FARU PROCEEDINGS - 2016
9th FARU International Research Conference
9th & 10th September 2016, Colombo, Sri Lanka

Building the Future
'sustainable and resilient environments'

Faculty of Architecture Research Unit
Faculty of Architecture
University of Moratuwa
Sri Lanka

NATIONAL SCIENCE FOUNDATION

FARU PROCEEDINGS - 2016

'Building the Future - sustainable and resilient built environments'

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

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Editor's Note

In recent years, there has been a need to make buildings able to withstand natural and man-made disasters and disturbances as well as long term changes in the surrounding environment resulting from climate change effects. Further, there is starting to be researched and practice initiatives to understand the dynamics of changes in the environment in this respect. This effort is not only focused onto natural disasters due to climate change, but to other significant and unforeseen areas such as quality of life, indoor and outdoor environments, energy use, health and well-being of people due to built environments and environmental and social cultural sustainability of the buildings.

Resilient built environments are the appropriately and intentionally design spaces, neighborhoods, cities and communities in order to address and challenge the negative effects of disturbances. However, with building owners, occupiers and designers constantly trying to meet project timelines and goals to deliver maximum profits and short term benefits, resilience of built environments is least concerned. Therefore, designing the future resilient built environments, protecting occupants and users, our cities and neighborhoods is a question to address and investigate.

FARU (Faculty of Architecture Research Unit) has been bringing together academics, students and professionals to share research outcome and knowledge in this regard. This year’s theme, “Building the future – sustainable and resilient *environments*”, focuses on multi-dimensional responsibilities of the designers of built environment and allied professionals. This conference is focused on discussing the need to make our living indoors and outdoors resilient to negative effects of human activities, natural disasters including warming climates. The presentation of refereed papers is organized around several sub topics involving urban environments, energy sustainability and human comfort, design technology, materiality, economizing space, knowledge and education on current practices, and historic environments and practices.

In the process of *building the future* of built environments, we should have the appropriate attitude and courage to start thinking needs of people and response to them through innovative and sustainable design and economic solutions. Research will help in this way to a greater extend more meaningfully. Finally, we will be able to discourage all inappropriate attitudes and be free to design the future environments more sustainable and resilient.

It is glad to mention that all the conference papers went through a rigorous double-blind peer review process. I acknowledge the hard work done by our national and international reviewers, and authors who revised their papers after addressing valuable comments given by reviewers present at the conference.

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KEYNOTE ADDRESS 1

URBAN FORM AND ENVIRONMENTAL PERFORMANCE

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1. Introduction

This paper demonstrates the 'systems thinking' characteristics of urban environmental research[1]. The work reveals the importance of an approach that crosses boundaries: i) of scales from city wide to individual buildings and people, ii) from fundamental technical research to more sociological and behavioural research, and iii) from theoretical studies to design and practice. Systems thinking provides a useful foil to discuss environmental urban research and I will refer to it as a framework for such investigations. After briefly introducing systems thinking, the paper is divided in to three parts to explore urban form that draw on current and recent research findings:

1. Simplified design rules: density and energy
2. Techniques: urban performance and comfort
3. Integrated modelling: urban futures and energy

2. Systems thinking

Systems thinking[2] is an approach that is particularly suitable for urban research. This is because it is used to address complex and uncertain real world problems, and it recognises that the world is a set of highly interconnected technical and social entities. These are characteristics of cities.

The purpose of systems thinking is to identify effective action by looking at connected wholes rather than separate parts, to identify interrelationships rather than things, and seeing patterns rather than static snapshots. These are all concerns with regard to urban environmental performance, where interactions

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[1] This paper is based on an oral presentation first delivered at the *Sustainable Built Environment (SBE) Conference* in Zurich, 2016.
[2]Source: Open University Definition of Systems Thinking and International Council on Systems Engineering, http://incoseonline.org.uk/Normal_Files/WhatIs/Systems_Thinking.aspx?CatID=What_Is_SE (accessed 26 Aug 2016).

between for example urban form (e.g. density) and performance (e.g. energy demand) are complex, and where technical (e.g. environmental systems) and human concerns (e.g. comfort and wellbeing) interconnect. A systematic approach is characterised by, on the one hand, uncertainty, complexity and diversity, and on the other hand, it requires a combination of quantitative and qualitative analysis.

The aim here is to demonstrate the value of systems thinking as a framework for the analysis of urban performance, drawing on recent research and its relationship to practice. It explores the role of simplified design strategies, the development of modelling techniques, and concludes with more comprehensive integrated analysis.

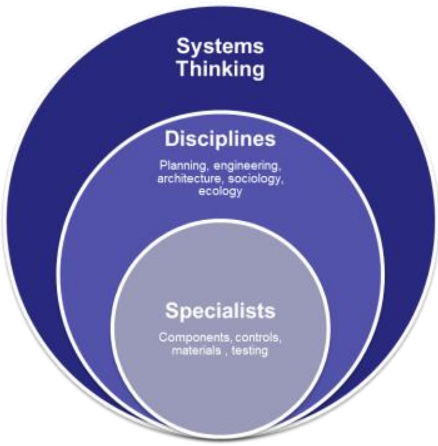

Figure 1: Diagrammatic representation of systems thinking.

- **Simplified design rules: density and energy**

The reason for considering simplified design strategies is because when collaborating with architectural practices, the aim is it to communicate key messages in a clear and coherent way. In order to integrate environmental performance in to the wider complex challenges of designing urban neighbourhoods, the guidance needs to be simple enough as well as robust.

The more accessible the rules, the more likely they are to have an impact on design. For example, key rulesfor sustainable urban planningare considered to be: i) high density, ii) mixed used and iii) polycentric development. The reasons include that people can live near to facilities (such as shops, offices, leisure) so they do not need to travel far. Furthermore, people can more easily walk to public transport nodes to reduce the reliance on private vehicles. Finally, polycentric development means that developments can be linked efficiently with mass transport, and new nodes can be added. Combined with high local densities, such transport can be more accessible and efficiently provided to large numbers of people.

Such strategies are derived from studies on density and transport energy, most notably findings by Newman and Kenworthy published in 1989[3]. Figure 2 below is a familiar graph to many, showing transport energy as a function of urban density, suggesting that there is a link whereby high density equates to low energy, and low density cities use more energy for transport.

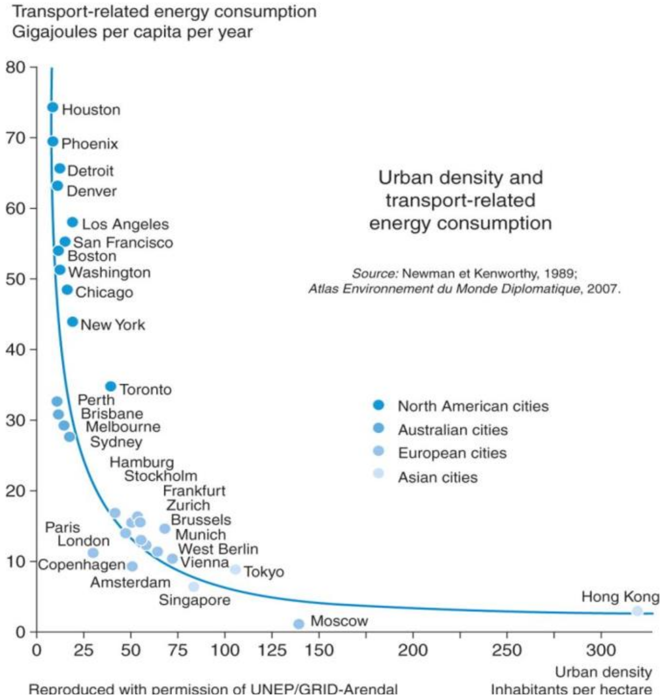

Figure 2: Urban density and transport-related energy consumption (Source: Newman and Kenworthy, 1989; A UN Guide to Carbon Neutrality Published: 2008)

The apparently simple rule, that high density cities are more energy efficient, has been repeated often but a closer look at related data suggests that an equally powerful causal relationship may lie elsewhere. Figure 3 reveals that an increasing density is correlated with lower income. Thus, low density cities are associated with high income nations where private car use is high.

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[3]Newman P.W.G. and KenworthyJ.R.(1989).*Cities and Automobile Dependence: An International Sourcebook*, Gower, Aldershot, UK.

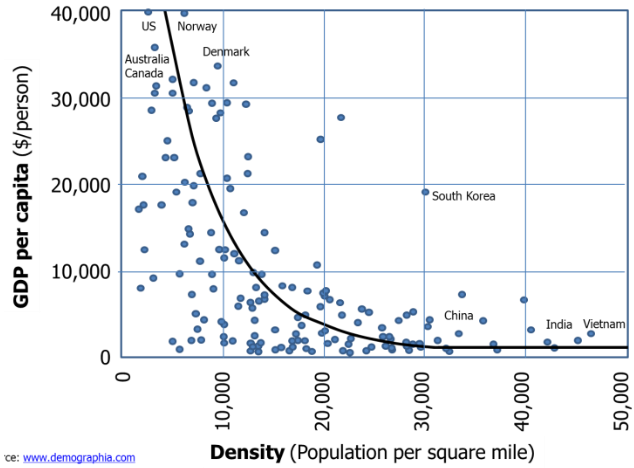

Figure 3: Urban density and prosperity.

Will increasing income result in more energy use or can limiting urban sprawl, and thereby increasing density, result in less per capita energy consumption? Will increasing the density of a city reduce energy use or increase it? Transport studies in the US have suggested that doubling the density (i.e. by 200%) can reduce car use by up to 20%[4]. This seems low, particularly as it means that the overall car use of the denser city could still rise by ca. 180% (i.e. 200% - 20%). It is certainly less than for example using Figure 2 to compare San Francisco with a city like London, at double the density, showing a 5-fold reduction in transport energy use.

