Therefore, the well-being and future of Sri Lankan MDC firms in the long run depend on analyzing the various dimensions to the effects of globalization on such firms.

Sandanayake and Senaratne (2012) have stated that there is a need for the Construction Industry to innovate in order to respond successfully to the global challenges facing the Industry as lack of innovation and research would lead to failure. Hence, a discussion on the effects of globalization on Sri Lankan MDC firms has become vital. The preliminary survey and questionnaire survey address this requirement.

Preliminary survey

The preliminary survey was conducted based on semi-structured interviews with four versatile construction consultancy related professionals who have significant experience in the subject from three distinguished consultancy firms in Sri Lanka.

At the inception, a set of contemporary MDC practices in Sri Lanka as derived from the literature survey was provided for consideration by the interviewees, ranging from the feasibility phase to the maintenance phase. However, it should be noted that these contemporary practices were the outcome of previous phases of globalization. Moreover, the results obtained from the literature survey and actual MDC practices were strikingly similar. Secondly, the existing consultancy practices/tendencies, suggestions to improve current practices and the steps followed by the consultants to avoid threats, all of which were aligned with globalization, were identified. Hence, it is possible to identify an evolution in practices.

The measuring criteria to capture the practices were obtained from the literature survey and the findings were categorized under a few headings as given in Figure 2 above. The highlighted categories were identified as the results of the preliminary survey. These derived categories contained both the positive and negative trends of globalized practices.

Practices/tendencies and suggestions recognized under the preliminary survey, after categorizing under above headings through a content analysis done with NVivo, were then subjected to an industrial evaluation in order to identify their impacts and acceptance in order to determine the effect of globalization respectively.

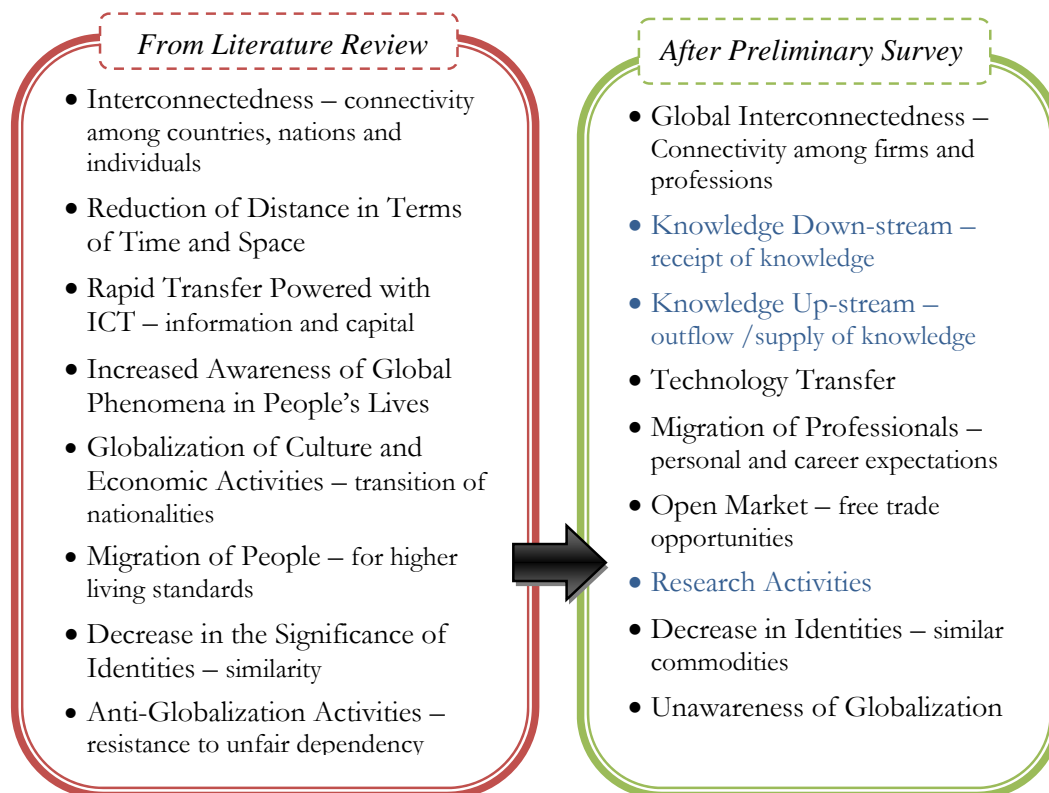


Figure 2: Results of the Preliminary Survey

Questionnaire survey

A pilot survey was initially carried out to ascertain the feasibility of the research before meeting the designated respondents who are MDC professionals such as architects, engineers, quantity surveyors (QSs) and town planners (TPs). Out of the 92 questionnaires distributed among five of the six functioning MDC firms in Sri Lanka, 52 valid responses were obtained resulting in a 58.7% response rate because those working at MDC firms are very busy. Proportionately, it was approximately 50% of the concerned population. A cross-section of respondents is given in Table 2, which validates the sample.

Table 2: Cross-section of Respondents

Professionals	Number	Work Experience				Foreign Exposure
		0-5	5-10	10-15	15 <	
Architects	18	38.9%	27.8%	5.6%	27.8%	33.3%
Engineers	16	31.3%	31.3%	25.0%	12.5%	50.0%
QSs	19	47.4%	21.1%		31.6%	36.8%
TPs	1	100%				
<i>Total</i>	<i>54</i>					

When obtaining responses for hand-delivered questionnaires, assistance was provided, via face-to-face discussions/explanations, to respondents to help them understand the intended meaning of the categories that had been developed on concepts like globalization as well as statements (practices/tendencies and suggestions) in the questionnaire. It helped the respondents to answer easily and effectively, concluding the questionnaire survey phase of the study successfully.

The consultancy practices thus elicited by the survey were aligned with globalization and the appropriately formulated suggestions were put into a statistical evaluation with the help of one sample t-Test and were checked for significance of each practice and the acceptability of each suggestion. The significance was checked in relation to a five-digit response scale, which can consider both extremities. Hence, the t-Test was carried out as a two-tailed test.

The significance of the test hypotheses (statements) was identified with respect to the middle value of the response scale, which is three (**3 – average/neutral**). Accordingly, the hypotheses can be stated as follows:

H₀: $\mu_{\text{sample}} = 3$ (a particular statement having average effect/suggestion is neutrally accepted - *null hypothesis*)

H₁: $\mu_{\text{sample}} \neq 3$ (a particular statement having non-average effect/suggestion is non-neutrally accepted - *alternative hypothesis*)

The significance of statements were to be determined with p_{cal} value (probability) which resulted from the t-test in contrast to 95% confidence interval as explained in Figure 3 below.

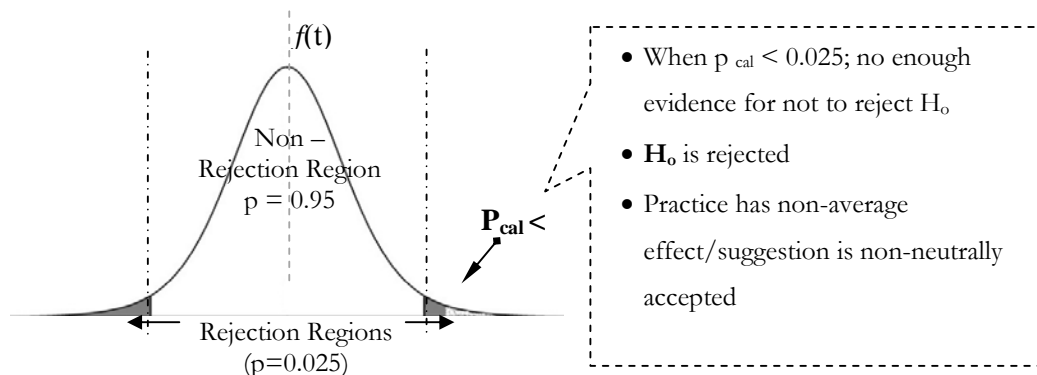


Figure 39: Hypothesis Testing

The effect of globalization on MDC firms in Sri Lanka

The analysis of current consultancy practices aligned with globalization demanded a separation between positive and negative practices/tendencies according to the responses received. Such a separation was helpful for a better understanding of the multi-faceted impacts of globalization. A detailed analysis to identify the level of each impact on MDC firms was done based on this separation.

Determination: If a practice/tendency has acquired,

Percentage response $\geq 50\%$: practice/tendency is positive

Percentage response $< 50\%$: practice/tendency is negative

This separation resulted in 23 positive practices and 5 negative practices from the 28 statements given in the questionnaire for consideration under eight categories.

The level of effect by positive practices on multi-disciplinary consultancy firms

The current consultancy practices having a considerable/higher effect on MDC firms are highlighted in Table 3 according to the formulated results. Provided p_{cal} illustrated the significant levels, where values closer to the non-rejection region imply lesser significance and vice versa.

As the Table shows, aspects such as technology transfer, knowledge down-stream, knowledge up-stream and open market conditions are located at the top of the effects ladder in comparison with other aspects. Although these have been previously identified as the outcomes of globalization, the present study is the first where the level of effect of each, in terms of up-to-date sensors, have been measured for modern usage.

Table 3: Significance Values (p_{cal}) for Existing Positive Practices/Tendencies

Category	Existing Positive Practices/ Tendencies	p_{cal}
Global Interconnectedness	Use of International Standards	0.000
	Regional & International Co-operation among Professionals	0.185
	Pressure on Firms to Perform on a Global Level	0.142
	Following Business Practices	0.001
Knowledge Down-stream	Collaborative Projects with Other Countries	0.001
	Ability to Transform Foreign Theories into Local	0.017
	Use of Industrial Magazines, Journals	0.007
	Participating in Conferences, Exhibitions	0.000
Knowledge Up-stream	Undertaking of Foreign Projects	0.000
	Representing Industrial Magazines	0.020
	Participating in Conferences/Exhibitions as a Resource Provider	0.011
	Marketing Themselves in Prospective Markets	0.077
Technology Transfer	Updating on New Technologies	0.000
	Usability and Applicability of New Technologies	0.000
	Practice of Professionals	0.000
	Use of Modern Communication Media	0.000

Category	Existing Positive Practices/ Tendencies	p _{cal}
Migration of Professionals	Professionals Practicing an International Career	0.000
	Reputed Place for Well-Experienced Professionals	0.018
Open Market	Foreign Direct Investments (FDI)	0.004
	Awareness of Regional and International Trade Agreements	0.008
	Establishing Branches of Firms in Foreign Markets	0.505
Research Activities	Projects Giving Optimum Benefits to the Public	0.001
	Projects Which Can Change Attitudes of Users	0.010

Additionally, many of the identified existing positive practices/tendencies of globalization, which were on a par with their level of impact, exercise significant effect over MDC firms in Sri Lanka according to the analysis done above. A few of them (four in number) have an average or less-than-considerable impact on the changing dimensions of consultancy services provided by the Sri Lankan MDC firms.

Level of effect by negative practices on multi-disciplinary consultancy firms

Table 4 below identifies conclusively the level of negative impact of existing negative practices/tendencies that are considered. Similar to previous findings, the impact level of known influences have been tabulated here under a negative brand.

Table 4: Significance Values (p_{cal}) of Existing Negative Practices/Tendencies

Category	Existing Negative Practices/Tendencies	p _{cal}
Global Interconnectedness	Threats generated by foreign consultancy firms established in Sri Lanka	0.096
Migration of Professionals	Lack of professionals for in-house activities due to migration	0.000
Unawareness of Globalization	Lack of awareness of firms that prevent them from determining and refraining from riskier practices on consultancy aspects (e.g., pseudo architecture)	0.471
	Reluctance of firms to compete for international project opportunities	1.000
	Unawareness of emerging changes in consultancy practices (e.g., project management)	0.211

Except for the dearth of professionals for in-house functioning of MDC firms, the other negative practices considered have been marked as insignificant practices / tendencies by the respondents. Therefore, though they prevail as negative tendencies, the impact of their accumulated risk on the proper functioning of MDC firms is minor.

Thus, to sum up, the findings of the analysis on the effects of globalization on MDC firms in Sri Lanka shows that, when considered as influences of globalization, 19 out of the 23 existing positive practices/tendencies under consideration have a significant effect on MDC firms in Sri Lanka. The rest were found to have only average significance. Simultaneously, 1 out of 5 of the existing negative practices/tendencies under consideration was found to have withholding or negative effects according to respondents. These findings address the third objective of the research study as specified above.

Activities to enhance existing practices and to avoid remaining threats

Various suggestions that were obtained during the preliminary survey with respect to derived categories were used as industry opinions in order to judge the acceptability of implementation requirements. These suggestions delineate both how to improve existing practices and to defend against threats experienced by local MDC firms during the current phase of globalization, focusing on the sustainable ability of firms for an oracular mission. However, their practical value was suggested in the latter framework derived from the findings of the survey.

Level of acceptance of suggestions to enhance existing practices

Table 5 below tabulates the obtained significance values through the t-test for suggestions that were considered based on the received responses.

Table 5: Significance Values (p_{cal}) of Suggestions to Enhance Existing Practices

Suggestion	P_{cal}
Global Interconnectedness	
Local practices need to conform to global standards more rapidly than they do now	0.000
Setting up help desks at regional or international basis is vital for consultancy work	0.000
Knowledge Down-stream and Up-stream	
Encouraging professionals to engage in career development	0.000
Motivating professionals to take part in international level events such as conferences, exhibitions and official tours	0.000
Technology Transfer	
Recognizing the profile/requirements of local construction firms in order to improve local consultancy firms	0.000
The need for firms to follow precedence studies (<i>i.e., starting from where they have stopped</i>)	0.000
Open Market	
Understanding global market trends and business practices for the effective functioning of firms	0.000
Undertaking new consultancy aspects (<i>e.g., project management for foreign funds and donations</i>)	0.000

Suggestion	P _{cal}
Research Activities	
Commencing proper database handling for large projects which would be helpful with regard to possible future projects	0.000
Expending efforts on project model testing for feasible, significant projects	0.000
Unawareness	
Improving awareness of professionals regarding advantages of global effects	0.000

The p_{cal} values show that almost all the suggestions represent the rejection region, being non-neutrally /significantly accepted. Some suggestions show the possibility of improvements with knowledge usage (e.g. professional helpdesks), technology usage and avenues for future practice enhancements through open market and research activities, which are not yet in operation in Sri Lanka at a satisfactory level. Others addressed certain deficiencies such as lack of awareness of global advantages.

Level of acceptance of suggestions to avoid remaining threats

Table 6 carries the calculated significance values of suggestions that were evaluated in order to identify potential activities that needed to be implemented in order to avoid the possible threats faced by MDC firms in Sri Lanka. These suggestions have been culled from the results of the preliminary survey.

Table 6: Significance Values (p_{cal}) of Suggestions to Avoid Remaining Threats

Suggestion	P _{cal}
Global Interconnectedness	
Enhancing the legal system to provide the right conditions to establish foreign firms (<i>e.g., established in association with local firms</i>)	0.000
Allowing firms to start practicing as separate firms (<i>non-multi disciplinary firms</i>)	0.003
Knowledge Down-stream and Up-stream	
Enhancing legal measures and ensuring the adaptability of down streamed knowledge to suit local requirements	0.000
Technology Transfer	
Introducing advanced standards for compatibility tests regarding new technologies	0.000
Migration of Professionals	
Offering attractive and reasonable remunerations to professionals	0.000
Appreciating professional values and employing them appropriately	0.000
Unawareness	
Convincing clients about the benefits of modern innovations (<i>e.g., energy efficient buildings</i>)	0.000

The two types of suggestions elicited from the study demonstrate that local MDC firms need to be encouraged to adopt and adapt appropriate responses in order to withstand the possible adverse consequences of current globalizing processes.

The t-test underscores both the significance of suggestions made as well as the urgent need to respond to those suggestions by firms. The suggestions obtained under the preliminary survey that are evaluated here also anticipate solutions as envisaged by professionals. Understanding the level of impact of existing practices/tendencies and by evaluating the suggestions made to withstand those impacts, local MDC firms would be better able to sustain themselves at a global level. This paper intends to develop a framework for such purposes.

Framework for sustainability of MDC firms in Sri Lanka against globalization

Firstly, the framework proposed keeps in mind the magnitude of the effects of globalization experienced by MDC firms in Sri Lanka. Secondly, it keeps in mind the need for the improvement of management prospects for the betterment of the organization. Figure 4 (in page 15) gives the conceptual framework developed based on the findings of the research study that also keeping in sight the two considerations outlined above.

Accordingly, the management of the MDC firm, or professionals who are employed in such firms, have to identify the status of the firm vis-a-vis globalization (see Step 1). It would permit the management to evaluate their current practices/tendencies for the level of impact of globalization as well as their positive or negative aspect (see Step 2). The results would enable the management to decide on whether to upgrade current practices and/or to remove or rectify such practices where necessary (see Step 3). With regard to the implementation of suggestions for improvement derived from the research, they could be used either as an internal or external application where appropriate (see Step 4). Therefore, activities to enhance current practices and activities to avoid the remaining threats from globalization effects are expected to bring Sri Lankan MDC firms on sustainable grounds vis-a-vis globalization.

The researchers recommend the use of the framework developed in this study only by versatile professionals operating at the management level of Sri Lankan MDC firms who possess the decision-making skills to judge the requirements of and uplift the firms that they work for. Being frequently updated on the effects of globalization yields benefits to the professionals individually as well as to the Sri Lankan MDC firms, in terms of being able to offer a better construction consultancy service.

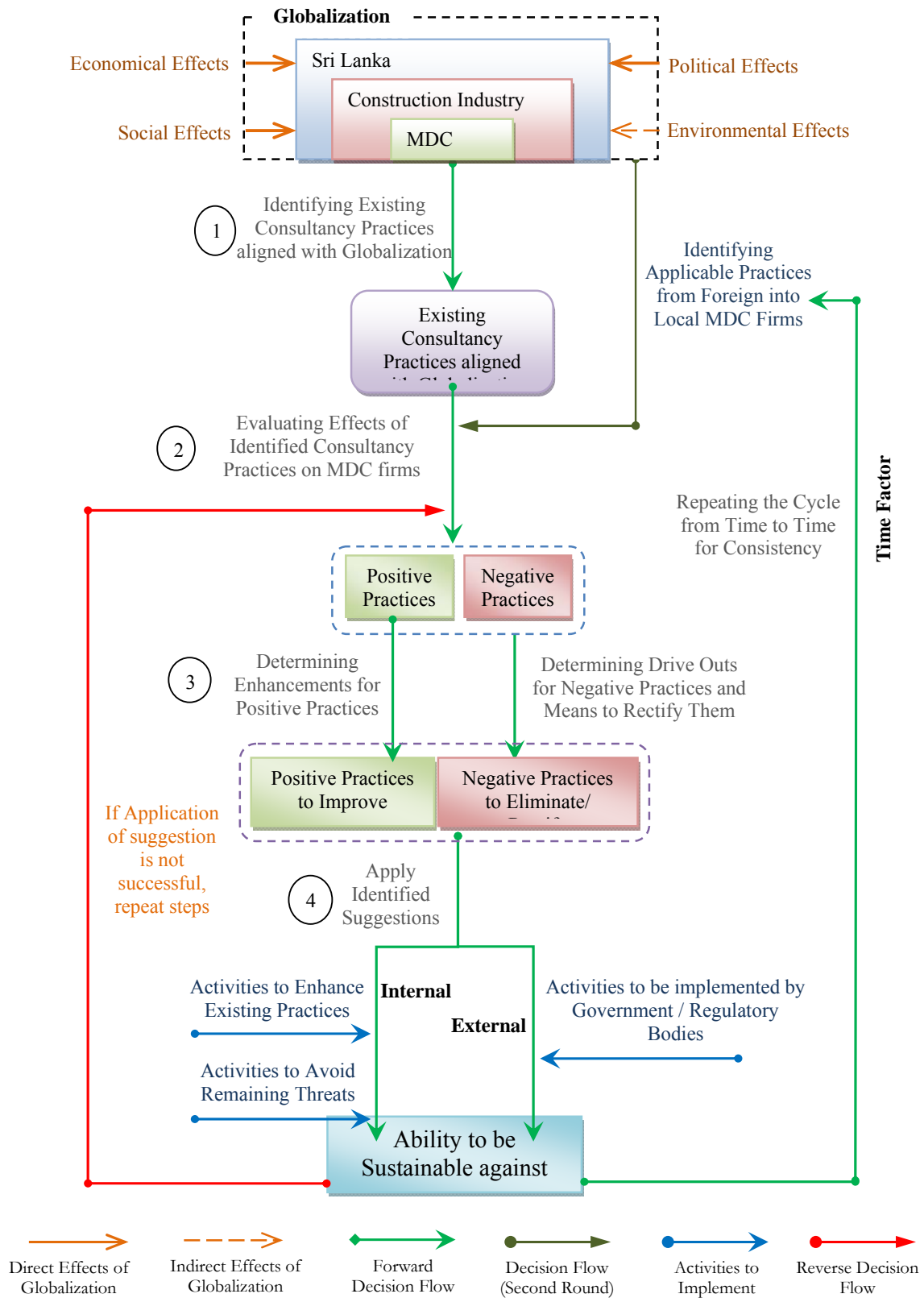


Figure 4: Framework for Multi-disciplinary Consultancy Firms in Sri Lanka to Sustain against Globalization

When availing themselves of the framework, the MDC management or professionals first need to estimate their current (up to date) practices. This estimation should be made against the backdrop of the effects of globalization on such practices. By factorizing practices separately, the users would be able to identify certain practices such as those up to standard, those demanding improvements those that should not be continued and those that can be rectified. Prompt and accurate identification of these different types of practices should then be subjected to the application of necessary actions. The application of the suggestions made in the framework has to be executed by different types of functionaries such as professionals, management or by government or regulatory bodies such as the law courts. In order to activate regulatory bodies to implement activities, the practice or issue identified has to be one that is common to all MDC firms in Sri Lanka.

The main point highlighted here is the need for consistent execution of the framework by Sri Lankan MDC firms because that would enable them to remain sustainable in the dynamic global construction arena in the end.

Conclusions and recommendations

As described at the outset, scholars over time have described globalization as the continued compression/shrinking of the world, the growing interdependence of countries in terms of economic activities and technological exchange or as the socio-cultural, economic and political connectivity of different parts of the world which bring countries, nations and individuals more and more onto a common platform. The more visible phenomena such as free trade activity, connectivity, composite processes and the global status of local lives exhibit the evolving process of globalization.

In keeping with the above, the present research has shown how all aspects to the activities undertaken by local MDC firms, ranging from designing, estimating, tendering, construction administrating and dispute resolving to feasibility testing, the maintenance phase are susceptible to the effects of globalization. The core business practices of MDC firms are empowered with qualities such as skill, care, diligence, impartiality and expertise. In addition, the impact of globalization on Sri Lankan MDC firms can be gauged by the use of the performance level of construction activities underpinned by reports of regulatory bodies and the protective measures taken against globalization by the Government of Sri Lanka. Therefore, a balanced evaluation of the recognized status of MDC firms vis-a-vis globalization was necessary, which was subsequently obtained through the preliminary survey.

The questionnaire survey distinguished current consultancy practices aligned with globalization as positive and negative trends, based on responses obtained from the professionals working at Sri Lankan MDC firms. A statistical valuation of the two types of practices indicated that many positive practices have a higher or considerable effect on MDC firms while the majority of the negative practices do not have such an effect. The main objective of the study was to measure the appropriate suggestions that the MDC firms could adopt in order to withstand the effects of globalization. Most of the suggestions listed have obtained a higher level of acceptance for providing quick solutions that can be easily executed. As the final two objectives of the study, a framework has been developed for Sri Lankan MDC firms, which would enable them to sustain themselves against the effects of globalization.

The effects of the globalization experience on Sri Lankan MDC firms demonstrate that, though local MDC firms have not been able to escape the different attributes of the globalization processes, some of which are harmful or detrimental, they are at a manageable level except for a few risky practices. Prompt identification of harmful effects helps the management or the professionals to apply the necessary precautions, thereby minimizing their detrimental impacts and to foreground their more beneficial dimensions.

The gist of this particular research can be summed up as the identification of the level of effects acting on Sri Lankan MDC practices that fall within the spectrum of forces identified as globalization rather than identifying the different forces separately. In addition, the prospective aim is to energize or restructure the current MDC practices in order to make them compatible with the new propensities of globalization. It should be mentioned that in future, the MDC firms discussed here would engage in business not exclusively within the Sri Lankan context but would also expand outwards beyond national borders to become globalized MDC practitioners. Hence, their aim should be to assure themselves of sustainability globally in anticipation of a future as a globally co-operative construction consultancy service imbued with a sense of social responsibility.

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Shortcomings in the UK's Current 'Fabric' First Approach towards Building Energy Targets

Julie ann Futcher

University College Dublin, Ireland

julie@climate22.com

Abstract

Buildings consume between 40 - 50% of the world's energy, and as a result have become a prime focus towards achieving net-target energy and greenhouse gas reductions. Within the UK, building policy sets minimum standards for building regulated loads (demands associated with building fabric and energy demanding systems), which has resulted in policy driven 'generic' fabric first approach to building energy management. However, concerns are increasingly being raised that this 'fabric' approach can result in an increased energy demand. The work presented in this study investigates the appropriateness of a 'fabric' first approach and evaluates the effectiveness building fabric (U-values) in the urban context. The case study area is Central London, an area populated with prestigious office buildings that can be considered representative of many central Europe cities.

Keywords: *Fabric' first approach, mean Height to Width ratio, overheating risks*

1. INTRODUCTION

Within the UK building energy management considers three key efficiency measures; the delivery of energy via renewable technologies, optimising building fabric and energy demanding systems (regulated), alongside managing loads associated with occupant activity (operational). However whilst operational loads are managed through guidelines and recommendation, minimum targets for both renewables and regulated loads are set by legislative policy. This approach has not only resulted in building energy management being policy driven, where a generic 'fabric' first methodology prevails, but focuses attention on the energy performance of individual buildings. And whilst building energy performance studies recognise that the performance of each subsystem has an influence on the other, they often overlook that in an urban setting, the thermal performance of a single structure is significantly influenced by the myriad of surfaces that surround it; which in turn, influences the thermal performance of surrounding system (Futcher et al 2013). It should be noted this lack of integration is in part due to an underestimation by building designers of the significance of micro-climatic formation on building performance, but also as a result of urban climate research (with a few notable exceptions) focusing on the resultant external thermal comfort conditions.

The basic premise behind a 'fabric' first approach is that the building fabric itself is considered inherently efficient before any additional measures are taken. However research is increasingly finding that lower building fabric U-values results in an increasing overheating risk and higher cooling loads (Al-Homoud, 1997; Korolija et al., 2009); however these examples consider the building in a standalone setting, overlooking the implications of dynamic urban shading at the building surface, which can significantly change performance patterns.

The first section of this paper briefly outlines the influence of urban geometry on micro-climate formation. The second section reports on an observation when a comparison is made between the output performances of typical open-plan UK office buildings and an identical building simulated in the context of a surrounding urban setting. Here the effects of over-shadowing and building U-values are examined using a commercially available computer simulation tool.

2. MICRO-CLIMATE FORMATION

In an urban area the cumulative effects of the local surface energy exchanges (micro-scale), the accumulation of these surface energy exchanges (local-scale), alongside those of the surrounding non-urban area (meso-scale) often result in higher surface, air and near surface air temperatures when compared to the surrounding non-urban area. This urban/non-urban temperature difference is commonly referred to as the urban heat island (UHI) effect (Oke, 1987). The intensity of these temperature differences (which are both spatial and temporal in nature), are found to be dependent on a combination of the background climate, plus modifications brought about by the particular topography of a site, alongside the accumulated thermal effects that result from the myriad of activities and morphologies found within an urban area (Arnfield, 2003). The point where these effects are most profound is at and below the building roof level, referred to in the climate literature as the urban canopy layer (UCL) (Oke, 1987). The canopy layer is distinguished by the unique energy exchanges that occur at the surfaces of buildings and streets. The most obvious example of this is that of the geometric forms that directly impact shortwave (solar) radiation receipt at the urban surface. The prime parameter in determining these daytime dynamic effects is the ratio between the averaged building height (H), to the width (W) of the street that separates them. This daytime urban climate parameter (mean H/W ratio) determines the radiation exchanges with the sky and the surface, and is shown to influence both the thermal conditions for pedestrians (Emanuel, 2003; Toudert, 2006; Tzu-Ping Lin et al., 2008) and the energy required maintaining thermal equilibrium for the buildings' occupants (Rajagopalan, 2007). It is the significance of this daytime urban climate parameter mean H/W ratio as an energy management parameter which is the focus of this study.

At the scale of the city street, the arrangement of the buildings within the street defined by their mean H/W ratio determines the amount of visible sky or 'sky view' from any given point, which in turn determines both the incoming and outgoing radiation exchanges. Whilst a lower sky view will decrease daytime surface heating it will also increase exchanges with the surrounding surfaces. The net effect is a reduced rate of night-time cooling, a critical factor in the formation of the UHI, but whilst important for nocturnal heating or cooling strategies is of minimal significance for buildings with a daytime function such as office buildings. Unlike night time radiant loss daytime radiant gain is dynamic; the solar (direct and diffuse including reflected) receipt at a surface is dependent not only on the surrounding morphology, but latitude and orientation (Fletcher et al, 2013). At this scale, a higher H/W ratio will increase overshadowing, resulting in lower radiant temperatures (Pearlmutter et al, 1990) and daytime urban air temperatures often found to be equal or lower than those of the surrounding non-urban environment (Grimmond et al, 2010). The level of solar receipt along with emitted and reflected longwave radiation is significant in influencing the internal temperature of a building, which in turn will determine building conditioning load.

This paper sets out to investigate the localised effects of urbanisation on building performance by comparing cooling and heating loads of identical office type building simulated in various urban configurations. Here various climate files for the same region are used to identify the role of urban form as a building energy management parameter, and the shortcomings in the UKs current fabric first approach, when buildings are considered in their urban setting.

3. METHODOLOGY

Within the UK, dynamic thermal modelling techniques are increasingly used to demonstrate compliance with building regulations. However there is no requirement to represent the complexities of the surrounding urban terrain. This omission is due in part to the complexity involved in the parameterisation of the UCL, where (although undergoing significant research) not one commercially available tool or methodology has been found that has successfully couples the dynamic external conditions to the buildings thermal performance, and in part due to the

under estimation of the significance of the urban setting on building performance. The aim of this study is to highlight the significant influences of the urban effect on building performance.

In this study the performance of a typical 'office' type buildings (placed in a standalone setting alongside 2 different urban configurations) are compared using a commercial available thermal dynamic building energy simulation software tool. The tool determines annual heating and cooling loads based on input data such as building fabric, location and climate, whilst allowing daily, weekly and annually timed controls for the energy demanding systems. Note, that aside from the occupation schedule associated with the daytime activities commonly carried out in commercial districts of urban areas, occupant behaviour and comfort are not considered here.

The software was chosen for its ability to analyse the geometrical relationship that exists between direct solar receipt (insolation) and the placement of an individual buildings within an urban street or urban street canyon. The software used here cannot calculate the effect of urban morphology on changes to external air temperatures or give external surface temperatures, but allows the rate of transmission gains and losses resulting from surface temperature differences to be analysed. In addition the software cannot account for anthropogenic heat and pollution, evaporative processes or turbulent transport, other than those provided by the tools boundary conditions. These limitations restrict this study to modified short and longwave exchange on internal temperatures only. The tool used here has been validated in accordance with both CIBSE AM11 standards alongside ANSI/ASHRAE Standard 140-2001.

The results presented will be used to make qualitative comparisons of building performance so that trends and insights into early design decisions can be made.

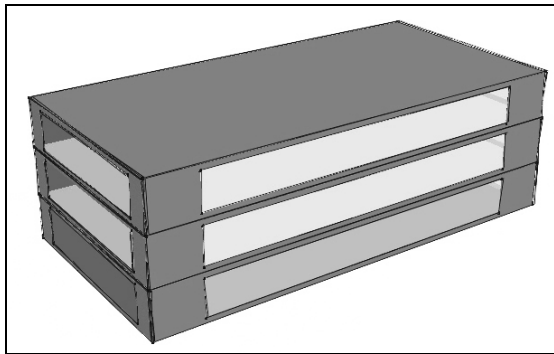


Figure 01.Office-01

Building Model

For this study a typical UK air-conditioned open plan office building has been used (**Office-01**). This building type is represented in the Energy Consumption Guide 19 (ECG01) building 'type 3', and has been used in numerous performance studies that relate to energy management

Office-01 represents the base line building and will be first simulated in a standalone setting, and then in various urban configurations. However the software boundary conditions for an urban environment are set as;

- Ground reflectance - 0.15
- Terrain type – City
- Wind exposure (CIBSE heating loads) – Sheltered

Office-01 is a narrow, 3 storey, open plan layout, 10.5 m high, 32 m long and 16 m wide, 60% glazing to all façades, orientated with the longer façade east to west (Figure 01). The model uses clear double glazing with no shading devices. Walls are insulated and of brick and block

construction, with a flat concrete insulated roof and insulated concrete ground floor. The intermediate floors are of concrete with false ceilings. The default thermal properties of the materials have been kept, as these represent global standards alongside limiting variables.

Energy loads

The heating and cooling set point temperatures are 19°C and 23°C respectively, with setback temperature 28°C and 12°C (CIBSE 2006). The heating season runs from October 1st to April 1st whilst cooling operates all year. Fresh air requirements are 10 l/s per person (Building Reg. App. Doc. F, 2006). Whilst infiltration rates 0.3 air changes per hour. Internal gains are shown in Table-01. Operational times are between 7:30 am and 7:30 pm with a 10% continuous load (Econ19 guide), using benchmark values.

Table 01- internal gains

Internal Gains	W/m ²
Occupants - 10m ² /person at 100 W/person – The Metric Handbook	10
Office equipment - CIBSE, 2005	15
Artificial lighting - ECG019, 2003	12

Height to width ratio

To compare results between identical buildings simulated in isolation and in context, two further configurations are considered; Office-01A and Office-1B; both are identical to Office-01. Office-01A is represented by Configuration-A, a street width of 12m in both an east/west and north/south direction, heights to width (H/W) ratio 0.88, whilst Office-1B - Configuration-B has a street width of 9m east/west but remains at 12m in the north/south direction, H/W ratio 1.17 [Figure 02]. All buildings in the surrounding system are of equal height to avoid over shadowing at roof level.

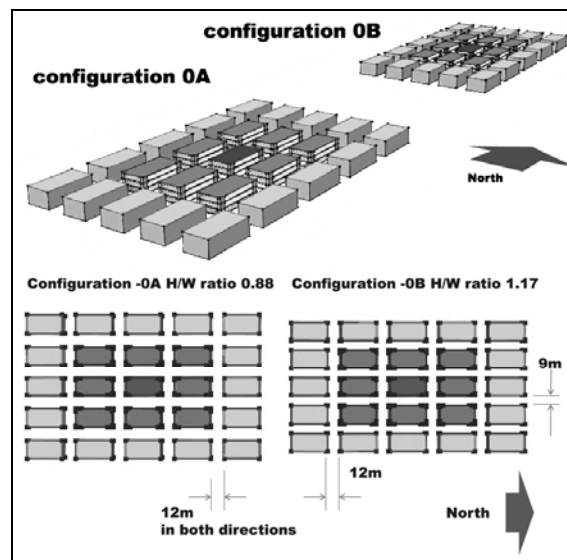


Figure 02. Office-01A & Office-01B (shown in red) in context – surrounded by identical buildings – the outer buildings represent the extent of the boundary (pale blue)

U-Values

Office-01 represents a typical UK construction method, the brick and block wall, with an internal plaster finish and an admittance of around 6 W/m²K. This type of construction can be found in most towns throughout the UK, and is considered a high thermal mass building type.

As before the tool cannot calculate the influence of thermal mass on external surface or near surface air temperatures, therefore for the purpose of this study, different U-values are evaluated in terms of H/W ratio. *Office – 01, 1A & 1B have been given 3 sets of U-values* [see table 02], to allow a comparison of building fabric on performance in the context of urban setting against different weather files. It is also worth noting that the glazing U-value for the both the 2006 building regulations and Best Practice are identical as a way of understanding transmission through the opaque surfaces in context of urban fabric.

Table 02 U-Values

(UK part L) U-Value W/m ² ·K	1990	2006	Best Practice
standard wall construction	0.53	0.35	0.25
flat roof	0.45	0.25	0.13
standard floor construction	0.84	0.25	0.15
low-e double glazing	3.21	1.98	1.98

Weather files

The consequence of using historic out-of-town weather files to determine urban energy load has undergone significant research (Oke, 1987; Watkins et al., 2002; Kolokotroni et al., 2012, Fitcher et al., 2013); this research points to the dissimilarities between ‘ideal’ meteorological sites and those actually found in urban systems, at both the urban scale and at the localised microscale. Most commercial available dynamic thermal simulation tools use climate data frequently collected from these idealised meteorological sites, but allow for the insertion on new and future climate scenarios. However regardless of climate file these tools are unable to report on the full extent to which the localised urban configuration within the UCL modifies local climate as a result of the modified shortwave and longwave radiation exchanges, anthropogenic gains alongside changes in latent and turbulent transport.

The case area for this study is London (51°32’N), a temperate marine climate with average high summer temperatures fall between 21°C – 28°C. For this study 4 London weather files (LondonDSY05, HeathrowEWY, Hrow9697 and Kew) are used. These files were chosen as to some extent they represent the different accumulative effects of urbanisation on climate whilst under the same synoptic conditions, allowing the influence of variables such as solar radiation and temperature on building performance to be examined.

4. RESULTS

The methodology used here highlights the limitations of the generic ‘fabric first’ approach to building energy management through a series of dynamic thermal simulation. This approach is evaluated in the context of the urban environment by comparing different scenarios against an identical office type building placed in isolation.

Energy balance

An initial investigation was carried out to establish the energy balance for an office building **Office-01**, in a standalone setting against two identical offices **01A & 01B**, in context. Table 03 summarises the annual loads for the three buildings. Table 03 highlights the overall difference in space conditioning, solar gains and external conduction gains, as a result of the surrounding urban configuration; and show that Office-01A & 01B require 70 and 63% of the annual space

conditioning load, whilst receiving 72 and 63% of the solar gains and a 10 and 12% decrease in external conduction gain, respectively against Office-01. The results point to the mutual relationship between space conditioning, internal load, solar receipt and the density of the surrounding urban fabric. These early results indicate the importance of simulating in the context of the surrounding urban system.

Table 03- Energy Balance for all configurations - 2006 UK U-values – London DSY05weather file

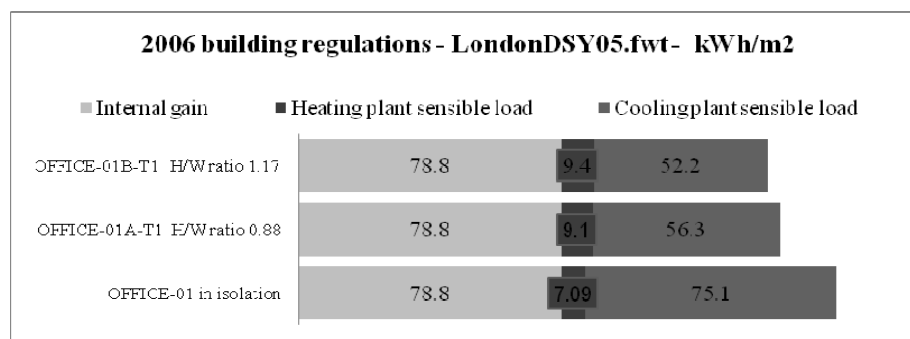
<i>LondonDSY05.</i>	OFFICE-01	OFFICE-1A	OFFICE-1B
Space conditioning sensible (MWh)	-99	-69	-62
Internal gain (MWh)	115	115	115
Solar gain (MWh)	166	119	109
External conduction gain (MWh)	-142	-128	-125
Internal conduction gain (MWh)	0	0	0
Infiltration gain (MWh)	-40	-37	-36

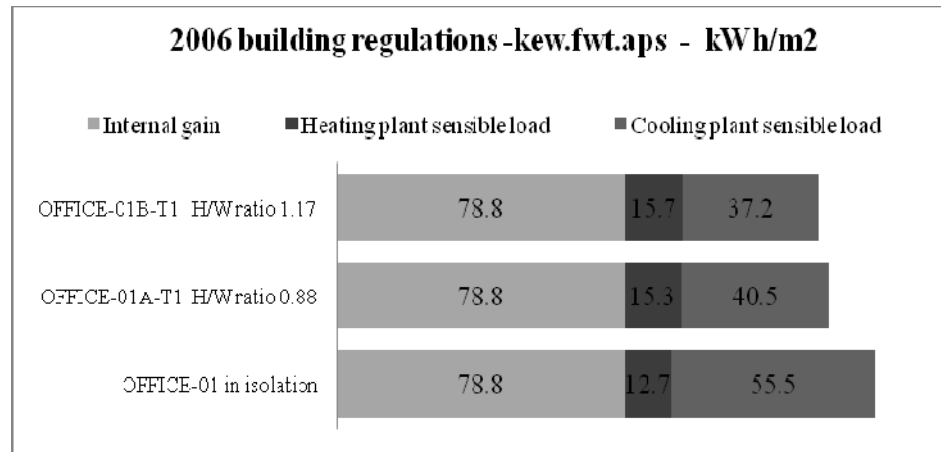
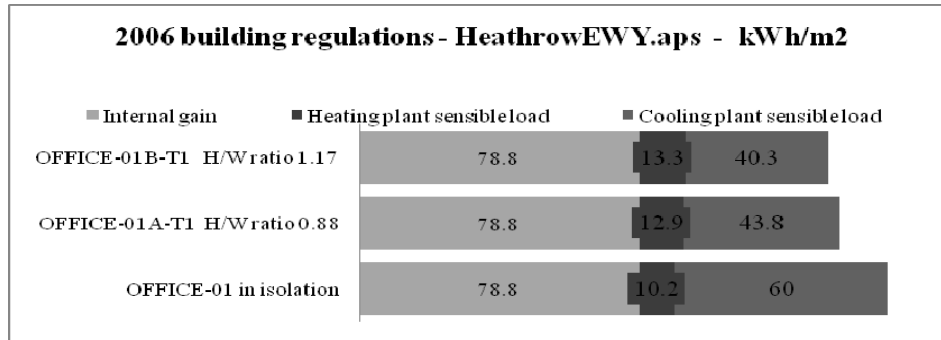
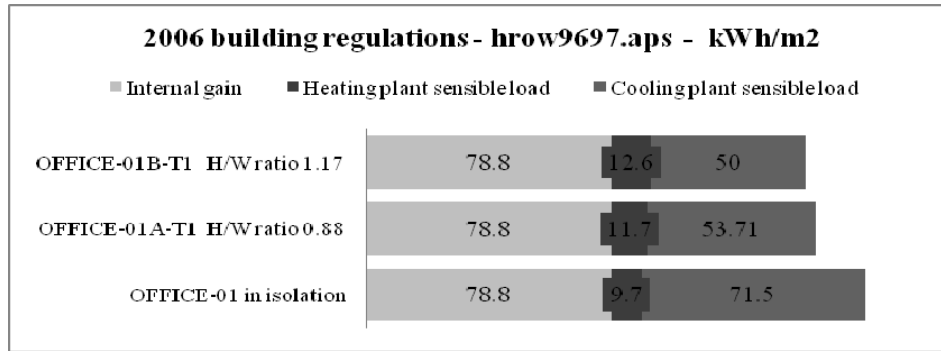
The breakdowns of the space conditioning loads are presented in Graph-01. Here we see the comparative heating and cooling loads alongside internal gains for all three configurations (2006 U-values - all weather files). The results highlight 3 significant points; firstly that the denser the immediate environment the lower the cooling load (overshadowing). Secondly the more rural the location ‘Kew’ the higher the heating loads (lower ambient air temperatures) and finally the dominance of internal gains (energy demanding activities). High internal gains, common in buildings of this type, place a strong emphasis on cooling over heating strategies (Jenkins et al., 2008).