Nevertheless, from a top down aggregate level we can see that there is an indirect inverse correlation (if not a causal relationship) between density and energy use. How does this compliment a more bottom-up perspective related to individual behaviour and choice regarding mobility. Figure 4 below shows a simple relationship between distance travelled and time taking with respect to a number of transport modes (walking, local bus or tram, cycling, car or local train).

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[4]Ewing R. and CerveroR. (2010). 'Travel and built environment: A meta-analysis'. *Journal of the American Planning Association*, 76(3): 265–294.

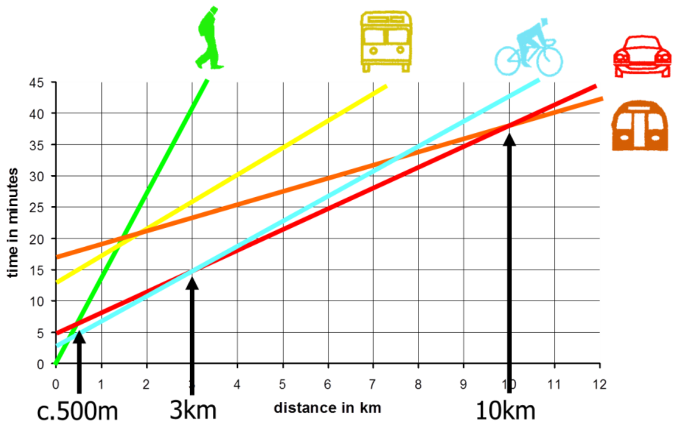

Figure 4: Time versus distance travelled for different modes of transport (walking, bus/tram, cycling, car, train).

This representation suggests thataranking of the fastest options:walking (for 3-500m), cycling (up to 3km), car (3-10km) and train (over 10km). The precise figures are affected by the frequency, quality and other characteristics of transport. Nevertheless, the graphic suggests that walking can start immediately, whereas cycling might require a few minutes extra to retrieve the bicycle and put on cycling clothes. With a car one might expect a further delay of a minute or two to retrieve the car from the garage, de-ice the windscreens, and leave the neighbourhood – by which time the walker and cyclist will already be some 500 meters en route. In this scenario, a car would overtake the cyclist after 3km but would be overtaken by a train after 10km.

From such simplistic propositions comes the notion that the distance from the home to local amenities and transport hubs should be no more than 500m in order to encourage walking. This rule of thumb, depicted in Figure 5 (left), has been widely applied in urban planning.

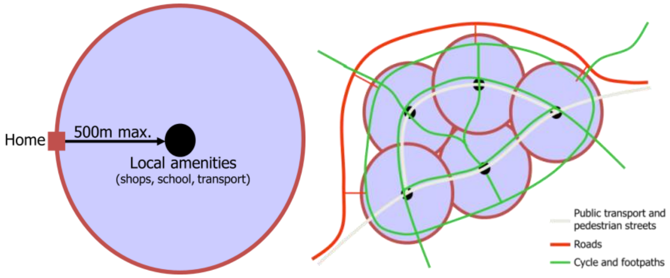

Figure 5: Diagrammatic representation of maximum extent of walkable neighbourhoods (left) and the conglomeration of neighbourhoods (right).

The circular diagram represents an urban area of about 80 hectares, but reveals nothing about the appropriate population density, which would typically equate to approximately 1,200 inhabitants for US cities, 4,000 inhabitants for European cities and 28,000 for Hong Kong. The potential economic effectiveness would be greatest for higher densities.Larger urban developments can be created by the agglomeration of such neighbourhoods – polycentric development (Figure 5, right). In order to encourage walking, cycling and public transport, the shortest pleasant routes (e.g. via green links) are reserved for these modes, whilst car journeys are more indirect and a less attractive option.

Such simplified diagrams have been used to plan a number of urban developments, including those depicted in Figure 6, showing the power of such strategic ideas.

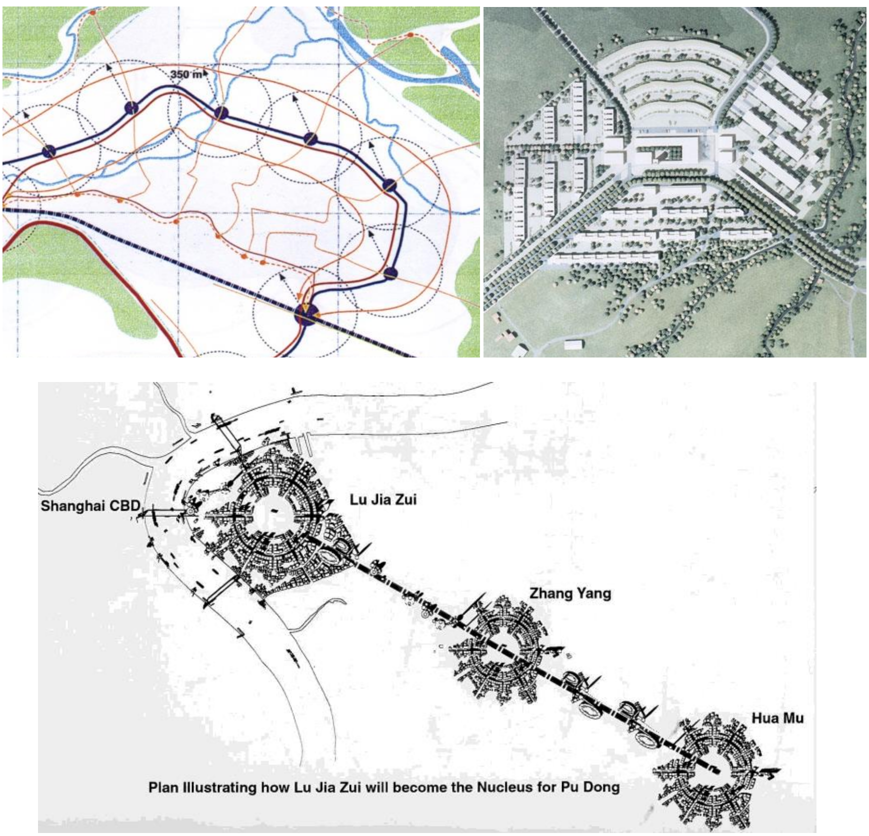

Figure 6: Strategic design for the Solar City in Linz, Austria (top left and right) and urban proposals for Shanghai (bottom) by Richard Rogers Partnership.

To inform urban design we need to translate complex and systematic analysis of urban environments in to simple and robust rules of thumb. The issues that are raised regarding the examples of simplistic rules outlined above are:

i. They are too simplistic to be robust, but simplistic enough to be influential.
ii. There is insufficient evidence that high density equates to low (building and transport) energy demand.
iii. Systems thinking and tools need to be used to model more complex scenarios in order to support the rules, to apply them only where appropriate, to change them, or to reject them.

The next section of the paper briefly describes research related to the development of techniques that help to answer the kind of concerns outlined above.

- **Techniques to assess urban performance**

Cities are complex, as exemplified by the geometry of their built form. This raises a concern about whether simplified rules can represent such complexity and suggests that techniques are required to validate them. In this section I will be addressing the following questions to demonstrate my point:

i. Is the modelling of simplified urban geometries good enough?
ii. What are the implications of complex morphologies?
iii. What techniques are there to assess real, complex urban forms?

In order to reduce the mathematical complexity, urban analysis typically uses simplified urban arrays[5]. This is valuable in testing the modelling techniques themselves and saves modelling time, but may not be representative of real urban form and performance. An example of the evolution of simplified analysis of urban form has been carried out to look at various aspects of urban performance[6]. Figure 7 shows urban arrays ranging from uniform spacing and uniform heights, to random spacing and random heights, whilst keeping either site coverage or density constant.

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[5] Martin L. and March L. (eds) (1972). *Urban Form and Structures*, Cambridge University Press.
[6]Cheng V.,Steemers K., MontavonM. and CompagnonR. (2006).'Urban Form, Density and Solar Potential', *23rd Intl. Conf. on Passive and Low Energy Architecture*, Geneva, Switzerland, 6-8 September, 701-706.

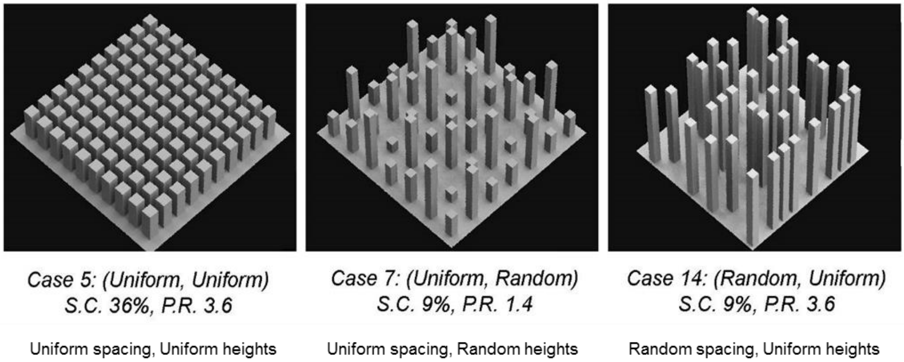

Figure 7: Examples of uniform and random urban configurations used to study the effect on environmental performance (SC = site coverage, PR = plot ratio or floor area ratio (FAR)).

The sky view factor (SVF) is a useful indicator of the heat exchange between the city and the sky (and is often used to assess the heat island effect[7]) and also indicates the daylight availability in the city – both important in terms of determining energy use. It is thus a useful strategic indicator.

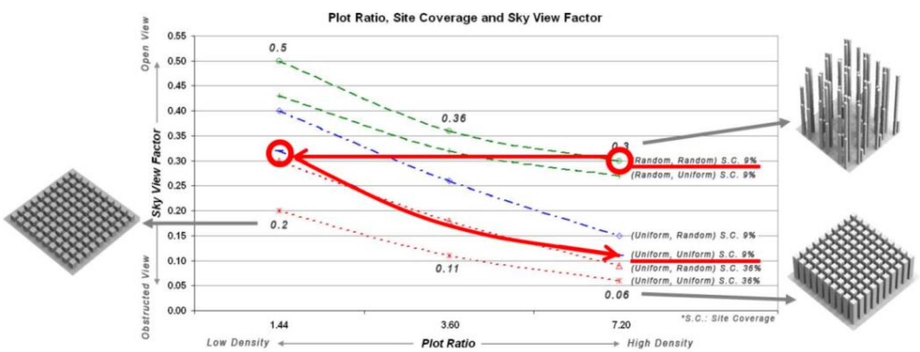

Figure 8: Comparing density and SVF for urban arrays (Cheng, Steemers, et al, 2006).

The analysis, depicted in Figure 8, shows that an urban form with variable heights and spacing, at a high density (FAR=7.2), achieves the same sky view factor (SVF=0.3) as a regular array at one-fifth of the density (FAR=1.44).
This is significant: a regular urban form can have the same SVF as one that is five times as dense.

[7] Oke, T. (1981). 'Canyon geometry and the nocturnal urban heat island: comparison of scale model and field observations'. *J. Climatol*. 1: 237–254.

Analysis of daylight availability and solar photovoltaic energy potential reveals similar trends:

i. Urban diversity at a high density (FAR=7.2) achieves higher daylight availability than a regular array at half the density (FAR=3.6), and c.50% more than at the same density.
ii. Urban diversity achieves a 25% increase in PV solar potential for low site coverage and density, and twice the solar potential for high density and site coverage.

Two key conclusions can be drawn from this study: First, increasing density can reduce urban performance, in contrast to the Newman and Kenworthy study of transport energy. Second, complexity in urban form is a key determinant of environmental performance. It is clear that regular urban arrays are not representative of the more complex forms of real cities and therefore using simplified urban form can be highly misleading. It is nevertheless valid to use simple forms to test models, but it is important to recognise that the outcomes will not be representative of real cities.

The rules of thumb that emerge from this are more nuanced than simply assuming that urban density is a sustainable option:

i. It is advantageous to vary the spacing between buildings, in response to for example the creation of different street hierarchies, urban squares and green spaces. This can be used to support social and commercial activities whilst avoiding the monotony of regular grids.
ii. Low site coverage is preferable, and is useful to create more useable urban spaces between buildings. This is particularly important in high density cities where access to open space for people is even more important.
iii. Vertical variation in height has environmental benefits and can also be used to create change in density across a city. Thus the highest densities could be used to reflect the location of transport nodes, neighbourhood centres or commercial land value.

It is worth noting that many cities have such characteristics of variability, though rarely associated with environmental benefits. If one looks at London's variation in urban form and the implications for solar access, one can immediately see that dense parts of the city have less access to sunlight but these are intermingled with lower densities where solar access is more available. Figure 9 shows the results of solar analysis as a function of urban form[8], showing the variation in performance but also the tendency for high density areas to be less amenable for solar design whereas the less dense suburbs typically have good access.

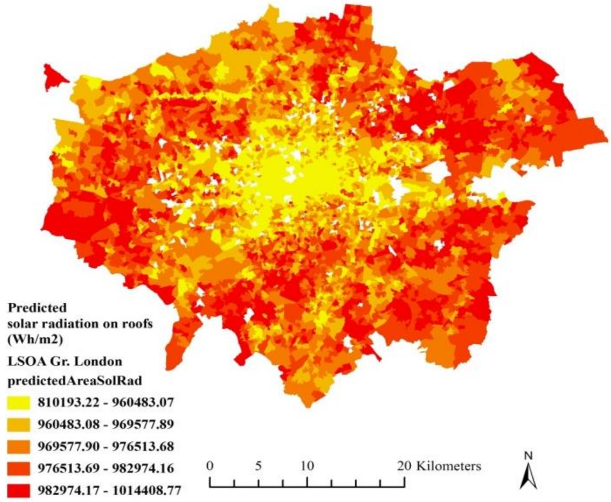

Figure 9:
The distribution of solar radiation on roofs as a function of simple urban form descriptors (H/W, orientation, density, etc.). Source: Sarralde et al, 2015.

This kind of analysis reveals that, depending on the density and the location, the energy strategy should vary. In a high density area, solar is less effective than in a less dense neighbourhood. Thus city centre renewable energy strategies should favour centralised energy networks using CHP or deep (vertical) ground source heat exchange, whereas less dense areas can exploit solar, wind or shallow (horizontal) heat exchange strategies more effectively.

By applying similar techniques to urban texture, and defining building plan depth, orientation, obstruction levels and other relevant parameters related to building energy use, it is possible to take complex forms and assess building energy use[9]. This analysis reveals that, for office-type uses, increasing the density will increase energy demand per square meter, as shown in figure 10. For example, doubling the plot ratio from 2.00 to 4.00, and assuming a constant 50% glazing ratio, increases energy demand by approximately 25%.

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[8] Sarralde J.J., Quinn D.J., WiesmannD. and Steemers K. (2015).'Solar Energy and Urban Morphology: Scenarios for Increasing the Renewable Energy Potential of Neighbourhoods in London', *Renewable Energy*, 73, January, 10–17.

[9] Ratti C., Baker N. and Steemers K. (2005). 'Energy consumption and urban texture', *Energy and Buildings*

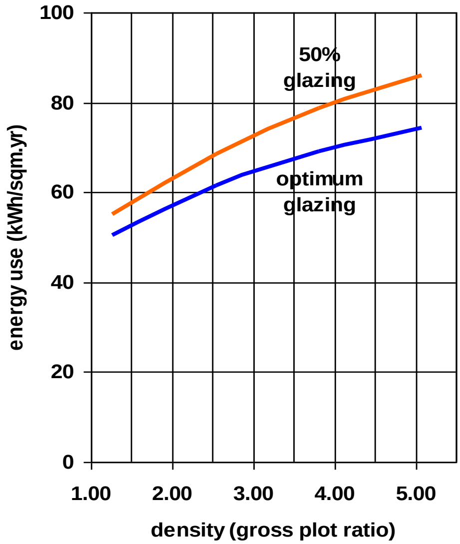

Figure 10: Energy demand for offices related to urban density. 'Optimum glazing' refers to adjusting the glazing area of the façade to minimise energy demand for lighting, heating and cooling. Source: Ratti, Baker and Steemers, 2005.

This outcome contrasts with the overly simplistic interpretation of the Newman and Kenworthy data, comparing San Francisco with London, that suggests doubling the density will reduce transport energy to one fifth. However, it is comparable in scale to the data that suggests a 20% decrease[10]. Recent research has demonstrated that for housing, doubling density has a relatively modest effect – a reduction in energy demand of up to 10%[11]. In summary, doubling urban density can increase office energy demand by 25%, reduce domestic energy demand by 10% and reduce transport energy demand by 20%. The overall energy benefit of increasing density would thus seem to be marginal, contrary to the simplified rules we started with. As a result, other questions of urban planning and design, relating to for example quality of life, liveability, cultural or commercial performance, etc., can play a more important role. The simple rules of thumb do not always hold true.

[10] Ewing R. and Cervero R. (2010). 'Travel and built environment: A meta-analysis'. *Journal of the American Planning Association*, 76(3): 265–294.

[11] Cheng V. and Steemers K. (2011).'Modelling domestic energy consumption at district scale: A tool to support national and local energy policies', *Environmental Modelling and Software*, 26(10), 1186–1198.

Similar research techniques referred to above have also been used to explore the urban microclimate, supplemented with monitoring data and survey questionnaires. Of interest is the performance of the spaces in between buildings – related to wind, sun and temperature – with respect to implications for outdoor comfort as well as building energy demand. Initial studies suggest that there are significant variations across urban spaces – some areas are more windy or more exposed to sun or retain their warmth (e.g. due to thermal mass and a low SVF and thus low radiation of heat out to the night sky). Do these variations over space and time affect the perception of thermal comfort or the energy demand of buildings? It is well known that the Urban Heat Island (UHI) effect in cities, correlated with the SVF, will impact on the thermal performance for buildings (notably by increasing overheating risks and increasing the demand for air conditioning). The work discussed here will comment briefly on outdoor comfort.

For a cool climate or season one would conjecture that people would prefer more sunny environments out of the wind, whereas in a hot climate there would be preference for shady and breezy conditions. This notion is confirmed by Brown (1985) Sun, Wind and Light[12] where the 'desirability' of such environmental parameters are related to difference predominant climatic conditions. Our work goes beyond that by asking subjects about their comfort levels. A comparison of microclimate maps with measured data and user surveys of almost 10,000 subjects in various European urban spaces revealed some interesting outcomes[13].

First, we were able to confirm that 'desirability' increases with the diversity of microclimatic conditions. This leads us to hypothesis that users of urban spaces have different preferences over time and space, and that they seek out different thermal conditions in the space to suit their needs (e.g. those sitting still might prefer some sun out of the wind, whilst those energetically moving about may seek out shady and breezy locations). A lack of options – or a low level of environmental diversity – will result in fewer subjects expressing satisfaction. This hypothesis was indeed found to be supported by the survey outcomes. Correlations with environmental diversity were stronger than correlations with any single physical variable such as temperature.

[12] Brown G.Z. (1985). *Sun, wind, and light.Architectural design strategies*. United States: John Wiley and Sons Inc., New York, NY.
[13]Steemers K. and Ramos M. (2010).'Urban environmental diversity and human comfort', in E. Ng (ed.)*Designing High Density Cities*, Earthscan.

Thus simple assumptions about optimum conditions are misleading. Diversity is preferable. Systems thinking encourages us to look for the complex and variable rather than the static, and this is particularly relevant in the understanding of outdoor thermal comfort.

This work has been further extended by research that finds that variation in urban form – in building heights and street widths – can not only increase environmental diversity but also improve the conditions in certain climates. A study of urban form and outdoor comfort in Dhaka – a warm humid climate – reveals that traditional (irregular) urban areas are cooler and more comfortable than their formal (regular) counterparts[14]. Comparing measured data has revealed an air temperaturereduction of on average 1.7^0C and a maximum reduction of 6.2^0C in traditional areas, a mean radiant temperature reduction of up to 10^0C, and a concomitant difference in perceived comfort.