Internal gains

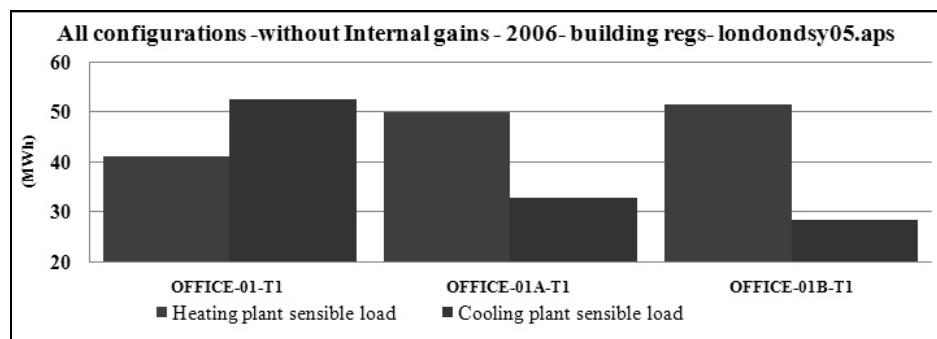
In an effort to isolate the urban effect on heating and cooling loads, the internal gains were removed [Graph 02]. This allows a comparison of the climate conditions on space conditioning loads to be evaluated.

From this we can see that the heating load (heating season only) is significantly greater than the cooling load for both Configurations-A and -B. However when modelled in isolation the cooling load dominates; It is worth noting that as we move towards lower operational loads the dominants of internal gains as a driving force for conditioning loads will become less significant placing higher emphasis on designing in context of the external environment. (Internal gains are included for the rest of this study)





Graph 01- comparative energy load for all office-01,01A&01B (kWh/ m²)



Graph 02 - comparative cooling & heating loads—without internal gains

Building loads under the different scenarios

Having defined both the building and urban parameters, annual simulations were run to determine building loads under different scenarios;

- Climate files - LondonDSY, Harrow, Heathrow and Kew
- U-values -1990, 2006 & Best Practice
- Context – in isolation alongside H/W ratios 0.88 & 1.17

These parameters have been defined as a way to determine the effects of local climate, building fabric and the significance of the surrounding setting. It is worth remembering that Office-01-DSY-2006, represents the current UK building benchmark model and is used here as the 'base case' for comparison.

Table 04 shows the ratio of heating and cooling loads for the identical buildings Office-01,1A &1B for all scenarios as a percentage difference against the base case building (examined in more detail in Table 05). All buildings are shown to have higher heating and lower cooling loads compared to the base case building, with the exception of Office-01 Best Practice - in isolation – DSY; whilst the heating load was found to be 16% lower the cooling load 5% higher. This highlights that when overshadowing is not represented in the model, lower U-values can result in higher cooling loads.

From Table 05 we can see how U-values determine the ratio of the conditioning loads, over both climate and configuration when compared against the base case scenario. This was done to highlight how climate, the form of the surrounding setting (H/W ratio) and U-values influence building performance when internal gains and building form are identical. Presenting the results in this way demonstrates cooling loads have a high dependence on H/W ratio, and that the reduction in cooling loads is not proportional to increase in heating loads. The results suggest the significance of canyon geometry on determining cooling loads regardless of U-value and local climate variations.

The largest comparative load ratio differences occur for the heating loads 1990 U-value scenarios; the most thermally transparent buildings. They show a significantly greater percentage of heating loads over the base case building with a dependence on local climate variations. The 'semi-urban' Kew weather file (01B-1990 - H/W 1.17 – Kew), experiences both the highest heating and the lowest cooling load. But when looked at in more detail (Table 05), we can see that despite the large percentage difference in the load ratio, the sum of the annual loads is lower by around 35% against the base case building. These two buildings make a biased comparison as a result of their different U-values, climate conditions and surrounding surfaces, but they do highlight (despite high internal gains), the importance of simulating in context and using an appropriate climate file to allow suitable levels of insulation to be applied alongside conditioning system sizing. These results go against the current UK generic form first approach to building energy management.

Table 04—percentage comparison of annual cooling & heating loads for all configurations against 'base case' building Office 01-DSY-2006regs- in isolation (a standalone setting)

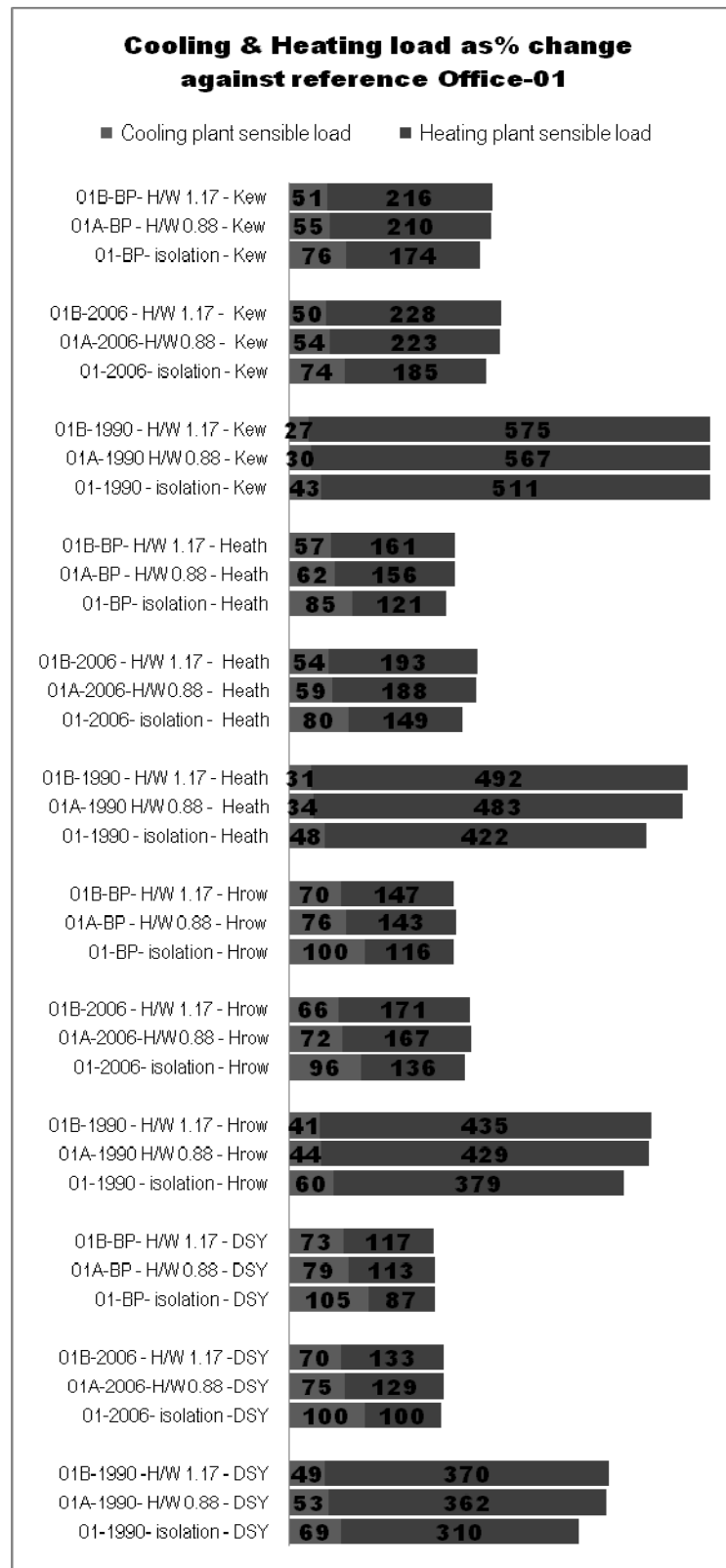


Table 05- Total Annual Cooling & Heating (MWh)

	Cooling plant sensible load	Heating plant sensible load	Annual Totals
01-1990- isolation - DSY	75	32	107
01A-1990- H/W 0.88 - DSY	57	37	95
01B-1990 -H/W 1.17 - DSY	53	38	92
01-1990 - isolation - Hrow	65	39	104
01A-1990 H/W 0.88 - Hrow	48	44	92
01B-1990 - H/W 1.17 - Hrow	44	45	89
01-1990 - isolation - Heath	52	43	95
01A-1990 H/W 0.88 - Heath	38	50	87
01B-1990 - H/W 1.17- Heath	34	51	85
01-1990 - isolation - Kew	46	51	98
01A-1990 H/W 0.88 - Kew	33	57	89
01B-1990 - H/W 1.17 - Kew	30	58	87
01-2006- isolation – DSY BASE CASE BUILDING	109	10	120
01A-2006-H/W 0.88 -DSY	82	13	95
01B-2006 - H/W 1.17 -DSY	76	14	90
01-2006- isolation - Hrow	104	14	118
01A-2006-H/W 0.88 - Hrow	78	17	95
01B-2006 - H/W 1.17 - Hrow	72	18	90
01-2006- isolation - Heath	87	15	102
01A-2006-H/W 0.88 - Heath	64	19	83
01B-2006 - H/W 1.17 - Heath	59	19	78
01-2006- isolation - Kew	81	18	99
01A-2006-H/W 0.88 - Kew	59	22	81
01B-2006 - H/W 1.17 - Kew	54	23	77
01-BP- isolation - DSY	114	9	123
01A-BP - H/W 0.88 - DSY	86	11	97
01B-BP- H/W 1.17 - DSY	80	12	91
01-BP- isolation - Hrow	109	12	121
01A-BP - H/W 0.88 - Hrow	82	15	97
01B-BP- H/W 1.17 - Hrow	76	15	92
01-BP- isolation - Heath	93	13	105
01A-BP - H/W 0.88 - Heath	68	16	84
01B-BP- H/W 1.17 - Heath	62	17	79
01-BP- isolation - Kew	82	18	100
01A-BP - H/W 0.88 - Kew	60	22	82
01B-BP- H/W 1.17 - Kew	55	22	77

U-values in the context of the urban system

For a fairer comparison, two buildings with the same H/W ratio and under the same local climate conditions are examined [01A-1990- H/W 0.88 – DSY and 01A-2006-H/W 0.88 –DSY] (table 05). These two buildings coincidentally have equal annual loads; however the ratio of these loads is quite different. The building with the lowest U-value shows a greater tendency to overheat as a result of the significantly higher cooling load (around 30% higher), even in the context of the surrounding system. The importance of an accurate representation of the surrounding system in terms of H/W ratios can be seen in table 05. Here a difference in heating and cooling loads occur for small change in H/W ratio (3 meters east/west direction). This change to the urban configuration adds approximately 1 MWh to the heating load, whilst

reducing cooling between 3 and 6 MWh; implying (in terms of cooling load) the significance of dynamic insolation received at the surface in the context of the urban environment, which is missed when simulated in an isolated or standalone setting.

5. CONCLUSION

The objectives of this work is to explore the role of the urban setting as an energy management parameter and to highlight that the current generic ‘fabric first’ approach encouraged by UK building legislation may result in an increased energy demand. This is investigated through a series of studies that are concerned with the difference in regulated loads of modern building types in their standalone setting (as is current practice) against identical buildings in various urban settings. The work reports on the outcome of a series of dynamic thermal simulation studies for various street configurations comprised of generic building forms assigned specific occupation and activity (function) patterns. Here ‘mean H/W ratio’ is used to identify performance patterns associated with the form of the surrounding setting, the timing of the buildings function and levels of insulation. All buildings are assigned typical building parameters including operational and activity loads associated with the building function. Importantly, these types of buildings are occupied during the daytime and have significant internal energy gains.

In an urban context where neighbouring buildings provide shade, building performance patterns change significantly. In short, for occupied office buildings for which the cooling load dominates, improved energy performance is related to the level of solar masking provided by the surrounding urban morphology. In an urban canyon setting these effects are captured by the ratio of building height (H) to street width (W). The H/W value is an effective measure of the performance of both individual buildings in an urban context. The results demonstrate that the urban setting for a building is a significant factor in determining its energy requirements: the performance of identical buildings varies with different urban settings.

Whilst buildings were identical, building performance was compared in various urban configurations, in addition buildings were assigned 3 different sets U-values and exposed to 4 different weather scenarios. The results highlight 3 significant points; firstly the significance of the urban setting. Secondly identical buildings perform differently as a result of small changes in background micro-climate conditions. And thirdly internal gains significantly dilute the influence background micro-climate conditions on building performance. This challenges the current generic blanket approach to U-values. It is also worth noting that all energy whether delivered from renewables or not ends up as heat energy, adding heat to the external environment, increasing conditioning needs. This results in higher urban temperatures requiring further energy to cool the internal temperature – a catch 22 situation.

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Applicability of Centrality Measures to explain Vehicular flow in Colombo Municipal Council Area, Sri Lanka

Chathura Gunawardana

Department of Town & Country Planning, University of Moratuwa, Sri Lanka

chathurag88@gmail.com

Amila Jayasinghe

Department of Town & Country Planning, University of Moratuwa, Sri Lanka

amilajayasinghe@gmail.com

Abstract

Traffic congestion has become a major issue for all of the cities in the world. Sri Lanka also incurs 1.5% of GDP due to massive financial and man-hour loss due to traffic congestion. Thus, this sets the importance of understanding how development and design of future built environment influence travel demand and traffic flows. Traffic flow modeling enables us to envisage traffic flows in urban areas. Yet most of the current conventional models require the acquisition and analysis of large quantities of data such as the network topology, its traffic flow data, vehicle fleet composition, emission measurements and so on. Data acquisition is an expensive process that involves household surveys and automatic as well as semiautomatic measurements performed all over the network. Currently Sri Lanka and most of the Developing Countries follows these conventional Traffic Flow models, which identified as expensive affair and inefficient method. Therefore, predicting or understanding traffic flow has become an emerging challenge for Sri Lanka in this context.

Given this background this study focused on an emerging set of research literature that are employed in transport planning applications in developed countries. Those researches have based on network centrality parameters that revealed successful results in measuring traffic flow. Yet, all above studies based on developed countries and there are none or very limited applications with referring to the emerging cities in developing world where such research need the most. Therefore, this study looks at the applicability of centrality measures to access the traffic flows in Sri Lankan context. Accordingly, the objective of this research is to study the applicability of centrality measures to explain vehicular flow in Colombo municipal council area.

In this study we employed three centrality measures such as Degree, Betweenness and Closeness, which are borrowed from the domain of complex network analysis. Centrality values have been computed by axial map which was generated using motorable road network of the CMC. Then it calculated using UCL-Depth map and ArcGIS software applications. Generated Centrality values have been evaluated using actual traffic flow data along the CMC road network. Correlation analysis indicates that actual traffic flow values has a significant correlation with Degree (0.337 with significant at the 0.05 level), Betweenness (0.771 with significant at the 0.01 level) and Closeness (0.742 with significant at the 0.01 level) centrality measures. Multiple regression analysis results indicated that centrality measures have capabilities to explain over 78% of the variation of actual Traffic flow values. Therefore, the study suggests that Centrality Measures can serve as an alternative method to identify and predict traffic flow pattern of cities. Accordingly method developed in this study can be consider as robust and dynamic planning tool that will offer promise for spatial and transport planners to overcome emerging challenges and changing needs in the built environment.

Keywords: Centrality Measures, Road Network and Traffic Flow

Introduction

Sri Lanka incurs a massive financial and man-hour loss due to traffic congestion and it is 1.5% of GDP (Gross Domestic Product). It has identified that the poor city planning, inappropriate public transport facilities and insufficient traffic system are the main reasons for traffic congestion (Kumarage, 2011).

CMC (Colombo Municipal Council) area which is the commercial capital of Sri Lanka, has the highest vehicle density in Sri Lanka. 225,000 vehicles enter CMC daily and it creates a traffic congested environment in the peak hours of the day. Especially severe traffic congestion can be observed in entry points of the CMC area. It has found that the loss to Sri Lanka economy due to traffic congestions in Colombo city is Rs. 32 billion per year (Kumarage, 2011). It is 2% of the value of entire economic activities in Colombo city. The average speed of the vehicular flow in CMC is 22 km per hour. It is estimated that figure would drop to 15 km per hour, by 2031 (Kumarage 2011). Thus, this sets the need to look at how development and design of urban areas influence travel demand and traffic flows.

The vehicular flow studies in Sri Lanka starts after late nineteen sixties and since then number of studies carried out and transport models have been developed by different organizations. Most of the modeling procedures developed follows the conventional four-stage (Trip Generation, Trip Distribution, Mode Choice and Route assignment) sequential type of model structure. This has makes the traffic studies in Sri Lanka too quantitative or expensive and data-consuming tasks. TRL report published in Transport Research Laboratory 2004 (cited in Cairns 2011) emphasized that the applications of traditional transport modeling which are commonly use in developing countries is an expensive affair and inefficient method. (Chiaradia 2006 cited in Paul, 2009).

Given this background this study focused on an emerging set of research literature those employed in transport planning applications in developed countries. Those researches have based on network centrality parameters which revealed successful results in measuring traffic flow.

Amongst, the work of Hillier and Hanson (1984); Hillier (1996) informed the development of the Space Syntax methodology, which has been applied in numerous cities world-wide. Multiple Centrality Measures (MCA) also identified as a crucial method to understand the structural properties of complex relational networks (Crucitti, Latora, and Porta, 2006).

Yet, all above studies based on developed countries and there are none or very limited applications with referring to the emerging cities in developing world where such research need the most. Further, many researches those are focused on cities in developed world do not directly applicable to cities in Asian Context (Munasinghe, 2007; Kishimoto, 2007; Hassan, 2008; Munshi, 2009). Therefore, this study looks at the applicability of centrality measures to access the Traffic flows in Sri Lankan context. The main objective of this research is to study the applicability of centrality measures to explain vehicular flow in Colombo MC, Area.

Centrality Measures

Centrality Measures is a fundamental concept in network analysis since its introduction in structural sociology (Bevalas, 1949). It had been frequently used in economic geography and city planning, to investigate the territorial relationships among communication flows, population, wealth and land-uses (Wilson, 2000).

Centrality in modern spatial analysis is strongly tied to graph theoretic measures of nodal relations in topological space. Erdos and Renyi (1960) defined centrality measures as analytical methods developed based on "Graph Theory"; centrality is relative importance of a vertex within the graph in terms of the degree of properties as number, distance, travel time, optimal path. According to the Freeman (1979) Centrality is a measure of the contribution of network position

to the importance, influence, prominence of an actor in a network. Recent study done by Jayasinghe(2011) defines that centrality is an analytical method which has developed based on Graph Theory and it applies to compute levels of centrality in a network based on set of parameters.

Main Centrality Measures developed are as follows:

Degree centrality (Freeman, 1979) (Wasserman, 1994)

Degree centrality is the simplest form of vertex centrality. It is based on the idea that important vertices have a large number of ties to other vertices in the graph. The degree centrality of a node in a graph is defined as

$$C_i^D = \frac{\sum_{j \in V} a_{i,j}}{n-1} = \frac{d_i}{n-1}$$

Where d_i is the degree of node i , i.e. the number of nodes adjacent to i .

Closeness centrality (Freeman, 1979) (Sabidussi, 1966) (Wasserman, 1994)

Measures to which extent a vertex i is near to all the other nodes along the shortest paths Closeness centrality, and is defined as

$$C_i^C = \frac{n-1}{\sum_{\substack{j \in V \\ i \neq j}} \delta_{i,j}}$$

Where $\delta_{i,j}$ is the shortest path length between i and j ,

Betweenness centrality (Freeman, 1979)

Edge Betweenness of an edge is defined as the number of shortest paths between pairs of vertices that pass through the given edge (Newman, 2002). Betweenness centrality is based on the idea that a vertex is central if it lies between many other vertex pairs, in the sense that it is traversed by many of the shortest paths connecting the vertex pairs. The Betweenness centrality of vertex i is where $n_{j,k}$ is the number of shortest paths between j and k .

$$C_i^B = \frac{1}{(n-1)(n-2)} \cdot \sum_{\substack{j,k \in V \\ j \neq k \neq i}} \frac{n_{j,k}(i)}{n_{j,k}}$$

$n_{j,k}(i)$ is the number of shortest paths between j and k that contain node i .

Straightness centrality (Latora, 2001)

Straightness centrality CS, originates from the idea that the efficiency in communication between two nodes i and j is equal to the inverse of the shortest path length $\delta_{i,j}$. The straightness centrality of node i is defined as:

$$C_i^S = \frac{\sum_{\substack{j \in V \\ j \neq i}} \frac{\delta_{i,j}^{Eucl}}{\delta_{i,j}}}{n-1}$$

Where, $Eucl_{ij}$ is the Euclidean distance between nodes i and j along a straight line.

This measure captures the extent to which the connecting route between nodes i and j deviates from the virtual straight route.

Information centrality (Latora, 2001)

Flow of information in a graph depends on how efficiently its vertices transfer information. The efficiency of communication between two vertices, say i and j , is inversely proportional to the shortest distance, $\delta_{i,j}$, between them. The communication efficiency of the entire graph is defined as the average of efficiency values for all vertex pairs in the graph:

$$E(G) = \frac{\sum_{i \neq j \in V} \frac{1}{\delta_{i,j}}}{n \cdot (n-1)}.$$

However, when dealing with urban street patterns, centrality has been studied in relational Networks (Hillier 1984) where known as the dual representation (Jiang, Porta 2004) or information city network (Rosvall 2005), a city is transformed into a relational (topological) graph by mapping the streets into the graph nodes and the intersections between streets into edges between the nodes (Node Axis Diagram).

Freeman (1979) introduced axial map by converting roads into center lines and road intersections into nodes. This is more sensitive for centrality analysis as it considers metric distances for compute axis lines rather than the previous modal.

According to the axial map representation use by Hillier in space syntax, axial lines depict the line of visibility from the origin, or the eye level, to the point of maximum vision. Thus it termed as a visual network or graphical representation of the visibility lines. On that basis, centrality has considered as sensitive to topological distance. Further, an axial map of the city is defined as the least set of straight lines that pass through all the open space (Batty and Carvalho, 2003).

Centrality measures has been used to explain concepts related to network configuration, accessibility, integration, human behavior movements, land use in urban planning and transport planning studies.

Amongst, Betweenness centrality has been successfully applied to predict the Mobility patterns in Israel cities (Yaniv 2003). This study shows that considering travel time through links we can create a strong correlation between the traffic flow through nodes and their betweenness centrality. Also significantly higher correlation can be achieved when clustering the roads into groups based on their types while also giving increased weight to data that is associated with certain hours. Using this method they have created “Mobility Oriented Betweenness Centrality” and its correlation value is approximately $Z2 = 0.8$. AisanKazerani (2001) examined Betweenness centrality with the time dependent travel demand. In this work, dynamic and temporal aspects of people’s travel demand were studied by implementing a modified version of betweenness centrality. By approaching the hypothesis, the result showed a significant difference between traditional betweenness which was used to be utilized for traffic flow prediction and the so called modified betweenness centrality.

Literature identifies centrality as a key factor in shaping both urban space and urban life. Places that are perceived as central in respect to all others in the system of reference are assigned more value, are easier to reach and are more clearly conceptualized. This tends to attract more vehicle flows to central areas.

Most of the studies done and models developed in Sri Lanka in relation to Vehicular flow follow conventional methodologies. This can be simplified with the intervention of network analysis methods like centrality.

Method

The CMC is the largest local authority in Sri Lanka and one of the oldest in South Asia. Established in 1865, it has resident population of 637,865 (2001 census) and a floating population of nearly 400,000 (estimated). It covers an area of 37.31 sq km.

CMC area consists with 661.15 km long road network. It has four A class roads and two B class main roads. CMC area has the highest Vehicle density in the country. On an average, 250,000 vehicles, made up of 15,000 buses, 10,000 trucks and 225,000 private vehicles enter CMC daily. This creates severe traffic congestion in entry points of the CMC area (Colombo police Close Circuit Television (CCTV) unit).

Vehicular flow values have been extracted by the 2011 Traffic data base of Traffic Laboratory of University of Moratuwa (UOM) and Planning & Monitoring division of Road Development Authority (RDA). This includes 56 Traffic surveyed points along the CMC road network which has been surveyed for 16 hours starting from 6.00 a.m. to 10 p.m.



Figure1: Traffic surveyed points in CMC

Source: Author constructed

Conceptual framework

A series of empirical research studies dealing with built environment resulted strong co-relations between street centrality (configuration/accessibility) and the parameters as population & population density (Rosenbloom, 1996), employment (Cervero, 1996), land use (Cervero, 1996; Munasinghe, 2007; Min et al., 2006), land value (Min et al., 2007), and urban density (Peponis et al., 2007), spatial form of cities and different patterns of urban phenomenon (Abubakar and Aina, 2008; Hillier, 1998; Hillier and Iida, 2005; Sarma, 2006; Vaughan and Hillier, 2007)

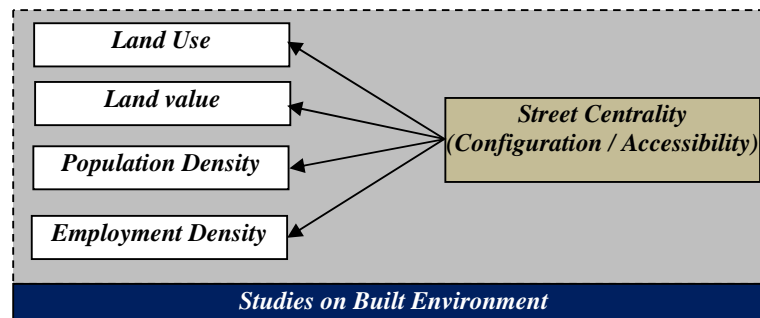


Figure 2: Identified relationship between urban form / land use with street centrality by research studies dealing with built environment

Source: Author constructed

Whilst, there was a series of studies emerged in the field of transport planning to find out alternatives to measures traffic volume. Earliest in 1977, Pushkarev and Zupan pointed out residential density and traffic volume are mutually correlating each other. Hendrickson (1986) examined the relationship between employment density and traffic volume in 25 USA metropolitan areas. Liu (1993), Kain and Liu (1995) established the relationship between regional development and ridership based on temporal development of Chicago transit system from 1976 to 1995. Studies on urban form and transit users Cervero (1993), Kain and Liu (1995), Nelson and Nygaard (1995), (Gomez-Ibanez, 1996), (TCRP, 1996), (Spillar and Rutherford, 1998), (Chung, 1997), (Carane, 2000) found that residential density, employment density, land use mix and network connectivity as factors in relations to traffic volume. These findings can be summarized as below:

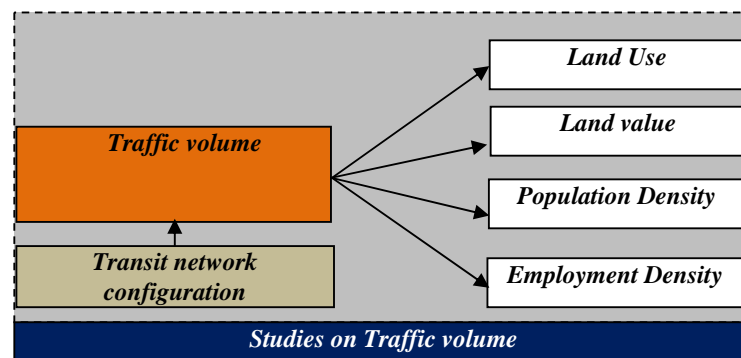


Figure 3: Identified relationship between urban form / land use with traffic volume by research studies dealing with transit demand

Source: Author constructed

Figure 3 illustrated the relationship of traffic volume to a set of attributes as land use, land value, population density and employment density. Figure 2 presented above illustrated the relationship of the same attributes to street centrality. Therefore, the non-transiting relationship of Figure 2 and Figure 3 can be illustrated in Figure 4.

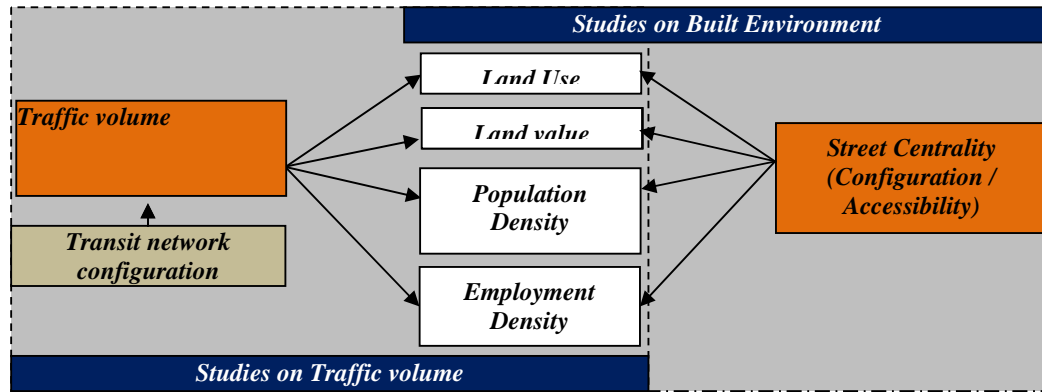


Figure 4: Non-transiting relationship between findings of built environment studies and transit demand *Source:* Author constructed based on relationship in figure 2 and 3

Based on that logic, this study argues that there is a direct relationship between street centrality and traffic volume.

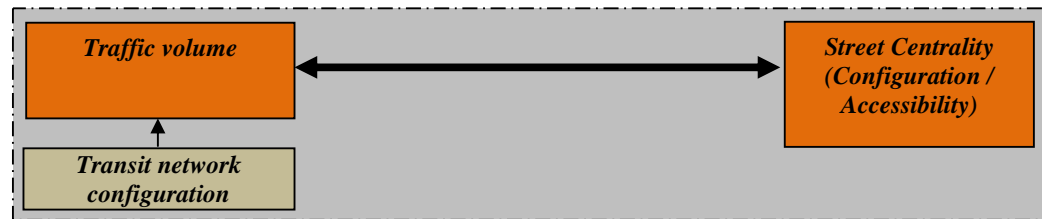


Figure 5: Research argument; Relationship between street centrality and transit network configuration with PT demand

Source: Author constructed based on relationship in figure 2, 3 and 4

Considering above, this research attempts to answer whether there is a relationship between traffic volume and network centrality and if so, to what extent?

Preparation of Axial line maps for CMC road network has been done by using Google earth satellite images and Arc GIS 9.3.

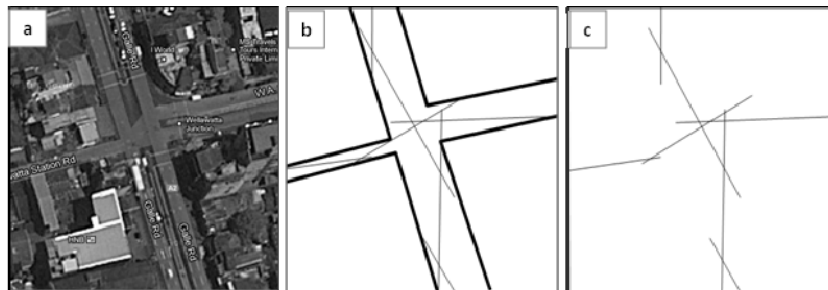


Figure 6: Preparation of axial lines

Notes: a. Google image, b. axial line preparation, c. axial map

Source: Author constructed

The vehicle flow count was considered all types of vehicles during the study. Most importantly one traffic data point consists of total number of vehicles travels to both directions in specific time period. This vehicular flow value then given for the respective axial line segment of the network.

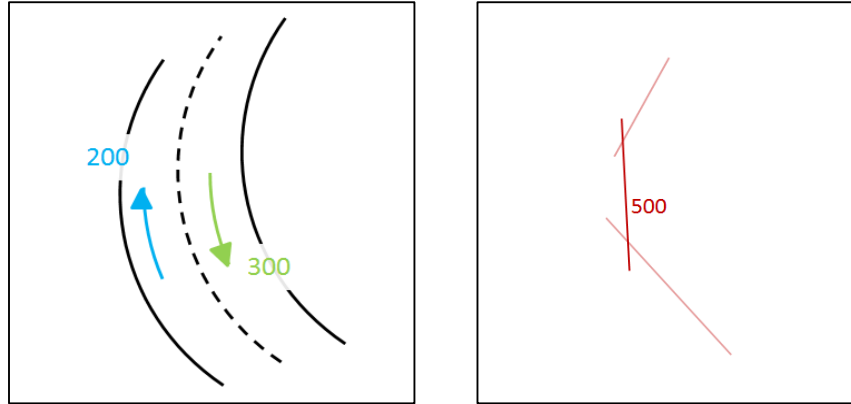


Figure 7: Computation of vehicular flow values

Source: Author constructed

Centrality values for CMC axial line network were calculated using UCL depth map 10. Only the following centrality measures were considered based on the applicability and the scope of the study.

Table 1: Selected centrality measures

Degree Centrality(DC)	To measure the extent that a road segment is connected to all segments in a network.	$C_i^D = \frac{\sum_{j \in V} a_{i,j}}{n-1} = \frac{d_i}{n-1}$
Closeness Centrality(CC)	To measures the extent that a road segment is near to all segments in the road network along the shortest paths.	$GC_i = (N-1) / \sum_{j=1, j \neq i}^N L_{ij}$
Betweenness Centrality(BC)	To capture the idea that a road segment is central if it lies on the shortest paths that links all segments with each other.	$Be_i = \frac{1}{(N-1)(N-2)} \sum_{j=1, k=1, j \neq k \neq i}^N \frac{n(i)_{jk}}{nik}$

Source: Author constructed based on literature

Analysis

Vehicular flow index

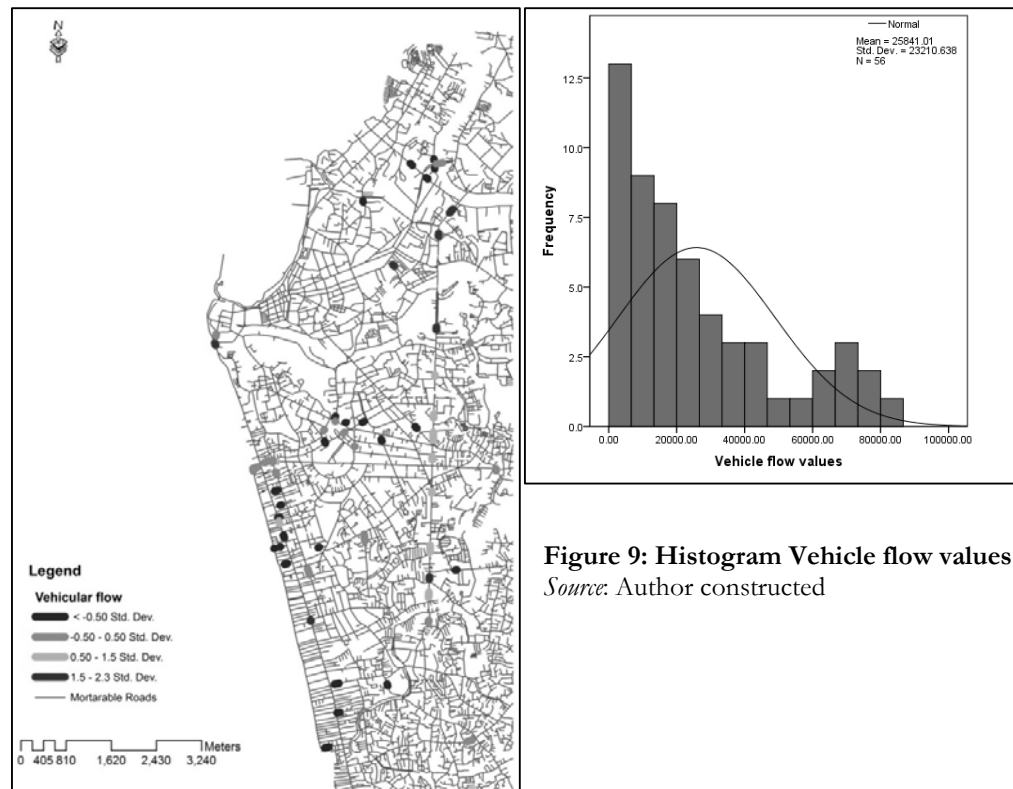


Figure 8: Vehicle flow values

Source: Author constructed

Figure 9: Histogram Vehicle flow values

Source: Author constructed

Histogram reveals that vehicular flow values show leftward skewness distribution and it has standard deviation of 23210.63 and Mean of 25841.01. The highest vehicular flow values recorded in baseline road and Gall road Traffic points.

Centrality Values of CMC

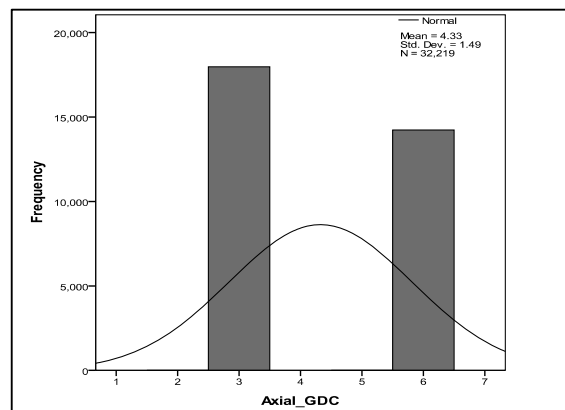


Figure 10: Histogram Degree Centrality

Source: Author constructed

Histogram shows that the large portion of the values of the Degree Centrality (DC) comes under value 3 and 6. It indicates that the majority of the road axial lines obtained Moderate or High DC values. High DC values can be observed in Road junctions. Other road segments have Moderate DC value.

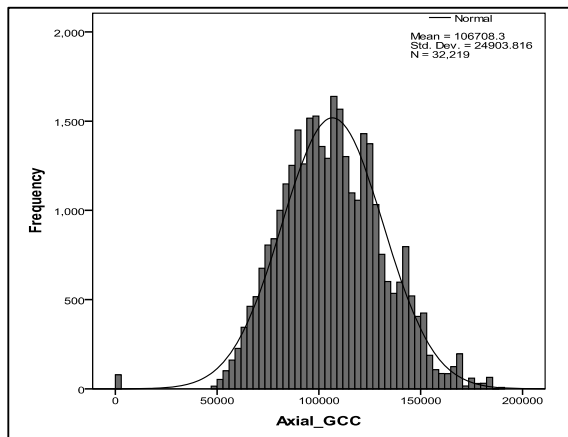


Figure 11: Histogram Closeness Centrality

Source: Author constructed

The histogram of Closeness Centrality (CC) shows that high CC scored in straight arteries. CC values have a mean of 106708.3 and standard deviation of 24903.81.