The design recommendations that flow from such analysis can be summarised as follows:

i. Use of urban form to promote environmental diversity.
ii. Consider spatial and temporal diversity, rather than ‘optimal’ conditions.
iii. Maximise appropriate diversity (and desirability) with respect to climate and seasons.

- **Integrated modelling: Urban futures and energy**

This section aims to demonstrate a more integrated approach that follows the principles of systems thinking. This involves having a clear objective (e.g. the role of urban density with respect to environmental performance) in order to identify the interconnected areas of research required (such as technological, socio-economic and demographic effects). The approach to this research can be summarised as follows:

i. Define future urban development scenarios.
ii. Link socio-economic, land use, transport and building modelling to test scenarios over time.
iii. Identify the relative impact of urban, building and behaviour policy.

The research starts by identifying key urban form scenarios to test with respect to the various criteria mentioned in point (ii.) above. Essentially three urban planning scenarios are explored:

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[14]Sharmin T., Steemers K. and MatzarakisA. (2015). ‘Analysis of microclimatic diversity and outdoor thermal comfort perceptions’, *Build. Environ.*, 94, 734-750.

i. Compaction (restricting urban spread and increasing density of existing developments).
ii. Planned extensions (linear and corridor developments or new satellite towns).
iii. Market-led development (unconstrained development).

The analysis is based on integrated socio-economic and spatial modelling. The modelling framework is explained in detail elsewhere[15]. The focus for the purpose of this paper is the supply and demand aspects of buildings and energy, modelled as a function of the three future urban scenarios outlined above. The building energy model uses national building stock and energy consumption data, combining bottom-up physics-based models with top-down monitoring energy data. The model shows very strong correlations with real data which

gives confidence in its robustness to explore various aspects[16]. Figure 11 depicts the key results of domestic energy use related to density.

The first aspect to notice in the graph is that as density increases, the proportion of apartments increases and the proportion of detached houses reduces.

A most significant finding is that the energy consumption <u>per floor area</u> for the current housing stock is constant, independent of density. Thus there is no correlation between density and domestic energy use. However, the energy use <u>per dwelling</u> does reduce as density increases. This is simply a function of the fact that urban dwellings, such as apartments, tend to be smaller than suburban detached houses. As a result, increasing density is only seen to be more energy efficient because dwelling sizes are smaller.

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[15]Echenique M., Hargreaves A., Mitchell G. and NamdeoA. (2012). 'Growing Cities Sustainably: Does Urban Form Really Matter?',*Journal of American Planning Association* (JAPA) 78 (2), 121-137. AND: Hargreaves A., Cheng V., DeshmukhS., Leach M. and Steemers K. (2016). 'Forecasting how residential urban form affects the regional carbon savings and costs of retrofitting and decentralized energy supply', *Applied Energy*, DOI: 10.1016/j.apenergy.2016.02.095 (in press).
[16]Cheng V. and Steemers K. (2011).'Modelling domestic energy consumption at district scale: A tool to support national and local energy policies', *Environmental Modelling and Software*, 26(10), 1186–1198.

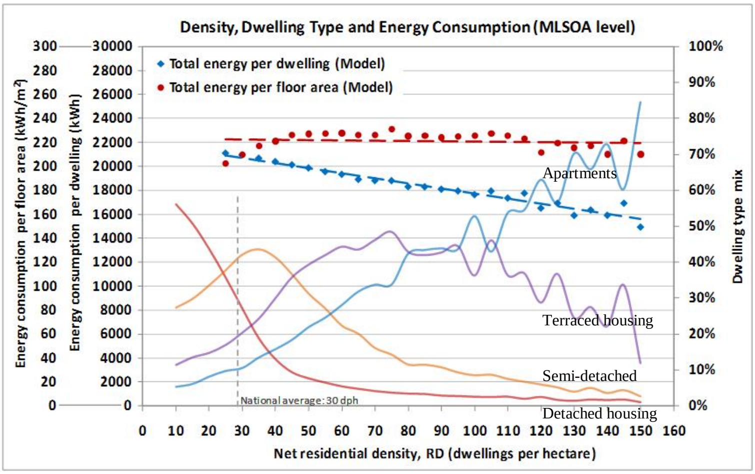

Figure 11: Dwelling type density versus energy use. Source: Cheng and Steemers, 2011.

Using the same model, the most sensitive parameter that influences energy consumption is the internal temperature chosen by the occupants. A 1^0C increase in indoor temperature results in a 10% increase in heating energy demand, which is equivalent to approximately a doubling of the density from 30 to 60 dph. Thus human behaviour can have a more profound relative effect on energy use than urban planning decisions. This type of finding is particularly noticeable in research we have carried out in China where the

comfort expectations of the younger affluent urban generation is significantly higher than older more frugal householders[17].Although we started off by exploring energy use at the urban scale, it is the behaviour of individualsthat also significantly influences the energy demand, revealing the importance of systems thinking.

Using the modelling approaches outlined above, three future urban form scenarios were exploredover a 30 year period. An energy retrofit scenario for existing buildings based on the accepted uptake rates of different measures (e.g. wall insulation, double glazing, low energy lighting, etc.) was adopted for all plans. Such refurbishment strategies can halve the energy demand. Building new can reduce energy use of individual dwellings to about a quarter of current average homes.

The findings of this integrated analysis are summarised as follows:

[17]Chen J., Wang X. and Steemers K. (2013). ‘A statistical analysis of a residential energy consumption survey study in Hangzhou, China’, *Energy and Buildings*, 66, 193-202.

i. At an aggregate and regional level, urban planning scenarios have a modest (5.4%)impact on energy demand (-3.1% for compaction; +2.4% for market-led).
ii. Spatial distribution of energy demand changes significantly (it is increasingly centralised for compaction; and distributed for market-led options).
iii. This has implications for energy provision and renewable technologies (e.g. centralised - neighbourhood CHP/ground source systems and networks; distributed - solar and wind).
iv. At the neighbourhood and building scale, much more significant opportunities are evident: The uptake of retrofitting technologies for existing buildings, occupant behaviour/expectation and the rate of energy efficient new-build have a great impact on energy demand for all scenarios.

- **Conclusions**

Systems thinking provides us with a valuable framework for developing our knowledge related to urban environmental performance and leads to more subtle and nuanced findings. This is because such an approach has the following characteristics that map on to urban design challenges[18]:

i. Address complex and uncertain real world problems (e.g. urban structures and change over time as a function of economic and demographic developments).
ii. Explore interconnected technical and social entities (e.g. physical change versus behavioural change).
iii. Look at connected wholes rather than separate parts (e.g. integrating socio-economic and environmental parameters).
iv. Identify interrelationships rather than things (e.g. between urban form and energy performance).
v. Identify patterns rather than static snapshots (e.g. urban conditions are dynamic and potentially beneficial with respect to outdoor climate).
vi. Embrace uncertainty, complexity, diversity (e.g. complexity of urban form is a positive characteristic for comfort and energy use).

[18] Source: Open University Definition of Systems Thinking and International Council on Systems Engineering, http://incoseonline.org.uk/Normal_Files/WhatIs/Systems_Thinking.aspx?CatID=What_Is_SE (accessed 26 Aug 2016).

Rajapaksha.Upendra, et al (eds), 2016, “Building the Future – sustainable and resilient environments”*: Proceedings of the 9th International Conference of Faculty of Architecture Research Unit (FARU), University of Moratuwa, Sri Lanka, September 09-10, Colombo* pp. 19 - 30. ©

RELATING URBAN GRID AND PEDESTRIAN MOVEMENT THROUGH SPATIAL ANALYSIS:
Using ‘Old Dhaka’, Bangladesh as a case study

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Abstract.
This paper investigates the relationships between the pedestrian movement pattern and the urban grid dynamics of Dhaka-one of the largest megacities of the world containing over 16 million people. In recent years, Dhaka city faces rapid and haphazard urbanization without proper planning process ignoring the inherent urban characteristics. Now it has become a congested city with numerous urban problems including severe traffic congestion. The older part of the city known as ‘Old Dhaka’ grows spontaneously over more than 400 years and still retains an organic urban pattern with mixture of varied land-uses. Though enhancing pedestrian movement in urban areas is a prime issue for a resilient urban development, pedestrian facilities are observed to be overlooked in different streets of Dhaka. In resent researches of ‘Space Syntax' it is evident that the urban grid itself is the most influential shaper of urban movement patterns. This paper focuses on 'Old Dhaka’ to reveal the correlation between urban grid configuration and pedestrian movement pattern. The study method is as follows: first, the present condition of the land was investigated: second, a spatial network was created using space syntax and pedestrian volume examined: and third, the correlation between pedestrian volume and spatial network data was analysed through regression analysis. Though according to Space Syntax Local and Global integration values has been proved to be the decisive factor accordingly for pedestrian movements and vehicular movements, however the result of this research indicates a strong correlation of pedestrian volume with global integration rather than local integration values in the context of ‘Old Dhaka’.

Keywords: *Urban Grid; Pedestrian Movement; Space Syntax; Old Dhaka*

1. Introduction

Now a day, Pedestrian movement is a crucial issue in modern urban design practices, nevertheless in many cases it is not reflected in the city planning due to the lack of proper awareness(Choi 2013, Shin et al. 2007). In western

countries, urban designers are continuously trying to encourage pedestrians in urban areas through different innovative urban design solutions, whereas in many Sub-Continental cities like Dhaka pedestrians are overlooked in the urban planning process. Many traditional and historical cities in the sub-continent have narrow and tortuous streets and alleys, where the full street is observed to be used by pedestrians. Unfortunately allowing automobiles into these types of streets create heavy traffic bottlenecks and make movement dreadful. Though a pedestrian friendly city is considered to be more sustainable and resilient in modern urban design arena, allowing automobiles into narrow pedestrian streets is a common phenomenon in many sub-continental cities.
Dhaka, the capital of Bangladesh, has grown from a small trading centre and has transformed to one of the megacities of the world. Through the process of urban growth and change, the city has expanded a lot but still the older part retains its significance. Even with the lack of authorized and political support, ‘Old Dhaka’ has constantly adjusted to its new role serving significant economic, cultural and communal functions not only for the whole city but for the hinterland as well. Rashid & Rashid (1985) observes that ‘Old Dhaka’ has a distinctive urban character and strength similar to that found by Fonseca in Old Delhi. The excitement and life found in the streets of Old Dhaka are to a great extent due to the cheerful chaos randomly built into it. The fact that old Dhaka still serves vital social and economic functions tells of the vitality and strength of the culture that produced it. Though Old Dhaka do not conform the western concepts of urban design and planning, are not aberrations. It is the circumstances, culture, society, politics and economy of their origin and growth that make them different. Such cities have to be understood and evaluated in terms of different form those used in other cultures. The dynamic elements of movement, activities, culture and life styles are as integral to the composition of the city as are the physical elements. Narrow streets of Old Dhaka that were designed for horse carriages elephants and foot traffic are now being used by the pushcarts, rickshaws, cars and trucks as well as pedestrians. Public transport is under-developed and mal-administrated. Traffic jams in old Dhaka are a way of life. The narrow tortuous roads and alleys are further constricted by public stand pipes, hawkers and spill-over of business onto the street where pavements are literally absent. The residential density of old Dhaka is more than 300 persons to an acre. If the number of people includes working in this area is included the gross density will be much higher. Most of the structures of Old Dhaka stand shoulder to shoulder without the minimum of open space necessary for light and air (Rashid & Rashid 1985).

In recent years, researchers have drawn increased attention to the synergistic interactions between the urban spatial structure and pedestrian movement. Space Syntax, originally conceived by Bill Hillier, Julienne Hanson and colleagues at the Bartlett, University College London in the late 1970’s to early

1980's, an important theory and method to study the interplay between space and behaviour. Space Syntax method has been used for the assessment of spatial accessibility that analyses spaces by their configuration and calculates numerical values for all the accessible space in an urban area.

2. Literature review

The literature review section investigates the basic theories of 'Space Syntax' regarding urban grid and movement pattern. It also focuses on the relevancy of enhancing pedestrian movement as well as different factors influencing pedestrian movement in urban areas from different literature.

2.1. SPACE SYNTAX-GENERAL THEORY

The ethos of Space Syntax is based on how built space configuration affects the way the city works, influencing urban dynamics (Hillier et al. 1993; Hillier 1996). Holanda (as cited in Pereira et al. 2012) states that Space Syntax theory aims to study the social implications of urban space.[…] in a few words, it aims to establish a relationship between the spatial structure of cities and buildings, the spatial dimension of social structures, and broader social variables. It seeks to reveal both the logic of urban space at any scale and the spatial logic of societies.

Configuration modelling of urban networks has become a major focus of space syntax studies. Such type of models are constructed by breaking up the urban layout of a city or town into the fewest and longest lines of sight and access that pass through all possible routes of movement. The resulting axial map can then be analysed by using a number of statistical measures that describe the configurational properties of the urban network. A measure of how accessible each line segment is to neighbouring lines can be obtained by simply counting the number of connections per segment (Dawson 2003; Hillier 1993: 35). In addition to measuring the connectivity of a line segment, the relationship of each axial line to the whole urban system provides an important measure called 'integration'. The global and local integration measures the topological attributes of any street in respect to the whole urban system and to the nearby streets accordingly. Radius 3 of local integration means a value for integration among the spaces up to three steps away from the root. The most integrated lines in a network are those with the shortest average trip lengths to all other destinations within the grid. In contrast, the most segregated lines in which trip lengths vary to a much greater degree. In other words, integration measures the mean depth of every axial line in the grid relative to all other lines(Dawson 2003, Hillier et al. 1993: 35).

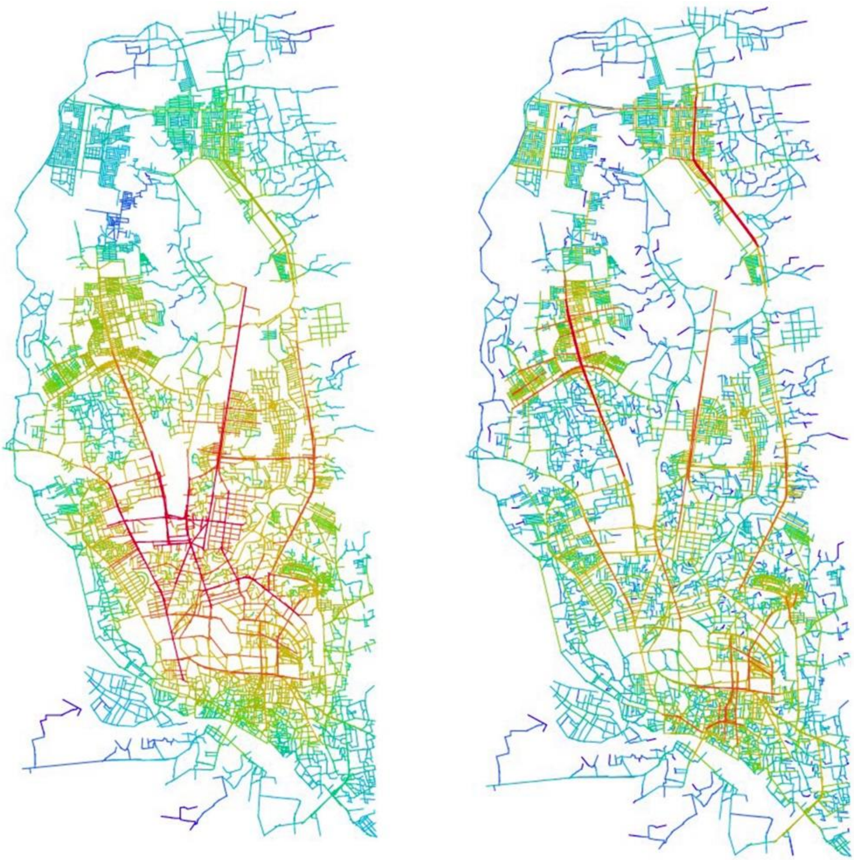


Figure 1 & 2, Axial Map of Dhaka City (2009) with Global Integration (R=n) and Local Integration (R=3)

The software for Space Syntax analyses and calculates the spatial integration values by first selecting a line from the axial map and then calculating how many other lines are required for accessing each line in the whole axial map both for local and global level. The lines with higher integration values have higher accessibility than the other lines and marked through red lines in the analysed axial map. The integration cores of the system are suitable for central activity by the reason of having an integrated structure (Hillier & Hanson 1984; Ozer&Kubat 2007).

2.2. IMPORTANCE OF PEDESTRIAN MOVEMENT IN URBAN DESIGN

Middleton (as cited in Lindlow et al. 2014) states that walking can be seen as the most fundamental transport mode in accessible and sustainable cities and is practised by people of almost any age. Environments suitable for walking constitute a vital part of a successful public transport system as well as an attractive urban environment. Research on walking is often justified for instrumental reasons, with the ability to fulfil societal goal such as public health, modal shift, traffic safety, neighbourhood security or a more attractive urban environment.

Mangin & Panerai (as cited in Foltete & Piombini 2007)observe that it is important to encourage pedestrian movement for limiting the consequence of excessive automobile use in urban environment. In this respect, knowledge of pedestrian movement is a key issue for better urban planning and design. For several years, urban planners have been paying more attention to the expectations of the pedestrians who are more conscious of the urban environment. Choi (2013) states that the planning and design of pedestrian friendly urban environment is receiving more attention in recent years not only for urban planning issues rather for its various benefits related to public health, sustainability, economy and social life. Therefore, there is an increasing need for knowledge about the walkability of the urban built environment. Urban planning and transportation research have examined walking in the urban environment. There is also an emergent field often referred to as 'walkability' research which is a multidisciplinary form of research initiated from the preventive medicine field with the health beneficial aspect of walking as the most significant motivation

2.3.CORRELATIONS BETWEEN BUILT ENVIRONMENT AND PEDESTRIAN MOVEMENT

Dijst et al. (as cited in Lindlow et al. 2014) stated that walking is, as with any other transport mode, not only something happening in the context of the built environment, it is also a part of most people's everyday life. The choice to walk is influenced – either positively or negatively – by both the built environment and the demands of everyday activities of people. Pedestrian movement is a strong and resilient phenomenon thatbrings liveliness to the place. Walkability studies have provided evidence through statistical analysis between the time spent on walking and the factors of the built environment that individual walking behaviour is related to the condition of the urban form (Choi 2013). Ozer&Kubat (2013) argued that the movement potential generated by the urban grid has direct or indirect effects on many factors other than land uses. According to Helbing et al. (2001) patterns of movements of pedestrian crowds are predictable, although there are individual preferences, aims and destinations in effect. Walking behaviour of pedestrians is influenced by other pedestrians' movement and if their footprint were traced, it would be possible to see systems of these trails (Helbing et al. 2001, Ozer&Kubat 2013).Studies related to walkability that deal with the relation between urban built environment and walking behaviour have been examining different properties of urban built environment that affect pedestrian movement pattern.In numerous studies correlation between pedestrian movement and built environment has been frequently found. The factors that have most consistently been proven for positively influencing pedestrian movement in urban areas include land-use mix, connectivity and density. Through various studies from transportation and urban planning research and the recent walkability studies, it has been suggested that neighbourhood with higher residential and employment densities, more connected street patterns, and a variety of destinations show higher rate of walking (Choi &Sayyar2012). Theories and studies from Space Syntax field have also provided significant findings and discussions on the relation between movement and urban form (Choi &Koch 2015).

2.4. URBAN GRID AND PEDESTRIAN MOVEMENT

Space Syntax is always claimed that the geometrical and topological structure of the street network is the most influential shaper of the movement patterns in urban areas (Hillier et al. 1993).According to Hillier et al. (1993), the spatial configuration plays a primitive or principal role for the pedestrian mobility. The urban grid or spatial configuration affects the pedestrians when they have to take the decision about what route they want to select for their trips. So the urban grid could encourage or discourage the selection of a route about which pedestrian can to arrive to the opportunities, even more if the street has different design properties(Era 2012).