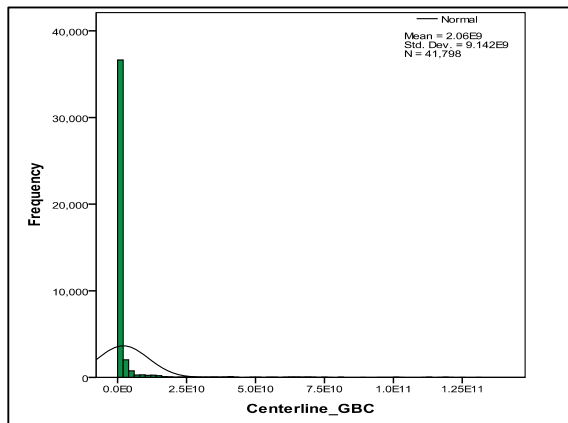


Figure 12: Histogram Betweenness Centrality

Source: Author constructed

Histogram of the Betweenness Centrality (BC) shows leftward skewness distribution. It reveals that mean BC value for axial lines is 3357223.03; Standard Deviation is 18111123.29. BC values show its highest in much straighter roads which links number of road intersections to each other.

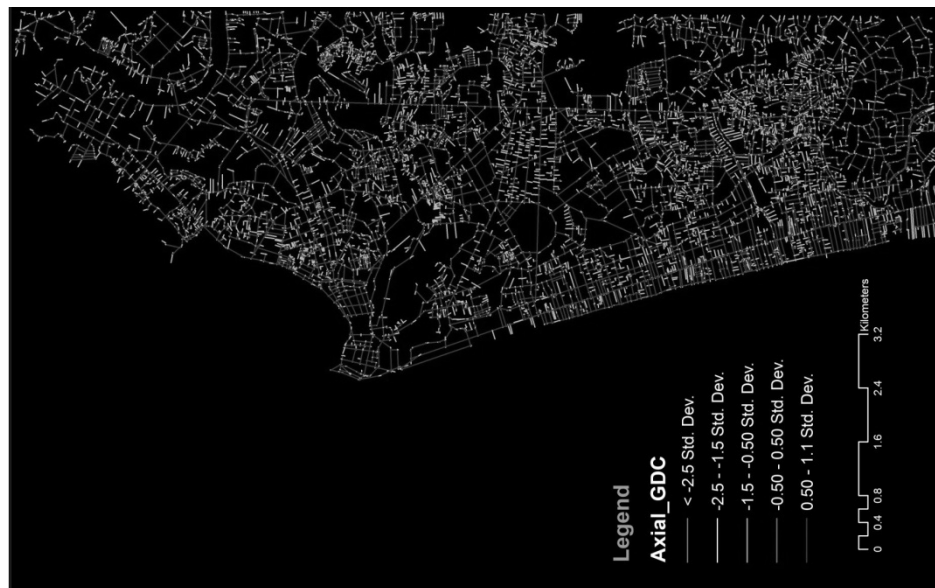


Figure 13: GraphDegree Centrality

Source: Author constructed

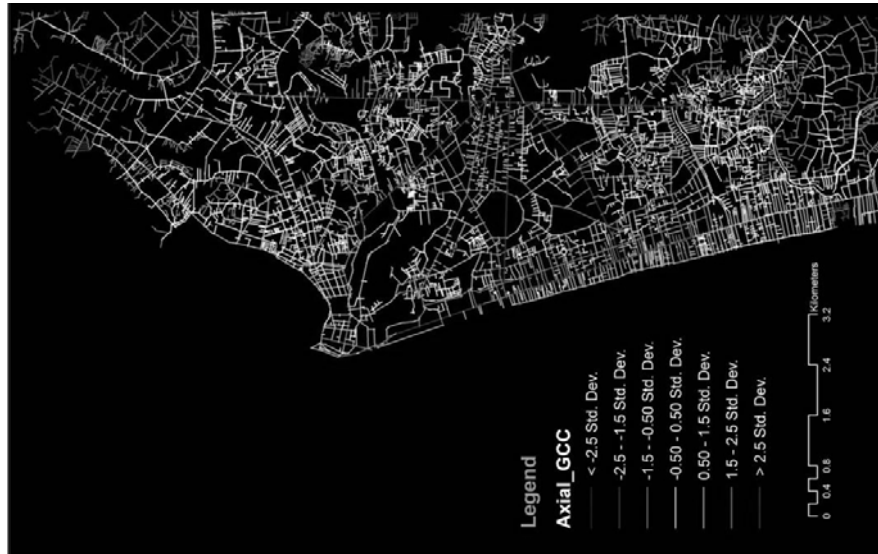


Figure 14: GraphCloseness Centrality

Source: Author constructed



Figure 15: GraphBetweenness Centrality

Source: Author constructed

Correlation and Regression Analysis between Vehicular Flow and Centrality measures of Road Network

This test carried out with an understanding that vehicular flow of a road segment is directly proportionate to the network centrality values (DC, CC, BC). 'Bivariate Pearson correlation coefficient test' in SPSS (Statistical Package for Social Science, 18th version) software was used to perform this computation. Also this has been conducted for actual and log values for higher accuracy.

Table 2: Correlation value of axial lines - actual values

	Vehicular Flow		
	Pearson Correlation	Sig (2-tailed)	N
DC	0.266*	0.047	56
CC	0.557**	0.000	56
BC	0.655**	0.000	56

Source: Author Constructed

Note:**Correlation is significant at the 0.01 level (2-tailed)

*Correlation is significant at the 0.05 level (2-tailed)

Table 1: Correlation value of axial lines - log values

	Ln_Vehicular Flow		
	Pearson Correlation	Sig (2-tailed)	N
Ln_DC	0.337*	0.011	56
Ln_CC	0.742**	0.000	56
Ln_BC	0.771**	0.000	56

Source: Author Constructed

Note:**Correlation is significant at the 0.01 level (2-tailed)

*Correlation is significant at the 0.05 level (2-tailed)

Betweenness centrality and vehicular flow of road segments shows a highly significant coefficient of correlation (for actual values: $r=0.655$, $p < .01$ & for natural log values: $r=0.771$, $p < .01$) compare to other centrality values. Closeness centrality (for actual values: $r=.557$, $p < .01$ & for natural log values: $r=.742$, $p < .01$) reveals a significant coefficient of correlation with Vehicular flow. Degree centrality (for actual values: $r=.266$, $p < .05$ & for natural log values: $r=.337$, $p < .05$), shows a low significant coefficient of correlation with Vehicular flow. As correlations of those indicators are positive it can be concluded that centrality value directly proportionate to the vehicular flow.

It is observed that natural log values have higher coefficient of correlation value than actual value. It indicates that centrality value and Vehicular flow has 'Ln relationship' than 'liner relationship'.

Table 4: Ranking of centrality parameters based on correlation of coefficient

Centrality Parameter	For Actual Values		For Ln Values	
	R	Rank	R	Rank
DC	0.266*	4	0.337*	4
CC	0.557**	3	0.742**	2
BC	0.655**	2	0.771**	2

Source: Author Constructed

Multiple Regression Analysis

Forward linear regression is performed in this step. In forward entry method, variables in the block are added to the equation one at a time. At each step, the variable not in the equation with the smallest probability of F is entered if the value is smaller than probability of F-to-enter (the

default value is 0.05). The response variable is the Vehicular flow (Pax). The predictor variables are Degree centrality (DC), Closeness centrality (CC) and Betweenness centrality (BC).

The study applied natural logarithms value for centrality and vehicular flow based on the correlation results. In that sense, a quasi-hedonic model explaining the vehicular flow values taking the following form is going to be created, tested, and analyzed.

$$\text{Ln_Pax} = f(\text{Ln_DC}, \text{Ln_CC}, \text{Ln_BC})$$

Table 5: Coefficients - Regression models for axial line log values

Coefficients ^a												
Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Correlations			Collinearity Statistics	
	B	Std. Error	Beta			Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1 (Constant) Ln_BC	.572 .416	1.017 .047		.562 8.894	.576 .000	-1.468 .322	2.611 .509	.717	.771	.717	1.000	1.000
2 (Constant) Ln_BC Ln_CC	- 23.074 .268 2.429	5.897 .055 .599		-3.913 4.890 4.057	.000 .000 .000	-34.902 .158 1.228	-11.246 .379 3.630	.717 .742	.558 .487	.374 .310	.563 .563	1.775 1.775
3 (Constant) Ln_BC Ln_CC Ln_DC	- 25.098 .233 2.350 5.321	5.338 .050 .539 1.454		-4.702 4.614 4.356 3.659	.000 .000 .000 .001	-35.810 .131 1.268 2.403	-14.387 .334 3.433 8.239	.771 .742 .474	.539 .517 .452	.318 .300 .252	.542 .562 .916	1.845 1.778 1.092

a. Dependent Variable: Ln_T

Source: Author Constructed

Together the two predictor variables, Ln_BC and Ln_CC explain over 75% of the variance in Ln_Pax. Individually Ln_BC explain over 59% of the variance and Ln_CC explain over 11% in Ln_Pax. This finding is significant in that the assertion of network centrality being an effective explanatory or predictor variable for vehicular flow.

$$\text{Ln_Pax} = -23.074 + .268*\text{Ln_BC} + 2.429*\text{Ln_CC}$$

Table 6: Coefficients - Regression models for axial line log values

Model Summary ^c										
Mode	R	R	Adjusted	Std. Error	Change Statistics					Durbin-Watson
1		Square	R Square	of the	R Square	F Change	df1	df2	Sig. F	
				Estimate	change				Change	
1	.771 ^a	.594	.587	.88788	.594	79.095	1	54	.000	1.090
2	.831 ^b	.690	.679	.78287	.096	16.459	1	53	.000	
3	.868 ^c	.754	.740	.70483	.063	13.386	1	52	.001	
a. Predictors: (Constant), Ln_BC										
b. Predictors: (Constant), Ln_BC, Ln_CC										
c. Predictors: (Constant), Ln_BC, Ln_CC, Ln_DC										
c. Dependent Variable: Ln_T										

Source: Author Constructed

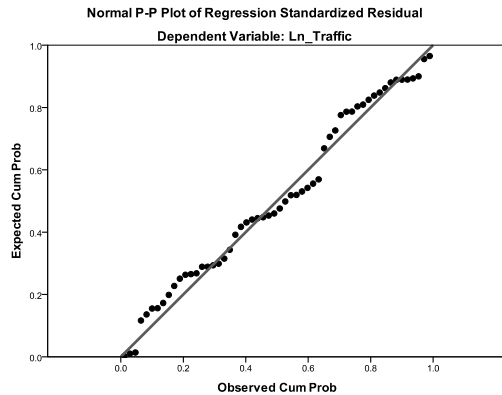


Figure 16: Diagnostic plots for the final regression model for axial lines
Source: Author constructed

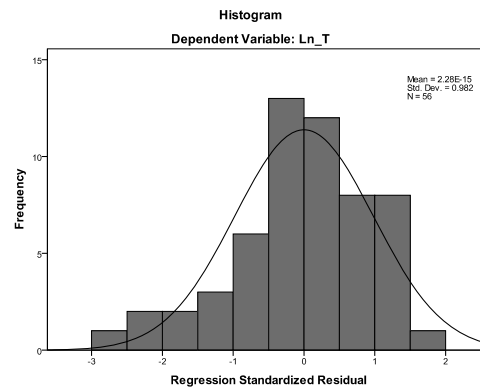


Figure 17: Histogram for the final regression model for axial lines
Source: Author constructed

Results indicate that centrality values of axial lines explain vehicular flow to a greater accuracy level. This study proves that the level of Betweenness or the extent that road segment locate intermediary to other road segments is the key factor (65%) on volume of traffic flow. Closeness of the road segment to other road segments also has 55% influences on volume of traffic flow.

Conclusion

This study is carried out in a locality where there are very limited research attempts on vehicular flow. Further, the current practices in this nature are hampered by methodological, technical, financial and information availability issues. Therefore, this research pays attention to a series of recent, popular traffic demand studies based on centrality measures which bring good results in measuring vehicular flow.

The results of this study show that centrality measures have a significant correlation with vehicular flow values. As aimed in objective this research, Degree, Closeness and Betweenness centrality were identified as appropriate centrality parameters that can use to measure network centrality of road network. Amongst, Betweenness centrality (65%) resulted significant relationship with traffic flow and Closeness centrality (35%) too had significant relationship with traffic volume.

For Actual Values = 0.655

For Ln Values = 0.771

Correlation is significant at the 0.01 level (2-tailed)

Finally this study concludes that centrality measures and method developed in this research is useful method to explain the traffic volume of road segment that could otherwise be very difficult to extract and to analyze from the conventional approaches. Further, study suggested that method developed in this research can be used as a planning and policy tool to identify the impact from road augmentation, new road constrictions to traffic volume of existing road network; to identify the impact from proposed land use plans to traffic volume of existing road network.

Though this research successfully achieved desired objectives, this can be developed into much advance analysis by conducting further studies in relation to network centrality and temporal change in traffic volume changes (peak – off peak). And the same analysis can be tested at some other areas to validate the applicability.

The methods developed in this research offers promise for spatial and transport planning applications in Sri Lankan context that it is urgently called for. This research has contributed to with a robust, dynamic planning tool that will guide spatial and transport planners in justifying their planning decisions in designing transportation or urban development strategies in Sri Lankan cities. Further, this is a positive contribution to emerging literature on spatial applications of network centrality parameters in Asian cities.

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Road Traffic Crashes and Road Configuration; A Space Syntax Application

Uditha Dasanayaka

Department of Town & Country Planning, University of Moratuwa
uditha05@gmail.com

Amila Jayasinghe

Department of Town & Country Planning, University of Moratuwa
amilajayasinghe@gmail.com

Abstract

Transport provides a range of benefits to society in terms of mobility, access and economic growth. However, there are negative impacts of transport, not least in terms of environmental degradation, damage to property, traffic accidents and loss of life. In Sri Lanka, Road Traffic Crashes (RTCs) are responsible for a substantial fraction of morbidity and mortality and are responsible for more years of life loss than most of human diseases. Taking its cues, this paper focuses on RTCs, the reduction of which is an important aim of suitable transport policy worldwide. In this study, the authors have tried to delineate road specific factors that collectively represent the principal cause of three (people, vehicle and road) out of RTCs and which is less concerned in Sri Lankan transport researchers. In that context, the primary objective of this paper is to identify a series of relationships between RTCs and road pattern focusing road configuration by using space syntax.

Road Network Configuration is examined based on four different road configuration parameters that is (i.) Choice, (ii.) Connectivity, (iii.) Integration and (iv.) Line length in two levels (Local & Global) using Space Syntax. The RTCs data along the A1 road (from Peliyagoda to Kegalle, Sri Lanka) was collected from the Traffic division of Sri Lanka Police and entered in to Geographic Information System (GIS) database. Then statistical analysis have been conducted to identify the relationship between RTCs and Road Configuration Parameters. The results show notable/noticeable relationship between RTCs and Local level variance of Integration values ($r = 0.874$, $p < .01$); Connectivity ($r = 0.768$, $p < .01$) and Global Level Choice ($r = 0.759$, $p < .01$). Further regression analysis indicated that combination those three variables have more than 90% of impact for RTCs.

With that notable relationship between RTCs and road configuration, this study highlights the need for preventive efforts that incorporate road pattern specific strategies in road network planning and design to create sustainable built environment rather than focusing only on human factors.

Keywords: Road Traffic Crashes, Road Configuration and Space Syntax

1. Introduction

“Unsustainable increase in private *vehicle ownership* in urban cities has created several problems in increased traffic congestion, road accidents and air pollution in the city centers” (Draft National Transport Policy, 2008 ,Sri Lanka). In Sri Lanka, about 33,721 crashes were reported in year 2010. Out of those crashes 2,225 caused loss of lives. The highest number of crashes reported in Nugegoda, Kelaniya and Gampaha Police Divisions (respectively 3149, 3112, and 1570). 40,887 crashes were reported in year 2011 out of those accidents 2,471 caused loss of lives. The highest number of crashes reported in Nugegoda, Kelaniya and Gampaha Police Divisions (respectively 3709, 3515, and 2038). (Police Headquarters, Colombo, 2011).

Recent researchers have investigated that land use, population, employment, road length, land-use mix, area deprivation (i.e. poverty) and alcohol consumption as key factors of road casualties

(or accidents) and Chao Wang et al (2009), Hadayeghi et al. (2006), Milton and Aljanahi et al. (1999) and Mannering (1998) emphasized that road geometry or configuration of the road as key factors of road crashes. It indicates that a not only socio economic characteristics of the drive but also Road Network Configuration is one of the important factors for road crashes.

The number of road crashes and fatalities has increased over the years. Major reasons for these are poor conditions of infrastructure, traffic congestion in the urban areas, undisciplined behaviors of road users including drivers, riders, passengers and pedestrians in Sri Lanka (Hewage, P, 2000). Furthermore, following factors were identified and published in news paper articles from 2004 to 2011 as the causes for vehicular crashes.

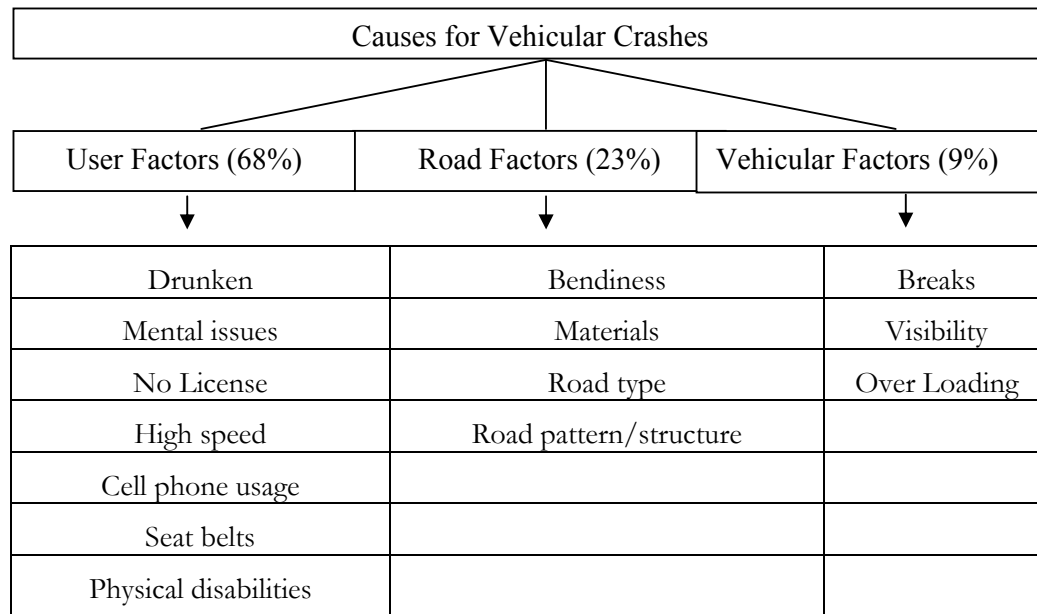


Figure 1 Courses for Vehicular crashes, Source : Based on News paper Articles from 2004-2011

Out of those causes, 68% was mentioned as user factors like drunk, mental issues, no license, high speed, cell phone usage, no seat belts, physical disabilities and 23% mentioned as road factors like bendiness, materials use in roads, road type and road patterns. Furthermore, breaks, visibility and overloading are recorded as vehicular factors (9%).

Although most researchers (professionals) have identified user factors (68%) as the major causes for vehicular crashes, it emphasizes that lower consideration in road factors and there are limited studies related to road network configuration and vehicular crashes in Sri Lanka. Therefore, there is a need to see whether there is relationship between road network configuration and vehicular crashes in the context of Sri Lanka and if so, to what extent? How can it be measured in road networks? How can it be useful in planning and decision making process in Sri Lankan context? In such a situation, this study focused on the factors that affect on vehicular crashes which have been considered less in Sri Lankan context. Thus, this study attempts to cater the need by carrying out the research on finding correlation between road configuration and vehicular crashes.

2. Literature review

2.1 Road traffic crashes

" Traffic collision is as an unforeseen event , also known as a traffic accident, motor vehicle collision, motor vehicle accident, car accident, automobile accident, Road Traffic Collision or car

crash, occurs when a vehicle collides with another vehicle, pedestrian, animal, road debris, or other stationary obstruction, such as a tree or utility pole.” (L.G.Norman-1962)

2.2 Factors affecting to the Vehicle crashes

Chao Wang et al (2009), Hadayeghi et al. (2003), Milton and Aljanahi et al. (1998) and Mannering (1998) emphasized that road geometry or configuration of the road as the key factors of road accidents. It indicates that a not only socio economic characteristics of the drive but also road network configuration is one of the important factors for road accidents. “Speed is one of the basic risk factors in traffic” (Wegman & Aarts, 2006). The combination of horizontal curves or “bendiness” of a length of road contributes to traffic crash occurrence. This gives rise to the notion of “curviness” or “bendiness”, which is traditionally known as the cumulative variation in horizontal direction along a length of road (McLean 1989).

The human factor appears in the literature as being the prevalent contributing factor of road traffic crashes .This includes both driving behavior (e.g., speeding, drinking and driving, traffic law violations) and impaired skills (inattention, fatigue, physical disabilities, impaired sensory perception, and so on).(*Hermann Nabi, Silla M. Consoli, Jean-Francois Chastang, Mireille Chiron, Sylviane Lafont, and Emmanuel Lagarde, 2005*) Furthermore F.D Hobbes classified the different factors affecting the road crashes. Those factors affect with different scales and different scopes .Out of those factors, the road factors are the major causes for occurrence of road accidents. (Hobbes F.D, 1974). Therefore the patterns of roads and physical characteristics of roads may have direct relationships with these road crashes causing factors.

2.3 Road Patterns

Streets connect the private with the public domain and also link different parts of a neighborhood. These linkages support social interaction and exchange—both vital functions. Street design contributes significantly to the quality and character of a community since appropriately designed streets create safe, quiet and healthy environments. Current thinking on street pattern design appears to be divided between concern for the efficiencies of infrastructure and traffic flows. The different patterns of street networks may affect the physical and social functions of the city. The traditional grid patterns that predate the automobile have required major adaptations such as one-way streets and traffic lights in order to achieve a good automobile traffic flow. (Street Patterns, source Marshall , 2005)

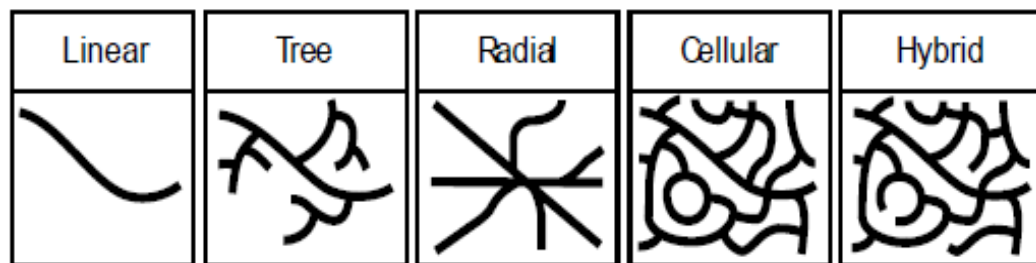


Figure 2 Road network patterns, Source F. Heinze , K.-H. Anders, M. Sester, 2005

There are four main important patterns. Such as strokes – as a linear configuration, grids – as a cellular configuration, stars – as a radial configuration and ring roads – as a cellular configuration. The Composition, Configuration and Constitution are the major concerning attributes for the road design (Heinze , Anders, Sester, 2005)

2.4 Different types of Configuration Measures

There are different types of configuration measures which are explained by different experts.

- **Connectivity (complexity):** Connectivity refers to the density of connections in path or road network and the directness of links. A well-connected road or path network has many short links, numerous intersections, and minimal dead-ends. As connectivity increases, travel distances decrease and route options increase, allowing more direct travel between destinations, creating a more accessible and resilient system. A Connectivity An index can be used to quantify how well a roadway network connects destinations.

$$ctrl_i = \sum_{j=1}^k \frac{1}{C_j} \quad \text{where, } k = \text{number of direct connections,} \\ C_j = \text{connect value of the directly linked line 'j' (Hillier, 1984)}$$

- **Mean Depth:** Distances always mean topographical distance and refer to it as “depth or D”. Depth is measured in steps. The depth between two lines that intersect is 1. In every other case it is the maximum number of line that must be costed to get one line to the other, plus 1. The sum of the depths of a line to all the other lines of the axial map is called the Total Depth or D_T of that line. The D_T Value tends to get very large and is not easy to work with. Therefore, the analysis works with Mean Depth or MD of lines.

$$MD_i = 1/(n-1) \sum_{j=1}^{n-1} d_{ij} \quad \text{M distance of the i-th axis from all the other } n-1. \quad (\text{Hillier, 1984})$$

- **Bendiness (Bend density, BD):** This gives rise to the notion of “curviness” or “bendiness”, which is traditionally known as the cumulative variation in horizontal direction along a length of road (McLean 1989). **Bend density** is defined as the number bends per kilometer of a road. This does not include the bends at intersections, i.e. includes only vertices which are not also nodes in its analysis. Bend density is calculated by using below equation: (Megan Fowler, 2007)

$$BD = (N_v - N_n) / (a+b+c+d) \quad \text{where: } N_v = \text{number of vertices within the study region;}$$

N_n = number of nodes within the study region; and
a,b,c,d = road link lengths.

- **Integration:** Integration measures how many turns one has to make from a street segment to reach all other street segments in the network, using shortest paths. If the amount of turns required for reaching all segments in the graph is analyzed, then the analysis is said to measure integration at radius 'n'. The first intersecting segment requires only one turn, the second two turns and so on. The street segments that require the least amount of turns to reach all other streets are called 'most integrate' and are usually represented with hotter colors, such as red or yellow. Theoretically, the integration measure shows the cognitive complexity of reaching a street, and is often argued to 'predict' the vehicular accident probability of the street. (J.A.F Teklenburg, H.J.P Timmermans, 1993)

$$0 \leq ND_i := \frac{2(MD_i - 1)}{k - 2} \leq 1. \quad \text{Where, } MD_i \text{ is given by the total depth divided by } k-1, \quad k \text{ is the total number of nodes in the graph}$$

Local Integration and **Global Integration** are two Space syntax parameters; indicate the integration of the line with the rest of the lines in the graph. It can be measured by Relative Asymmetry (RA). Relative Asymmetry is the ratio between the actual depths of the system from a particular line to the theoretical depth of the same.

- **Straightness:** Straightness is defined as the same direction throughout its length, having no curvature or angularity. Straightness, originates from the idea that the efficiency in communication between two nodes i and j is equal to the inverse of the shortest path length $\delta_{i,j}$. The straightness centrality of node i is defined as:

$$C_i^S = \frac{\sum_{\substack{j \in V \\ j \neq i}} \frac{\delta_{i,j}^{Eucl}}{\delta_{i,j}}}{n-1}$$

CS_i = Straightness centrality of node i
 $\&_{ij}$ = Cumulative no of straight link between nodes i and j
 L_{ij}^{Eucl} = the Euclidean distance between nodes i and j , N = all nodes in the network

The straightness values express the level of straightness of the streets and the high and very low levels of straightness are causes for vehicular accidents.

2.5 Axial lines and Road-centre lines in global and local context

Axial analysis is one of the fundamentals of space syntax. Hillier has proposed that it picks up qualities of configurational relationships between spaces which are not illuminated by other representations. However, critics have questioned the absolute necessity of axial lines to space syntax, as well as the exact definition of axial lines. An often asked question is: why there is not another representation? In particular, why there are not road-centre lines, which are easily available in many countries to use within geographical information systems. The major difference between road-centre line networks and axial networks is that road-centre lines are broken across junctions, and therefore graph measures of the corresponding road-centre networks tend to vary with physical distance rather than the changes of direction as measured within axial networks. As a solution it has been proposed that we abandon both changes of direction and physical distance as graph measures: instead we should use the angular change between segments.

There are strong theoretical and cognitive arguments for this new approach (Alasdair Turner, 2005). However, the axial networks make accurate measures for the pedestrian movement patterns, yet the vehicular movement measures make some errors because the vehicle movements patterns are related to the center line in both directions and the axial lines always start from one side of the road and end up again in the side of the road (consider only one direction). The road center line measures make accurate analysis for the vehicular movement of both directions. Therefore in order to analyze accidents, we may have to consider the above both methods because the accident risk means both vehicular crashes and pedestrian crashes risk.

Global and local road network analysis have been done to measure the road network configuration. The high lengthy road segments analyze in global analysis and its make expected accurate results for the analysis like prediction of the future land uses, land values using configuration values which came from the global road segment analysis. In the case of accidents, the analysis must consider the local context. These studies clearly define how earlier studies measured these factors and the methods to find the relationship of these factors and crashes probability. Further, it also provides the limitations which should be considered in these studies.

3. Study Area

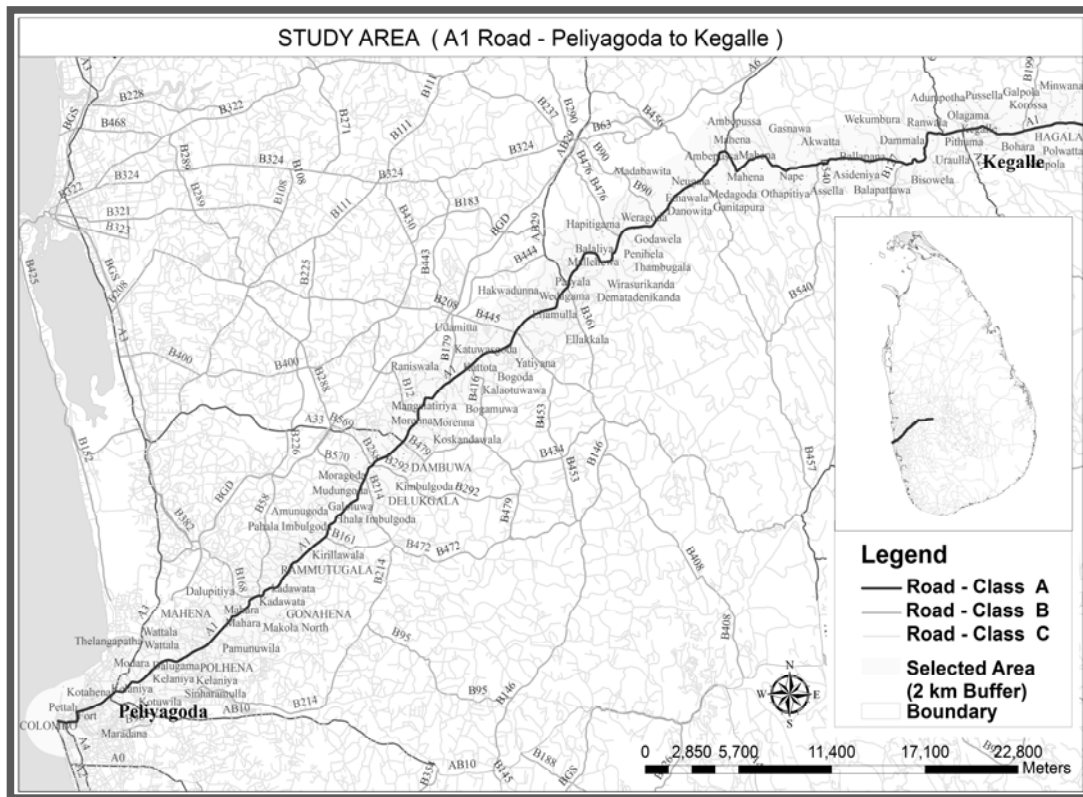


Figure 3 study area ,Colombo –Kandy road from peliyagoda to Kegalle

	2010	2011
Division	Accidents	Accidents
Nugegoda	3149	3709
Kelaniya	3112	3515
Gampaha	1570	2038
Kurunagala	1158	1530
Panadura	774	1119
Kegalle	1179	953
Negombo	945	1078

Case study conducted at Colombo-Kandy A1 road which is the road where highest accidents were recorded. The highest number of accidents has occurred in the following police divisions in last two years; Nugegoda, Gampaha and Kelaniya (*Accident data from police Headquarters Sri Lanka*). Furthermore, Gampaha and Kelaniya Police Divisions are directly related to Colombo-Kandy A1 road which displays the highest crashes records. Therefore, Kandy-Colombo Road was selected as the most suitable road for this study.

Table 1 Accident data, Source Police Headquarters Sri Lanka

4. Methodology

The research methodology employed for the study included five-steps (Figure-3). A special feature of the methodology is that it attempted to develop simple and affordable methodological framework to measure the relationship between traffic crashes and road network configurations.

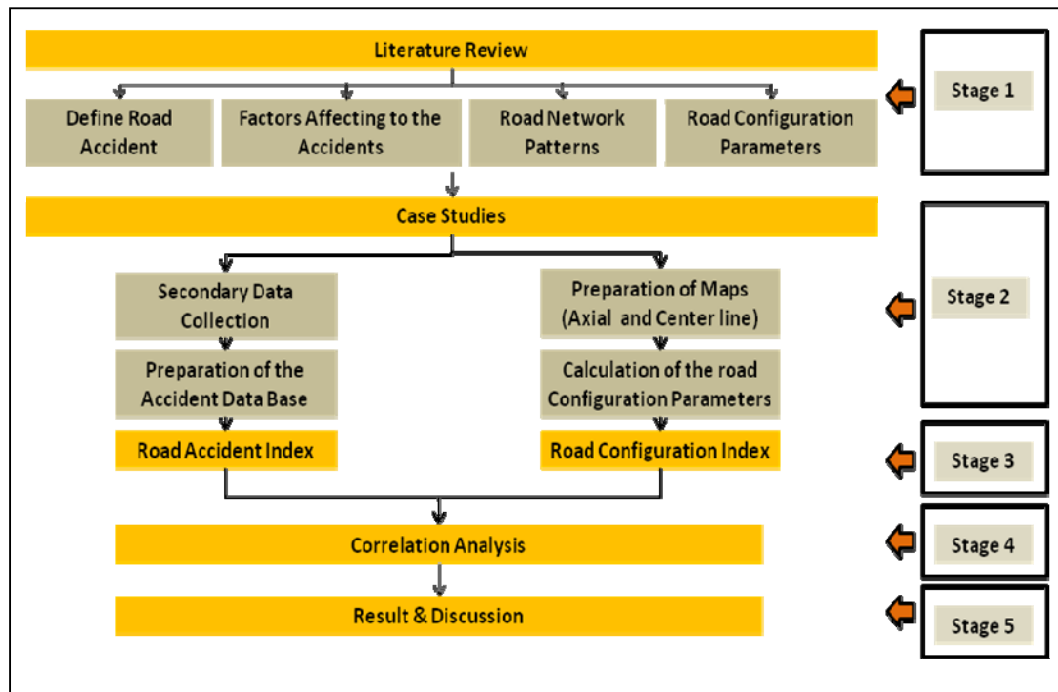


Figure 4: The research methodology

Step 1: Literature Review of the relationship between road network configuration and vehicular accident

A literature review was conducted on vehicular accidents, factors affect in accidents, different road patterns, concept of road network configuration, configuration parameters.

Step 2: Selection of the case study , Data collection and data process

In this step, the road network was selected as the study area and accident data and other relevant details were gathered. Then the data was processed by using GIS and Depth map software's (preparation of the accident map and axial map).

Step 3: Preparation of the Accident Index and Configuration Index

Two types of indexes were generated in this step to measure the relationship between accidents and road configuration. The recorded accident data was used to calculate the accident index and the configuration values calculated using Depth map software.

Step 4: Correlation Analysis

Relationship analysis between two indexes was carried out at two stages. First, correlation analysis, and second stage was multiple regression analysis.

Step 5: results and discussions

This step brought the results and further recommendations were listed.

According to the above methodology the crashes recorded maps along the Colombo-Kandy Road from Peliyagoda to Kegalle were collected from Police Divisions (seven divisions & year 2011) after the literature review. Those maps include recorded accidents as fatal accidents, minor injuries and property damages. The data collected by secondary sources was entered and prepared in ArcGIS. First, locations of crashes were digitized as points in ArcGIS. Then crashes data were added to the respective shape-files as attributes. Attributes of points are FID, Name of the location, No of fatal accidents (High), injury (Medium), property damage (Low) and total accidents.

Calculation of Road Configuration Parameters

First, a base map was prepared indicating the motorable road network. A digital format 1:50000 topographic map (survey department-1984) and updated road network using satellite image (Google-earth) to prepare this map. Use “Depth map” software to convert the road network in to an axial network using “Depth map” software. Further separate road configuration values were calculated based on the axial map prepared in the above stage using Depth Map. Connectivity (Complexity), Mean Depth (length), Integration (Visibility), Straightness and Choice parameters which are based on the applicability and the scope of the study were employed in calculating road configuration of road segments. Calculations are based on two scales, local scale ($n=3$, compare with 3 adjacent road segments) and global scale ($n=n$, compare with all road segments).

For this analysis, main three configuration parameters were considered:

- Integration (visibility level of the road segment)
- Connectivity (Complexity of the road segment)
- Choice (Vehicular flow)

These configuration values were calculated using Depth map and values calculated respective/ relevant to the particular axial line. After the calculation the output file was converted and opened in ArcGIS. The attributes of axial lines are FID, Shape, Choice, Choice_Nor (Normal), Connectivity (Complexity), Integration (Visibility).

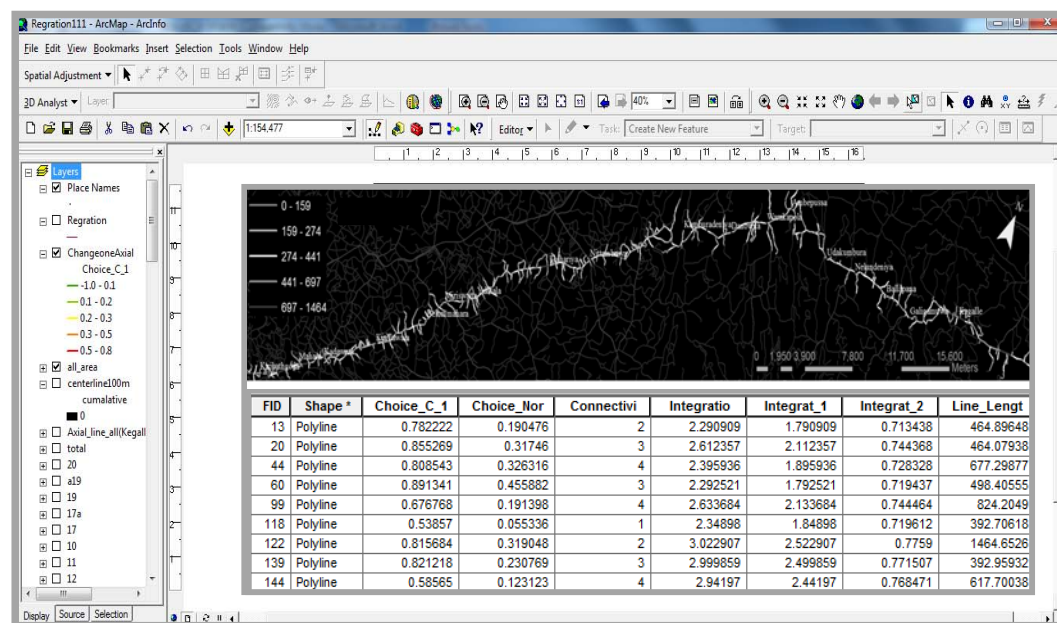


Figure 5 Over lay the Accident map and axial map with Configuration values using GIS

The parameters calculated using the Depth Map Software which was explained in the previous chapter. Configuration index is comprised with configuration values of axial lines based on local level Choice, Connectivity, Integration as indicated in the maps. Each map follows a color scale based on Configuration values.

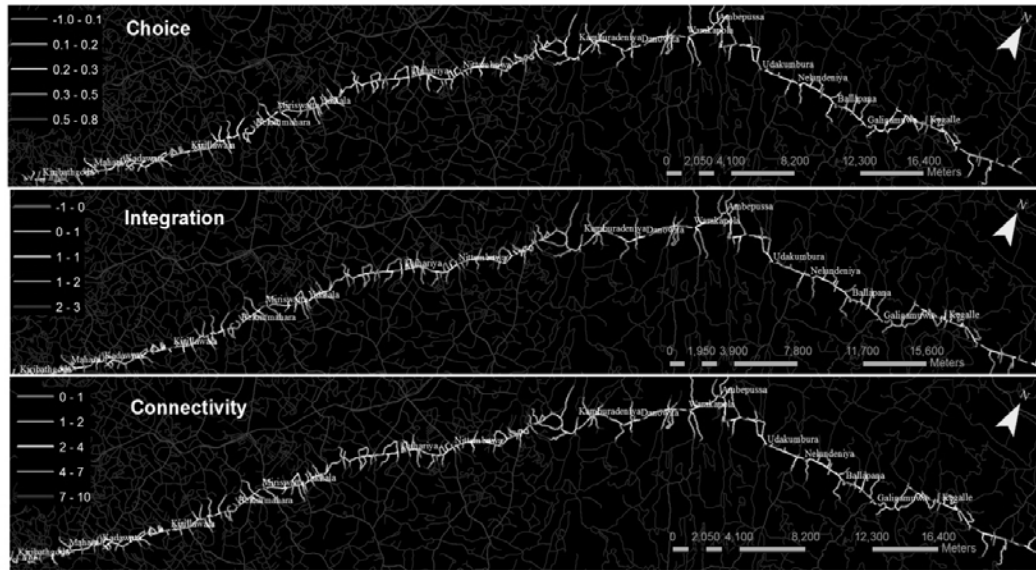


Figure 6 Variations of the Configuration values.

The parameters variance calculated using Excel and following map display the values of Choice Variance, Connectivity Variance, Integration Variance, Line length Variance with the colour variance.