The discovery of significant correlations between the integration value of an axial line and the amount of pedestrian and vehicular traffic that flows along it suggests that the spatial configuration of an urban network exerts a strong effect on human movement. What is especially interesting about this relationship is that it contradicts the idea that movement density is determined primarily by patterns of land use. Early examinations of pedestrian movement tended to apply a point to point approach in which the presence or absence of attractors such as retail shops and other service providers along a route of movement determined how ‘busy’ or ‘quite’ it would be. But Hillier (as cited in Dawson 2003) conclude that attractors tend to serve as multipliers on a basic pattern of movement and that movement densities are therefore more an outcome of the position occupied by a route of movement in the urban grid.

A number of researches conducted by Space Syntax have proved that pedestrian movement in urban areas is significantly influenced by spatial configuration (Hillier et al. 1987, Song et al. 2013). Integration value, that are used to describe its mean depth from other lines within a certain radius is closely related to the urban movement (Hillier 1996, Song et al. 2013) especially reflected in two dimensional level. The ‘radius 3 integration’ was proved to be the most powerful determinant of pedestrian movement in urban areas (Penn et al. 1998).This effect of spatial configuration on pedestrian mobility has created a new concept in planning studies, the concept of “Natural Movement” (Hillier et al 1993; Era 2012) This ‘Natural movement’ concept serves as a solid foundation for the later concepts such as ‘Movement Economy’ and Centrality process etc. and it has been verified in many cities of the world after the first case studies in London. In a research conducted in London it is found that 60% of pedestrian movement flows are due to the pattern of street network itself. (Hillier &Lida 2005; Hillier 2005; Penn et al 1998, Dai &Yu 2013)

3. Research Methodology

Literature, space syntax data, photographs, maps, pedestrian counts – calculated several times in weekdays by the author and personal impressions of the research area are the materials of the research. Steps of the research are; Literature research, Space Syntax Analysis, Pedestrian counts, Land uses patterns, comparison and conclusion. Space Syntax data and the analysis belonging to the research area was performed by the software Depthmapdeveloped by Alasdair Turned. Local and global integration, connectivity are some of the most interesting measures of Space Syntax analysis that is used to analyse the urban grid pattern of Dhaka.The data of pedestrian movement were collected by using the ‘Gate Count’ method developed by Space Syntax research. The aim is to investigate the pedestrian distribution on different street segments within the study area.

Measurement of connectivity and integration were taken from the axial maps constructed for Dhaka. Integration is measured at both the local (Radius 3) and global (radius n) scales for study area. Fieldwork was then undertaken in ChawkBazzarand surrounding areas of Old Dhaka during the month of June 2016 to collect observational data on rates of pedestrian movement along various road segments. Observations were taken at 26 gate positions covering a range of heavily used, moderately used and poorly used streets. Each route was observed for 2.5 minutes in morning and afternoon interval and a sunny and moderate weather in several workdays.The pedestrian data was converted to pedestrian count per hour for analysis.

3.1 DESCRIPTION OF THE STUDY AREA

Chawk Bazaar and surrounding areas BoroKatra, ChotoKatra and nearby streets Champatoli lane, Buckland Road, SwariGhat road and Devi Das Ghat lane are the subject area of this research.Basically these areas are famous for business areas of Dhaka. Some zones are used for retail goods, whereas some are for wholesale markets and some areas are for store houses of the wholesale shops.Chawk Bazaar was one of the most famous business and social meeting centres of Dhaka in the Mughal Period. Even after 400 years it is still famous as before though Dhaka extends a lot. It is one of the Dhaka's old markets and it formed in the place where old markets once were. In the 18th century, Chawk Bazaar was a famous social and business centre. Along with the historical significance, the geological settlement of this zone also contributed to its massive activities, expansion, population increase and popularity. The Great

Figure 3, 4, 5&6 (Clockwise) Different street activities in the study area (Source: Author)

Buriganga River was just at the south of Chawk Bazaar, which contributed easy water transport and thus made trade more frequent and efficient. Chawk bazaar was located in such a way that 10 different other places were connected with straight roads. Chowk bazaar is famous for its special food items for iftar.During the month of Ramadan one part of the street of Chawk Circular Road (in front of the famous mosque) is fully occupied by the street food shop from afternoon till iftar time and all kind of vehicle even rickshaws are prohibited in that street. This bazaar attracts a huge number of people not only from old Dhaka but from different parts of Dhaka (Wikipedia).

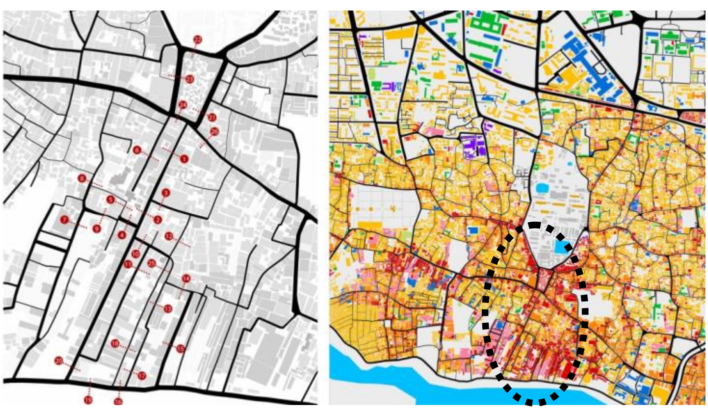


Figure 7&8, Different gate points of pedestrian count and existing land use pattern in the study area.

4. Findings and Analysis

The analysis and findings of the research are discussed in the following sections.

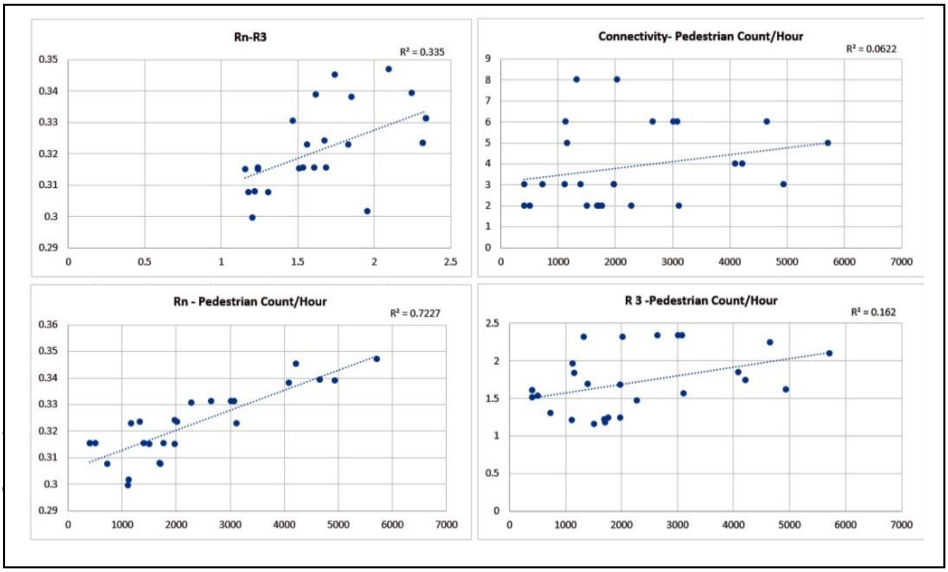
4.1.ANALYSIS OF THE CORRELATION BETWEENPEDESTRIAN VOLUME AND CONNECTIVITY

Table 1b shows the regression analysis between the amounts of pedestrian traffic in the case study area with the street connectivity. The coefficient of determinant (R Square Value) is .0622 between the two factors. It means there is almost no relation between these two. So, in this area pedestrian movement pattern is not related with connectivity of street segments.

4.2.ANALYSIS OF THE CORRELATION BETWEEN PEDESTRIAN VOLUME AND LOCAL AND GLOBAL INTEGRATION

Table 1c & 1dshows the regression analysis between the amount of pedestrian traffic in the case study area with local (Radius 3) and global (radius n) integration values accordingly. The coefficient of determinant (R Square Value) is .162 for the relationship between pedestrian volume and local integration which means that local integration (R3) values is not working as a guiding factor in the study area. In Table 1d, it shows that the global integration value works a guiding factor for the pedestrian movement where the coefficient of determinant (R Square Value) is .7227 that means a very strong correlation between these two determinants.

Table 1 (a,b,c,d-clockwise) Correlation between a. Rn & R3, b. Connectivity & Pedestrian count, c. Local integration (R3) & Ped. count. d. Global integration (Rn) & Ped. Count.



of retail shops for toys and cosmetics item. It is also famous for different types of foods especially during the months of Ramadan. There is also a very old and large mosque in this zone. The pedestrian movement volume is observed the highest in this zone.

In BoroKatra lane and the SwariGhatLane there are retail shops as well as some store houses. Here the pedestrian count is also higher. Champatoli lane is mostly used for wholesale goods especially for spices. Here the observed pedestrian movement is lower than the SwariGhat lane and BoroKatraLane. In some part of Champatoli lane where the store houses are situated, the pedestrian volume is observed very low with respect to the other zones nearby.

4.4. FINDINGS

Though, in many western countries positive correlations between connectivity and pedestrian movement was found but in the study area where the street grid is deformed and the culture is different, connectivity is not found as a influencing factor for pedestrians. Even according to Space Syntax the radius 3 integration has been proved to be a guiding factor for pedestrians, but here very poor correlations were found. Whereas Global Integration Value that has been proved to a decisive factor for vehicular movements in many western cities, here it is found to be a decisive factor for pedestrian movement pattern.

5. Conclusion and future directions

In this study, the correlation between spatial network by Space Syntax analysis and the observed pedestrian volume was analysed. The study result shows that the pedestrian movement pattern in a traditional city like ‘Old Dhaka’ acts differently than the western countries.Though, a strong relationship is found between global integration values and pedestrian volume. In a city like old Dhaka, where the street are very narrow and tortuous in pattern local (radius 3) integration is found inappropriate for determining pedestrian volume.

Another interesting finding of this research is that though the full study area is served as a business area, there is a huge difference in pedestrian count according to wholesale, retail and storehouse areas. This proves that there are different pedestrian characteristics according to different types of business zones.

In order to acquire better understanding of how urban form affects pedestrian movement in such type of traditional cities like Old Dhaka, it is important to acknowledge both in the way built environment factors affect movement and also the differences of land uses as well. This study, although limited in the amount of data and statistical testing, was an attempt to investigate these differences. Further investigation may be done by testing the detail data on different land use zones in the greater parts of 'Old Dhaka'.

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CLIMATE RESILIENCE: TOWARDS A COMPLIMENTARY SETTLEMENT ATTITUDE FOR THE SOUTH-WESTERN COASTAL REGION OF BANGLADESH

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Abstract
Though nature's behaviour is predictable most of the time but there are some movements that affect human life or livelihood is termed as natural disasters which are very frequent now a days for Bangladesh. Immature lands [developed due to siltation] are being used for settlements before time so the unique alluvial soil is also being mishandled. Climate change has also become one of the major challenges because of the geographic position and greater reliance on climate sensitive sectors, particularly agriculture. However nature gives the main difficulties, but here in coastal region, nature is only destination also. Almost every year 'natural disasters' cause substantial damage to the basic rights of life, food, health, water, housing etc. This paper aims to understand the 'nature of disaster' and it’s 'vulnerability', the strength of a land which guides people at the preliminary stage of settlement in the coastal region and present an extensive research of zoning with respect to site, surroundings, hydrology, climate and of course natural disaster focusing on a particular union* of Bangladesh affected by cyclone. However the core issue is most contextual approach focusing the settlement, which promotes the increase of the resilience of a community.

Keyword:. *Climate resilience, coastal region, rural settlement*

1. Introduction
Bangladesh has a 711 km long coastline that consists of a vast network of river systems draining the vast flow of the Ganges-Brahmaputra-Meghna River system [Minar and et al., 2013]. Roughly 80% of the landmass is made up of fertile alluvial lowland called the Bangladesh Plain. Although altitudes up to 105 meters above sea level occur in the northern part of the plain, most

*Union is the smallest rural administrative and local government units in Bangladesh. Each Union is made up of several Wards. Usually one village is designated as a Ward.

elevations are less than 10 meters above sea level; elevations decrease in the coastal south, where the terrain is generally at sea level. With such low elevations and numerous rivers, water and concomitant flooding is a predominant physical feature [Library of Congress, 1989].

The coastal zone of Bangladesh is prone to multiple threats such as cyclones, storm surges and floods, as well as earthquakes, tsunamis, and above all, climate change. The government has identified the zone as an “agro-ecologically disadvantaged region”. Scarcity of drinking water, land erosion, the high groundwater arsenic content, water logging, water and soil salinity and various forms of pollution have also slowed down not only the social and economic developments but also the perennial water-logging due to inadequate drainage [Islam, 2007].

There are three adaptive options: those are retreat, accommodation and protection. Retreat is not possible by considering the high population density, future population projections, and shortage of land. We must follow the two other options [Minar and et al., 2013].

The objectives of this paper is-

- To understand the land and settlement formation in the coastal region.
- To investigate waterlog situation and its impact.
- To explore the age-old local ways of adaptation and morphological reformation based on it.

2. Literature Review

The coastal region of Bangladesh covers about 20% of total land area and over 30% of the cultivable lands of the country. It includes highly diverse ecosystems e.g. the world’s largest single tract of mangroves (the Sundarbans), beaches, coral reefs, dunes and wetlands [Minar and et al., 2013].

2.1 LAND CHARACTERISTICS AND HYDROLOGY OF THE COASTAL REGION

The Ganges river meander floodplain systems are standing higher than the adjoining tidal lands. The estuarine islands are constantly changing shape and position as a result of river erosion and new alluvial deposition. Peat basins are located in some of the low lying areas between the Ganges river floodplains and tidal floodplains occurring in the western part of Khulna.

2.1.1 Tidal Effect

The effect of the tides is manifested in a regular alternation of rise and fall of the water level of the sea and the estuarine/tidal channels and creeks. The flow repeatedly inundates the soils and impregnates them with soluble salts, thereby rendering the soils and subsoil water saline [Haque, 2006].

2.1.2 Embankment

A vast tract of low lying tidal flood plain in the coastal area of Bangladesh is flooded twice in a day. Paddy cultivation in rotation with fish production was the main activities of the people of the area. The Government started construction of Coastal Embankment Project in 1961 under USAID assistance to increase agricultural production by preventing saline water inundation, reducing the flood hazards and preserving sweet water in the internal channel system. Effect of river confinement and future land use pattern were not taken into consideration and century long practice of paddy-cum-fish culture was stopped. An important consequence of the river confinement was the rapid river siltation (FAO report, 1985).

2.1.3 Cyclone in Bangladesh

Present day in Bangladesh, due to its unique geographic location, suffers from devastating tropical cyclones frequently. Cyclones originate from low atmospheric pressures over the Bay of Bengal. They generally occur in early summer (April-May) or late rainy season (October-November).

2.1.4 Water Log Situation

Bangladesh has a tropical monsoon climate characterized by heavy seasonal rainfall, high temperatures, and high humidity. Natural disasters, such as floods, tornadoes, and tidal bores affect the country yearly. Tropical storms associated with the Indian Monsoon system affect the GBM delta coastline every few years, and over the last decade, two major cyclones (Sidr in 2007 and Aila in 2009) caused flooding and hundreds of fatalities while displacing an estimated 1 million people (DELTAS project, 2016).

2.1.5 Salinity Intrusion

The water is not usable for domestic purposes if salinity is higher than 1ppt, though it is still favourable for crop and livestock agriculture unless salinity exceeds 2ppt. Some freshwater aquaculture is still possible when the salinity is below 4ppt. However, in the south and western part of the coastal region of Bangladesh, salinity is higher than 4ppt during the dry season which has intrigued brackish water shrimp farming in Satkhira, Khulna and Bagerhat districts (Palash, 2015).

2.2. STRATEGY FOR MANAGEMENT OF COASTAL SALINE SOILS

Coastal region is very sensitive to manage thus requires special measures.

- Protective embankment: Land may be protected from inundation of saline water through establishment of embankment of suitable size. The recommended size should be 1 meter high above the high tide level.
- Provision of sluice gate on the embankment: There should be provision of sluice gate in the embankment system to remove excess water and also to prevent ingress of saline water during high tide (Haque, 2006).

2.3. ADAPTATION EXAMPLES

Though adaptation options are constrained by economic, social, technological and political conditions, the measures depend on particular impacts and geographical factors in each country (Mowla and Kabir, 2012).

2.3.1. Netherland Experience

Presently, about one quarter of the Netherlands' total territory lies below sea level and are protected by dykes. At Oosterschelde, a high-tech bridge was completed in 1986 that can quickly be turned into a dyke. If a heavy storm is approaching, shields with a weight of many tons come from the bridge down into the water in order to prevent flooding due to storm surge (Germanwatch, 2004). Apart from these high cost engineering measures of protection, a new way of living afloat is emerging in the Netherlands where houses are built over a hollow concrete basement with expanded polystyrene which can float up to certain flood limit (Yang, 2007).

2.3.2. Bangladesh Experience

'Coastal greenbelt projects' (1995-2002) was implemented by Forest Department of Bangladesh involves mangrove plantation along nearly 9000 km of the shoreline (MoEF, 2009). Experiment and experiences shows that planting mangrove along the coastal belt would help stabilize the land, create more accretion leading to more land and also raise the level of land so that inundation by sea-level rise is reduced. Mangrove also reduces the wave height due to their ability to dissipate wave energy. It has been estimated that a 100-200 m wide mangrove belt reduces wave heights by 20 to 25% (MoWR, 2000). The coastal belt of Patuakhali, Noakhali, Nijhum dip and Chokoria is protected by planned afforestation of mangrove plantation. Settlements in foreshore areas are predominantly linear or semi dispersal in pattern following the embankment or communication network taking advantage of slightest variations in ground level.

The concept of 'Urir char project' (1985) was a nucleated dyke settlements elevated on stilts and nucleated around a fresh water reservoir. The settlement layout was kept open ended to allow growth. Natural process of land formation was allowed to work and afforestation was proposed on the seaward side of the island.

3. Research Methodology

A mixed research methods are applied based on primary data collection through field investigations (qualitative interviews by random selection), participative observation, many informal discussions with locals and the experts, the analysis of satellite images, Shyamnagar upazila statistics and a secondary data collection by desktop research from different issues of the newspapers, published and unpublished research reports, articles and various relevant web sites so as to identify the extent and impact of Aila on settlement and the coastal environments.

3.1. METHODOLOGICAL FRAMEWORK

Objective Formulation

Data Collection

Observation Literature Review

Analysis and Accumulation

Findings and Recommendations

4. Findings and Analysis

According to Forest Peoples Programme (2009) the devastating cyclone Aila struck the south-western coastal region of Bangladesh and eastern coast of the neighbouring West Bengal province of India at midday on 25 May 2009.Satkhira and Khulna of Bangladesh were the worst hit districts. According to the official statistics nearly four million people have been affected. Huge numbers of livestock have been lost with nearly 2,000 km of road either fully or partially destroyed. Thousands of acres of crops have been wiped out. The horrifying fact is that nearly 2,000 km of the coastal embankment (locally known as 'polder') was damaged, causing extensive flooding. Communities have reported that activities associated with shrimp farming, such as the frequent practice of opening the embankments to move saline water into shrimp ponds, has made the half-century-old earthen embankments weak, causing them to break during the tidal surge inflicted by the cyclone. The area remains waterlogged, causing the salinization of soil and inland water. As a result, agriculture in the region is under serious threat.