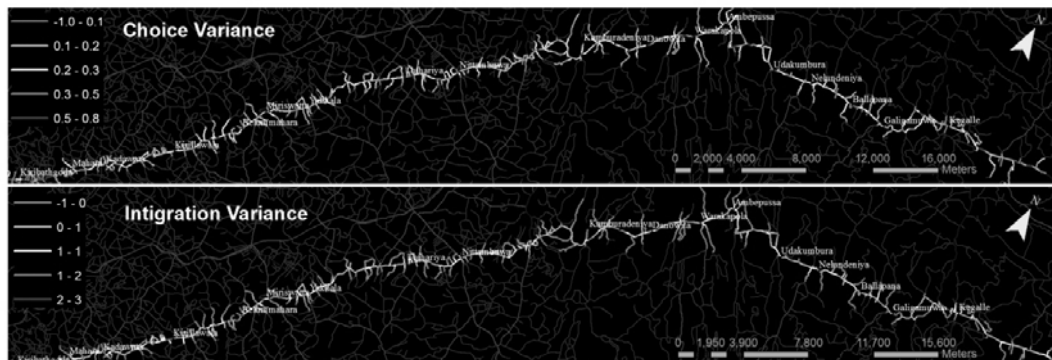


Figure 7 Variations of the Configuration values.

By using Spatial Overlay tool, overlay the Crashes point layer and axial line layer to correlate crashes and parameters. Overlaid shape file contains Attributes of FID, Shape, Choice, Choice_Nor (Normal), Connectivity(complexity), Integration(visibility), fatal accidents (High), injury (Medium), property damage (Low) and Total Crashes. Furthermore Crashes Probability Index was prepared as follows. Probability Index displays only the probability of crashes occurrence (Ex: Locations having at least one crash got 1).

Relationship analysis between Crashes Index and the Configuration Parameters

Correlation Analysis and Multiple Regression Analysis were used as analysis methods to measure the correlation between the Crashes Index and the Configuration Parameters. The analysis was carried out in two stages. At first stage correlation analysis was carried out to find out the strength of a relationship between crashes index of road segments and each configuration parameter in local and global scales. Then multiple regression analysis was carried out to find out the nature of a relationship between above two indexes as the second stage.

5. Results and Findings

Many researchers have categorized road crashes under several categories. Fatal, Injury, property damage are used as a three main categories of crashes in this study. There are 1,230 incidents recorded according to the crashes data profile of Colombo-Kandy Road in 2011. Out of those incidents further categorized 25% fatal crashes, injury 35% and property damages 40%. The highest number of fatal crashes was recorded in Galigamuwa and it was recorded 14 fatal crashes. The highest injury crashes were recorded in Ranwala, Mahara, Galoluwa, respectively 12, 12 and 10. Although the highest number of property damages occur in Thorana Junction, Kelaniya and Kadawata. There are about 24 crashes recorded. In addition to that there are above 45 total crashes recorded in Galigamuwa, Kadawatha and Morenna area which were mentioned in the previous chapter.

Relationship analysis between Configuration Parameter and Crashes Index

Relationship analysis between two indexes was carried out at two stages. First, correlation analysis was carried out to find out the strength of a relationship between Crashes Index of road segments and each Configuration Parameter. This analysis is one of the important qualitative analysis/analytical methods used in many of the recent studies. For this stage the configuration parameters were ranked based on significance of the coefficient of correlation. In the second stage, Multiple Regression Analysis was carried out to find out the nature of a relationship between above two indexes. It allowed estimating the dependent variable using more than one independent variable and increasing the accuracy of the estimation.

Correlation Analysis between Crashes Index and Configuration Parameters of Road Network

Crashes index (total crashes)

Parameter	Pearson Correlation	Sig. (1-tailed)	N	Rank
L Integration	-.874**	.000	1233	1
Connectivity	.768**	.000	1233	2
G Choice	.759**	.000	1233	2
G Integration	-.611**	.000	1233	2
L Choice	.302**	.000	1233	4

Table 2 Correlation between configuration values and crashes index (total crashes)

**Correlation is significant at the 0.01 level (1-tailed)

L Integration Parameter and Crashes Index of road segments show a highly significant coefficient of correlation when comparing to other parameters. For Local Integration Parameter: $r = .874$, $p < .01$. Further the G Choice, Connectivity and G Integration reveal a moderate significant coefficient of correlation with Crashes Index. For G Integration Parameter: $r = -.611$, $p < .01$. L Choice Parameter reveals a lowest significant coefficient of correlation. All parameters make proportionate relationships but in particular case of Integration Parameter correlates with the

Crashes Index making inversely proportionate relationship. It indicates that Configuration Parameters have 'Linear Relationship' with Crashes Index (Total crashes).

Crashes index (fatal crashes)

Parameter	Pearson Correlation	Sig. (1-tailed)	N	Rank
L Integration	-.722**	.000	1233	2
Connectivity	.603**	.000	1233	2
G Choice	.564**	.000	1233	3
G Integration	-.477**	.000	1233	3
L Choice	.212**	.000	1233	4

**Correlation is significant at the 0.01 level (1-tailed)

Table 3 Correlation between configuration values and crashes index (fatal crashes)

L Integration parameter, Connectivity parameter and crashes index of road segments shows a highly significant coefficient of correlation in comparison to other parameters. L Integration Parameter shows the highest. For L Integration Parameter: $r = .722$, $p < .01$. Further the L Choice and G Integration reveal a lower significant coefficient of correlation with Crashes Index. For L Choice: $r = .212$, $p < .01$ and for the G Integration parameter: $r = .477$, $p < .01$. All parameters make proportionate relationship except Integration Parameter and it indicates that Configuration Parameters have 'Linear relationship' with Crashes Index.

Parameter	Rank (Accidents)	
	Total	Fatal
L Integration	1	2
Connectivity	2	2
G Choice	2	3
G Integration	2	3
L Choice	4	4

As a conclusion all five parameters show the reasonable correlations. Only the L Choice Parameter shows the lower ranks. Other four parameters display high ranks indicating the high correlations with Crashes Indexes. In particular the L Integration, Connectivity Choice makes the highest correlation.

Table 4 Summary of the correlation values

Multiple Regression Analysis

Forward linear regression is performed in this step. In forward entry method, variables in the block are added to the equation one at a time. At each step, the variable not in the equation with the smallest probability of F is entered if the value is smaller than probability of F-to-enter (The default value is 0.05). The response variable is the crashes Index (Total Crashes (CIT) and Fatal crashes (CIF)). The predictor variables are G Choice, Connectivity, G Integration, L Choice, L Integration.

Crashes index (total crashes)

For the first step Regression Analysis was done with the G Choice, Connectivity, G Integration, L Choice, L Integration and Crashes Index (total crashes). The Correlation results indicated that configuration values have liner relationship with Crashes Indexes. Model summary results (table) indicate that L Integration and Connectivity parameters made significant values for R-Sq Change.

L Choice and G Integration show the moderate level of R-Sq Change. After the 4th run of forward regression is that R, R Square and Adjusted R Square values were saturated. Model four obtained more than 0.001 level of Sig. F Change and beta value of G Integration which is insignificant in comparison to other predictor variable. (Table 4.5) summarizes the linear regression model with confidence interval at 95% level, of forward regression. Three predictor variables: L Integration, Connectivity, G Choice, G Integration, together explains over 97% of the variance in *CIF*. Individually, however, *L Integration* explains nearly 61% of *CIF* variance and *Connectivity* explains only about 27% of the variance, and *G Choice* explains only about 10% of the variance, *G Integration* explains an even smaller portion (1%). Considering the above relationships, the model can be specified as follows. Therefore, Model four can be considered as the appropriate model to explain the relationship between Crashes Index (Total Crashes) and above parameters. Therefore, the model can be illustrated as follows.

$$\text{CIT} = -23.905 - 0.245 \text{ L Integration} + 2.252 \text{ Connectivity} + 0.992 \text{ G Choice} - 0.073 \text{ G Integration}$$

Model Summary									
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df 1	df2	Sig. F Change
1	.944 ^a	.892	.892	.48412	.892	10868.519	1	1316	.000
2	.982 ^b	.965	.965	.27472	.073	2771.867	1	1315	.000
3	.986 ^c	.972	.972	.24585	.007	327.959	1	1314	.000
4	.986 ^d	.972	.972	.24499	.000	10.245	1	1313	.001

a. Predictors: (Constant), L Integration
b. Predictors: (Constant), L Integration, Connectivity
c. Predictors: (Constant), L Integration, Connectivity, G Choice
d. Predictors: (Constant), L Integration, Connectivity, G Choice , G Integration

Table 5 Regression model summary for (Total) Crashes index

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	2.820	.014		201.580	.000					
	LIntegration	-.409	.004	.944	104.252	.000	.944	.944	.944	1.000	1.000
2	(Constant)	-16.369	.365		-44.902	.000					
	LIntegration	-.268	.003	.618	76.751	.000	.944	.904	.395	.407	2.454
	Connectivity	3.019	.057	.424	52.649	.000	.900	.824	.271	.407	2.454
3	(Constant)	-23.604	.516		-45.762	.000					
	LIntegration	-.246	.003	.567	73.335	.000	.944	.896	.337	.354	2.827
	Connectivity	2.296	.065	.322	35.309	.000	.900	.698	.162	.254	3.940
	G Choice	1.001	.055	.167	18.110	.000	.878	.447	.083	.250	4.004
4	(Constant)	-23.905	.523		-45.749	.000					
	LIntegration	-.245	.003	.534	73.479	.000	.944	.897	.337	.354	2.829
	Connectivity	2.252	.066	.313	34.016	.000	.900	.684	.156	.243	4.114
	G Choice	.992	.055	.165	17.993	.000	.878	.445	.082	.249	4.014
	G Integration	-.073	.023	.015	3.201	.001	.457	.088	.015	.774	1.292

a. Dependent Variable: ATT

Table 6 Coefficients – Regression model for (Total) Crashes index

Crashes index (fatal crashes)

For the second step Regression Analysis were done with G Choice, Connectivity, G Integration, L Choice, L Integration and Crashes Index (fatal Crashes). The Correlation results indicated that values have linear relationship Crashes index. Model summary results (Table 4.7) indicate that L Integration and Connectivity parameters made significant values for R-Sq Change. G Choice shows the moderate level of R-Sq Change. Up to the 4th run of forward regression is that R, R Square and Adjusted R Square values were saturated. (Table 4.7) summarizes the Linear Regression model with confidence interval at 95% level, of forward regression. Three predictor variables: L Integration, Connectivity, G Choice, G Integration, together explains over 98% of the variance in CIF. Individually, however, *L Integration* explains nearly 53% of CIF variance and *Connectivity* explains only about 31% of the variance. and *G Choice* explains only about 16% of the variance, *G Integration* explains an even smaller portion (10%). Considering the above relationships, the model can be specified as follows.

$$\text{CIF} = -24.005 - 1.245 \text{ L Integration} + 0.252 \text{ Connectivity} + 0.992 \text{ G Choice} - 0.003 \text{ G Integration}$$

Model Summary									
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df 1	df 2	Sig. F Change
1	.948 ^a	.899	.899	.48412	.899	10868.519	1	1316	.000
2	.986 ^b	.972	.972	.27472	.073	2771.867	1	1315	.000
3	.990 ^c	.980	.980	.24585	.008	327.959	1	1314	.000
4	.990 ^d	.980	.980	.24499	.000	10.245	1	1313	.001

a. Predictors: (Constant), L Integration
b. Predictors: (Constant), L Integration, Connectivity
c. Predictors: (Constant), L Integration, Connectivity, G Choice
d. Predictors: (Constant), L Integration, Connectivity, G Choice, G Integration

Table 7 Regression model summary for (fatal) Crashes index

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	2.820	.014		201.580	.000					
	LIntegration	-.409	.004	.944	104.252	.000	.944	.944	.944	1.000	1.000
2	(Constant)	-16.369	.365		-44.902	.000					
	LIntegration	-.268	.003	.618	76.751	.000	.944	.904	.395	.407	2.454
	Connectivity	3.019	.057	.424	52.649	.000	.900	.824	.271	.407	2.454
3	(Constant)	-23.604	.516		-45.762	.000					
	LIntegration	-.246	.003	.567	73.335	.000	.944	.896	.337	.354	2.827
	Connectivity	2.296	.065	.322	35.309	.000	.900	.698	.162	.254	3.940
	G Choice	1.001	.055	.167	18.110	.000	.878	.447	.083	.250	4.004
4	(Constant)	-24.05	.523		-45.749	.000					
	LIntegration	-1.245	.003	.610	73.479	.000	.944	.897	.337	.354	2.829
	Connectivity	0.252	.066	.270	34.016	.000	.900	.684	.156	.243	4.114
	G Choice	.992	.055	.101	17.993	.000	.878	.445	.082	.249	4.014
	G Integration	-.003	.023	.019	3.201	.001	.457	.088	.015	.774	1.292

a. Dependent Variable: AIF

Table 8 Coefficients – Regression model for (fatal) Crashes index

Two linear regression models were created, tested, and analyzed in this stage with confidence interval at 95% level. Following table illustrates the summary of results.

Steps	Model	R square
Crashes Index(Total)	CIT = -23.905 – 0.245 L Integration + 2.252Connectivity + 0.992G Choice - 0.073 G Integration	0.972
Crashes Index(Fatal)	CIT = -24.005 – 1.245 L Integration + 0.252Connectivity + 0.992G Choice - 0.003 G Integration	0.980

Table 9 Summary of regression model results

Results indicate that all two models obtained high R square values. Configuration values having significant correlation with Crashes Index (total) G Choice, Connectivity, L Integration. Further, in analysis with Crashes Index (fatal) also displays significant correlation specially G Choice, Connectivity, L Integration. Accordingly, those models are capable enough to explain the relationship in between Road Network Configuration and Vehicular Crashes.

6. Conclusion

This research is placed in a milieu where there are very limited research attempts to figure out the road configuration related reasons for vehicular crashes studies in Sri Lanka and the current practices are hampered by methodological, technical, financial and information availability issues. This research reveals the relationship between roads network configuration and vehicular crashes.

Road Configuration values which are calculated based on three different configuration parameters shows a significant correlation between transit demand values. Thus, argument (configuration measures are capable to explain the level of vulnerability of vehicular crashes in road segments) put forward in study is well recognized and valid. Yet, the level of coefficient of correlation is different by configuration parameters and considered scale. Local integration values which capture the idea that a visibility level change in road segment obtained the strongest correlation (> 0.8 at 1% Significance level) with both indexes(CIT and CIF)and scored the highest rank of correlation results among three configuration parameters. Connectivity (which captures the level of complexity of the road segment by considering the number of connections) and Global Choice (which captures degree of vehicular flow) configuration parameters also obtained strong positive correlations with both Crashes Indexes. Though the correlation coefficient is highly significant ($R > 0.7$ at 1% Significance level).Global Integration values recorded a moderate level correlation (< 0.6 at 1% Significance level) with accident indexes but Local Choice revealed a lower correlation (> 0.4 at 1% Significance level I). Regression models developed in the study which having more than 80% accuracy, are applicable in measuring the level of vulnerability for Vehicular Crashes in road segments based on Configuration Parameters. To conclude, measures of Road Configuration reveal strong relationship with the Road Crashes. Thus the level of variation in Road Configuration values is a major cause for road Crashes. Sudden Visibility Change (Local Integration) is the key factor for accidents. And Complexity (Connectivity) is revealed as a secondary impact factor. Further any location having these two factors with higher choice for drivers (vehicular flow) will further increase the Crashes. The models developed in the study are capable to identify the locations which are vulnerable for Road Crashes in existing networks and the adjustments in Configuration Parameters may reduce the vulnerability. Road Configuration Assessment is a sophisticated tool for urban and transport planning process: mostly applicable in Sri Lankan context. Therefore, it can be used as a planning

tool to identify the level of vulnerability for road crashes in existing roads and to identify the impact from proposed land use plans with new road networks.

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Using walk-recordings and images: How Students experience safety in a city centre

Rangajeewa Ratnayake

Community Planning and Development Program, La Trobe University, Australia

R.Ratnayake@latrobe.edu.au

Abstract

This paper reflects on using self-recorded walk and auto-photo-elicitation as qualitative methodological components in studying students' sense of safety at night in a Central Business District (CBD) area of a regional city in Australia. This paper documents the use and potential of self-recorded walks (SRW) auto-photo-elicitation based on a study on sense of safety at night in a city centre. Fifteen domestic and international students participated in the self-recorded walks, taking photos while they walked alone at night in selected sites. Participants made comments into hand-held voice recorders while walking as well as capturing scenes to express feelings of personal safety about their environment. The paper confirms the value of self-recorded walking and auto-photo-elicitation approaches as tools beyond traditional interviews and surveys to understand feelings of fear or safety associated with environmental and social clues in the urban fabric. The paper also documents achievements and constraints encountered by researchers/investigators in carrying out field research of this kind.

Keywords: CBD, auto-photo-elicitation, self-recorded walk, sense of safety, students

Introduction

Self-recorded walking (SRW) and auto-photo-elicitation both require research participants to record thoughts, feelings and/or visual features into a hand-held recorder or camera as they walk in an area, with the intent of discussing these recordings with the researcher. SRW and auto-photo-elicitation have been employed in empirical studies in the areas of planning, urban design, visual anthropology and visual sociology and these methods have certainly broadened conventional empirical research practice. However, little is known about their usefulness and challenges in real-life urban studies. The aim of this paper is to reflect on using self-recorded walk and auto-photo-elicitation as qualitative methodological components in studying students' sense of safety at night in a Central Business District (CBD) area of a regional city in Australia. This paper informs the use and potential of SRW auto-photo-elicitation to understand of the effect of different environmental features on individuals' perceived safety. The paper also informs achievements and constraints encountered by researchers in carrying out field research of this kind.

Related literature

In the last few decades, participatory research studies such as self-recorded walks, and auto-photo-elicitation have been used to understand social and physical conditions that impact on the daily life of individuals (Harper, 2010; Kaplan, 2001; Nasar and Fisher, 1995; Nasar and Jones, 1997). These methods are associated with phenomenology because SRW comments and photo images attempts to record the immediate subjective experience of people in different places at particular times for later analysis and interpretation (Seamon, 2000). Fear and sense of safety are emotional states contribute to the experience of places, and triggering of these states and experiences are often associated with environmental clues and social determinants. Giving cameras and hand-held voice recorders are only two methods of recording people's experience and perspectives on a given topic such as feelings of individuals' personal safety. There are other methods to investigate people's fear of crime or sense of safety such as surveys and word only interviews. But why tape recorders or images? What are their advantages? Is it possible to capture the nuance of scenes that are associated with feelings of fear? Could the walk-talk recordings and images serve to understand fear generating factors? Likewise many questions arise

when researchers attempt to employ these qualitative methods (Nasar and Jones, 1997; Yates, 2010).

Self-recorded walks can be used as tools to investigate the both subjective and objective ratings of the environmental features, spaces and places in relation to participants' perceived safety from crime, or alternatively, their perceived pleasure or accessibility of the sites. In SRW, participants usually walk in chosen routes or sites and make comments into a hand-held voice recorder. Participants can be asked to comments on their experience on the walk: like/dislike, enjoy/ do not enjoy, safe/unsafe and how different features influence their environmental experience (i.e., walkability or safety) (Brown, Werner, Amburgey, and Szalay, 2007). Self-recorded walks allow participants to reflect on places and everyday actions as they occur and capture participants' original and immediate feelings about the topic under investigation; this same quality of data which cannot be properly elicited from quantitative methods and interviews. Likewise, a survey cannot properly investigate participants' 'feelings of fear or safety within a place or detailed descriptions of participants' sense of safety or their assessment of the environmental features that generate fear, as surveys are based on memory rather than the 'in-the-movement'. Therefore, the SRW method offers a freedom to feel, think, express as one wishes, and uninterrupted lengthily reflections on topics which participants may find hard to explain or that makes them uncomfortable or embarrassed. Discussions on actual field experiments and photos on a fear of crime study, Warr (1990, p. 905) suggest that 'it is certainly not possible to fully capture variety and nuances of different features of the environmental settings without the use of photographic reproductions of scenes or better yet, actual field measurements.'

In auto-photo-elicitation, participants are asked to take photos and describe photos from their perspective. Generally photo-elicitation studies use photos to represent subjectivities that are embodied through the framing of events that occurred in the life times of participants, and depict intimate dimensions of social life. Furthermore, auto- photo-elicitation have been used to categorise quality of housing (Collier, 1957), to understand how urban residents transform urban neighbourhoods based on their own identities and social locations, to reflect patterns of strategies over the time and changes (Harper, 2002), and to understand culture, memories associated with places and people and meanings of every day actions (Samuels, 2004). In comparison to data gathered from surveys and word-only interviews with the data gathered from auto-photo-elicitations, images produce more 'concrete' information through the material evidence that the photo provides and the discussion it supports. Photos tend to relieve the strain of being questioned, sharpen the interviewee's memory, reduce areas of misunderstanding, and initiate a rich discussion (Collier, 1957). Similar to SRW, auto-photo-elicitation is participatory in nature and therefore it empowers respondents to document and reflect on the phenomena under study.

While it is valuable to highlight the benefits of SRW and auto-photo-elicitation, it is equally important to note technical and practical limitations of these methods. In this regard, Prins (2010) noted that some studies provide few details of the photographic data analysis process and describe a romantic vision of the changes and transformation. SRWs or photo process may lead to outcomes unforeseen or unrelated to the research objectives as participants have the control over it (Lamas and Pascual, 2013). These methods also produce ethical issues about taking photos of sites and persons without consent, personal security and confidence of respondents (Allett, Keightley, and Pickering, 2011). There is an issue of confidence involved for some people when speaking alone to a recorder. It is also important to build rapport with the respondents, communicate fully in advance with them on what they need to do, what would like them to cover, and how to use cameras and voice recorders (Samuels, 2004).

This paper is about the value of SRW and photo-elicitations as qualitative methodological components in studying students' fear of crime or sense of personal security. The next section of the literature will provide a briefly discussion of both environmental clues and social clues as symbolic objects related to fear of crime.

Sense of safety and environmental clues

Environmental clues affect sense of personal security of individuals when walking alone at night in urban settings. Many case studies found that sense of safety or fear of crime is associated with environmental conditions such as enclosure, visibility, lighting, activities, escape routes and density of people (Jorgensen, Ellis, and Ruddell, 2012; Nasar, Fisher, and Grannis, 1993; Nasar and Jones, 1997; Petherick, 2000). The results presented in this paper from a recent research by the author, focuses on Appleton's Prospect and Refuge Theory which analyses the association between environmental clues and fear of crime. In this context, Appleton (1975) assumes that one's ability to see (prospect) without being seen (refuge) increases perceived safety. Based on this theory, Fisher and Nasar (1992) proposed a safety model and they argued that areas of large amount of refuge (concealment for attackers) and minimal prospect would provoke the highest degree of fear among students in a campus setting.

To further the work of Nasar and Fisher (1997), the research participants took their own photos and voice recordings in the author's study, rather than the researcher as occurred in previous studies (Fisher and Nasar, 1992, Jorgenson, Ellis and Ruddell, 2012). The participants recorded their feelings on sense of safety in selected sites in the Bendigo Central Business District (CBD) area in Australia. In the study presented here, it was assumed that students would feel less safe in areas characterised by low degree of prospect, high amount of concealment for attackers and low density of activities and people. However, the study participants were not informed about this assumption prior to the fieldwork.

Research context procedure and analysis of SRW and photo data

This study centred on the Bendigo CBD area. Bendigo CBD is located in the City of Greater Bendigo local government area in central Victoria, Australia (see Figure 1). Greater Bendigo is a major regional service centre within the Loddon region in Victoria about 150 kms North West of Melbourne which is the capital city of Victoria. Past research shows that the incidence of crime within the Bendigo CBD was not particularly high compared to the city of Melbourne, however the perception of Bendigo residents was that the CBD area was unsafe particularly at night (City of Greater Bendigo, 2004). In this study, two field surveys were conducted.

Australia



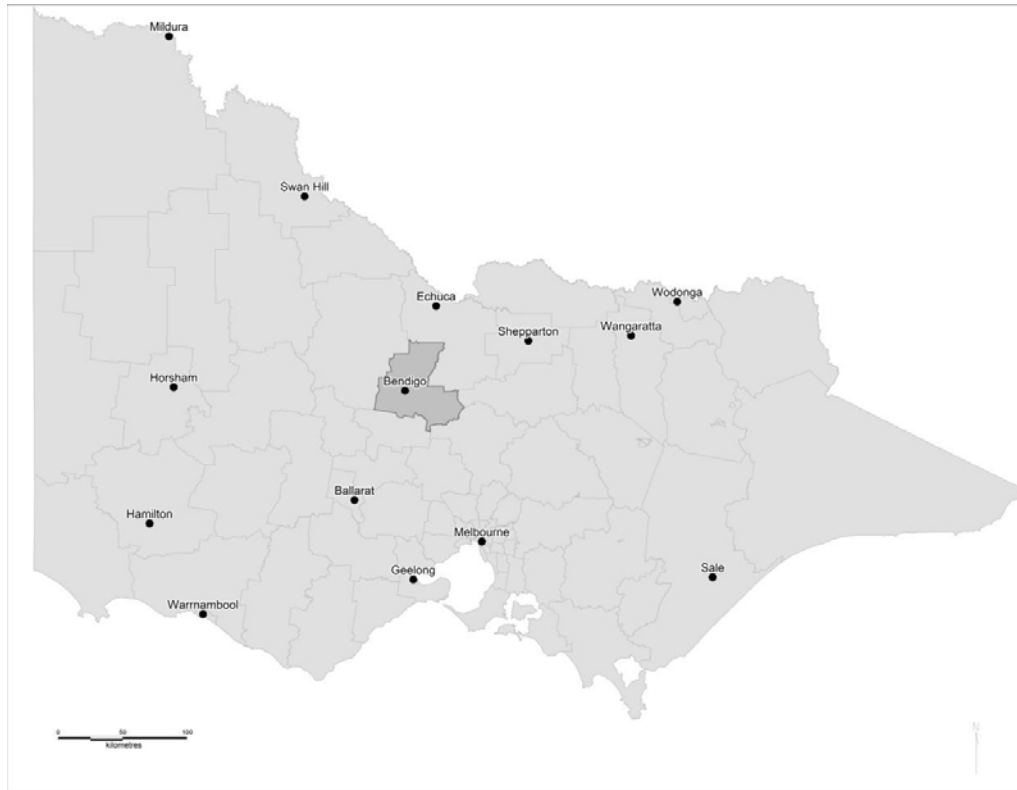


Figure 1: Bendigo in the Regional Context

Source: City of Greater Bendigo, CBD Plan 2005

Field survey stage 1

First, in order to understand the climate of fear or feelings of personal insecurity in the Bendigo city centre area, the study conducted a field study to select areas that provoke fears - 'hots spots of fear'. For this, 12 international Asian students were asked to walk on all the streets in the CBD area at night between 7.30 pm to 10.00 pm on two nights in autumn so it would be dark.

Respondents were given a Bendigo CBD map and asked them to walk alone on CBD streets and circle any sites or areas that they felt to be unsafe. All respondents had spent more than 24 months in the city of Bendigo area and they were familiar with the CBD areas. The Bendigo CBD area is a relatively a small area so that the participants were able to cover the all streets. Prior to the field survey, a training session was organised to explain research expectations, instructions and anticipated security issues while walking alone. The participants were asked to bring their mobile phone as a defensive device in case.

The participants marked areas and sites on the map that they felt unsafe and the location of marked areas were varied. However, by overlapping individual maps on one another and counting frequency of same areas, a fear maps was created with three unsafe areas/sites in the Bendigo CBD area (Nasar et al., 1993). The three unsafe areas were found in St. Andrews' Avenue (Site: A), Hopetoun Street (Site: B) and Edward Street (Site: C). these three areas are shown in Figure 2 and Figure 3.



Figure 2: Selected three sites



Characteristics of selected sites from the field survey stage 1

Site A: St Andrew's Avenue

This site is positioned in the centre of the Bendigo city area and it is placed in a medium size urban block. St Andrew's Avenue is a wide street with street trees, sidewalks and parking bays. It is a unique area compared to other sites in the CBD as it the majority of the spaces are used for administrative functions. Office buildings, welfare agencies such as Centrelink, Municipal Council building, Bendigo Town Hall and Gold Fields Library are located in this area. These office buildings close after office hours and on weekends, resulting less busy at night. A considerable amount of space is allocated for car parking in this area. These car parks are empty and poorly lit at night. There are no restaurants, retail stores, or any other business activities on this street during the day or at night. These conditions are likely to make some people less secure, anxious, and scared when walking alone at night. Considering planning zones and overlays, this site belongs to Business 1 Zone (B1Z), and the applicable overlays are Design and Development Overlay (DDO5), and Heritage Overlay (HO223). The existing land use and design policies protect open spaces (in the Town Hall area), heritage buildings and ensure the low rise character of the CBD. This area's generous street width makes the city buildings appear relatively low and allows ample sunlight to pavement levels. However, these design policies tend to discourage the construction of slightly higher new buildings (three or four storey).

Site B: Hopetoun Street

This site is also located in the centre of the area under study. The area is not well-lit, lacks street lighting in the middle of the road, and the extensive tree cover makes the street dark. The area also has some unexpected nooks and corners which could be used as hiding places. In relation to land uses, this site is a relatively small urban block with a mix of land use activities. The area comprises service sector activities with government institutions, retail stores and a few houses on one side of the street. The buildings are mostly single storey. Most of the shops are open during the day and close at night. Due to the fact that the office buildings and the shops close after office hours (6.00 pm) and weekends, this street is quiet and less vibrant at night. These conditions are likely to make people feel less comfortable when walking alone at night. The site is positioned in close proximity a residential area and it exhibits transition characteristics. Similar to site A, this site is also located in Business 1 Zone (B1Z) and the key applicable overlays for buildings are Design and Development Overlay (DDO5) and Heritage Overlay (HO223). The land use and design policies indicate that this area will be preserved with existing heritage buildings and character and maintain the role of the area for business activities which support the retail business and residential communities within the city centre area.

Site C- Edwards Street

The site area is generally well-lit at night. However, some areas in the site have nooks and corners, fairly high shrubs and small trees creating darkness and concealment at night. Since the area consists of many car parks, institutional buildings (government offices), and fewer retail shops, the area tends to be quiet and less vibrant at night. In terms of land use activities, the area is predominantly comprised of service sector activities with government institutions and shopping centres. The area (street front) also contains fewer retail shops compared to city Main Street (Pall Mall). A considerable area of land is allocated for car parks. It was observed that this area was used by many pedestrians during the day; however, few used the area at night. Due to the dominance of office buildings, car parks, few retails, and few people, the site area tends to be quiet at night and therefore pedestrians are likely to feel less secure walking at night on this area. Similar to site A and B, this site is also located in Business 1 Zone (B1Z) and the key applicable overlays for buildings are Design and Development Overlay (DDO5) and Heritage Overlay (HO223). The zoning policies indicate that the heritage and existing character (building form and streetscape) of the area is preserved in the future. The policies encourage a mid-height built form that addresses the street frontage and enhances surrounding retail activities in the future.

Field survey stage 2

The second stage of field study involved SRW and auto-photo-elicitations to identify specific environmental features and conditions that participants associated with feelings of unsafety in the sites that were selected in the stage 1. At this stage, an opportunity sample of 15 students was used who volunteered to participate in this study. None of these participants took part in the stage 1 of the field survey. Prior to the field study, a short survey was conducted to obtain participants' personal information. This sample comprised of domestic students (7), international Asian students (8). It also comprised of undergraduates (9) and postgraduates (6), males (8) and females (7), who had spent more than 24 months in the Bendigo city area. None of the participants indicated they had experienced victimisation in the Bendigo CBD area. Each participant was taken to the field on a separate occasion for night-time SRWs and photos.

Even though it was expected to take 45 minutes for each participant to complete SRW on each day, it took about 90 minutes. This is due to some slow walk patterns involved in each site as the participants had to make observations while taking photos. The participants also took many pictures though they were asked to take one photo of each place. Further, auto-photo-elicited interviews were much longer than was anticipated. Nevertheless, SRW and photo comments provided a rich description of what participants considered as unsafe.

In order to prepare the students' SRW and auto-photo-elicited comments for the analysis, the digital recordings pertaining to each site were transcribed word for word immediately after every walk. Participants made a total of 313 comments in relation to all sites. As mentioned previously, instructions were given to respondents to comment on sense of safety of each site and the features that made them safe or unsafe. Content analysis was used to analyse comments to identify variations of safety in relation to the selected three sites. The next section will discuss how these qualitative field methods facilitated to identify spatial variations of safety and environmental features that made participants feel safe and unsafe.

Spatial variations of feelings of safety and environmental features that generated feelings of unsafety

SRW and auto-photo-elicitation methods allow participants to experience the site and provide judgements of different sites in relation to safety. Participants' comments indicate that sense of safety varies according to sites. As shown in the table below, the majority of respondents identified St. Andrews Avenue (80%) and Hopetoun Street (53%) as sites that induced a sense of insecurity or fear. The respondents' comments indicated that a considerable proportion of respondents (33%) felt less safe in Edward Street. Findings also show that both Asian males and Asian female students tended to feel less safe or very unsafe than domestic students. For instance, in St. Andrews Street, as many as 87% of Asian students felt unsafe compared to 71% of domestic students. This analysis shows that the participants were able to make some emotional assessment in relation to safety with these field methods.

Table 1: Level of Safety in Selected Sites in the Bendigo CBD at Night

	Site A Edward Street	Site B Hopetoun Street	Site C St.Andrews Avenue
	%	%	%
Most safe	13.3	0	0
Safe	53.4	46.7	20.0
Less unsafe	33.3	53.3	46.7
Unsafe/Very unsafe	0	0	33.3

Participants' SRW and auto-driven photo-elicited interviews provided judgements of different sites as well as provided rich descriptions with which to understand the specific features that made participants feel unsafe. Descriptions of St Andrews Avenue and Hopetoun Street sites demonstrate, the methods used for this research allow a more nuanced and richer recording of participants' views and experiences of the site in relation to safety. The images allow researchers to examine the space more carefully in the photo, and provide an exact location to revisit for further observation and analyses. For example, as the SRW and photo comments of St Andrews show, participants made descriptions on intertwining aspects of physical and social features such as prospect and concealment, people and activities in relation to safety:

'I can't see any one, this is Bendigo CBD, and I can't see any one even though I am in CBD. So at night this is like a ghost town'. (Asian, male)

'when walking alone this street and specially, I feel uncomfortable may be due to quietness... not many people' ...The quietness is the issue.' (Asian, male)

'I am walking up in St.Andrews Avenue. It is very dark and quiet. As next to the trade link there is a car parking area that is also very dark to or lights, trees in that car park make that very dark and again empty and Not very safe.' (Domestic, male)

'.. there are lots of places where people could jump out. Hope that won't happen today. But still don't feel as walking on my own.' (Domestic, female)

'there is a lot of nooks and corners, lots of trees and bushes, alleyways , gates, even though this just council office just over here, I am not feeling comfortable going here.' (Domestic, male)



'It shows just path. Nothing much you can see. Because less street lights. I feel safer if I use another major street down there.' (Domestic, female, who also took the photo)

Figure 4: This photo shows quietness, darkness and hiding places for potential attackers in St. Andrews Avenue

SRW and photo descriptions facilitated participants to experience site features that made them feel safe or comforting when walking alone at night in the CBD area. As the site descriptions indicate, feelings of safety were associated mainly with a high degree of prospect. The participants' comments also highlight that feelings of safety are associated to a lesser extent with signs of humans (i.e., cars), familiarity and landmarks (i.e., vista). One participants' photo description is presented in figure 5 below:



'Even though it is well lit, still like a ghost town. It's bit creepy. Yeah I do not know how safe here every day and would not come here in the at 2'clock in the morning. But definitely seeing land marks that I know, I feel bit safe. Like sacred heart cathedral, having that in the distance I can see that little spot on the middle, yeah that really comforting, just know where you are then you do not feel like you are getting lost.'(Domestic, male, who also took the photo)

Figure 5: This photo shows a well-lit quiet site in Edward Street, but distance vista/land mark structures make respondent feel safe

The data derived from these field methods indicate that, in addition to prospect, concealment and presence of people, participants made comments related to other environmental clues, albeit not as many. Participants noted certain design features that made them feel safe. When walking alone at night, participants commented on appearance of well-maintained landmark buildings improved their feelings of safety. As the participants indicated, some of the tall iconic buildings such as Bendigo bank and the Sacred Heart Cathedral act as vista. These distanced vistas in the city centre tended to improve spatial confidence of participants as such features enhanced navigation in the city centre at night.

Discussion

Looking at SRW and auto-photo-elicitation comments, it appears that these tools facilitated an understanding of spatial inequalities in relation to feelings of safe or unsafe insecurity in the CBD area. These tools also provided rich descriptions for understanding environmental clues and nuances that generate feelings of safety or fear in an urban setting. It also appears that this type of methods offer a check and balance for assessing proposition, and also facilitates discoveries. The next paragraph will further reflect on the benefits of SRW and auto-photo-elicitation in this study.

It appears SRW and participants' photographs provided opportunities for participants to explore real-life conditions associated with a sense of fear and of safety in a familiar urban fabric. Using SRW and auto-photos participants explored the naturalistic environmental conditions, and these tools facilitated the capture of participants' immediate emotions or feelings at the assessed sites. It is believed that word-only interviews or surveys to certain extent provide data about past memories and spark reflections about safety, fear and victimisation. This kind of real experience cannot be elicited from other tools such as surveys or word-only interviews. Therefore these field methods would be beneficial for future researchers wishing to explore mundane practices, every day remembering (Allett, Keightley, and Pickering, 2011), symbolic meaning of actions, objects or spaces (Samuels, 2004) and reflective considerations of places.

One important aspect of these field methods relates to free expression. Participants had the freedom and liberty to record their feelings, thoughts and impressions without disruptions from the interviewer and consequently they produced data as they wished. In many ways, the participants controlled the process once the researcher provided the instructions prior to the field survey. Since the participants walked alone and took images on their own, the participants were provided the time to reflect on what they considered to be important to them without the guidance of the researcher. In this way, the participants made comments and pictures without the researcher's influence; this approach essentially challenges the traditional hierarchical relationship between researcher and the researched as these tools enable ordinary people to air and represent their views through their own eyes. This was evident as reference to one of the participants' SRW comments reveals:

'So I am walking down this street in Bendigo. It seems really well lit which is a good thing. That building over there is incredibly ugly. Probably can't see on the recording. I don't know if you can see it on the recording, but, one thing I really notice is how like a ghost town around here at this time of the day. Even though it is well lit, still like a ghost town. It's bit creepy. Yeah I do not know how safe here every day and would not come here in the at 2'clock in the morning. But definitely seeing land marks that I know I feel bit safe. Like Sacred Heart Cathedral, having that in the distance I can see that little spot on the middle, yeah that really comforting, just know where you are then you do not feel like you getting lost....'(continues)(Domestic, male student) check and make sure you transcribed accurately if you can

The data derived from SRWs particularly tended to spark memories in relation to participants 'past life and practices'. This method often provided participants opportunities to explore similarities and differences in relation to safety. Therefore, it seems the SRW method is useful for studies that aim to disclose memory and comparisons. Memory needs to be narrated and consequently elicitation tools such as auto-photo-elicitations can be used as clues and a guidance tool for a rich discussion on the topic. Some comments regarding past memories and comparisons include:

'I feel comfortable to walk alone this area. But little bit quiet. As not many cars around here, not many people, although big buildings office around here. In comparison to my country most of the city areas have lots of people. This is

different to my country city spaces, completely different, we have narrow streets not big as here. I used to environment where people, lots of people, and now I come to very quiet. I feel a little bit comfortable to walk alone here.' (Asian, male student)

'So this is Hopetown Street. At this stage, I feel not safe as the other streets. Because it is of shadows and still dark. I can see little bit of light here and there.' (Domestic, female student)

Auto-photo-elicitation particularly appears to be a useful research method to bridge the gap between researcher and the researched. In word-only or sit-down interviews, the interviewer faces communication challenges with the interviewees (Harper, 2002). This is very true if the researcher conducts interviews with people in a different country who speak a different language/s and have a different culture. In this study, prior to the field work, the researcher being an outsider who spoke English as a second language with an Asian background and without much cultural literacy about the Australian way of life in a regional city context assumed that it was quite challenging to communicate with domestic students (Australian born) and lead the discussion on the topic. Auto-photos proved an important tool for bridging the communication gap as the photo facilitated discussion. It also appears that images also facilitated Asian students to better explain their reflections. This is evident when the researcher asked an Asian participant about his reflections on one of his SRW. In this instance, while reflecting on what made him uncomfortable to walk in this particular street, he referred to his photo as follows: 'This photo tells me everything what I told: vacant spaces and quietness'.

Another important potential showed in this study was that auto images tended to make the field research interesting. It was expected that each SRW and images would be completed within 10 minutes. The participants were asked to capture one image in each of site. However, the participants volunteered to take 3-4 pictures in each site and they wanted to explain why they took each and every photo. Therefore it took about 30-45 minutes to complete the discussion on each site. It was also noticed that due to the participants' interest in the images that they took, photos facilitated focused attention on the topic and elicited more information.

Although SRW and auto-photo-elicitation have many advantages in field research, it is important to highlight the challenges of these methods that future researchers may encounter. In this study, due to ethics requirements, the participants were informed that this study was about sense of safety. This may have led the participants to focus their attention on safety or fear concerns more often than would others under similar environmental conditions in the Bendigo CBD. This is a limitation to naturalistic studies (Nasar and Jones, 1997). In this study, in order to overcome this situation, the participants were asked to comment on more than clues that make them feel fear, unsafe and safe; they were also asked what they generally think about the setting.

Another potential challenge for researchers who wish to use these methods is that researchers have to expect unexpected environmental conditions that may disturb the field study and validity of the results. Such conditions cannot be avoided when researchers study real situations using tools of this nature. In this research study, when one SRW was about to commence, the researcher came across a roadwork scene in one of the sites and this site is usually a very quiet and poorly lit area. On this particular day, the researcher avoided the SRW in this street as it did not represent the real condition of the location. On another day, when an Asian male student was walking alone in a street, a drunken gang of boys suddenly parked their car in front of the participant and shouted at him. It was totally an unexpected situation and it was also intimidating. The participant was dumbfounded and consequently the field survey was delayed for some time until he was confident enough to walk alone. This highlights that the researchers need to anticipate that there might be events and environmental conditions that cannot be controlled.

A further challenge associated with the above-mentioned conditions, is that the researchers need to consider the security and safety concerns of participants when using tools of this kind at night. This is a limitation with regard to being prepared for adverse situations and for capturing the

real emotions of participants. Participants may not be very confident to walk alone while observing their surroundings and recording their views. In this study, when the participants walked alone, some commented: 'I want to pass this area as quickly as possible.' The researcher found that many (i.e., Asian females) were reluctant to participate in this study due to security concerns. It is believed that walking with another person, security person or police officer may improve the personal security of participants in the case of being attacked or experiencing threatening situations, but walking with someone else may not accurately reflect the participant's real emotions pertaining to the setting. In this study, in order to improve and address the security concerns of the participants, the participants were informed that the researcher would be following from a distance to ensure their safety. Further, this study employed an Asian female research assistant to improve the confidence of Asian females when Asian females walked alone in the sites.

Another challenge of these tools is that the participant may provide information that is irrelevant to the topic and they may not follow the instructions. As mentioned previously, when in the field, the researcher cannot influence or intervene in the process and the participants have freedom to comment on, or take photographs of whatever he or she wishes.

It could be helpful to future researchers to consider some other practical and technical considerations when using SRW and auto-driven photo-elicited interviews. It was found that it was useful to provide instructions relating to how to use voice digital recorders and cameras and how to change batteries. It may be useful to provide an extra voice recorder or camera. It is useful to ask respondents to bring mobile phones with them. Researchers also need to make arrangements with regard to time frame and collection of participants: how to pick them and drop them to home after the field survey if they do not have their private transport modes.

Concluding remarks

The reflections on using SRW and auto-photo-elicitation presented in this paper from a section of a recent research by the author, focuses on the association between environmental clues and fear of crime among students at night in a Central Business District (CBD) area of a regional city in Australia. In this paper, the achievements and constraints and the lessons learnt from SRW and auto-photo-elicitation as qualitative methodological components in studying students' sense of safety were documented.

Traditionally, questionnaires and word-only interviews have been mainly employed to investigate sense of safety issues of people in many parts of the world. The data derived from questionnaires do provide enormous amount of quantitative data as well as qualitative data. Questionnaires and interview data is useful for making correlations with variables that provoke fear or safety and for testing hypothesis. The findings of this study confirm that there are alternative ways to investigate differing spatial inequalities in relation to fear of personal security. SRW comments and auto-photo-elicitations also confirm that these methods facilitate researchers' understandings of the effect of different environmental features on individuals' perceived safety. Despite the practical challenges and constraints encountered, it is acknowledged that these methods provided qualitative data for describing and documenting participants' sense of safety and their spatial reference. The study findings indicate these methods are useful in studies that are empirical and phenomenological. It may be beneficial for researchers to employ these qualitative methods as such data may add strength and reliability to survey and conventional interviews.

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Industrial Hazardous Waste Management: Avenues for Collaborations

Gayani Karunasena

Department of Building Economics, University of Moratuwa, Sri Lanka

gayanik@uom.lk

RMNU Rathnayake

Department of Building Economics, University of Moratuwa, Sri Lanka

uthpalarathnayake@ymail.com

Abstract

As nations industrialized people benefited greatly from the advances in technology but with negative effects of pollution and production of hazardous waste. On the other hand, with growing demand for raw materials for industrial production the non-renewable resources are declining gradually. Disposing of any kind of waste including industrial hazardous wastes is a loss of resource as disposed wastes contain a lot of reusable substance of high value as one industry's hazardous waste could be resource to another industry. This paper aims to present a framework to manage industrial hazardous waste through a collaborative strategy in Sri Lanka. The study was conducted through survey approach and semi structured interviews were carried out to elicit relevant opinions from industry professionals and waste management experts. Content analysis was used to arrive findings of the research. Findings revealed that few collaborative strategies for industrial hazardous waste management are exist while more to implement.

Keywords: Industrial Waste, Hazardous waste management, Collaborative approach, Sri Lanka

1.0 Introduction

Globalization, rapid population growth and industrial development have led to the huge quantity of industrial waste during last few decades (Rai and Rao, 2005). The term industrial waste refers to all waste arising from industrial operations or derived from manufacturing processes (Jasem, Alhumoud, Fatima and Kandari, 2008). Industrial waste is broadly divided into hazardous and non-hazardous waste.

An industrial waste can be considered hazardous if its extract concentration exceeds maximum concentration of contaminants according to the toxicity characteristic leaching procedure (Tsai, 2010). Therefore, when hazardous waste dumped indiscriminately in any environmental media it readily contaminates surface and ground water and finds its way into food chains creating both short and long-term effects on both human and ecological systems (Misra and Pandey, 2004; Nelson, 1998). The need for a long-term management of industrial hazardous waste is obvious in terms of the impact upon the environment, and consequences for human health (Collier, 2003). Lal and Reddy (2005) stated that scientists and industrialists have made efforts to solve the challenging problem faced due to industrial hazardous waste including introduction of certain alternatives for disposing of the same waste.

Merely disposing of any kind of waste including industrial hazardous wastes is a loss of resource as disposed wastes contain a lot of reusable substance of high value. Launfenberg (1996) further added that these residual products could be transferred into commercial products either as raw materials for secondary processes or as ingredients for novel products. For examples, chemicals and chemical products manufacture industries sell their outdated products as secondary raw material in Turkey and Eckert (Salihoglu, 2009) and the substitution of hazardous waste-derived fuel for conventional fossil fuels in cement and aggregate kilns (Guo, 1998). There are short and

long-term benefits from utilization and recycling of Industrial Hazardous Waste (Haq and Chakrabarti, 1998). Alternatively, collaborative industrial hazardous waste management approaches can serve as an effective way of disposing such waste without causing ill effects. Thus, this paper intends to identify what are the potential avenues for collaborative industrial hazardous waste management in Sri Lanka.

2.0 Industrial hazardous waste and its impacts

Industrial hazardous wastes are special wastes that, being toxic, infectious, irritant, explosive, flammable, or having carcinogenic, teratogenic or mutagenic effects, are or may be harmful to human health or the environment (Vasillis, 2011). Cheremisinoff (2013) defined industrial hazardous waste as all non-product or product hazardous outputs from an industrial operation into all environmental media, even though they may be within the permitted limits. Therefore, industrial hazardous waste could define as an unwanted product aroused out of an industrial activity as a by-product or discarded material which has a potential of damaging to the environment and/or living beings.

The increased use of chemicals in the industrializing world has resulted in many residual hazardous substances. Waste produced due to increasing trend of consumption has reached to threatening levels in terms of quantity and hazardous content. In Lebanon an estimated 347 000 tons of solid waste 16 000 tons of hazardous waste are generated annually from 41 industrial zones (El-Fadel, Zeinati, El-Jis and Jamali, 2001). In China, the reported generation of industrial hazardous waste was 11.62 million tons in 2005, which accounted for 1.1% of industrial solid waste volume (Duan, Huang, Wan, Zhou, and Li, 2008). This emphasizes amongst industrial waste a considerable volume is hazardous.

According to the studies carried out by the Metropolitan Environmental Improvement Programme in collaboration with the Central Environmental Authority of Sri Lanka in 2003, it was revealed that, about 50,000 metric ton of hazardous waste is annually generated in Sri Lanka quantity wise (Weerasundara, 2013). Moreover, Weerasundara stated that the information is currently not available to readily figure the amount of hazardous waste being generated in Sri Lanka but only a rough estimate of 80,000 metric tons of hazardous per annum. Among this quantity, 65% are from various industries. According to the Central Environmental Authority of Sri Lanka (2013), the major hazardous waste generating industries in Sri Lanka are,

- | | |
|-------------------------------------|--|
| ▪ Agro chemicals repackaging | ▪ Pharmaceuticals |
| ▪ Waste oil handling and processing | ▪ Insulated cable and wire manufacturing |
| ▪ E –waste processing | |
| ▪ Tyre manufacturing | |

Therefore, hazardous waste management in particular has become a crucial issue for individual industries and for the industry and other sectors in Sri Lanka. Conversely, the volume is high or low, the Industrial Hazardous waste cannot be neglected because of its properties or characteristics (Wang, Hung, Lo & Yapijakis, 2004).

The hazards related to the industrial hazardous wastes may stem from various factors, including their ignitability, corrosivity, reactivity or toxicity (Huitema, 2002). According to the Resources Conservation and Recovery Act, these are the characteristics of industrial hazardous waste and if a waste indicates any of these characteristics should be treated as a hazardous waste (Texas Commission on Environmental Quality, 2011). Into the bargain, materials can turn out to be hazardous waste status if they are mixed with, or contaminated with, or are derived from, other wastes that are themselves hazardous.

Industry has become an essential part of modern society, and waste production is an inevitable outcome of the developmental activities. According to Haq and Chakrabarti (1999) the impacts from the industrial hazardous waste include but not limited to, degradation of lands, air pollution, ground water and surface water contamination, unpredicted risks to human health and loss of valuable resources. This was further assured by German advisory council on global change (2001), disclosing that industrial hazardous waste contribute substantially to air pollution, to localized impairment of the water quality of the oceans and to the conversion of coastal eco systems.

Humans, plants, and animals can be exposed to hazardous substances through inhalation, ingestion, or dermal exposure. Breast cancer, prostate cancer and childhood brain disorders are increasing at an alarming rate and the increasing rates of contamination and pollution have only furthered these health problems. Moreover, hazardous waste is a motive behind the rise in certain maladies like autism and learning disabilities (Dutt, 2007).

In addition, the cost linked with industrial hazardous waste has caused an impact upon the organisations. Philips (as cited in Gracia, Pongracz and Keiski, 2004) reported that the true cost of waste includes disposal costs, purchase cost of materials, handling/processing costs, management time and monitoring costs, lost revenue, any potential liabilities and post-disposal segregation. Thus, it is important to manage the industrial hazardous waste in a proper way to mitigate the impacts declared above.

3.0 Industrial hazardous waste management: Collaborative approach

To safeguard both individuals and ecosystems, specific waste treatment and waste minimization techniques should be systematically implemented throughout the waste management cycle: generation, separation, collection and recovery (Amador, 2010).

In determining on the superlative method for managing any waste there is a hierarchy for decision making which addresses issues for instance sustainability, cleaner production, health, safety, and environmental protection (Lee, 2013). As illustrate in Figure 3.1 current thinking on the best methods to deal with waste is centered on a broadly accepted hierarchy of waste management which gives a priority listing the waste management options available (Datta, 1999).

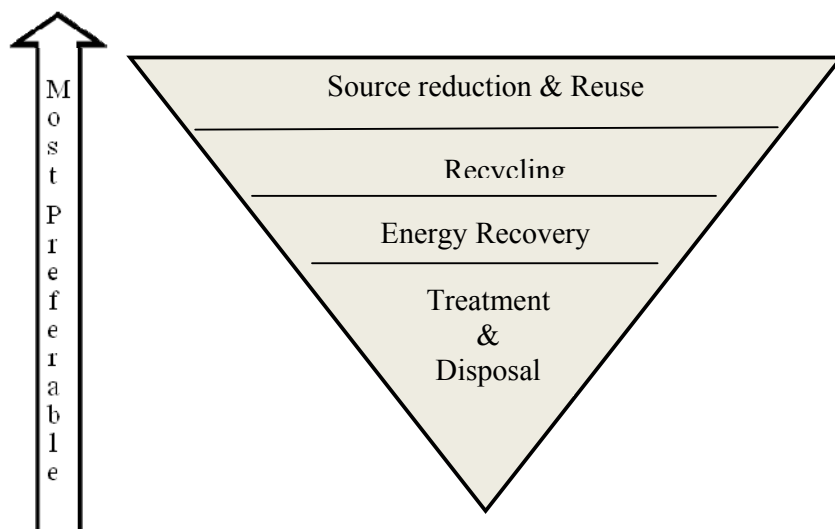


Figure 3.1: Waste management hierarchy

Source: Lee, 2013

The hierarchy directs the industrialists to develop their industrial hazardous waste management plans by first seeking to prevent the production of solid waste. When further elimination is not feasible, the industrialists would envisage actions that promote reuse. Subsequently, recycling options should be considered. The next action should be to energy recovery while treatment and disposal being the final. According to Muthukudaarachchi (2013), existing Industrial Hazardous Waste management performs in Sri Lanka are, dispose along with the Municipal waste, market the scrap containers, burning and thermal destruction. Moreover, Muthukudaarachchi argued that even though, there are some acceptable ways to manage the hazardous waste most of the industries' practice is to dispose the hazardous waste with the municipal waste.

Equally when the industrial hazardous waste avoidance or minimization is intolerable then the most acceptable way of managing such waste is reuse recycle or disposal in a correct way. The reuse, recycle or energy recovery can be done inside the same industry that generate waste or through another industry which has a need and the capacity of using such waste as a raw material or energy. Similarly, the waste generator can do the industrial hazardous waste disposal itself depending on the ability or through another organization which has the capability. The reuse, recycling, energy recovery or disposal of Industrial Hazardous Waste through an organization outside the waste generator is considered as a collaborative approach for industrial hazardous waste management. Figure 3.2 presents a collaborative industrial waste management system established in Kalundborg, Denmark. The system involves an oil refinery, a cement factory, a pharmaceutical firm, a coal-fired electrical power station, a plaster board plant and a construction industry. Kalundborg collaborative industrial waste management system eventuates within the closely located factories and it is not limited only to hazardous waste.

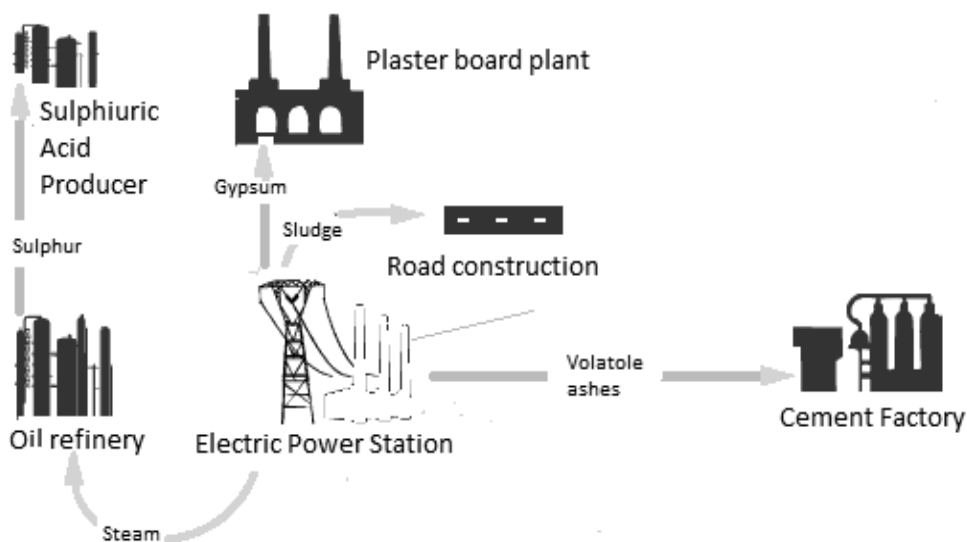


Figure 3.2: Collaborative industrial waste management Kalundborg, Denmark
Source: Peck, 2012

Many industrial hazardous wastes streams are or could be valuable raw materials for other industrial processes (Shen, 1999). Accordingly, the benefits associated with such collaborative approach for industrial hazardous waste management are,

- a. Reduced risk of liability
- b. Cost savings
- c. Improved company image
- d. Public health and environmental benefits

Many researchers have identified collaborative approach for industrial hazardous waste management as an effective method of managing such waste (Nemerow 2007; Haq and Chakrabarti, 1998). For examples, in Chile used oil and oil-contaminated materials are used oil as alternative fuel in high energy demanding facilities (i.e., cement facilities) (Navia and Bezama, 2008). Navia and Bezama (2008) found that spent oils in the mining facility used as raw material for the production of the explosives. Moreover, it was found that Bark, sawdust, and shaves produced in sawmill and wood remanufacturing facilities are recovered and burned in the different plant boilers for energy recovery. In addition substitution of hazardous waste derived fuel for convention fossil fuel in cement and aggregate kilns (James, Eckert and Guo, 1997).

Consequently, the said researches argued that the collaborative industrial hazardous waste management could happen in diverse conducts. The dropping use of energy and the use of industrial by-products as feed stocks for processes other than the ones that shaped them are central to this approach (Ehrenfeld and Gertler, 2007). Moreover, as illustrated in the Figure 3.3 the collaboration can be done directly within the industries or through an intermediary (Navia and Bezama, 2008).

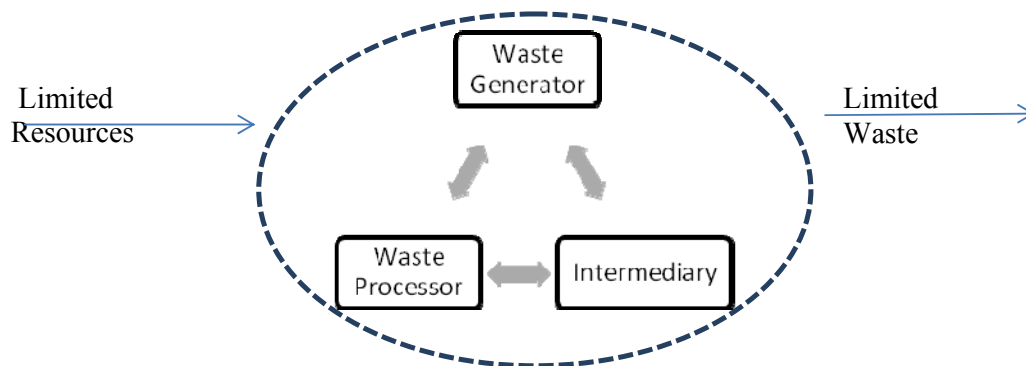


Figure 3.3: Schematic model of Collaborative approach

Jacobsen (2006) argued that manufacturing industries produce two kinds of wastes. One is basically sole material wastes, such as unused or dirty solvents, paints, or plastic or metal scrap. Further the said researcher stated such wastes can be used directly by other companies. The direct collaboration for industrial hazardous waste management is materialises in such cases. Figure 3.4 shows the schematic model of direct collaboration for industrial hazardous waste management.

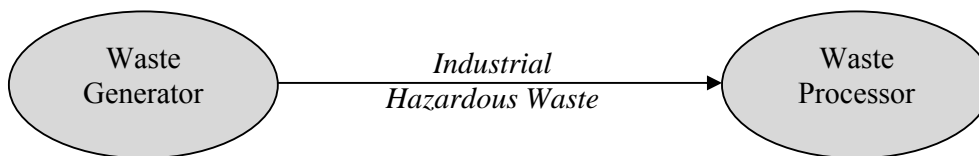


Figure 3.4: Schematic model of Direct Collaboration

Here waste generator is the industry that generate hazardous waste and the waste processor is any industry which can reuse, recycle, recover energy or disposal the waste generator's hazardous waste.

Nemerow (2007) stated that the concept of regional exchanges or markets for transferring hazardous materials from one supplier to another user is a novel and intriguing potential solution to the dilemma facing society.

Waste management through waste collectors is a different practice that comes under collaborative approach. Both informal waste collection and formal waste collection can include in the approach. Wilson, Velis and Cheeseman (2006) identified Itinerant waste buyers, Street waste picking, Municipal waste collection crew and waste picking from dumps as the informal waste collection whereas Bai and Sutanto (2001) identified the licensed waste collectors as the formal waste collectors. Haq and Chakrabarti (1998) described the collaborative approach as waste exchange. Moreover, Haq and Chakrabarti pronounced waste exchange is a simple process whereby the waste stream or waste products of particular industrial application are used or reused by another industry. Further, the said researchers divided the waste exchange into two approaches as Active exchange and Passive exchange.

Figure 3.5 further elaborates the types of intermediary approaches used in the world for industrial hazardous waste management. It should be noted that particular organisation can use both active and passive waste exchange approaches for the industrial hazardous waste management.

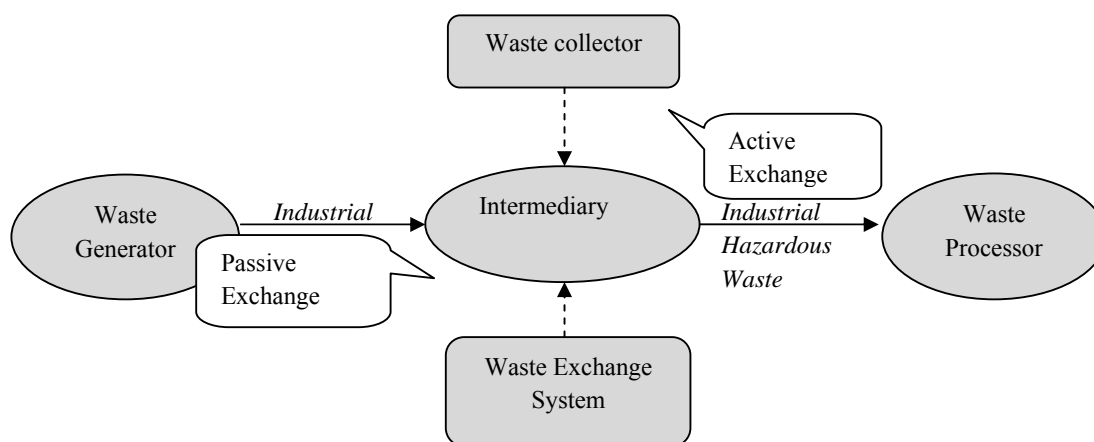


Figure 3.5: Schematic model of Collaboration through an intermediary

These are few examples for the collaborative approaches for manage the industrial hazardous waste used in the world. However, depending on the types of hazardous waste generate the approaches may vary.

Even though, the industrial hazardous waste can be managed through the collaborative approaches, the application of collaborative approach has limited to Waste programme and Holcim Lanka LTD in Sri Lanka. This situation may be a result of the challenges in implementing the collaborative approach.

Even the collaborative approach seems like a much tolerable option for manage the industrial hazardous waste in Sri Lanka it has challenged due to many reasons. The challenges or the

obstacles for the implementation of such approach are (De Alwis 2013, Worrell & Vesilind, 2011),

- Reluctance of industry – lack of pioneers
- Lack of enforcement
- Alternative options much convenient
- Organisational lethargy
- Location of waste - if the source of waste generator is too far away from the waste receiver, the cost of the transport can beyond the profit of waste usage as a raw material.
- Administrative and institutional constraints
- Uncertainty of supply
- Legal restrictions
- Uncertain markets

These are the probable barriers in implementing a collaborative approach for industrial hazardous waste management in Sri Lanka. However, to gain maximum output from a certain source and for the sustainable future these barriers should overcome.

4.0 Methodology

The survey method is adopted to find out the most appropriate collaborative approaches for industrial hazardous waste management in Sri Lanka. Semi-structured interviews were selected together relevant information from experts who involve in solid waste management and industrial activities because semi-structured rather than structured interview enable sufficient flexibility to approach different respondents differently while still covering the same areas of data collection (Noor, 2008). The sample size of the study was limited to sixteen as at that point the data requirement was saturated. Interview guidelines were prepared prior to the data collection. The design of the interview guidelines was done in accordance to capture the required data to analyze the research problem. The questions of the interview guidelines were developed based on the objectives of the study. While interviewing, note taking and tape recording were done to maintain the accuracy of data collection and avoid losing data as it is impossible to note down everything during the interview. The collected data were analysed using the content analysis technique.

5.0 Research findings

5.1 Generation of Industrial Hazardous Waste in Sri Lanka

Current practices on industrial hazardous waste management through industrial collaboration cannot probe without recognizing the varieties of Industrial hazardous waste in Sri Lanka. Literature identified the topmost industrial hazardous waste originators in Sri Lanka by industry wise.

Table 5.1 presents the gathered data on industrial hazardous waste generation in Sri Lanka by industry wise in year 2012. While the average hazardous wastage per annum taken through the data collected by interviews, the number of establishments in each type other than E - waste processing plants and Oil processing plants were taken from the published survey data of the Department of Census and Statistics Sri Lanka (The final survey on industrial establishments is done in 2011) assuming that there are no any new establishments after 2011. Number of establishments for E-waste processing and Oil processing was taken from the Government Information Centre of Sri Lanka. Moreover, the total wastage is calculated based on the assumption that the establishments in same industry sector have equal production capacity.

Table 5.1: Industrial Hazardous Waste Generation in Sri Lanka

Industry	Average Hazardous Wastage(Per Annum)	No of establishments	Total Wastage
Agrochemical repackaging	48tons	4	192 tons
Oil Processing	867 tons	2	1734 tons
Pharmaceuticals	22 tons	28	616 tons
Tyre manufacturing	117 tons	31	3627 tons
E-waste processing	432 tons	14	6048 tons
Insulated wire and cables	528tons	4	2112 tons

Sources: Department of Census and Statistics Sri Lanka (Annual Survey of Industries), 2011; Government Information Centre of Sri Lanka, 2013

Literature revealed 50,000 metric ton of hazardous waste is annually generated in Sri Lanka. Figure 5.1 presents the ratio of contribution from each industry to the total Industrial Hazardous Waste production.

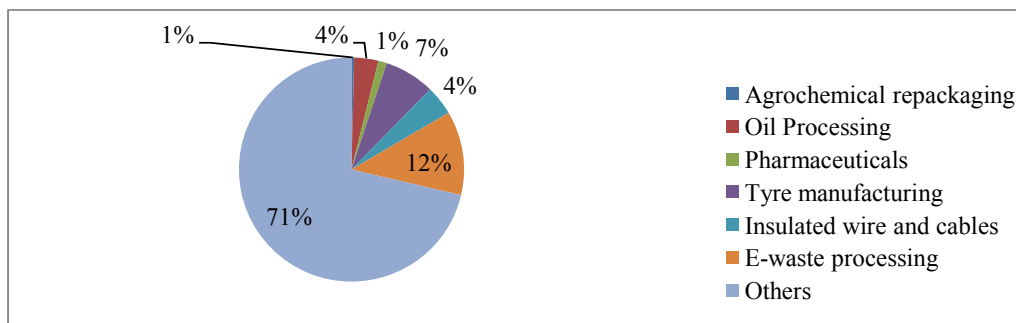


Figure 5.1:Sectorial hazardous waste distribution

The study found 16 types of hazardous waste. Some of these waste types are communal to all industries investigated, some are communal to several industries whereas some are germane only for a particular industry. As an example Chemical contaminated waste is common to all industries, Copper waste is common to E-waste processing and Metal manufacturing industries whereas Tyre waste is only applicable to Tyre manufacturing industries. Table 5.2 presents the findings on types of industrial hazardous waste generation in Sri Lanka.

Table 5.2: industrial hazardous waste generation in Sri Lanka

Industry Type of hazardous Waste	Agrochemical Repackaging	Waste oil handling and processing	E - Waste Processing	Tyre Manufacturing	Pharmaceuticals	Insulated wire and cables
Metal chips			✓	✓		
Contaminated containers	✓	✓	✓	✓	✓	✓
Agrochemical Packaging	✓					
Aluminium Dross						✓
Aluminium Alloy						✓
XLPE						✓
Aluminium			✓			✓
Copper			✓			✓
Oil Sludge		✓		✓		
Used oil		✓		✓		
Pharmaceuticals					✓	
E - Waste			✓			
Tyres				✓		
Grease				✓		
Chemical Sludge	✓	✓		✓	✓	✓
Chemical Contaminated Waste	✓	✓	✓	✓	✓	✓

The study revealed that chemical sludge, chemical contaminated containers and chemical contaminated waste have a high impact of industrial hazardous waste due to chemical applications in most of the industries. In addition, even though Aluminium Dross, Aluminium Alloy and XLPE is generated only from the Insulated wire and cables manufacturing industries they also has a high impact due to their quantity of generation. For example ratio of XLPE wastage in an insulated cable and wire manufacturing plant is 3% out of their total production.

It was discovered that most of the industrial establishments in the same industrial category follow the same production routes to develop a product outcome. Resultantly, the types of waste generated are similar to each other in the same industry category. Nevertheless, the study found that the method of industrial hazardous waste management in an establishment could vary to another despite the fact that the types of waste are common to both. Certain establishments practice planned waste management systems while some are not. 3R (Reduce, Reuse, Recycle) concept, energy recovery, open dumping and land filling were the most well-known waste management systems. Moreover, study found that Reuse and Recycling is taking place within the same industrial processes and as well as between different industrial establishments.

5.2 current collaborative industrial hazardous waste management systems in Sri Lanka

The study found the current collaborative industrial hazardous waste management systems in Sri Lanka directly within the industries and through an intermediary. Some industrial establishments follow the both approaches. Further, the study revealed that collaborative industrial hazardous waste management through an intermediary transpires in two conducts: Active exchange and Passive exchange. However, it depends on the type of the waste and the waste processing industry.

5.2.1 Collaborative Industrial Hazardous Waste Management directly within the industries

If an industrial establishment directly passes their waste to another for a waste utilization or disposal, without any intermediary it is considered as the direct collaborative industrial hazardous waste management (Section 3). As mentioned above the study revealed that most of the collaborative industrial hazardous waste management approaches eventuate directly within the industries. This happens in keeping with a contract between the waste generator and the waste processor. The waste consignment may be for a monetary value or for indisputability.

The identified existing collaborative industrial hazardous waste management approaches directly within the industries are shown in the Figure 5.2.

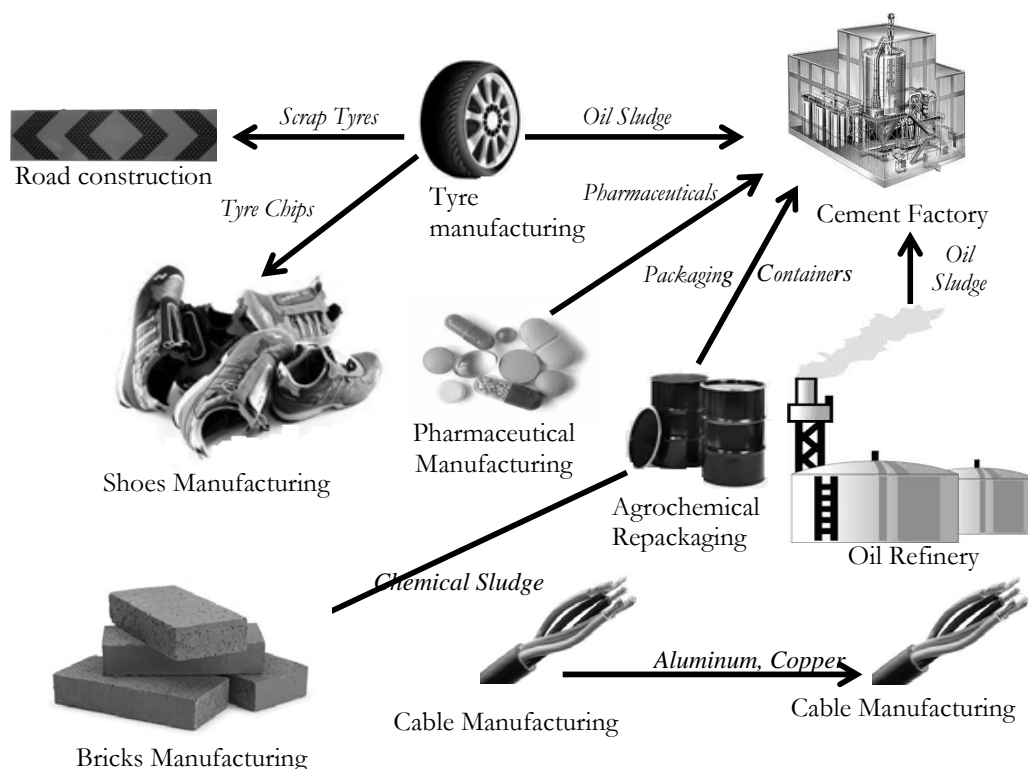


Figure 5.2: Existing collaborative industrial hazardous waste management approaches directly within the industries

5.2.2 Collaborative industrial hazardous waste management through an intermediary

Literature recognized that the collaborative industrial hazardous waste management through an intermediary could occur in two ways: Active exchange and Passive exchange. Through the data gathering, it was found that Collaborative Industrial Hazardous Waste Management through an intermediary in Sri Lanka transpires in the both ways.

Active exchange: Through waste collectors

The study found that some of the factories sell their waste to waste collectors who act as intermediaries. The waste collectors sell the collected waste to the potential users for a commission. Figure 5.3 shows the existing collaborative industrial hazardous waste management approaches through waste collectors.

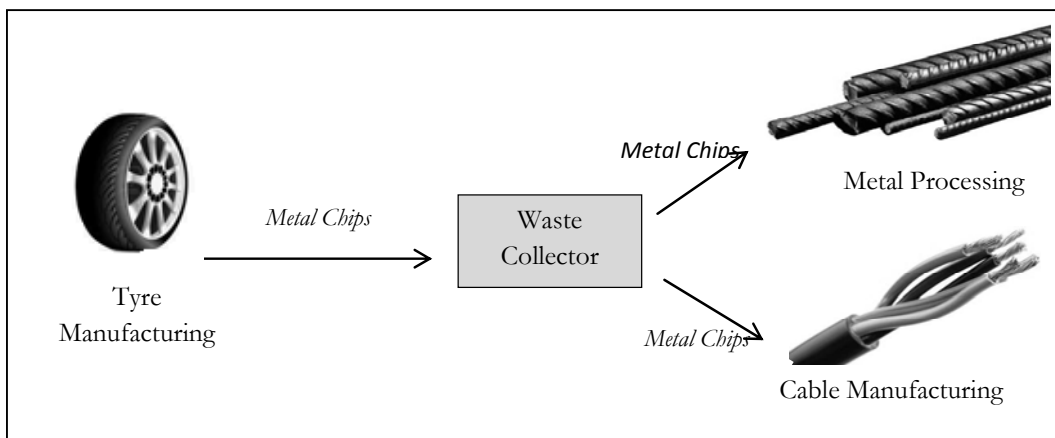


Figure 5.3: Existing collaborative industrial hazardous waste management approaches through an intermediary (Active Exchange)

Passive exchange: Through a Waste Material Exchange system (WasteX)

Passive exchange can define as a centralized station for collecting, displaying and disseminating information about wastes available from generators and wastes required by potential users. As illustrated in Figure 5.4 'WasteX' is an open source web based programme that affords detailed information on industrial waste material available to enable possible waste collection, management, re-use and recycling. This provides the industries with a platform on which they can publicize what waste materials they have for trade or necessitate. Basically, the project enables the exchange of industrial waste between waste generators and waste management organisations (Waste processors) in Sri Lanka.

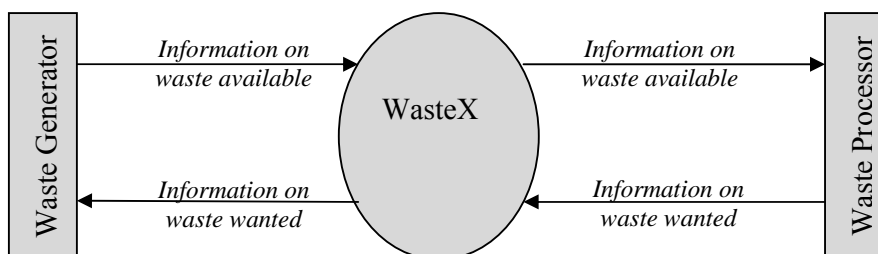


Figure 5.4: Waste exchange scenario through WasteX

The study found that in the initiation of the project in 2010, eight organisations were registered in it. Presently some of the investigated organisations do not have any idea on 'WasteX' while particular experts expressed the indication that at present no one is involved in it.

6.0 Proposed framework for industrial hazardous waste management through industrial collaboration

The study divulged 16 number of hazardous waste types. Moreover, it was identified that this waste is managed in dissimilar ways in diverse industrial establishments. Moreover it found that even the industrial establishments in same industrial category generates the same types of waste the method of managing may differ to each other. Therefore, one establishment may manage the industrial hazardous waste in a collaborative method while others manage them within the plant

or has no any managing method other than open dumping or land filing. Therefore, as illustrated in Figure 6.1 the developed framework for industrial hazardous waste management through industrial collaboration includes the existing approaches too. The framework was developed by means of expert's accepted wisdom, existing tactics together with the literature findings. Moreover, it proposes alternative options for the current collaborative approaches. The proposed methods can be practiced directly within the industries or through an intermediary.

Moreover, the initially designed framework was analysed by the industrial hazardous waste management experts and the evaluated framework is presented. The experts evaluated the framework based on economic feasibility, technical feasibility and environmental feasibility.

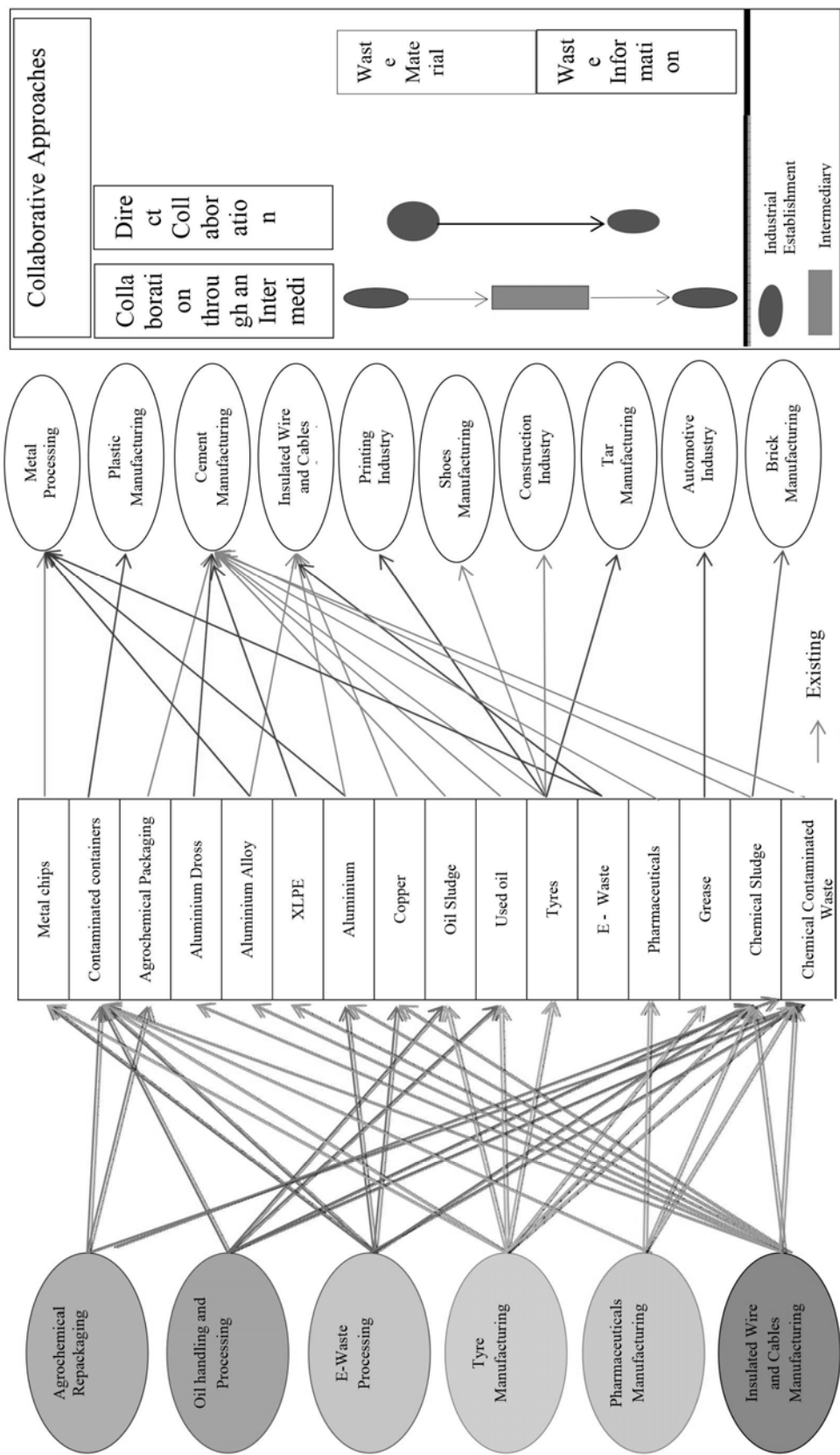


Figure 6.1: Framework for industrial hazardous waste management though industrial collaboration

7.0 Conclusions

Improper management of Industrial hazardous waste creates problems to the environment as well as living beings. The cost associated with the proper management of industrial hazardous waste may high due to its characteristics. Therefore, the study was conducted in order to find the ways of collaborative industrial hazardous waste management within the industries. Findings revealed that in present there are many collaborative stratagems directly within the industries and/or through an intermediary are working while more opportunities to awaken. Accordingly, the literature findings together with the experts' ideas the suggestions for improvement were developed. The study recommends the industrialists to consider the suggestions for industrial hazardous waste management for a cost effective, sustainable business operation.

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Political-Geographic Scales of Environmental Injustice: Understanding the Flood-Affected Neighbourhoods on the Banks of the Kelani River in Colombo

J K H H Perera

Department of Town & Country Planning, University of Moratuwa, Moratuwa, Sri Lanka
hiruniperera56@gmail.com

C.C. Abenayake

Department of Town and Country Planning, University of Moratuwa, Sri Lanka
abenayake@yahoo.com

Abstract

Environmental injustice has become a detrimental reality in urbanizing developing world. Branding of communities as 'encroachers' due to the absence of property rights has caused insecure rights to clean air, safe drinking water and live in a safe environment. This shows that the term 'property rights' is mis-defined as 'right to life'. The observable small geographic extent of the problem tends the decision makers to recognize that as a minor issue at neighborhood pockets but the author's reading argues such places as icebergs which cover the unseen broader geographic context. This study emphasizes how the negligence of the broader geographic context made many decision makers fail to address the burning issues exists at these vulnerable urban pockets.

The research has been built on the empirical evidences of two community groups which reside in frequent flood prone area as well as adjacent to a solid waste disposal site in the banks of Kelani River. This narrates the people's attempts to obtain their right to life through continuous attempts to cope, survive and adapt to environmental injustice. The revealed complexities of political-geographic boundaries urge to rethink the urban planners' perception of the scale and in that light to offer the duly importance to the issues of environmental injustice of the poor urban settlers.

Keywords: *Environmental injustice, community response, geographic scales*

1. Background of the study

In November 2013 I attended a presentation that was made to a plenary of urban planners in Sri Lanka about the environmental injustice confronted by the flood-affected communities who reside on the Kelani river banks of Colombo. The first part of the presentation explained the ecological crisis raised by floods and solid waste dumping in flood prone areas, while the second part discussed the community responses to adapt to this ecological crisis and socio-political processes influencing their responses. At the end of the presentation, there were three questions pointed by the plenary of urban planners. First, do these people have legitimate ownership to property? The question directed to a conclusion which implies that absence of property rights can challenge their human rights as to live in a non-harmful environment. Second question was, whether they live in a planned settlement which is a decision of urban planners or in an encroached land which is a choice of the settlers. The question implied an answer as if it is an encroachment then that is a mere individual's decision and planners do not have a responsibility. The third question was 'That is a way of environmental activists to enlarge negligible issues as of a national importance. Being a planner, do you think these minor issues are of importance at any level of planning (i.e. national, regional and local levels)?'

This paper is driven by the last two questions which largely ignore the broader socio-economic context which forces flux of the individuals to take undesirable decisions about their place to live; and the influence of political-geographic boundaries to neighbourhood level issues which question the urban planner's nomenclatures of mere geographic scale. 'To fully examine equity issues [environmental injustice] we need a more systematic analysis of what constitutes an equity

problem (what parameter do we measure), what is the appropriate scale for examining equity (which spatial unit of measurement), and what time-frame should be considered in looking at the causes of equity or its' spatial consequences (Susan L. Cutter, 'JDanika Holm: and Lloyd Clark', 1996)'. In such a milieu, this paper attempts to explain how political geographic scales expand over the physical limits of neighbourhoods, referring the environmental injustice the realities of two selected neighbourhoods along the Kelani River, Colombo.

1.1. Environmental injustice as an emerging concept in the field of urban planning

A healthy living environment is a basic right of all the Earth's inhabitants, a right reaffirmed by the Rio declaration (UN, 1992). When applying this concept by the United Nation in global context it defines the right of enjoying a healthy environment for every individual and local community. Thus environment justice became one of the guidelines to public decision making (Susan L. Cutter, 1995, p 1)

Political ecology is the study of conflicting social groups with different political powers projected on to a specific environment. It includes geographical scales that are simultaneously local, regional and global, a social scale that ranges from individuals to larger social groups, and to the interrelationships between developing and developed countries (Hosuk Lee, 2009, p.33).

Thus, in what is certainly the most widely cited statement of the principles of early political ecology, Blaikie and Brookfield (1987) defined the field like this: "The phrase "political ecology" combines the concerns of ecology and a broadly defined political economy. Together this encompasses the constantly shifting dialectic between society and the land-based resources and also within classes and groups within society itself" (Blaikie and Brookfield, p.17).

"The field of environmental justice can provide a practical base for political ecology" (Hosuk Lee, 2009). Political ecology, an approach to, but far from a coherent theory of, the complex metabolism between nature and the society (Johnston, Gregory *et al.* 2000). Political ecology becomes a study of different social groups with different political powers in a specific environment. These specific environments can be different geographical scales as local, regional and national levels. This social scale can be ranged from individual to large social groups. Moreover political ecology is also the study of marginalized people, environments, and regions (Hosuk Lee, 2009, p 35). In such context, political ecology has a direct relationship with environmental justice. Therefore, it has the ability to address the problems of environmental degradation and social marginalization for some certain levels with the bonding of environment justice. In addition, urban political ecology focuses more on justice issues. A just urban socio environmental perspective, therefore, always needs to consider the question of who gains and who pays and to ask serious questions about the multiple power relations through which deeply unjust socio environmental conditions are produced and maintained (Swyngedouw and Heynen 2003).

Thus, when considering the said environmental justice and political ecological perspective with respect to the urban planning, it becomes a strong concern in successful planning.

1.2. political geographic scales and environmental activism

This research concerns the broader socio-economic context which forces a flux of the individuals to take undesirable decisions about their place to live and the influence of political-geographic boundaries to neighbourhood level issues on environmental injustice face by low income minority communities. Scrutinizing such a situation calls for the need of comprehending the overlapping geographic scales.

The convenience of geographical scale within environmental justice movements has been addressed in a number of situations. "The continuous reorganization of spatial scales is an integral part of social strategies to combat and defend control over limited resources and a struggle for

empowerment' (Swyngedouw and Heynen 2003). 'Struggles over scale are not simply over who controls a given territorial unit, but about the scale at which that unit is defined (Herod 1991, 1997).'

Social movements scholarship highlights the ways in which scale inflects the environmental justice activism, and recent works in geography on the scaled politics of environmental justice activism lays important groundwork for closer examination of the practices that comprise a politics of scale....(Buell, 2001; Capek, 1993; Szasz, 1994; Sandweiss, 1998). Towers (2000), for instance, argues that the environmental justice movement is defined by scale, or more specifically by a tension between local scales at which grass-root protest over unwanted pollution takes place, and the broader geographic scale at which the discourse of environment justice is directed. (Holifield R, Porter M, Walker G: p,7)

It is by now widely recognized that 'geographic scale' is socially (i.e. politically, economically, and culturally) constructed. As Delaney and Leitner (1997) write: 'The common ground of this body of research is that geographic scale is conceptualized as socially constructed rather than ontologically pre-given, and that the geographic scales constructed are themselves implicated in the constitution of social, economic and political processes'(also see Marston 2000; Smith 1990). Scale has become increasingly important in studies of environmental justice, although the emphasis has most often been on the manipulation of scale as a political strategy for grassroots activists (Cutter, Clark, and Holm 1996; Kurtz 2003; Towers 2000).

Accordingly, it urges the need of rethinking the socially constructed geographic scales when responding environment activism. The following case study is an attempt to explain the political geographic scales of a neighbourhood community resides in flood prone areas of the Kelani river, Sri Lanka.

2. Environmental injustice issue of Kelani river bank settlements

The downstream of Kelani River which flows at the northern border of Colombo city is densely populated but severely affected by pollution, salt water ingress and flooding (Figure 3.1.).



Figure 3.1: Selected river strip to carry out survey

In this paper, the magnitude of the environment injustice that experienced by the settlers of Kelani River banks was addressed referring to the water pollution levels, frequency of flooding, air quality, noise level and access to sanitation. Accordingly, Sedawaththa was selected as the case study. This is an empirical study which gathered facts through an intensive field survey that includes direct observations, in-depth interviews, Key Informant Interviews and focused group discussions.

This stretch of the Kelani River is highly polluted and water users for daily needs are suffered the most. Many of the pollution sources such as saw mills, container yards, laundries are also located within the neighbourhood. There is a huge garbage dumping site next to the settlements and the polluted canal of Kiththampahuwa too flows through this site. The existing marsh is reclaimed by people to put up houses and aggravate the floods (Figure 3.2, 3 and 4).



Figure 3.2: oiled mix black coloured water in Kelani River



Figure 3.3: Laundromat in river reservation



Figure 3.4: garbage dumping site in the marshy land and Kiththampahuwa Ela in the site

Sedawaththa is a high density residential area where more than 700 families suffer from environmental issues. Many of them are known to be as under-privileged, less socially empowered community groups who settled in over congested poor quality housing. More than 80% of the dwellers are labourers who work for daily wages.

3. Community responses to Environmental injustice

3.1 Environmental Injustice in Sedawaththa; community perceptions

Settlers in Sedawaththa experience everine floods that occur twice a year and frequent flash floods that occur during monsoon rain. Height of the flood that occur frequently is about 1 – 2 feet but for a continuous rain it increase up to 3- 4 feet completely inundating the single storied houses. Flash floods at least exist for three hours whereas annual floods remain for about one week. The highest recorded flood which has occurred in 1989 is 12 feet in height and existed for two weeks. 4 feet flood is capable enough to fully destroy a single storied house constructed with temporary and discarded materials. That situation compelled people to be evacuated and they put up temporary shelters in non-flooded areas. Out-door labourers and their dependents are highly susceptible to flood because many of their daily income is low during rainy seasons as they find difficulties to do outdoor labour works in rain. Flooding in rainy seasons incurs additional costs to them in a situation where they find it is extremely unaffordable.

There are recorded post-flood health threats including mosquito borne diseases as Dengue fever, Malaria and waterborne diseases. 'After walking in the flood, rashes appear in legs...this flooded water is really harmful' (Grama Niladhari, personal communication, 2012). Overflowing septic tanks, mosquito breeding grounds in marsh and garbage dumped open areas increase the threat of post-flood health hazards. The oil spilled surface water in Kiththampahuwa Ela which is blocked by garbage is also harmful to the community.

'this flood affects very badly for the properties too...The oil which mixes with flooded water always remains in the walls as black and brown coloured patches...' (Government retired person, personal communication, 2012)

This community lives nearby an open-dumping yard of municipal solid waste over a long period of time. Nearly 20 -30 tons of garbage is dumped to the yard each day. Garbage dumping site makes the flood more unhygienic. There are plastic cups, bags, tyres, coconut shells which act as the breeding grounds for mosquitoes. Garbage dumping has caused to increase the number of stray dogs, flies and crows within the neighbourhood.

‘There are some days that we can’t go outside from the house because of the bad odour... We can’t do anything. We stay inside the house by closing all the doors and windows...It is hard to control the mosquitoes even by using mosquito coils, nets and sprays. (Sumanawathi, personal communication, 2012)

The frequent floods that spreads polluted water and the dumping site together has created an environmental crisis that threaten the lives of settlers. Amongst, how do they respond to the threats? Do they passive recipients?

3.2.Environmental Injustice in Sedawaththa; Community Responses

Local community make a range of range of efforts to cope up with the situation. Their responses can be seen at individual, family and community levels.

For the majority of people whose houses are single storied there is no other option than evacuating the house in a flood. ‘.....If we feel it is going to flood then we lift our furniture and leave from the house.....’ (Kumara, Personal communication, 2012).

Community has a strong support from army soldiers to be securely rescued but sometimes it limits the options as where could they put up temporary safe shelters. Many of the government officials’ responses are piece-meal solutions that allocated subsidized food and dry rations. GramaNiladhari is the mediator in the distribution of food and dry rations yet there are some people who question the accountability.

‘In flooded times politicians say that they sent aids but we never get them because they provide aids to the affected people by their representatives..... Only the people known by them will be received aids well. Others receive nothing.’ In response, the GN officer mentioned that many of them are not registered citizens of the Sedawaththa GN who are not eligible for subsidies.

In some occasions, the dwellers make small interventions that reduce the loss. Dwellers are used to have mosquito nets and coils to minimize mosquito borne diseases. They apply kerosene oil on the floor (especially at the kitchen) to minimize flies and also cover food without letting to exposure to flies. These small scale interventions exist among most of the housewives and they said that when somebody takes the first step to minimize the adverse situations, the rest join with that practice.

‘There are plenty of times that we have gathered and cleaned the Ele (canal) by collecting 200 rupees from each family.’ (Sriyani, personal communication, 2012).

‘There are Buddhists, Catholics, and Hindus who live this neighbourhood...They have a unity. But the outer powerful influences, tries to demolish this situation. Those people get together in any case like flood. They help each other. I provide them a place to stay here when they become helpless’ (Monk of the temple, personal communication, 2012). People have related to temple and it is always ready to welcome those who need help with hospitality.

A multinational company which has a container yard in this neighbourhood has been mentioned in community discussions as the main polluter that discharge oil and other effluents that mix into flood.

In response to that point, a speaker of the company mentioned that 'We do not do anything to increase flood. That comes from the river and according to the way of building up those settlements. If something happens to them it is only due to the mixing of oil to the water. Our hands are clear and we have not done anything to trigger floods. We also clean this channel when they inform us about it by spending our own money.' (An executive officer of the Company, personal communication, 2012)

The garbage dumping site collects waste from Mahara and Peliyagoda local authorities and the site is operated by a private company.

In response the questions, a speaker of the company mentioned that 'We, as the owners of this property... have initiated this as a composting site of municipal solid waste. We offered some job opportunities to local people in segregating and drying waste. But later because of the inability of earning profits from making compost, we compelled to stop. The project caused a lost of 4 rupees for each 1kg of compost. Therefore, now we practice open burning of waste. We have a plan to improve this in a more efficient way in future.' (An officer of the Company, personal communication, 2012)

They further mentioned that they address all the problems which may arise through the site. Whenever the community complains about the problems of the site, then they take necessary actions to cover the garbage from soil and if the canal is blocked with the garbage then they clean it.

Do they really act on complaints of people or do not community make complaints?

They themselves tempt to complain who should take the responsibility of the damages like oil leaking, garbage disposal etc... But most of them wait for others to initiate the action though they willing to take-part.

'...How can we tell them? We don't have any connection with them. If somebody leads this then we also join them. We can't directly connect to the situation well. It is useless.' (Mr.Ranjith, personal communication, 2012)

This is because of their less power to fight with other external influences. Therefore, most of the times the informal leaders of the community groups lead this but some dwellers say it is also useless.

'...Do you think it is only one time? We have informed this to them several times. (Complaints to responsible authorities) They don't do their job properly.' (Mr.Ranjith, personal communication, 2012)

The strong social cohesion within the neighbourhood has made them stronger in their response. When the situation is getting worse, community talk to the responsible government authorities. There are no formal organizations and when some actor/s of the community take the first step then others gather around him/them.

'When we go to talk to the responsible people in the company regarding this; they promise to take action. Later they offer bribes to some of the people and disapper problems (Kumara, personal communication, 2012) There are some people who work in the container yard. Some of them have used to use this garbage site to find their main income of living.

'Most of those people are controlled by powerful hands of political animators. Therefore they think those people who have the power are the only one who can manage everything. Therefore, dwellers tempt to inform the situation to politicians rather than to the responsible government authorities. When we try to mediate and solve the problems with police or other responsible

authorities then the situation becomes worse. Therefore, we also sometimes face difficulties in solving the problems....' (Gramaniladhari, personal communication, 2012)

There are many complexities in this response in the presence of powerful political and corporate actors.

'Of course there are some people who only depend on this garbage site by *selling pieces of iron, meta*etc....(Income) But most of them are people who cannot earn enough to eat. And also the people who got addicted to drugs also try to find money selling whatever they find from this...Some of such people consider this waste hill as the top most asset they possess' (Ranasinghe, personal communication, 2012)

The community is not passive recipients to the environmental injustice rather they do respond. However, their responses are tiered with number of actors; complex bonds in a wide social network.

5. Scales and counter-scale framing of the environmental injustice

According to the responses to the observations, it is clearly apparent that the people continuously attempt to create a healthy and safe environment in different manners. These responses are varying according to different levels of the organizing capabilities of the community as neighborhood level, local level, regional level and national level. Yet it is pointless to identify these responses without recognizing their connections over complex social networks and broader geographic boundaries.

These problems are linked with many factors beyond the neighborhood limits. Floods have been aggravated due to the changes in upper catchment and the pollution of KiththampahuwaEla is also out of the activities taken place in the neighborhood.

As some of these problems are bonded with the multinational level stakeholders they have high financial and political power which local stakeholders face difficult to challenge. Therefore, even the actors who can take the actions at local level become helpless in front of these high-handed authorities. Therefore, although the problem exists at a neighbourhood, its' roots go beyond. This situation has refrained many people from taking actions even though they want to act. As many responses are beyond the limits that the local stakeholders can play, the crisis remains unsolved and urges for a strategically planned spatial response.

6. Conclusion

The main objective of the research was to identify how political geographic scales expand over the physical limits of neighborhoods, referring the environmental injustice realities of two selected neighborhoods along the Kelani River, Colombo.

The research has been built on the empirical evidences of two community groups who reside inside an annual flood prone area and adjacent to a solid waste disposal site respectively. After a pilot survey, it was decided to collect the empirical evidences through observations, interviews and questionnaire surveys. But in the real situation it was much harder to achieve the target by questionnaires with the selected community. There it was accomplished by focus group discussions. And also depth information was able to be collected from key informant interviews, in-depth interviews and direct observations from community as well as from other key stakeholders.

The findings of the study revealed that with this existing environment they are struggling to carry out their daily rooting somehow. But many of them are not capable to avoid the occurrence of

floods and pollution although they make strong attempts to save their lives, assets and livelihoods being affected. Many such responses are small interventions, which are not significantly apparent but continuous.

This community is relatively weak in power as they represent the lower level of political geographic scale. This also has become a root to minimize their actions regarding the unfair situations in their own environment. Moreover there is a powerful political power which is strongly connected with the garbage dumping site. More than half of the community is adapted to that and therefore community leaders lead the neighborhood according to their manner. However there are many powerful actors involved with them who suppress the community actions as external and internal powers from higher scale.

Nevertheless the responses of stakeholders are hard to identify through a clear cut boundary of a political geographical scale. Each of those responses is combined in different ways together in certain geographical scales as there is a relationship between lower levels of the community into higher community levels or due to lower political geographical scale into higher political geographical scale. Thus the roots for the recipients' problems are sometimes going beyond the neighborhood level. Although the problems arise in the neighborhood it combines with local, regional and national levels. As a result of this the solutions may also go beyond the lower level to the national levels.

These research findings partially answer the failure of the resettlement schemes made by planners for vulnerable urban groups as they all know that they are vulnerable still settled by choice and attempt to cope-up. And also being a planner these issues must be considered well without considering only on the specific frame level of planning. Which menace in a decision making process, the answers always lay beyond the limits we exactly identify. Most of the time it runs across the other levels of planning too. Therefore we need to focus on minor issues too at any level of planning.

This report has mainly focused on few aspects as the community response of the field of environment justice and their situation, political geographic scales frameworks of environmental justice and activism etc... Furthermore through this research it could be found out the way of solving urban environmental injustice problems of land use planning system with respect to political geographic scales. Therefore I would like to recommend examining the current planning guidance taking into consideration the geographical scales of physical planning. It also can recommend investigating of the best practices of community to achieve environmental justice. And also for the further examination from this research it has the ability of examination of social, political and geographical structures that may breed injustice and associated problems in sustainable planning system.

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A Study on the trends of rainfall and temperature patterns to identify the influence of climate variation in coastal cities in Sri Lanka

P.K.B.D.B. Bandara

Faculty of Architecture, University of Moratuwa, Moratuwa, Sri Lanka
dilekabandara@gmail.com

C.C. Abenayake

Department of Town & Country Planning, University of Moratuwa, Moratuwa, Sri Lanka
chethika.abenayake@yahoo.com

A.B. Jayasinghe

Department of Town & Country Planning, University of Moratuwa, Moratuwa, Sri Lanka
amilabjayasinghe@gmail.com

P.K.S. Mahanama

Faculty of Architecture, University of Moratuwa, Sri Lanka,
mahanama_pks@yahoo.com

Abstract

Climate change has been universally recognized as a fundamental human development challenge in the 21st century and also it impacts both natural and built environments. Since different parts of the world have predicted to be affected by climate change in varying degrees, many of the studies are focused on climate change in global or region level. However, there is a dearth of climatological studies addressing the temporal trends in rainfall and temperature at city scale. On other hand, recent rainfall and temperature extremes have adverse impacts on the natural and built environment of most of coastal cities in Sri Lanka. In this context this research attempted to examine trends of rainfall and temperature patterns over the last four decades in seven coastal cities (namely, Rathmalana, Hambantota, Trincomalle, Puttalam, Katunayake, Batticaloa and Galle) in Sri Lanka to understand whether they support to claim the long-term climate change by identifying temporal trends in the rainfall and temperature during the period of 1971-2011. The findings of the study revealed average overall stations, the indices of temperature extremes indicate warming of both daily minimum and maximum temperature between 1971 and 2011. For precipitation, most of the indices show significant changes. Relative to the changes in the total amounts, there is a very significant change in the precipitation extreme days. Accordingly, this study emphasized the need of integrating the climatic variations wisely in the urban planning can invest the capital of the country to the development rather than unnecessarily spend it on post disaster rehabilitations.

Keywords – Climate variation, Rainfall and temperature trends, Coastal cities, Urban Development

1. Introduction

Rational scientific analysis of climatic factors or climatic dimensions and its practices seems to be ignored in the urban planning (Hebbert and Mackillop, 2011) and its relevant decision making process in both developed and developing regions considering climate as un-influensable factor in urban planning. Yet in the history our ancestors had taken the maximum benefits from the knowledge and experience they had about the climate and its variations in ancient city planning as many of the urban designs of the ancient civilizations originated with the geomantic understanding of the relationships between built forms and climatic factors as sun, rain, wind etc.

Yet at present, ignoring the climatic factors in urban planning has already influenced the modern developing and developed world as rapidly expanding urban settlements in the world are and will continue to face severe climatic risks in light of climate change specially in the category of

developing regions. Urban populations will increasingly be forced to cope up with increased incidents of flooding, air and water pollution, heat stress and vector-borne diseases (Wilbanks et al. 2001, Parry et al. 2007). Specially the cities in developing countries are at particular risk due to their high density populations rather than the developed countries (although the developed countries contributed to the extreme causes of the climate change), a lack of adequate drainage channels, a concentration of solid and liquid waste, expansive informal settlements and urban expansion onto risky sites.

In the twentieth century, the global average temperature has risen 0.6 degrees Centigrade, and even given aggressive measures to curb greenhouse gas emissions, scientists expect an estimated 2.2°C additional rise by 2100, with temperatures continuing to rise for centuries thereafter. This can have a direct effect on human health and energy use (IPCC, 2001c), particularly in urban areas, where it is exacerbated by the heat island effect. Mean sea level has risen 10-20 centimeters in the 20th century, due to glacial melting and the expansion of sea water as it warms. While the specific amount of melting is difficult to predict, the IPCC expects 30-50 centimeters of sea level rise by 2100 (IPCC, 2001c). This is a critical issue for major cities, which tend to be clustered near coasts, particularly in developing countries. Even in Europe, 70% of the largest cities have areas that are less than 10 meters above sea level (McGranahan, 2007).

Since most of the economic activities of the most of the countries are being produced from this coastal city based region whereas majority of the total population are lining in this region. In order to make sure the stability of the country's economic base as well as the social well-being, this sort of climate change adaptation planning approaches in the development plans initiatives are highly demanded today and importantly in future. Higher global average temperatures and sea level rise are the most widespread and predictable effects. (Hebbert and Mackillop, 2011)

Planning and planners are generally regarded to be responsible and capable to reduce vulnerability and to develop climate mitigation and adaptation capacities (Stern, 2006, IPCC, 2007). In the case, the important and most considerable factor regarding the climatic variation is the adaptation rather than the mitigation as, mitigation is the activity that we have to consider in global scale with huge scope and there should have strong evidences to prove the facts. (Kane and Shogren, 2000) As an example although a developed industrial country is responsible for poisonous gas emission, the negative impacts of that emission will be affected by another country in other side of the world.

However, in adaptation, there are some evidences for the effects of climatic variations as floods, post disaster health hazards, droughts, salt water intrusion and they have recorded locally and globally with the strong data and evidences. So in the case of urban planning with the data and proves planners can include the mitigation methods to their plans for the predicted effects of climatic variations with the consideration of the core benefits of those migratory plans to the society as well as the surrounding environment.

As a developing country, Sri Lanka, with a tropical climate pattern, has higher vulnerability for climate change impacts in extreme weather conditions such as high intensity of rainfall or extreme dry periods on unpredicted or unexpected periods of the year. Some of the cities in the country have already being experiencing the impacts of climate change specially which are located at the coastal region of Sri Lanka. As an island country, the coastal areas itself is an important environmental as well as economic resource to the country. The coastal zone of Sri Lanka consists of around 25% of total land area, hosts around one third of the country's population, accommodates over two thirds of all industrial facilities, and over 80% of tourism infrastructure (UNEP, 2001). Marine fisheries play a pivotal role in Sri Lanka's fish supply. According to the National Aquaculture Development Authority (NARA), in 2011, around 86% of total fish supply has come from marine fisheries. The marine fish catch comprises of 58% from coastal areas and 42% from off-shore. The contribution of the coastal sector to the national GDP is on the rise (Nayananda, 2007). The share of coastal GDP in national GDP has increased from around 35% in 1983 to 43% in 2005. Agriculture, fisheries, trade, and tourism have been playing a major

role in growing the coastal economy over the years. The contribution must have now increased further following the end of war in 2009. Importantly the coastal area of Sri Lanka plays major role in strengthen the economic, environmental as well as historic identity of the country but with the unexpected changes of the climatic conditions have being already interfered to the stability of all these aspects of Sri Lanka as a victim of climate change.

As similar studies are very limitedly done to the coastal urban areas, the findings of this study will be useful to the urban planning implementing agencies, decision makers, researchers in taking the decisions on future development plans and align with urban planning process. This research has built on few selected indicators such as yearly rainfall, monsoon rainfall, and number of rainy days, average maximum and minimum daily temperature with the reason that these selected indicators are mostly combined and influence to the built environment of the city. As an example, the unpredicted excessive rainfall or temperature in unexpected time of the year can mess up the day today activities of the people persuading the built environment by causing floods or droughts with post health hazards. And these climatic variations can change the day today work plans of the people and as well as working and infrastructure networks of the built environment, by increasing wear on technical infrastructure and the external walls of buildings and by increasing the risk of flooding in certain areas.

In this context this research attempted to examine trends of rainfall and temperature patterns over the last four decades in coastal cities Sri Lanka to see whether they support to claim the long-term climate change by identifying temporal trends in the rainfall and temperature during the period of 1971-2011 in Sri Lanka. Subsequently, the findings of the study contribute to the literature which emphasizes the importance of examine trends of rainfall and temperature patterns to urban planning discussion around this topic in research and policy circles.

2. Literature review

2.1 Climate Variability and Climate Change

Climate change refers to a statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer). Climate change may be due to natural internal processes or external forcing, or to persistent anthropogenic changes in the composition of the atmosphere or in land use. Note that the Framework Convention on Climate Change (UNFCCC) in its Article 1, defines "climate change" as: "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods". The UNFCCC thus makes a distinction between "climate change" attributable to human activities altering the atmospheric composition, and "climate variability" attributable to natural causes.

Climate refers to the average weather conditions in a place over many years (usually at least 30 years) (EPA, 2003). Climate is traditionally defined as the description in terms of the mean and variability of relevant atmospheric variables such as temperature, precipitation and wind. Climate can thus be viewed as a synthesis or aggregate of weather. This implies that the portrayal of the climate in a particular region must contain an analysis of mean conditions, of the seasonal cycle, of the probability of extremes such as severe frost and storms, etc. Following the World Meteorological Organization (WMO), 30 years is the classical period for performing the statistics used to define climate. This is well adapted for studying recent decades since it requires a reasonable amount of data while still providing a good sample of the different types of weather that can occur in a particular area. However, when analyzing the most distant past, such as the last glacial maximum around 20 000 years ago, climatologists are often interested in variables characteristic of longer time intervals. As a consequence, the 30-year period proposed by the WMO should be considered more as an indicator than a norm that must be followed in all cases. This definition of the climate as representative of conditions over several decades should, of course, not mask the fact that climate can change rapidly. Nevertheless, a substantial time interval

is needed to observe a difference in climate between any two periods. In general, the less the difference between the two periods, the longer is the time needed to be able to identify with confidence any changes in the climate between them.

2.2 Climate and meteorological parameters

Meteorology is the science that deals with the atmosphere and its phenomena. Major areas of research concern the weather, weather forecasting and atmospheric composition. There are number of climate and meteorological parameters which can be used to investigate and understand the changing patterns of climate. Each climate index is based on certain parameters and describes only certain aspects of the climate, so there are a variety of climate indices that have been defined and examined in numerous publications. Means and extreme values, linear trends and standard deviations of longtime time series can be calculated for each of these climate parameters. These results are a simple form of climate indexes, as they already describe changes in climate (Integrated climate data center). Some of the mostly used climatic indices are listed below:

Table 1: Mostly used climatic indices

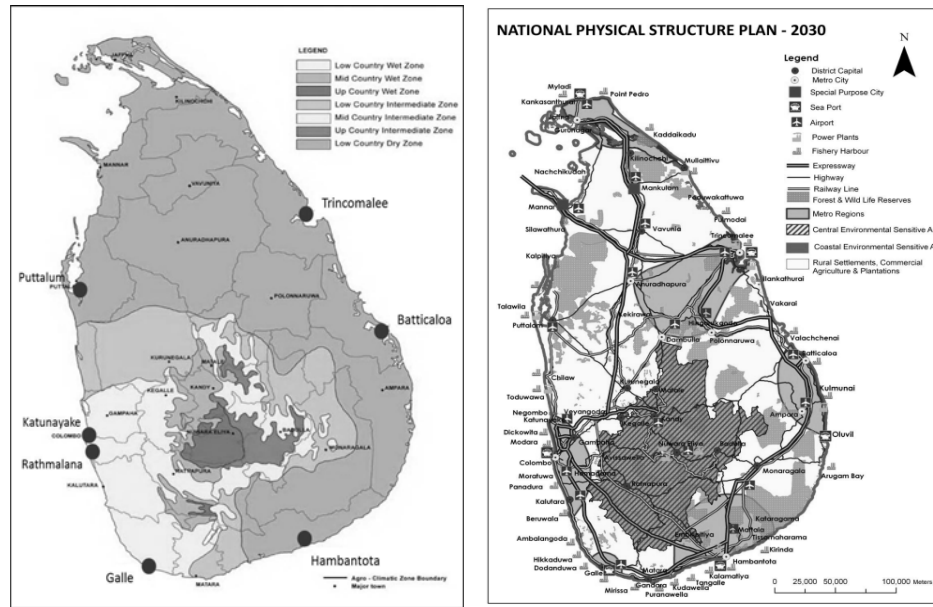
Parameter	Definition	Indices
Precipitation	The recording of precipitation amounts started a begin of weather recording. After some technical developments the duration of a precipitation event was recorded, too. Additionally information about the type of precipitation (rain, snow, hail) was collected by the observer	<ul style="list-style-type: none"> • Maximum 1- and 5-day precipitation per Year • Simple precipitation intensity index • Annual count of days when the precipitation is greater than a defined limit • Maximum length of dry spell • Maximum length of wet spell • Annual total precipitation when rain rate is above a defined limit (Percentile) • Annual total precipitation in wet days
Temperature	The air temperature is an atmospheric parameter that is recorded since the start of weather recording. The air temperature is measured daily in 2 m height above ground and long time series exist for many stations. Additional to the current temperature the daily minimum and maximum values are recorded that are used for index calculations as well.	<ul style="list-style-type: none"> • Number of frost and ice days • Number of summer days and tropical nights • Extreme values during a specific period • Exceeding specific limits (Percentile) • Daily temperature range • Heating degree day • Warm and cold spell duration • Growing season length

Source: Integrate climate data center, University of Hamburg

3. Methodology

3.1 Study area

This research is built on analyzing daily rainfall and temperature data collected at seven coastal meteorological stations of the Department of Meteorology Sri Lanka that are Rathmalana, Hambantota, Trincomalle, Puttalam, Katunayake, Batticaloa and Galle.



Map 1: Location of selected observatory stations of the study along the climatic zones (left) and proposed metro regions (right) of Sri Lanka

(Source: Author constructed based on National Physical Plan Sri Lanka 2030, NPPD and National Atlas, Sri Lanka)

All the selected seven meteorological observatories are coastal cities. The rationale behind selecting these seven cities as main observatories were these seven stations are well distributed - over the entire country in varied climatic regions (wet zone and dry zone) and ongoing and proposed major urban developments are mostly concentrated in these areas. The brief introduction on the seven selected observation stations is given in the following table:

Table 2: Selected observatory stations for the study

Observation Station	Climatic Zone	Elevation (m)	Metro region according to National Physical Structure Plan – Sri Lanka
Rathmalana	Wet zone	6	Western Metro Region
Katunayaka	Wet zone	2	Western Metro Region
Galle	Wet zone	12	Southern Metro Region
Hambantota	Dry Zone	16	Southern Metro Region
Trincomalee	Dry Zone	3	North Central Metro Region
Puttalam	Dry Zone	2	-
Batticaloa	Dry Zone	3	Eastern Metro Region

3.2 Data sources

This study is totally based on the secondary data which collected from the Department of Meteorology. Daily rainfall data were collected for the period of 40 years from 1971 to 2011 for selected 7 meteorological observatories

Statistical analysis such as linear and polynomial regression and time series analyses were utilized to examine periodic changes in daily, annual and seasonal contexts using the parameters as yearly rainfall, number of rainy days, monsoon rainfall and maximum and minimum daily temperature.

4. Results and discussion

4.1 Yearly rainfall

In order to examine trends in the yearly rainfall, the annual rainfall was obtained from the original daily rainfall record at each station. Regression analysis was performed on the yearly rainfall at each station. See Table 3 for the results.

Table 3: Trends in the yearly rainfall for the period from 1971 – 2011

Station	Liner Trends				Polynomial Trends
	m (Slope)	c (Intercept)	R ²	Remarks	Remarks
Hambantota	-0.5697	1595.7	0.005	Cannot be considered as a significant one according to the R ² values	Did not show significant change
Galle	6.4842	-1075.8	0.021	Cannot be considered as a significant one according to the R ² values	Did not show significant change
Rathmalana	47.438	9317.7	0.660	Increase in annual rainfall	10 year moving averages (R ² =0.73) seem to show an <u>significant increase in peak rainfall in 10 year cycle</u> (Ex: 1970s:1500mm, 1980s:1600mm, 2010s:2000mm)
Katunayaka	-9.2558	2042.3	0.053	Cannot be considered as a significant one according to the R ² values	Did not show significant change
Puttalam	-0.7323	2592.0	0.005	Cannot be considered as a significant one according to the R ² values	Did not show significant change
Trincomalee	-0.2227	1877.8	0.0005	Cannot be considered as a significant one according to the R ² values	Did not show significant change
Batticaloa	16.994	-3218.7	0.578	Increase in annual rainfall	10 year moving averages (R ² =0.82) seem to show an very <u>significant increase in peak rainfall in 10 year cycle</u> (Ex: 1970s:1600mm, 1980s:1800mm, 1990s:3000mm, 2010s:3600mm)

Source: Prepared by Authors based on Meteorology data, Meteorology Department, SL

As it is produced the annual rainfall of the country is conventionally considered as ranging between 1000mm in the dry zone to more than 5000mm in the wet zone. With this mean annual rainfall, a special spatial pattern has built up all over the Sri Lanka. However, at present the unequal and unbalance lengths and seasons shows great variation of rainfall distribution throughout the year in Sri Lanka. When considering the trend of the yearly rainfall in seven selected cities, it is observable that Rathmalana in wet zone and Batticaloa in dry zones how significant increase (significant one as the R^2 value is close to 0.6) in yearly annual rainfall while other five cities do not show significant changes. 5 year and 10 year moving averages in Batticaloa city seem to show an increase in rainfall (figure 1), but even the averages show strong variations. At the end of the observation period (after 2001) the yearly rainfall is 300 mm (25% increases) higher than at the beginning (1970-1977).

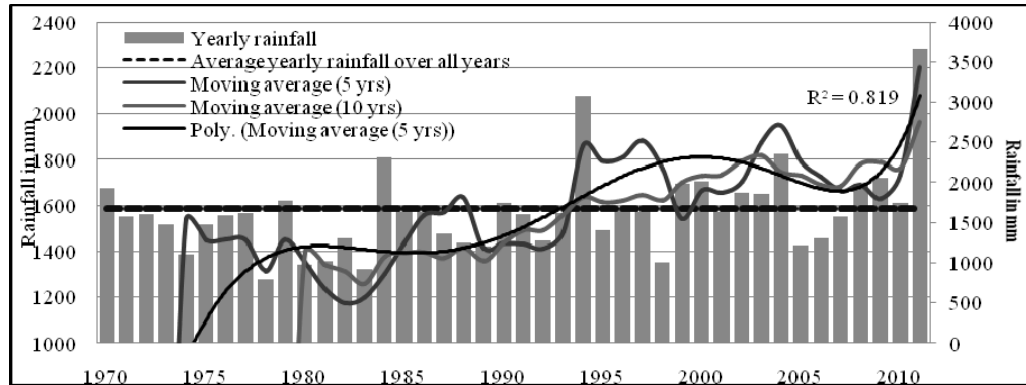


Figure 4.1.1: Annual Rainfall variations - Batticaloa Station

Source: Prepared by Authors based on Meteorology data, Meteorology Department, SL

5 year and 10 year moving averages in Rathmalana seem to show a significant increase in rainfall (Figure 2), at the end of the observation period (after 2001) the yearly rainfall is 500 mm (25% increases) higher than at the beginning (1980-1990). 10-year polynomial tends (significant one as the R^2 value is more than 0.7) clearly shows that annual rainfall of Rathmalana weather station continually increase in rapid rate.

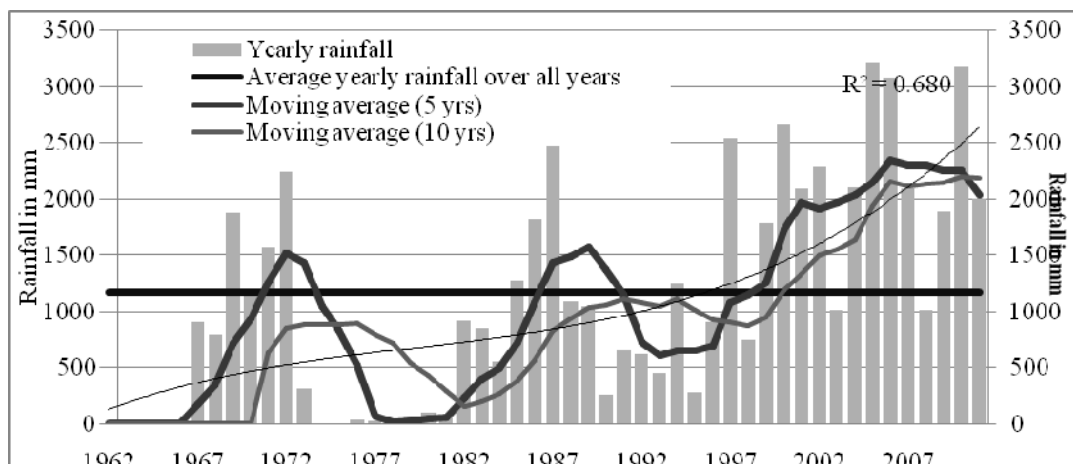


Figure 4.1.2: Annual Rainfall Variation – Rathmalana Station

Note: The unusual trend found for 1972-1982 may be due to the missing values

Source: Prepared by Authors based on Meteorology data, Meteorology Department, SL

4.2 Monsoon Rainfall

Table 4: Trends in the monsoon rainfall for the period from 1971 – 2011

Station	Northeast-monsoon (December-February)	First Inter-monsoon (March - April)	Southwest-monsoon (May-September)	Second Inter-monsoon (October-November)
Hambantota	The 10 year moving averages ($R^2=-0.23$) seem to show a slight decrease (Ex: 1980s:150mm, 2010s:80mm)	Did not show significant change	The 10 year moving averages ($R^2=0.27$) seem to show a slight increase (Ex: 1980s:100mm, 2010s:200mm)	Did not show significant change
Galle	The 10 year moving averages ($R^2=0.21$) seem to show a slight increase (Ex: 1980s:270mm, 2010s:370mm)	Did not show significant change	The 10 year moving averages ($R^2=0.88$) seem to show a continuous increase (Ex: 1980s:800mm, 1990s:1000mm, 2000s:1100mm, 2010s:1300mm)	Did not show significant change
Rathmalana	Did not show significant change	Did not show significant change	Show an very <u>significant increase</u> ($R^2=0.754$) (Ex: 1990s:600mm, 2010s:1400mm)	Show an very <u>significant increase</u> ($R^2=0.626$) (Ex: 1990s:400mm, 2010s:1300mm)
Katunayaka	Did not show significant change	Did not show significant change	Did not show significant change	Did not show significant change
Puttalam	Did not show significant change	Did not show significant change	Did not show significant change	Did not show significant change
Trincomalee	Did not show significant change	Did not show significant change	Did not show significant change	Did not show significant change
Batticaloa	Show an very <u>significant increase</u> ($R^2=0.596$) (Ex: 1990s:150mm, 2010s:400mm)	Did not show significant change	Did not show significant change	Show an very <u>significant increase</u> ($R^2=0.668$) (Ex: 1990s:800mm, 2010s:2500mm)

Source: Prepared by Authors based on Meteorology data, Meteorology Department, SL

When considering the trends in monsoon rainfall, again the Rathmalana and Batticaloa have shown a significant increase in monsoon rainfall. In the case of Rathmalana, a considerable increment of Southwest monsoon ($R^2=0.754$) and second inter monsoon ($R^2=0.626$) can be clearly observed with the positive R^2 factor while Batticaloa showed a substantial increase of second inter monsoon ($R^2=0.596$) as well as the North-east monsoon ($R^2=0.668$). From the other five stations even though Galle and Hambantota has also shows slight increase trend of the Southwest monsoon it is only very slight increase of the monsoon rainfall trend which can't be

taken significantly. The important factor is that in Hambantota, it has shown silt decrease in trend of Northeast monsoon rainfall. These factors can be clearly displayed in a graphical form as follows. Considering the “Southwest-monsoon” from May to September in Galle observatory station, the moving average for 5 years trend shows slight increase after 1995 and continued till 2003 while the moving average for 10 years trend shows a considerable increase from 1993 – 1999 and then 2003 – 2009 with positive R^2 factor ($R^2 = 0.8808$).

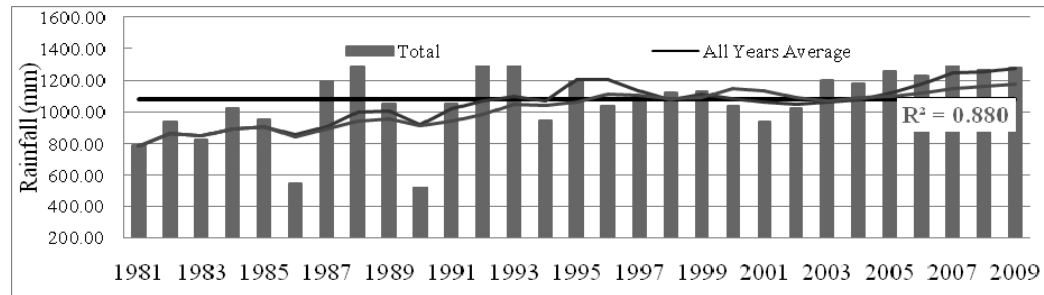


Figure 4.2.1: Rainfall “Southwest-monsoon (May-September)” season – Galle Station

Source: Prepared by Authors based on Meteorology data, Meteorology Department, Sri Lanka

As it has clearly shown in the below graph, Rathmalana observatory station shows significant increase of both “Southwest-monsoon season” from May to September ($R^2 = 0.754$) and “Second Inter-monsoon season” from October to November ($R^2 = 0.4624$). Considering the “Southwest monsoon” as well as the “Second Inter-monsoon” in Rathmalana, both of the seasons show to start the increment from 1993 and continuously increased till 2008.

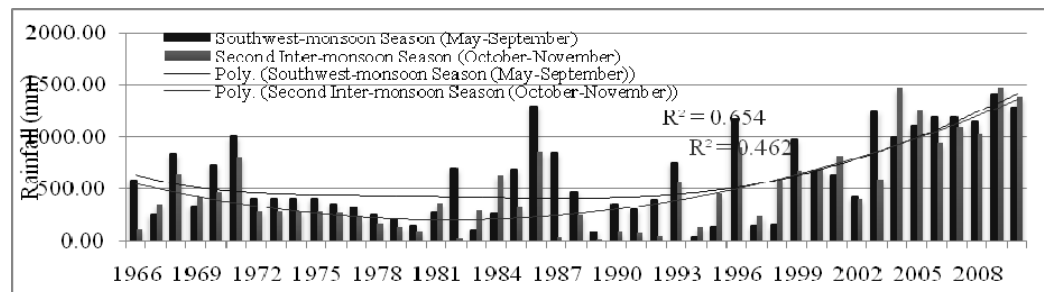


Figure 4.2.2: Rainfall “Southwest-monsoon (May-September)” and Second Inter-monsoon (October-November) season – Rathmalana Station

Source: Prepared by Authors based on Meteorology data, Meteorology Department, SL

When considering the Batticaloa Station, the “First Inter-monsoon” shows mostly a steady pattern with very tiny increments till year 2003 and after it appears to be slightly increased till 2009 ($R^2 = 0.501$). However, the “Northeast Monsoon” effected to the Batticaloa station shows very significant increase after the year 2006 ($R^2 = 0.6237$) with the increment pattern shows from 1991 slightly.

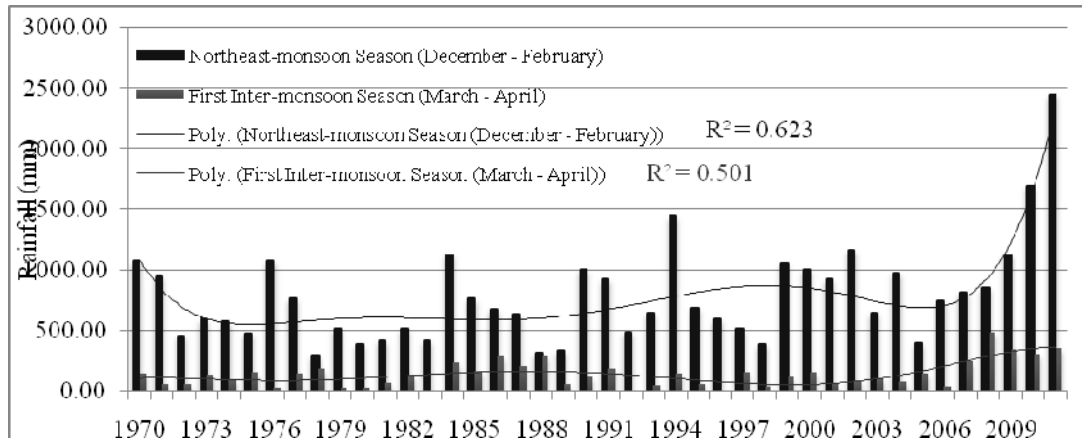


Figure 4.2.3: Rainfall “Northeast-monsoon (December-February)” and First Inter-monsoon (December-February) season – Batticaloa Station

Source: Prepared by Authors based on Meteorology data, Meteorology Department, SL

4.3 Rainy Days

In order to examine trends in the number of rainy days, the annual number of rainy days and extreme rainy days were obtained from the original daily rainfall record at each station. Regression analysis was performed on the number of rainy days at each station. Extreme rainy days include number of days more than the 90 percentile, 95 percentile and 99 percentile of rainfall according to the station between 1971-2011. See Table 5 for the results.

Table 5: Trends in the rainy days for the period from 1971 – 2011

Station	No. of rainy days	Extreme rainy days (90%)	Extreme rainy days (95%)	Extreme rainy days (99%)
Hambantota	Slightly decrease $R^2=0.29$ m (Slope)=-0.433 c (Intercept)=970	Slightly increase $R^2=0.23$ m (Slope)=0.19 c (Intercept)= -362	Increase $R^2=0.43$ m (Slope)=0.53 c (Intercept)= -1002	Slightly increase $R^2=0.22$ m (Slope)=0.47 c (Intercept)= -243
Galle	Slightly decrease $R^2=0.31$ m (Slope)=-0.400 c (Intercept)=991	Slightly increase $R^2=0.34$ m (Slope)=0.16 c (Intercept)= -287	Increase $R^2=0.47$ m (Slope)=0.59 c (Intercept)= -1021	Very significant increase $R^2=0.53$ m (Slope)=0.72 c (Intercept)= -1211
Rathmalana	Slightly increase $R^2=0.59$ m (Slope)=0.134 c (Intercept)=926	Increase $R^2=0.53$ m (Slope)=0.86 c (Intercept)= -1698	Significant increase $R^2=0.67$ m (Slope)=0.79 c (Intercept)= -1321	Very significant increase $R^2=0.64$ m (Slope)=0.82 c (Intercept)= -1041
Katunayaka	Slightly decrease $R^2=0.49$ m (Slope)=-0.510 c (Intercept)=1151	Insignificant increase $R^2=0.20$ m (Slope)=0.06 c (Intercept)= -66	Increase $R^2=0.55$ m (Slope)=0.57 c (Intercept)= -1132	Slightly increase $R^2=0.32$ m (Slope)=0.35 c (Intercept)= -335
Puttalam	Slightly decrease $R^2=0.43$ m (Slope)=-0.425 c (Intercept)=946	Insignificant increase $R^2=0.27$ m (Slope)=0.04 c (Intercept)= -53	Slightly increase $R^2=0.44$ m (Slope)=0.27 c (Intercept)= -428	Slightly increase $R^2=0.22$ m (Slope)=0.29 c (Intercept)= -473
Trincomalee	Slightly decrease $R^2=0.33$ m (Slope)=-0.321 c (Intercept)=738	Insignificant increase $R^2=0.11$ m (Slope)=0.03 c (Intercept)= -36	Slightly increase $R^2=0.27$ m (Slope)=0.22 c (Intercept)= -319	Slightly increase $R^2=0.39$ m (Slope)=0.23 c (Intercept)= -503
Batticaloa	Slightly decrease $R^2=0.44$ m (Slope)=-0.355 c (Intercept)=810	Slightly increase $R^2=0.58$ m (Slope)=0.29 c (Intercept)= -378	Significant increase $R^2=0.77$ m (Slope)=0.73 c (Intercept)= -1426	Very significant increase $R^2=0.63$ m (Slope)=0.91 c (Intercept)= -1121

Source: Prepared by Authors based on Meteorology data, Meteorology Department, Sri Lanka

The number of rainy days in a season is of particular importance for hydro system, drainage network, industrial activities and day today urban activities. Examining trends in the variability of the number of extreme rainy days is vital as it is a decisive factor in urban flooding including flash flood. With regard to the number of rainy days received in each season, considering the R^2 factor of the each study stations, all the study stations have shown slight decreases in number of rainy days. However, there is considerable increase in extreme rainy days. Considering the extreme rainy days (90%, 95% and 99%) Galle, Rathmalana and Batticaloa show very significant increase of the trends in rainy days. Figure 4.3.1 shows the Polynomial trends of all seven cities:

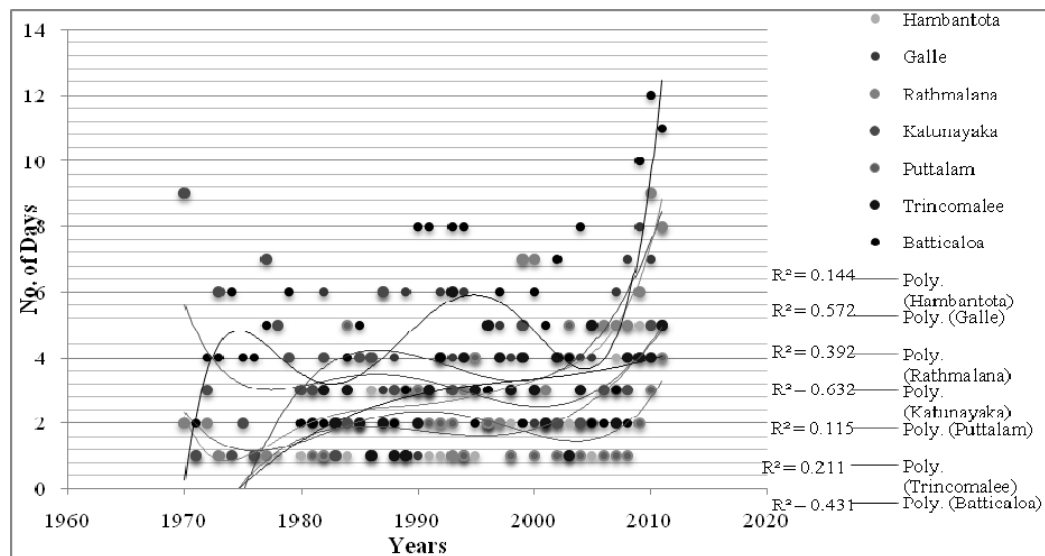


Figure 4.3.1: No. of days above 99% percentile of daily rainfall from all daily recodes

Source: Prepared by Authors based on Meteorology data, Meteorology Department, SL

4.4 Maximum and minimum daily temperature

4.4.1 Average maximum and minimum daily temperature

Average maximum and minimum daily temperature is also one of important indicator to identify the changing trends of the climate as it will be a factor which changes the built environments and purposely the changes of usual human activities. As an examples when temperature increase or decrease people used to use more air conditions or heaters according to their preferences and the structures of the buildings and built ups will be also changed accordingly.

Referring to the results obtained by the seven observation stations, Hambantota, Galle, Trincomalee and Batticaloa show positive trends in average maximum daily temperature while Rathmalana, Katunayaka and Puttalam show negative trends. Considering the average minimum daily temperature, while Rathmalana and Trincomalee show significant decrease, all the other five stations show significant increase in average minimum temperature. The important observation is that Rathmalana study stations show significant decrease in both average maximum and minimum daily temperature.

Table 6: Trends in the average maximum and minimum temperate for the period from 1971 – 2011

Station	Average maximum daily temperate	Average minimum daily temperate
Hambantota	Significant increase m (Slope)=0.034; R ² =0.92 1980s: 30.25°C 2010s: 31.20°C	Significant increase m (Slope)=0.033; R ² =0.53 1980s: 24.30°C 2010s: 25.15°C
Galle	Significant increase m (Slope)=0.021; R ² =0.21 1980s: 29.16°C 2010s: 29.96°C	Insignificant increase m (Slope)=0.007; R ² =0.04 1980s: 25.10°C 2010s: 25.25°C
Rathmalana	Significant decrease m (Slope)= -0.034; R ² =0.22 1980s: 28.12°C 2010s: 27.19°C	Significant decrease m (Slope)= -0.037; R ² =0.27 1980s: 24.10°C 2010s: 23.10°C
Katunayaka	Significant decrease m (Slope)= -0.022; R ² =0.36 1980s: 31.32°C 2010s: 30.93°C	Significant increase m (Slope)=0.085; R ² =0.26 1980s: 24.90°C 2010s: 26.90°C
Puttalam	Insignificant decrease m (Slope)= -0.010; R ² =0.33 1980s: 31.78°C 2010s: 32.99°C	Insignificant increase m (Slope)=0.011; R ² =0.10 1980s: 24.48°C 2010s: 24.67°C
Trincomalee	Significant increase m (Slope)=0.038; R ² =0.57 1980s: 31.75°C 2010s: 31.56°C	Insignificant decrease m (Slope)= -0.001; R ² =0.10 1980s: 25.07°C 2010s: 24.98°C
Batticaloa	Significant increase m (Slope)=0.033; R ² =0.61 1980s: 37.20°C 2010s: 38.00°C	Insignificant increase m (Slope)=0.0065; R ² =0.08 1980s: 24.60°C 2010s: 24.80°C

Source: Prepared by Authors based on Meteorology data, Meteorology Department, SL

4.4.2 Daily maximum and minimum daily temperature

When observing the trends in the daily maximum and minimum temperate for the period from 1971 – 2011, Hambantota, Rathmalana, Trincomalee and Batticaloa have very significant increase in number of days above the 95% percentile for temperature while number of days below the 1% and 5% percentile for temperature in those seven stations do not show significant changing pattern.

Table 7: Trends in the daily maximum and minimum temperate for the period from 1971 – 2011

Station	No. of days above the 95%-percentile for temperature	No. of days above the 99%-percentile for temperature	No. of days below the 5%-percentile for temperature	No. of days below the 1%-percentile for temperature
Hambantota	Very Significant increase	Significant increase	Significant decrease	Slightly decrease
Galle	Slightly increase	Did not show significant change	Did not show significant change	Did not show significant change
Rathmalana	Very Significant increase	Did not show significant change	Did not show significant change	Did not show significant change

Katunayaka	Very Significant increase	Did not show significant change	Did not show significant change	Did not show significant change
Puttalam	Did not show significant change	Did not show significant change	Did not show significant change	Did not show significant change
Trincomalee	Very Significant increase	Did not show significant change	Did not show significant change	Did not show significant change
Batticaloa	Very Significant increase	Did not show significant change	Did not show significant change	Did not show significant change

Source: Prepared by Authors based on Meteorology data, Meteorology Department, SL

Number of days above the 95% and 99% percentile for temperature amounts are considered as extreme events. Figure 6 shows that, in Hambantota, the number of days with temperature above 95% ($R^2=0.69$) and 99% ($R^2=0.46$) seems to significant increase in last decade. According to the meteorological information it has increased by 15 days by 2010s in comparison to 1990s.

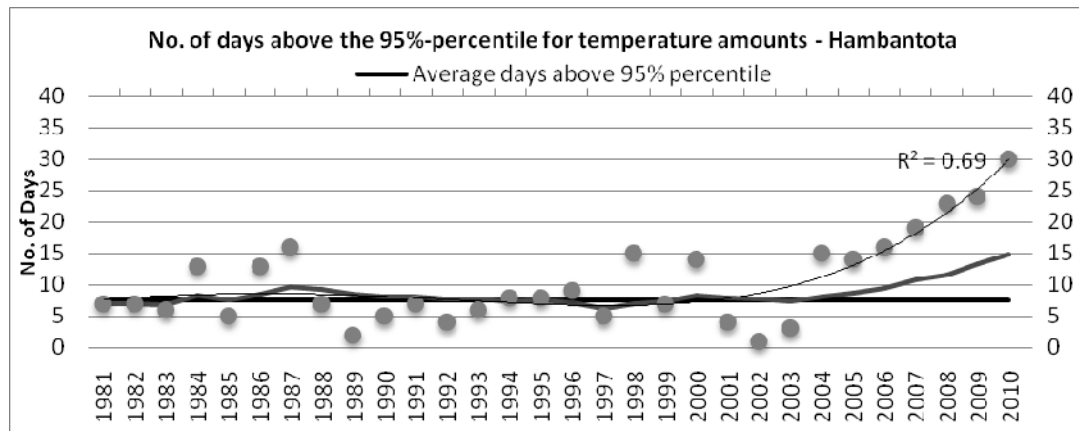


Figure 4.4.1: No of days above 95% percentile for temperature amounts - Hambantota

Source: Prepared by Authors based on Meteorology data, Meteorology Department, SL

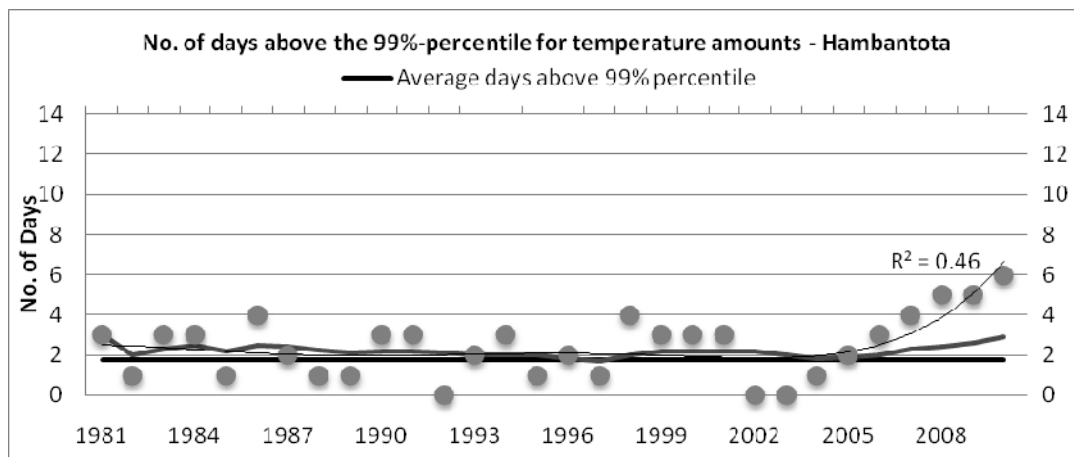


Figure 4.4.2: No of days above 99% percentile for temperature amounts - Hambantota

Source: Prepared by Authors based on Meteorology data, Meteorology Department, SL

Number of days above the 95% percentile for temperature amount is considered as extreme events. Figure 8 shows that, In Katunayaka, the number of days with temperature above 95% ($R^2=0.6417$) seems to significant increase continuously from the year 2005.

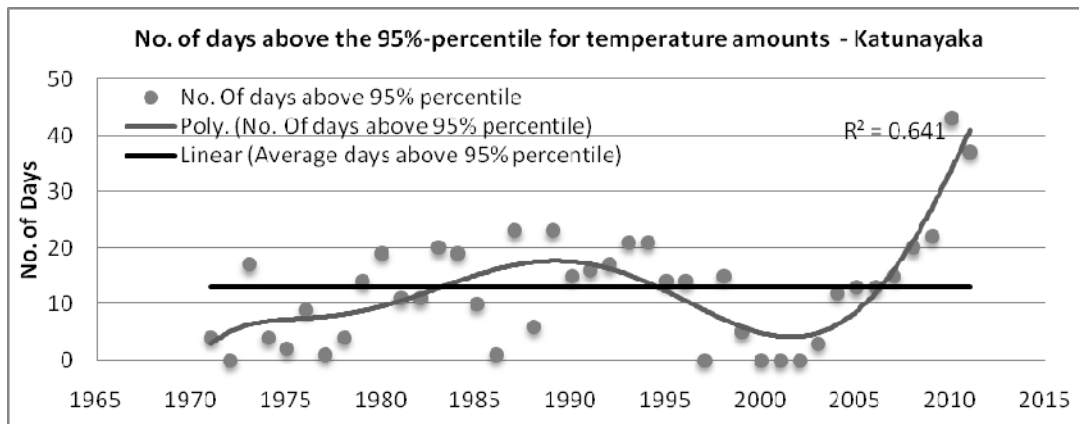


Figure 4.4.3: No of days above 95% percentile for temperature amounts - Katunayaka

Source: Prepared by Authors based on Meteorology data, Meteorology Department, SL

Number of days above the 95% percentile for temperature amount is considered as extreme events. Figure 4.4.4 shows that, In Galle, the number of days with temperature above 95% ($R^2=0.5285$) seems to significant increase continuously from the year 1995.

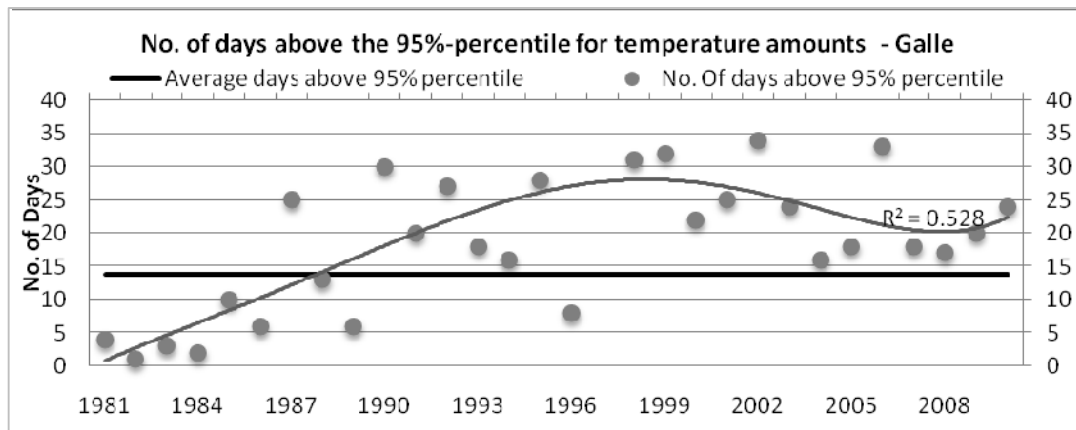


Figure 4.4.4: No of days above 95% percentile for temperature amounts - Galle

Source: Prepared by Authors based on Meteorology data, Meteorology Department, SL

Number of days above the 95% percentile for temperature amount is considered as extreme events. Figure 9 shows that, In Rathmalana, the number of days with temperature above 95% ($R^2=0.5466$) seems to significant increase continuously from the year 1995.

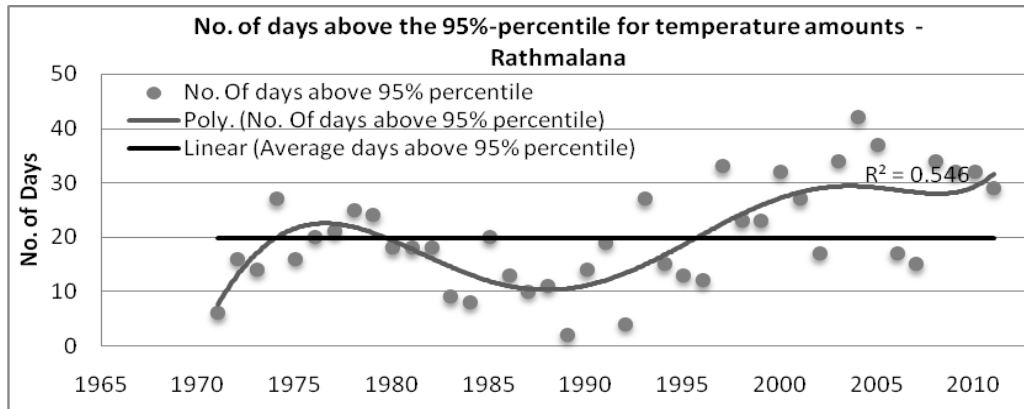


Figure 4.4.5: No of days above 95% percentile for temperature amounts - Rathmalana

Source: Prepared by Authors based on Meteorology data, Meteorology Department, SL

Number of days above the 95% percentile for temperature amount is considered as extreme events. Figure 8 shows that, In Batticaloa, the number of days with temperature above 95% ($R^2=0.5466$) seems to significant increase continuously from the year 1995.

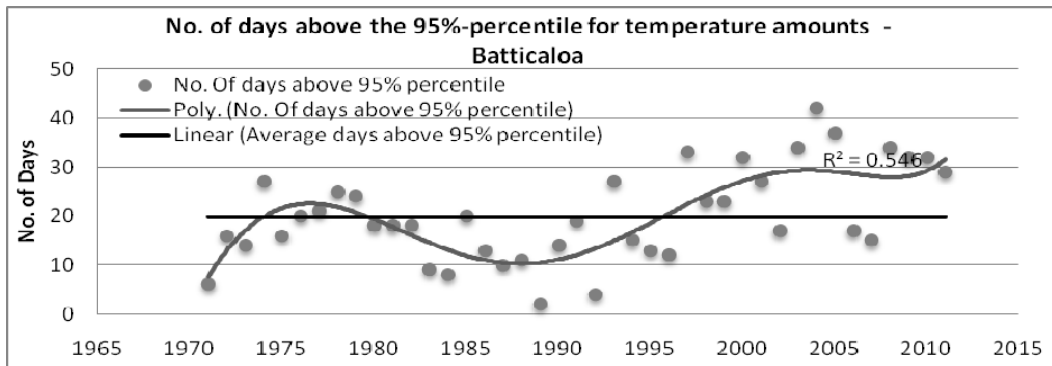


Figure 4.4.6: No of days above 95% percentile for temperature amounts -Batticaloa

Source: Prepared by Authors based on Meteorology data, Meteorology Department, SL

Number of days above the 95% percentile for temperature amount is considered as extreme events. Figure 8 shows that, In Trincomalee, the number of days with temperature above 95% ($R^2=0.2294$) seems to significant increase continuously from the year 1987.

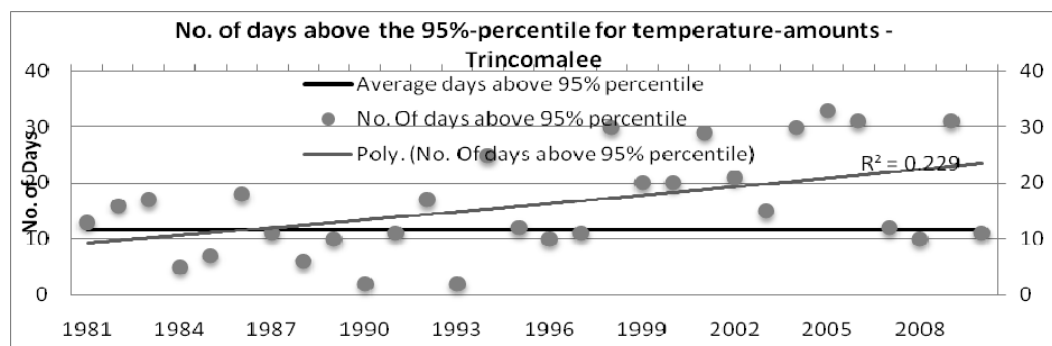


Figure 4.4.7: No of days above 95% percentile for temperature amounts -Trincomalee

Source: Prepared by Authors based on Meteorology data, Meteorology Department, SL

4.5 Summary of change

The results obtained by analyzing the selected climatic parameters of the study can be summarized as below. It gives clear understanding of the variation patterns of the different parameters in a way we can easily come to a conclusion.

Table 8: Summary of the changes

Parameters	Observatory Stations						
	Wet Zone			Dry Zone			
	Rathmalana	Galle	Katunayaka	Hambantota	Puttalam	Trincomalee	Batticaloa
Yearly annual rainfall	SI	IC	IC	IC	IC	IC	SI
Monsoon Rainfall							
Northeast monsoon	IC	II	IC	ID	IC	IC	SI
First inter monsoon	IC	IC	IC	IC	IC	IC	IC
Southwest monsoon	SI	SI	IC	II	IC	IC	IC
Second inter monsoon	SI	IC	IC	IC	IC	IC	SI
Number of Rainy Days	II	ID	ID	ID	ID	ID	ID
Extreme rainy days (90%)	II	II	II	II	II	II	II
Extreme rainy days (95%)	SI	SI	SI	SI	II	II	SI
Extreme rainy days (99%)	SI	SI	II	II	II	II	SI
Average maximum daily temperature	SD	SI	SD	SI	ID	SI	SI
Average minimum daily temperature	SD	II	SI	SI	ID	ID	II
Number of extreme warm days							
Extreme warm days (95%)	SI	II	SI	SI	IC	SI	SI
Extreme warm days (99%)	IC	IC	IC	SI	IC	IC	IC

(SI: Significant Increase, II: Insignificant Increase IC: Insignificant Change, SD: Significant Decreases, ID: Insignificant decrease)

5. Conclusions

The findings of the study revealed that there are significant changes in climatic parameters such as rainfall and temperature of the selected seven coastal observatory stations which can be

influenced to the decision making process of the urban planning. The slight or significant changes of the selected climatic parameters can highly influenced to the urban areas of specific locality as well as to entire region considering the concentrated activities in that specific areas. According to the results, although the number of rainy days has decreased in most of the observatory stations, the total annual rainfall has not decreased. This could indicate that the intensity of rainfall events may have increased together with increased durations of dry spells with maximized trend of the temperature. Practically with the nearby incidents which we heard about floods as well as the droughts also prove these findings as results of continuous climatic variations

In this context, the case for improved climate awareness in urban planning needs to be emphasized and essentially merged with the decisions in urban planning. Not only in Sri Lanka but also cities worldwide should have to begin to recognize their role in addressing anthropogenic climate change with modern city planning. As some examples, the increasing risk of floods needs to be controlled by identifying the areas that are most vulnerable to flooding and discouraging property development in those areas, by imposing regulations on planning in high risk areas. Moreover, the proposed plans should be detailed and suit to cope with making resilient built environment against climate change. More detailed recommendations can be issued in connection with local and regional plans and local authority regulations revised and supplemented as required. The easiest way to prepare for the effects of climate change is to factor them in when planning and developing new areas.

Therefore, emerging climatic variations according to the analyzed meteorological data has to be essentially considered in the process of decision making on urban planning because as this research revealed these climatic variables show different changing patterns. By integrating the climatic variations wisely in the urban planning can invest the capital of the country to the development rather than unnecessarily spend it on post disaster rehabilitations.

Acknowledgements

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Identification of Evaluating Criteria for Sustainable Visitor Management of National Parks in Sri Lanka

Lasanthi Nillegoda

Department of Town and Country Planning, University of Moratuwa, Sri Lanka
lnillegoda@gmail.com

P. K.S. Mahanama

Faculty of Architecture, University of Moratuwa, Sri Lanka
mahanama_pks@yahoo.com

T.K.G.P. Ranasinghe

Department of Town & Country Planning, University of Moratuwa, Sri Lanka
gayaniprasadika@gmail.com

Abstract

With the booming of Tourism industry,eco-tourism has been popularized and improved in the world. The places which are practicing eco-tourism attract increasing number of visitors day by day by exceeding their carrying capacity. Therefore, the environment of most of national parks in Sri Lanka adversely affected due to over visitation by local and foreign visitors. Adaptation of mechanism on sustainable visitor management for the national parks in other countries has been addressed this problem. Yet, there is no proper way to manage visitors for National parks in Sri Lanka and most are highly over visited. Sustainable visitor management is dependent on related set of criteria which are varying from country to country. In the Sri Lankan context, suitable criteria for sustainable visitor management are not yet identified. This study is supposed to fill this gap by identifying suitable criteria for sustainable visitor management in national parks in Sri Lanka. Sixty nine criteria were identified through literature review under category of fifteen factors and four attributes such as physical, environment, tourism demand management and operational capacity management. Sixty two criteria were prioritized based on how frequently they are used in various literatures and they were ranked. Multivariate technique was applied to prioritize the above sixty two criteria based on compatibility and usability between each criterion and relevant indicator. The sixty two criteria were short listed up to twenty four criteria considering criteria value more than 1516. These twenty four were applied to evaluate the current visitor management of Yala National Park as it is the highest over visited national park in Sri Lanka. Evaluation was done considering the perception of the expertise in tourism industry of Sri Lanka. Results indicate that Yala national park has moderate level of sustainable visitor management. And also there are more criteria have to be taken in to account in order to reduce over visitation of Yala national park while managing its environment in a sustainable manner.

Keywords: tourism, sustainable visitor management, national parks

1.0 Introduction

One of the world's largest and fastest growing industry is tourism and it is a crucial contributor to the economy of world's poor countries (PATA Tourism Forecast/ UNWTO). Tourism industry of Sri Lanka has contributed as 5th earner of the GDP of Sri Lanka in year 2010. After the 30 years of civil conflicts in Sri Lanka, tourism has been tremendously recovered from its lapses. The tourist arrivals have been gradually increased during post war period. In year 2009 tourists arrivals were 454,900 and in year 2010 it increased up to 654,398. Sri Lanka Tourism Development Authority has divided Sri Lanka into 7 tourism regions. Mainly high occupancy rate is available in South region and Greater Colombo region.

Tourism sites can be divided into two parts as popular and potential sites such as national parks, zoological gardens, botanical gardens, cultural places and coastal areas. Popular tourism sites have

a problem of over visitation due to marketing and booming tourism in Sri Lanka, which makes exceed the carrying capacity of the site. This leads to reduce the tourism value of the site while it is harmful to the environment. Many countries practice the mechanism of sustainable visitor management for dual purpose, i.e., protecting the tourism sites while gaining the profit. Scotland introduced a sustainable visitor management system to heritage sites, As Scott and Barrow (2002) cited; sustainable visitor management is a cyclical, iterative planning and management process. It is presented as a menu of procedures, processes and tools that can be used at a range of visitor sites according to their management needs. They enjoy the high quality environment, rich cultural heritage, as well as direct and indirect economic benefits. Higginbottom, Carter and Moore (2010) studied that national parks of Australia has long been concerned with monitoring visitor impacts and experiences, the efforts have largely been site and activity specific, with consistent methodological approach.

Although there are studies done on destination management system and sustainable tourism development in Sri Lanka were by Sri Lanka Tourism Development Authority and there is a special division for the visitor management in Department of Wildlife Conservation, there is no proper sustainable visitor management mechanism for Sri Lanka to address the problem of over visitation as a whole and for destination wise. This gap must be filled. This study identifies suitable evaluating criteria for sustainable visitor management in Sri Lankan National parks.

2.0 Criteria of Sustainable Visitor Management System

2.1 Sustainable Visitor Management System

Sustainable visitor management is much different from any other related concepts. As Scott and Barrow (2002) explained that sustainable visitor management system is resulting a repeated, iterative planning and management process. It is presented as a menu of procedures, processes and tools that can be used at a range of visitor sites according to their management needs. Understanding visitor use and its effect on biophysical resources is an important part of the sustainable management (Thorsell, 2002). There should be a concern on identification and use of indicators to report on the sustainability of visitor use and management of tourism protected areas (McCool and Stankey, 2004). Tourism development should be carefully planned by considering the carrying capacity of the site with regard to environmental, social and economic impacts (Scott, and Barrow, 2002). Such integration of environmental concerns the conservation of natural and cultural heritage in development plans are essential to encourage sustainable and high quality forms of tourism (Majorca, 1999).

2.2 Application of the Sustainable Visitor Management

Application of sustainable visitor management system is significance in the tourism planning and in spatial planning. and Manente, Minghetti, Celotto (1993) introduce that the principles and practices of visitor management have been acquired ever-increasing importance in the last decade, especially in popular tourism destinations characterized by large or unusual tourist flows. As highlighted, each destination is characterized by a consistent or a rising volume of visitor flows, in relation to tourism mobility patterns and city functions (McCool and Stankey, 2004). Sustainable visitor management ensures sustainable development, and then limits the dramatic pressure of demand. It requires the adoption of an integrated set of strategies that combine tourism, transport and land-use related measures. This is an adaptive management and application of the precautionary principles as the foundation of protected area management to resource status and threats, and visitor use (Higginbottom, et al, 2010). This system is used to protect tourism sites and as a solution for overcome the over visitation of sites.

2.3 Criteria for Sustainable Visitor Management

To develop the system of sustainable visitor management, there are many criteria and framework to pursue. Eagles, McCool, Haynes, (2002) identified four criteria which can be used to reduce

the negative impacts of visitors on protected areas as managing the supply of tourism or visitor opportunities, demand for visitation, resource capabilities and managing the impact of use. Manning (2002) introduced eight criteria that should be taken into account when managing visitors of protected areas and reducing use of the entire protected area, problem areas, modify the location of use within problem areas, the timing of use, type of use and visitor behavior and visitor expectations, increase the resistance of the resource and rehabilitate resources. Donk and Cottrell (2002) have developed a set of criteria and indicators which come under the sustainable visitor management as visitor management philosophy, interpretation, minimizing impacts, visitor experience/recreation opportunities, managing and monitoring risk, partnership co-operation, providing training and financial management.

There are fifteen 'factors' introduced by World Tourism Organization and World Commission on Protected Areas (WCPA) as improve the site access, area closures, managing the impact of use, special modes to travel on site, local traffic management, local infrastructure management, managing the resource capabilities, site hardening, visitor centers, promotion of low season travel, attraction and events, complementary sites, limiting group size, managing visitor movement patterns, responsive measures for peak periods and administrative measures. Sixty nine criteria which were identified as a main finding of literature review and they were categorized under fifteen factors and four attributes namely physical, environmental, tourism demand management and operational capacity management.

3.0 Research Methodology

This research claims that there should be suitable criteria for sustainable visitor management in the context of Sri Lanka. All identified sixty nine criteria from the literature review were prioritized considering the number of frequency of mentioning of each criterion in all referenced research articles and rank value of the research paper which was given considering the number of criteria introduced or mentioned. Then using following two formulas, sixty two criteria were selected.

$$\frac{\text{Value of the Criteria} \times \text{Ranked value of relevant research paper}}{\text{Total value of the criteria} \times \text{Total value of the relevant factor}}$$

In order to apply those criteria practically, there should be relevant indicators that support to measure those criteria. It was identified forty nine indicators which were given below by referring the above literature and considering opinions of expertise who are involved in tourism industry of Sri Lanka.

1. No. of entries to the park
2. No. of visitors
3. No. of providers and operators
4. Different prices of tickets
5. Available Signage
6. Area of protected Areas
7. Available barriers
8. Area with problems
9. No. of Tour operators
10. Fragile and sensitive areas
11. Risk assessment
12. Locations to see in site
13. carrying capacity of the area
14. No. of park vehicles
15. No. of vehicles

16. Type of vehicles
17. Existing policies for using vehicles
18. area of parking
19. path ways for differently abled people
20. Road Network
21. Public bus route
22. potential routes (roads)
23. No. of retail shops and Food outlets near to the park
24. No. of retail shops and food outlets in the park
25. Space of them
26. type of them
27. Building capacity
28. Types of Resources
29. Soil types
30. Vegetation cover
31. trial routes
32. No of visitor centers
33. Services of visitor centers
34. pre reservations methods
35. Events
36. potential sites
37. new attractions
38. Group Sizes
39. Regulations for groups
40. Safety regulations
41. Routes in the site
42. Peak periods
43. congestion issues
44. administrative structure
45. Tourism Operator Licenses
46. Existing visitor management plan
47. available admin resources
48. Available training programs
49. Capacity of the entry

Multivariate technique was applied to prioritize the above sixty two criteria considering compatibility and usability between each criterion and relevant indicator. Compatibility index which shows neutral (0), Low (1), moderate (2) and high (3) was used to give values for above each indicator against each criterion. Each value in Matrix was multiplied by the rank value of criteria. With those values, sixty two criteria were reduced up to twenty four criteria shown in Table 1 considering criteria which have total value more than 1516 (base value) that is the value when a criterion gets at least low compatibility value against all indicators.

Criteria	Total	Rank
Pre-assignment of recreation site	4488	1
Improve Visitor Movement Patterns around Site	3225	2
Expand the Range of Attractions	3193	3
Establish Consultative Mechanisms for Tourism Congestion Issues	3168	4

Establish a plan that identifies the maximum number of people that will be allowed in different locations	3080	5
Tourism marketing	3034	6
Develop Low Season Attractions and Events	2812	7
Different Options for Site Entry	2520	8
Improve Tour Guide Management on Site	2430	9
Introduce a Comprehensive Communications Policy	2409	10
Establishing the location and timing of individual group use	2304	11
Prevents sightseeing access for private vehicles, especially to sensitive areas of the site.	2301	12
Restrict access to certain areas except by guided tour	2280	13
Improve Peak Activity Management of Special Events	2048	14
Risk assessment techniques to crowd management	1972	15
Encourage Promotion of Low Season Travel	1860	16
Safety regulations concerning activities and the use of facilities	1836	17
Improve Arrivals and Departure Area	1820	18
Differential pricing	1800	19
Improve Visitor Movement Past Viewing Locations	1702	20
Ensure that additional, overflow movement pathways are available for use in peak periods;	1675	21
Restrictions by group characteristics	1656	22
Group size limit	1584	23
Park information	1536	24
Establish Administrative Responsibility for Congestion Management	1470	25
Enhance Physical Influences on Tourism Demand	1462	26
Implementation, monitoring and evaluation of effectiveness of visitor management plan	1403	27
Include Congestion Issues in the Management Plan	1386	28
introduction of special sightseeing vehicles on the site	1260	29
Training program is element of visitor management	1260	30
Introduce pre-reservation systems for groups or individuals, including internet, pre-purchase and telephone reservations	1248	31
Consider limiting visitors to riding in special purpose vehicles in order to access remote or difficult areas of the site	1220	32
Improve Responsive Measures for Peak Periods	1188	33
Focal gateways	1120	34
Manage the Movement of Visitors in Sensitive Areas	1040	35
Guide the management of crowd flow and movement in a range of public assembly venues	1026	36
Barriers	954	37
Distribute outlets around the site to spread the flow of visitors	840	38
Market trial routes	840	39
Develop Tourism Operator Licenses	736	40
Signage to the site on primary access routes	703	41
Encourage Expanded Travel Periods in Source Markets	693	42
Regulations to problem areas	689	43
Encourage Joint Promotion with Complementary Sites	627	44
Improve Access for the Physically Impaired	580	45

Sufficient parking area for private vehicles	552	46
Adequate resources for implementation of visitor management plan	437	47
food and retail outlets are located and have sufficient space with ensuring no disturbances to the visitors and park	414	48
Choose the appropriate ticketing system	400	49
Improve Coordination of Arriving Groups	335	50
Improve Physical Capacity of Local Infrastructure	324	51
Regulations to the entire protected area	294	52
Area protection through the restrictions	288	53
Improve Physical Capacity of Local Road Systems	256	54
Restrictions on the use of fire	222	55
reduce the impact of visitors on sensitive soils and vegetation	164	56
Increase the resistance of the resource	100	57
Improve range of public transport provision	87	58
Maintain/ rehabilitate resource	84	59
Improve Local Traffic Management	61	60
Managing the resource capabilities to handle use	41	61

Table 1 Prioritized Criteria

Those prioritized criteria are more suitable for sustainable visitor management which can be applied to overcome the over visitation issue of national park in any country. To distinguish the acceptability and applicability of those criteria for sustainable visitor management in national parks of Sri Lanka, the experts in the tourism industry in Sri Lanka and the officers of the Department of Wildlife Conservation in Sri Lanka were interviewed cross checking the criteria. It was mainly discussed about the acceptability and compatibility of Criteria to the Sri Lankan context. Other than those criteria some of the expertise mentioned new criteria as measuring method for vandalism of National parks and having visitor feedbacks continuously.

4. Application of Evaluating Criteria for the National Parks in Sri Lanka

There are 21 national parks in Sri Lanka. Among them, only 18 national parks are opened for visitors. To apply the above identified twenty four criteria, there should be a proper way to select one or few national parks. Since over visitation of the main problem which is focused in this study, it was selected 5 major national parks in the Sri Lanka which more visitors get attracted during the last 8 years (more than 300,000 visitors). Current visitor management mechanism which was practiced by these five national parks were evaluated by applying the above derived suitable criteria and related indicators. Non-probability judgment sampling method was used to interview the field officers, managers of these national parks, officers of Sri Lanka Tourism Development Authority, Department of Wildlife Conservation and few visitors of national parks were interviewed.

They were instructed to mention whether each criterion is applied or not in terms of index of availability as not available (0), low available (1), Moderate available (2), high available (3). The values of the availability index under each criteria were multiply with the rank of value of the criteria which got under the application of Multivariate Technique. Final values were categorized into three level high, moderate and low using following methods.

Highest level of sustainability Visitor Management = (Average Rank \times No. of Criteria) \times 3

Moderate level of sustainability Visitor Management = (Average Rank \times No. of Criteria) \times 2

Lowest level of sustainability Visitor Management = (Average Rank \times No. of Criteria) \times 1

According to the final total availability value, Horton plains, Udawalawe, Minneriya and Wasgamuwa national parks are in moderate level on application of sustainable visitor management while Yala national park is being lowest. Therefore, Yala national park was selected for further studies.

Yala national park is the most visited national park in Sri Lanka which is located in between Southern Province and Uva Province. This national park was named as Ruhuna National Park with adjoining Kumana National Park. It was declared in 1938 February 25 as a National Park which designated as wildlife sanctuary in year 1900. Total area of the Yala National Park is 978.81sq.km. This park was called as a heaven for leopards while there are many spices, mainly such as Sri Lankan elephant, Sri Lankan sloth bear, Wild water buffalo and aquatic birds. Also eco system of the park is varying. There are variety of moist monsoon forests, dry monsoon forests, semi deciduous forests, thorn forests, grasslands, fresh water and marine wetlands, and sandy beaches. After the civil war conflict in Sri Lanka number of visitors and revenue has been increased. In year 2008 total number of visitors was 43,368 and it was increased to 253, 545 by 2010 (Refer Figure 1 and figure 2)



Figure 1-Numberof Visitors to Yala National Park from 2004-2011

Source: SLTDA

Furthermore the revenue of the park also increased. Figure 8

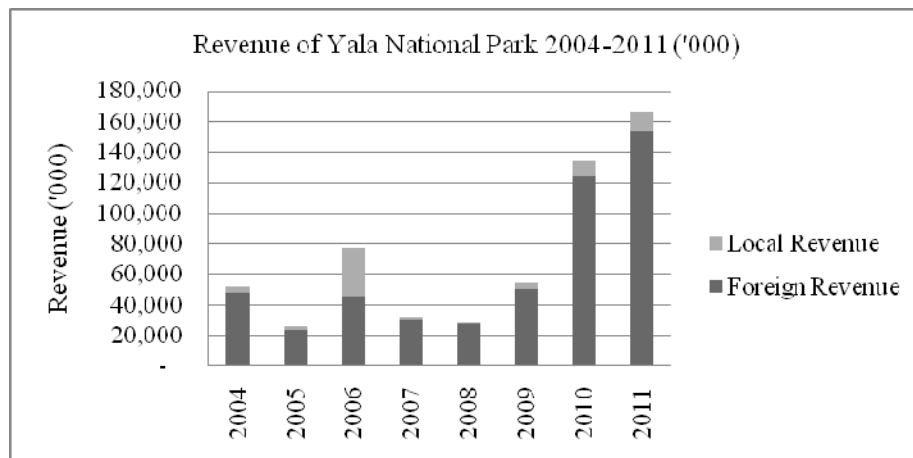


Figure 2 Revenue of Yala National Park 2004-2011 ('000)

Source: SLTDA

There are many threats to fauna and flora in the national parks. Main problem is the over visitation and the carrying capacity is exceeded in the Yala National Park. It will lead to arise impacts on wildlife, violate the road network due to high usage, waste, noise and air pollution (Miththapala, 2012).

As the final stage of this study, it was found that the availability of the Sustainable Visitor Management in Yala National Park using selected very best twenty four criteria with comparing values of availability index.

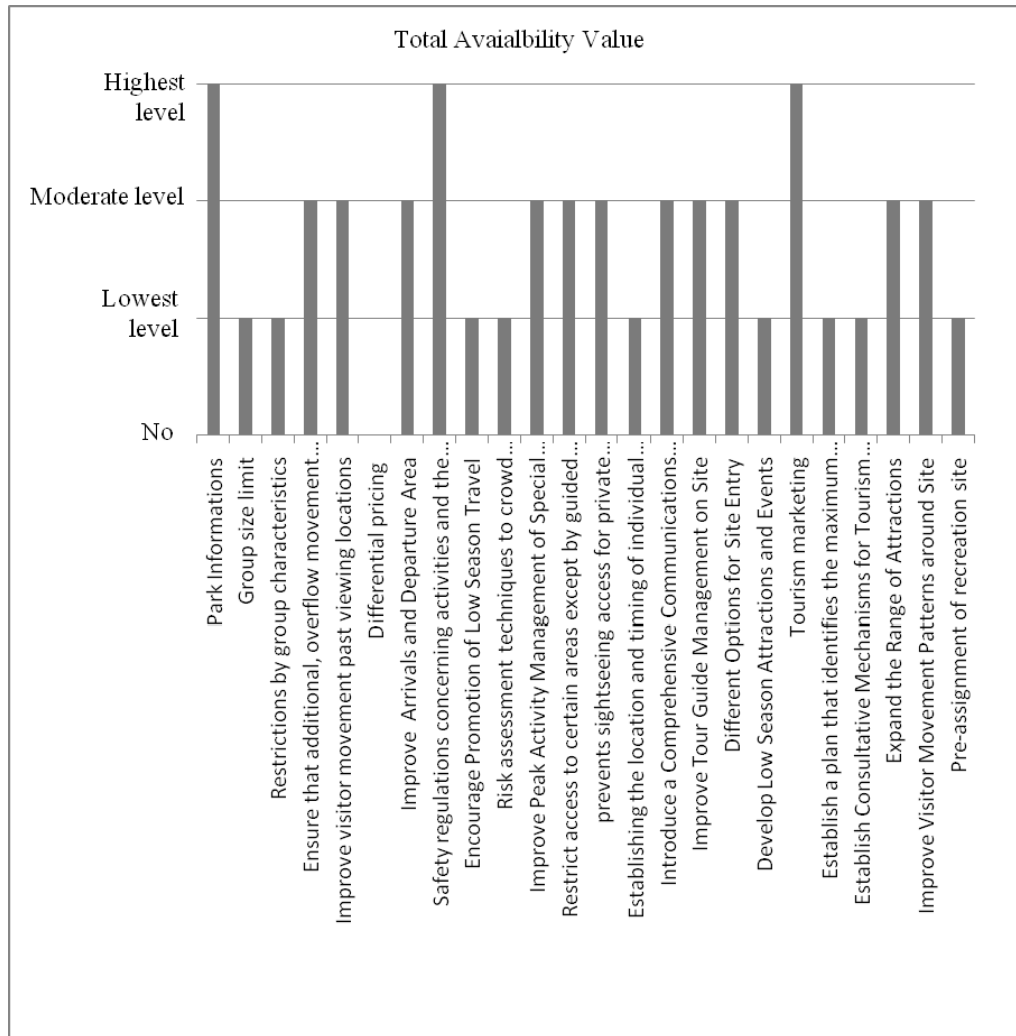


Figure 3 Total Availability Value for the Criteria in Yala National Park (For full criteria's name please refer grey criteria in table 1)

According to the results (Figure 3), Yala National Park is in the moderate level on availability and application of suitable criteria. Yala National Park is in critical situation in terms of over visitation and lack of application of most of criteria of sustainable visitor management. There are twenty one criteria that need to be applied in order to enhance the sustainability of visitor management.

5.0 Conclusion

There is an increasing interest on the national parks based eco-tourism. The national parks in Sri Lanka suffer from the issue of over visitation and it has caused many subsequent environmental degradations. Application of sustainable visitor management is a best solution to overcome the issue and this research paper identified suitable evaluating criteria for sustainable visitor management in Sri Lankan context.

Based on the literature review, sixty nine criteria were identified. Using multivariate technique and considering the opinions of the expertise, they were reduced to twenty four to create Sustainable Visitor Management while acting the best criteria that address the challenge of over visitations in the national parks of Sri Lanka. All these twenty four criteria were prioritized according to the order of high level to low level using multivariate technique. Application and the availability of these criteria in five national parks of Sri Lanka were examined and finally they were applied to Yala National Park which has lowest availability of application of criteria. The final result indicates that Yala National Park is in moderate level of practicing the sustainable visitor management. There are twenty one criteria that need to be applied in order to enhance the sustainability of visitor management.

Those identified twenty four criteria are more appropriate and more useful for the sustainable visitor management of the national parks in Sri Lanka and also in other countries, but not as same as the criteria identified in this study. They can be changed based on the context of different countries with different usage. Future studies can be carried out to prepare a model to apply the sustainable visitor management system to the national parks in Sri Lanka and it can be extended to the global context. Also this can apply to the cultural and heritage sites in the world as a model.

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Stakeholder Perception based Approach to Vulnerability Assessment: Case of Ratnapura Municipal Council Area

P. K.S.Mahanama,
Faculty of Architecture, University of Moratuwa
mahanama_pks@yahoo.com

T.K.G.P. Ranasinghe
Department of Town & Country Planning, University of Moratuwa
gayaniprasadika@gmail.com

E. J. Warusavitharana
Department of Town & Country Planning, University of Moratuwa
eme_jayani@yahoo.com

Abstract

The intention of this paper is to provide an alternative approach to the vulnerability assessment. Most of the present approaches that are involved in the vulnerability assessment process have been identified with various weaknesses. Most of the weaknesses are related to the elements that are considered in the approaches. Identifying the most suitable elements, when performing the vulnerability assessment, is crucial to the creation of disaster resilient cities. Stakeholder perceptions are vital to identify the site specific and disaster specific elements. This research develops an approach that is stakeholder perception based and mostly relevant to the site specificities. Through the literature review, thirty three elements were identified with reference to flood and landslide. Factor analysis method was applied to identify the most influential elements among them through the stakeholder perception. The Vulnerability Assessment was performed by applying the identified elements, taking Rathnapura as the case study area.

1.0. Introduction

The disaster incidents profile (2012) of Sri Lanka indicates that disasters during the period 1997-2006 indicates a clear trend of a very rapid increase, with about 200 incidents recorded in 1997 and more than 1800 events recorded in 2006. Therefore incorporating disaster risk reduction measures in the city development plans has become a major requirement since they are the means of directing the future growth of the city in a safe and sustainable manner. Any development plan or project or activity should be incorporated with disaster risk reduction measures since all natural hazards can lead to make vast disaster in every aspects of the environment (King and Bell, 2005). Hazards are potentially damaging phenomena, but they only precipitate disasters when they impact on elements at risk (Rashed and Weeks 2002). These elements can be physical structures such as schools, roads or houses, the environment or humans or human activities (Cutter 1996 and Weichselgartner 2001). In the process of mainstreaming disaster risk reduction in to development process, VA is the preliminary and supportive technique which can be used to identify hazard risk areas. An evaluation of the risk to an exposed element from a hazardous event requires a consideration of the right elements which expresses its propensity to suffer damage (Douglas, 2007). But these elements can be varied in terms of type of disaster and context of the area. Therefore main objective of this study is to identify suitable and important elements for vulnerability assessment considering both flood and landslides situations under different dimensions which supposed to be identified as one of the outcome of this study.

This paper discusses the definitions and concepts of natural hazard, vulnerability and risk assessments. Further it elaborates important elements that may contribute to vulnerability based on findings of literature review. Factor analysis was applied to categorize different types of elements under specific dimensions. Those identified 33 elements which categorized under nine

dimensions were applied to assess the disaster vulnerability of Ratapura MC area which hugely get affect from landslides and floods.

2.0. Literature Review

2.1. Natural hazard, Vulnerability and Risk Assessment

Glade (2003) defines that the term natural hazard implies the occurrence of a natural condition or phenomenon which threats disastrous in a defined space and time. Some authors characterize the “natural process” as “hazard”, and the “natural hazard” as “disaster”, and argue that hazards are natural, but in general, disasters are not, and that disasters should not be seen as inevitable outcome of a hazard’s impact (Alexander,1993). They stress on the conditions of people which make it possible for a hazard to become a disaster (Cannon,1993, United Nations,2004). Glade (2003) defines that vulnerability is commonly related to the consequences of a natural hazard. These consequences are generally measured in terms of damage or losses, either on a metric scale or on an ordinal scale based on social values or perceptions and evaluations. Characteristics of definitions of the term “vulnerability” with respect to elements at risk can be analyzed based on findings of literature as indicated in table1. Accordingly Vulnerability is the threat:

Table 1: Term vulnerability with respect to elements and factors at risk

to which people are exposed	Gabor and Griffith (1980), Cutter (2003), Amendola (1998)
To which a system acts adversely	Timmerman (1981)
To various types of buildings	Petak and Atkisson (1982)
To which different classes of society	Susman et al. (1983)
Between risk and preparedness	Pijawka and Radwan (1985)
For where vulnerable people and places are located	Liverman (1990), Comfort et al. (1999)
For socio economics groups or regions	Downing (1991)
aggregate measure of human welfare that integrates environmental, social, economic and political exposure	Bohle et al. (1994)
Biophysical, demographic, economic, social and technological factors such as population ages, economic dependency, racism and age of infrastructure	Dow and Downing (1995)
Sensitivity of land use	Gilard and Givone (1997)
Which affect characteristics of a person or a group in terms of their capacity to anticipate, cope with, resist and recover from the impact of a natural hazard	Wisner et al. (2004)
Vulnerability is highly dependent on the construction material used for exposed elements at risk	Fuchs (2007)

Source: Findings of Literature Review

King and Bell (2005) mention that consideration of right elements for VA from a given hazard requires expressing its susceptibility to damage. Fuchs (2007) shows that risk is expressed as a function of the hazard, the elements at risk and the vulnerability. Therefore estimation of the level of risk of any disaster prone area can be done with the identification of suitable and right elements for assessing vulnerability.

2.2. Identification of elements that may contribute to vulnerability

2.2.1. *Vulnerability assessment pertaining to Landslide*

Glade (2003) finds that there are lacks of studies on identification of right elements for VA pertaining to landslides and mention that population, buildings and engineering structures, infrastructure areas and lines, public service utilities and economic activities should be considered as major elements. Kaynia (2008) shows that landslides are responsible for significant loss of life and injury to people and their livestock as well as damage to lifelines, critical infrastructure, agricultural lands, housing and public and private infrastructure and assets. Further he shows that the concentration of property on steep slopes, high standard of living and high population density all combine to make society vulnerable to landslide events even those of small magnitude. Papathoma (2007) shows that considering material and use of the buildings, number of residents and employees, characteristics of the inhabitants (population density, age) are important for identifying vulnerable settlements. Further he ensures that the elements that affect vulnerability are important to visualize the physical, human and economic vulnerability.

Vulnerability to landslides is also discussed by Glade and Crozier (2005) who determine the vulnerability of people according to their location (open space, vehicle or building). Gomes (2003) mentions that elements should be included the presence, frequency and absolute number of human lives, infrastructure (public, residential etc.) and productive function and activities (industry, agriculture, etc.). Michael (2003) performed an analysis of the vulnerability of residents, buildings, and Roads/railway lines to landslides, material and age of the buildings and existence of surrounding wall, existence of large windows toward the mountain slope. As it is suggested by Centre (2000), the risk and vulnerability is a result of a combination of societal and natural conditions. When assessing the social vulnerability of the community, the data concerning the population are very important and include number of households per building, land use/building use, temporary houses, temporary high density of population (theatres/ski resorts/tourist buildings etc.) and buildings with particularly vulnerable populations (hospitals, elderly nursing homes, kindergartens, schools, jails).

2.2.2. *Vulnerability assessment pertaining to floods*

Flood damage refers to all varieties of harm caused by flooding. It includes a wide range of harmful effects on humans, their health and their belongings, on public infrastructure, cultural heritage, ecological systems, industrial production and the competitive strength of the affected economy (Volker, 2005). The actual amount of flood damage of a specific flood event depends on the vulnerability of the affected socio-economic and ecological systems (Cutter, 1996 and Mitchell, 1989). Elements supply information about the vulnerable location in terms of their elevation, their proximity to the river, their closeness to inundation areas and return periods of different types of floods in the floodplain (Alexander 1993, Heyman et al. 1991).

2.2.3. *Vulnerability assessment pertaining to landslide and flood*

An interesting study has been carried out by the Department of Hydrology and Meteorology of Nepal (Shrestha, 2005). This study includes both the physical and social elements of vulnerability pertaining to landslides and floods. The physical vulnerability was calculated and mapped on the basis of a combination between physical exposure (population, households, agricultural land and road length) and hazard. The social vulnerability assessment considered factors such as telephone lines, hospitals, banks, number of inhabitants and economic diversity. This study points out the significance of vulnerability assessment since it proves that although the hazard has decreased the vulnerability has risen due to higher physical exposure and lower adaptive capabilities on various elements (Shrestha, 2005). Volker (2005) shows that elements at risk specify the amount of social, economic or ecological units or systems which are at risk of being affected regarding all kinds of hazards in a specific area as persons, households, firms, economic production, private and public buildings, public infrastructure, cultural assets, ecological species and landscapes located in a hazardous area or connected to it.

Social vulnerability describes the demographic characteristic of social groups that make them more or less susceptible to the impact of hazards (Hill et al. 2001). Cutter (2003) suggests that social factors such as wealth and housing can contribute to greater vulnerability. Social vulnerability also is a factor of place inequalities. These inequalities include the characteristics of communities such as the level of urbanization, growth rates, and economic vitality (Cutter et al. 2003). Key social and demographic characteristics that are elements of social vulnerability are population density and distribution, socioeconomic status, age, experience, gender, race or ethnicity, and wealth (Hill et al. 2001).

Beck (2009) has considered elements such as population density (people/square mile), females, non-Whites, Persons under 18, persons over 65, mobile homes and median income. Carmarines(2010) has assessed vulnerability in terms of economic aspect, socio-cultural-demographic aspect and physical aspects considering six, eight and seven elements under each aspect respectively. Community based vulnerability assessment conducted for two Coastal Indonesian cities (2010) has utilized elements such as total number of households, number of children between 8–17 not currently in school, ratio of households to Motorcycles,percentage of households with access to city water supply, number of households who uses public wells and number of times rubbish is collected per week when assessing vulnerabilities in block wise.

The disaster risk and vulnerability assessment conducted for Teso, Lango and Acholi sub regions have considered vulnerable conditions with respect to asset type and elements at risk under economic, natural, constructed individual and social assets. Koh (2010) assessed local vulnerability to climate change in Korean city of Gyeonggi considering the vulnerability as a function of exposure, sensitivity and adaptive capacity. It was identified 8 elements to measure the exposure, 10 elementsto measure sensitivity and 15 elementsto measure adaptive capacity.

Literature clearly shows that the elements play a huge role in making the use of VA which directed to make effective decisions on disaster resilient planning of human settlements. The elements must vary in terms of the type of disaster or combination of more. Therefore decision makers should aware about these different elements which vary on type of disaster under suitable category of dimension.

3.0 Methodology

As a finding of literature review, thirty three elements which are suitable for VA pertaining to both landslides and flood were identified. Application of right elements in VA can be done effectively when they are in different category of dimension without overlapping each other. Therefore all above identified 33 elements should be selected based on their significance in terms of different context of city under suitable dimensions. Theseelements were ranked according to the rank values indicating in following Table 1.

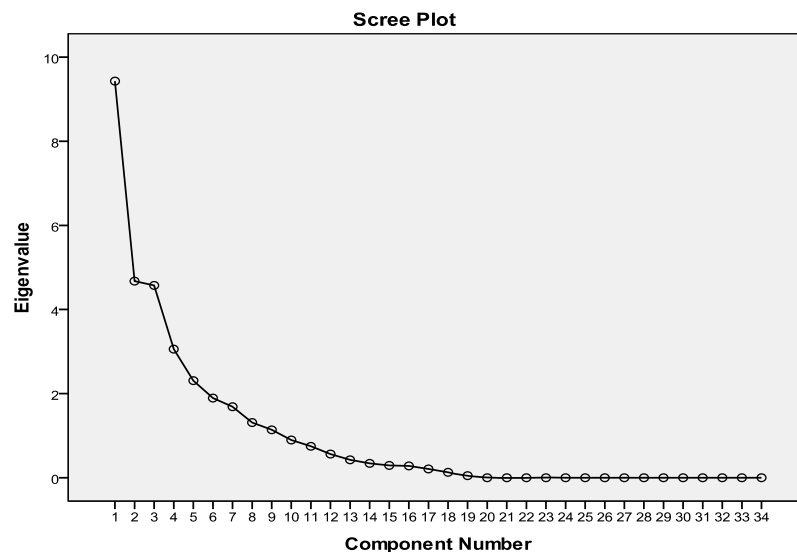
Table 1: Rank values used for factor analysis

Rank Value	Qualitative Value	Description
6	Very high important	The element was very highly important in vulnerability assessment
5	High important	The element was high important in vulnerability assessment
4	Moderately important	This element was moderately important in vulnerability assessment
3	Low important	This element was low importance in vulnerability assessment
2	Very low important	This element was very low importance in vulnerability assessment
1	Not important	This element was not important in vulnerability assessment

All elements were grouped using factor analysis considering the similar variance. Tabachnick and Fidell (2005) shows that factor analysis is based on the correlation matrix of the variables involved, and correlations usually need a large sample size before they stabilize. Robert (1999) advice regarding sample size: 50 cases are very poor, 100 are poor, 200 are fair, 300 are good, 500 are very good and 1000 or more is excellent. Hence to have fair result of this study, it was conducted 200 questionnaires by consulting 200 expertise who are involving in disaster risk reduction and climate change mitigation and adaptation programs in Sri Lanka by following snow ball method.

Kaiser-Meyer-Olkin measure of sampling adequacy is 0.869 and explains the satisfactory sampling adequacy which explains that the data selected for the factor analysis are fair or suitable in sample. In the correlation matrix, the highest coefficient values under each element were 0.3 to 0.9 and any elements were not removed from the list. Principal Axis factoring method is used as extraction method since it is more applicable for analysis of ordinal variables. In next analysis Rotated Component Matrix further validates the results. Idea of rotation is to reduce the number factors on which the variables under investigation have high loadings according to the relationship between factors. Rotation does not actually change anything but makes the interpretation of the analysis easier. Promax is used as rotation and interpretation method to correlate factors. This factor analysis was produced nine components (dimensions) according to the identified relationships as indicated in Table 3. All components indicate Eigen values more than 1 as shown in following scree plot chart. The canonical correlation value between these nine factors is 0.309, which is more than the Cohen's criterion of 0.3. Hence, the nine factors are interrelated.

Figure1: Scree Plot chart



Table

3-

Rotated Component Matrix

Elements	Environment factors (1)	Education facilities and income (2)	Population characteristics (3)	Housing characteristics (4)	Economic properties (5)	Emergency Access (6)	Population (7)	Electrical and telecommunication (8)	Microorganism sites (9)
1. Population density	-.198		.243		.102	.206	.839		
2. Day and night time floating population		-.205					.548	.247	
3. Self-employed / Micro entrepreneur / informally employed			.844			.137	.273		.195
4. Proportion of female population			.825		-.154		-.266	.280	.110
5. Proportion of children and elder population			.809						
6. Number of differently-able people	.224	.196	.864	.121			-.198		-.204
7. Unemployed population		.359	.782					.772	
8. Industries (small, medium and large scales)	-.168	.635	.161		.606		-.281	.178	
9. Commercial areas (shops, ect)	-.189	.497	-.120		.731	-.200	-.190	.258	
10. Education level and Literacy Rate		.780						.366	.281
11. Availability of schools (nursery, primary, secondary)	.137	.817	.274	.306	.117		-.238		
12. Type of roof used for houses				.895		.147			
13. Type of wall used for houses	.154		.234	.838	-.158		.323	-.163	
14. Household income	-.120	.851					.216		-.249
15. Number of Samurdhi recipients	-.197	.751				.167	.366	.144	-.144
16. Condition of the roads (rough & muddy, gravel, asphalt, concrete)	.417	.191		.423	-.203	.577		.197	
17. Materials used for bridges (wood/bamboo, concrete, steel)	.153		.194	.120		.610			

18.	Ecologically sensitive area(coastline, Wetlands, conservation area, forests)	.891	-270	.135									
19.	Agricultural lands(paddy, tea, chena)	.558	-108	-.233	.473	.436	.189	.345					-.115
20.	Open space, Parks and playgrounds	.684	.161		.326	.339	.157	.295					.108
21.	Medical centers and hospitals		.462	.265	.191	.544	-.129	.428					.123
22.	Electricity and Telecommunication lines	.493		.297	.580			.659					.340
23.	Power plants and transmission networks	.322	.210	.553	.450	.414		.612					
24.	Source of water supply	.465	.363	.345	.509	.133	.222	.183					-.233
25.	Type of sanitation facilities	.255	.463	.393	.583	.353	.101	.280					
26.	Storm water, drainage and channel systems	.668	.154		.460	.141		.137					.166
27.	Building density	-.364	-.152	.339	.311	.234	.282	-.189					.122
28.	% of temporary, semi-permanent and permanent houses	.285		-.267	.555	.193	-.193	.257					.298
29.	Solid waste dumping sites	.430	.791			.154	-.148	-.113					.505
30.	Land value	.325	.247	-.151	-.104			-.251					-.209
31.	Livestock farms	-.229	.162	.498	.274	.261	.361	-.194					.520
32.	Soil type/ character of slope	.630			.111		-.113						.628
33.	Health condition (nutrition status/physical and mental health of people	-.112		.531	.315	.182	.409						-.123

Ecologically sensitive area (coastline, wetlands, conservation area, forests), agricultural lands (paddy, tea, chena), open space, parks and playgrounds, storm water, drainage and channel systems and soil type/ character of slope are substantially loaded on component one which is suitable to be known as 'environment factors'. Education level and literacy rate, availability of schools (nursery, primary, secondary) are substantially loaded on component two which is suitable to be known as 'education facilities and income'. Self-employed, micro entrepreneur or informally employed, unemployed population, proportion of female population, proportion of children and elder population and number of differently-able people and health condition (nutrition status/physical and mental health) of people are substantially loaded on component three which is suitable to be known as 'population characteristics'.

Percentage of temporary, semi-permanent and permanent houses, type of sanitation facilities, source of water supply, type of wall used for houses and type of roof used for houses are substantially loaded on component four which is suitable to be known as 'housing characteristics'. Industries (small, medium and large scales), commercial areas (shops, etc), building density and land value are substantially loaded on component five which is suitable to be known as 'Economic properties'.

Condition of the roads (rough & muddy, gravel, asphalt, concrete), materials used for bridges (wood/bamboo, concrete, steel) and medical centers and hospitals are substantially loaded on component six which is suitable to be known as 'emergency access locations'. Population density and day and night time floating population are substantially loaded on component seven which is suitable to be known as 'population'. Electricity and telecommunication lines, power plants and transmission networks are substantially loaded on component eight which is suitable to be known as 'electrical and telecommunication'. Solid waste dumping sites and livestock farms are substantially loaded on component nine which is suitable to be known as 'microorganism sites'.

4.0 Case Study

The case study for this research is based on the project on "Disaster resilient city development strategies for Sri Lankan city" which is implemented by UN-Habitat in collaboration with University of Moratuwa in year 2012. This section of this research elaborates how the vulnerability elements have been applied, taking Ratnapura Municipal Council (MC) as a pilot city. Ratnapura MC is a city located in Sabaragamuwa Province of Sri Lanka which is frequently affected by floods and landslides. Rainfalls during the monsoon season are caused by the influence of both the south-west and inter monsoons, characterized by intense rainfall, and contributing to the highest amount of rainfall. During the monsoon, the two rivers Kalu Ganga and Way Ganga, which are flowing across the area, make riverine floods in Ratnapura MC Area which affect human lives. Landslides are one of the major hazards in Ratnapura MC Area which mainly affects the hilly areas. It will lead to rock falls, deep failure of slopes, shallow debris flows, decline of economy, damages to infrastructure and property and even loss of life.

Figure2: Geographical Location of Rathnapura MC



Source: Survey Department

The vulnerability assessment for RathnapuraMC was conducted taking the major dimensions and its respective elements obtained from the factor analysis method. The Table3 shows the different vulnerable elements and their significance under nine dimensions. The elements shown in Table 3 were selected based on the above literature review and stakeholder opinions obtained at the stakeholder meeting conducted at Rathnapura MC Area. The most significant elements were obtained from the rotated component matrix, by selecting values more than 0.5. They were highlighted in Table 3.

To measure the aforementioned elements, authors developed relevant indicators for each element. Then with the help of Geographical Information System, the indicators with respect to each element were spatially measured by dividing entire Rathnapura MC area into 10m×10m cells. In this manner, nine maps were prepared to represent the above nine dimensions. Then the vulnerability levels were classified based on the quantile interval method under 4 classes as low, moderate, high & very high. Figure 3, 4 & 5 show some of the dimensions prepared in this manner. Subsequently each dimension was weighted considering the average values of vulnerability elements obtained from the factor analysis method. Finally the composite map was prepared by overlaying 9 weighted dimensions while classifying them under the same category of level of vulnerability. Figure 6 shows the final composite vulnerability map and dark area show the very high vulnerable locations.

Table 4: Vulnerability Dimensions obtained from the factor analysis method

Vulnerability Dimension	Vulnerable Elements	Indicators
Environment factors	Ecologically sensitive area (Forest)	Area covered by forest
	Agricultural lands (paddy)	Area covered by paddy
	Open space, Parks and playgrounds	Area covered by Open space, Parks and playgrounds
Education facilities and income	Education level and Literacy Rate	% of GN wise population based on education level
	Availability of schools (nursery, primary, secondary)	Number of primary and secondary schools
	Number of Samurdhi recipients	Number of Samurdhi recipients
Population	Population density	% of GN Population
Population characteristics	Self-employed / Micro entrepreneur /informally employed	% of GN wise self employed
	Proportion of female population	% of GN wise female population
	Proportion of children	% of GN wise children (14 > Age Group)
	Proportion of elder population	% of GN wise elder population (60 < Age Group)
Housing characteristics	Type of roof used for houses	% of GN wise houses with different roofing materials
	Type of wall used for houses	% of GN wise houses with different wall types
	Source of water supply	% of GN wise houses with different water sources
	Type of sanitation facilities	% of GN wise houses with different sanitation facility types
	% of temporary, semi-permanent and permanent houses	% of GN wise temporary semi-permanent houses
Economic properties	Industries (small, medium and large scales)	Spatial distribution of industrial areas
	Commercial areas (shops, ect)	Spatial distribution of commercial areas
	Building density	GN wise building density
	Land value	Spatial distribution of land values
Emergency Access	Condition of the roads (rough & muddy, gravel, asphalt, concrete)	Condition of the roads (rough & muddy, gravel, asphalt, concrete)
	Materials used for bridges (wood/bamboo, concrete, steel)	Materials used for bridges (wood/bamboo, concrete, steel)
	Medical centers and hospitals	Availability of Medical centers and hospitals
Microorganism sites	Solid waste dumping sites	Spatial locations of solid waste dumping sites
	Livestock farms	Spatial location of livestock farms

Figure3: Dimension – Environment Factors

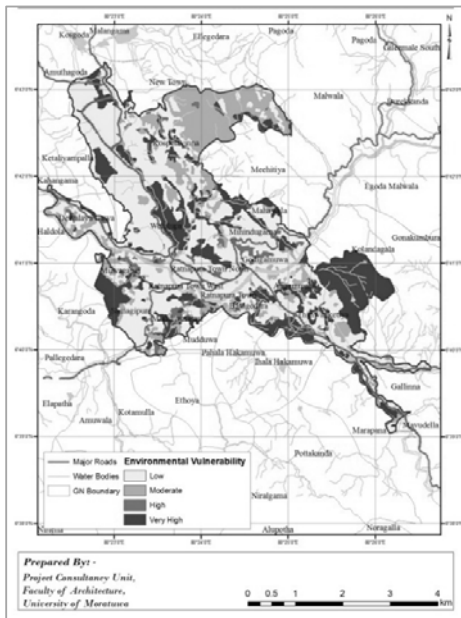


Figure4: Dimension – Economic Properties

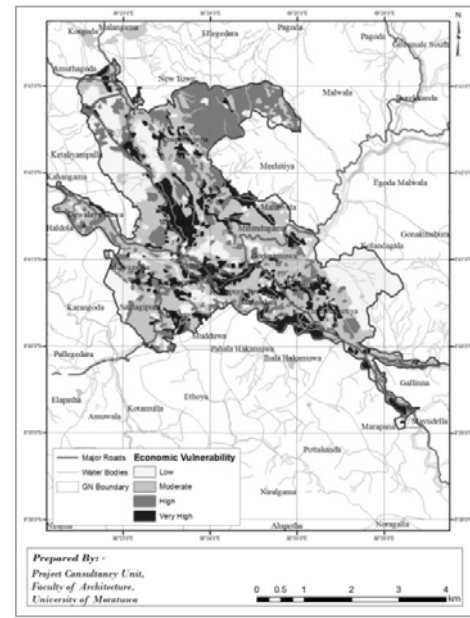


Figure5: Dimension – Population and Housing Characteristics

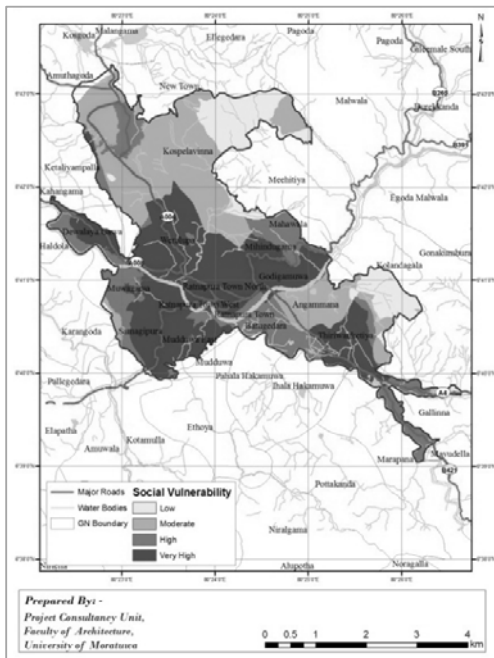
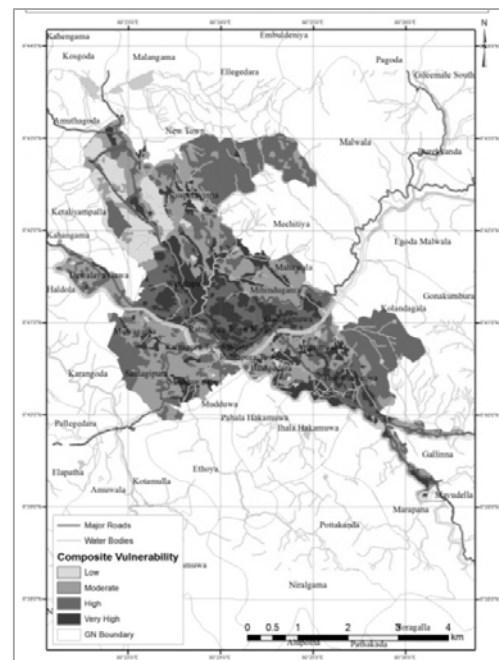


Figure6: Composite Vulnerability of Rathnapura MC



Source: Compiled by the Authors

The final composite map was further validated at ground level considering different levels of vulnerability in flood and landslide prone areas with respect to various types of elements. The final outcomes indicate that the above identified thirty three elements are more suitable for performing VA pertaining to Landslide and flood disaster situations, since it shows the high level of applicability and accuracy in ground level.

4.0 Conclusion

An important goal of vulnerability assessment is to create an index of overall vulnerability from suitable elements. At present, there are no standard and accepted elements for vulnerability assessment with respect to different types of disasters. The responsible organizations related to disaster management sector adopt different elements and different dimensions to perform vulnerability assessment. As a result of this, it is hard to measure & compare the vulnerabilities of cities by means of developing a vulnerability index. Identification of suitable elements to perform vulnerability assessment and develop a vulnerability index is more useful in comparing the vulnerabilities of different cities where the flood and landslide are dominant. Therefore the factor analysis method used in this research guide the professionals who involved in disaster management sector, to select and categorize vulnerability elements in more objective manner and weighing them in order to develop the final vulnerability index.

The main results obtained from the factor analysis method help to identify the most significant vulnerable elements with respect to flood & landslide. It also helps to group the significant vulnerable elements under 9 major dimensions. The values obtained for different vulnerability elements under factor analysis method are also important in assigning weights for such elements. The factor analysis methodology adopted in this research is perform well with varying elements under different indicators, and permit the subjectivity in selection of elements. It also highlights the importance of expert judgment in the process of vulnerability assessment. This paper demonstrates further validation of nine dimensions taking Ratnapura as a case study area.

6.0 References

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