4.1. SITE AND SURROUNDINGS

The focused study area is Gabura union located on Shamnagar Upazilla in Satkhira district. Situated beside Kholpetua & Kopotakhsa River. For geographical location a great numbers of people were affected by the devastating impact of AILA of this area. In Gabura, people mostly depend on river & Sunderban based livelihood, like fishing, fish business, river based transport business, etc.

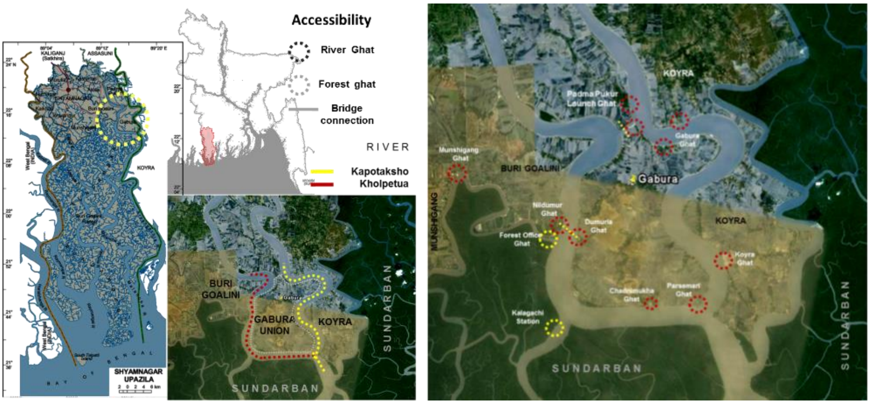

Fig 01: Gabura, Shamnagar, Satkhira, Source: Author

Gabura union is an island. Water way is the only way to connect Gabura with the rest of the world. In north side there was a bridge connection with Padmapukur union but it is now unusable after Aila.

4.2. TRANSPORTATION NETWORK

Internal road network is almost damaged. WAPDA bund acts as primary road network. Maximum road is kacha few are semi pucca. Boat is also used for communication. The internal way of transportation is bicycle or Three Wheeler but in rainy season the only way is to walk.

4.3. ROAD AND EMBANKMENT

Almost 45% of band is damaged by Aila. Bund breaks at 4 points. Almost 80% semi pacca road are damaged. Local authority repaired bund with bamboo, chatai, polythene etc. Replaced and make new bund where needed. Use bamboo bridge to connect house to road or bund.

Fig 02: Embankment, Source: Anonym.

4.4. RESIDENTIAL AREA

The residential area developed beside the canals and embankment. The fishermen are generally lives beside the embankment. The farmers live in the middle highland. After Aila almost 80% people took shelter on the embankment. Almost 95% of houses are damaged by Aila. The internal circulations of homestead become unusable. Make new plinth in their own land which are comparatively high, by digging small pond. Make temporary shelter in bund by available local material.

Fig 03: Residential land use, Source: Author.

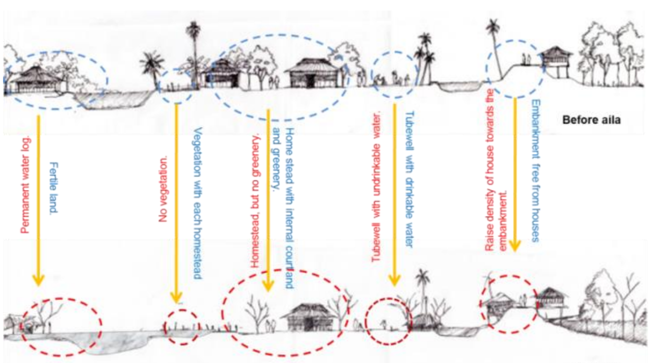

Fig 04: Overall settlement morphology, Source: Author.

4.5. LIVELIHOOD

All the cultivated land are washed away by the flood and affected by saline. The farmers become workless suddenly by the disaster. Tried to find out alternative income generating sector like fishing, honey collecting or collecting wood from Sunderban with high risk. Some people become day labourer. Women's started to contribute in income of their family.

Fig 05: Location of suitable area for agriculture and shrimp culture, Source: Author.

4.6. SHRIMP CULTURE

Convert agriculture land to shrimp farm for more benefit. It has International demand with Govt. co-operation.

4.7. FISHING AREA

River Kholpetua, Kapatakshi and the Sundarbans.

4.8. EMBANKMENT (WAPDA BUND)

It gives instant protection from natural disaster and ensure more seasonal crop instead of single seasonal crop. WAPDA bund being used as shelter during the disaster.

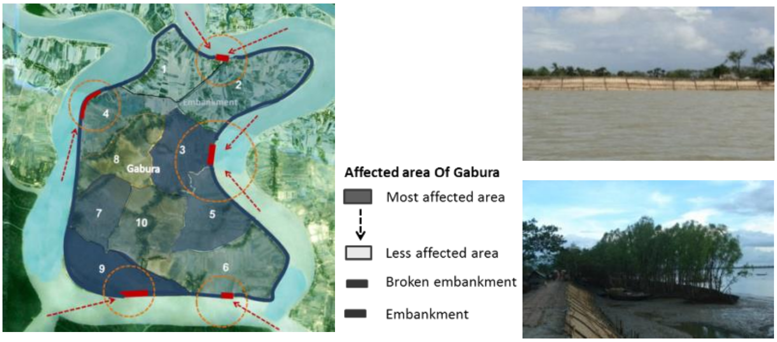

Fig 06: Location of breaking bund, Source: Author

4.8.1 Causes of Breaking Bund

Major causes are lack of proper setback from the river, lack of natural barrier of trees, lack of organic matter in bund soil, material of bund and direction change of river.

4.9. EXISTING SITE PLAN

There are 10 wards in Gabura union. The study focused on ward no. 07 for available local support.

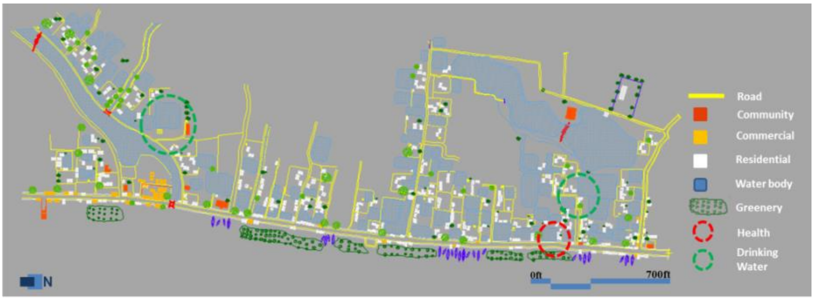

Fig 07: Existing site plan, Gabura Union (7 no. Ward), Source: Author.

5. Morphological Reformation towards Complimentary Settlement Attitude (Future directions)

It is organic that man stayed on higher lands and cultivate on low lands. They never built their houses on cultivable lands ignoring high land. Respecting the existing settlement pattern and ownerships this research tries to find out the negative points which are the main cause of the vulnerabilities. The recommendations are some natural and also some scientific solutions.

Proposed Structure Plan of Gabura

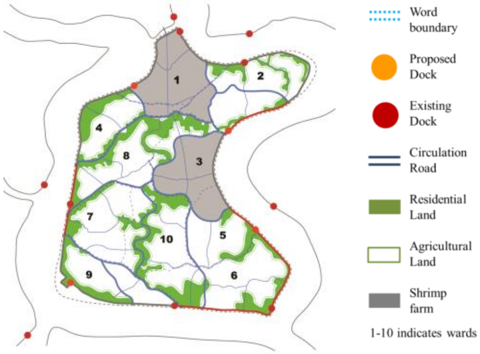

Fig 08: Proposed Plan, Gabura Union, Source: Author.

Prospect
Responsive to existing settlement.
Hydrology concerned.
Suitable zone for shrimp culture and cultivation.
Existing infrastructure emphasized.
Easy communication system.

Constraint
No option for land generation due to embankment.

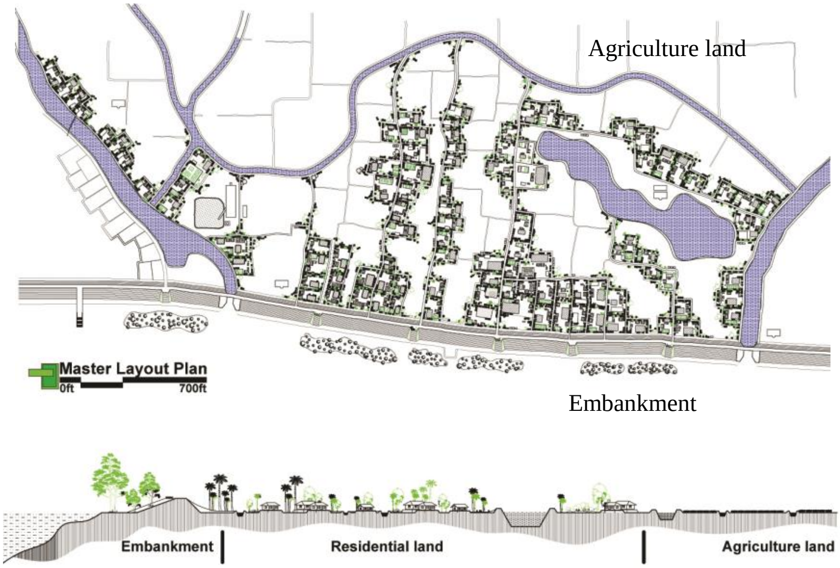

Fig 09: Proposed Plan and section, Gabura Union (7 no.ward),Source: Author

5.1. Phasing

With considering existing condition and categorizing the problems the recommendation is a five phases of development.

5.1.1 Phase 1-Canal and Drainage Development

Rectangular drainage system can be introduced by digging more canals which is effective for cultivation land and in settlement. Most of the canals will connect the existing canals. Some new canal will also have to provide with proper linkage with rivers. On this phase, water logging will be cured and salinity will decrease through washing out with rain water. Roads will be developed through the side of the major canals.

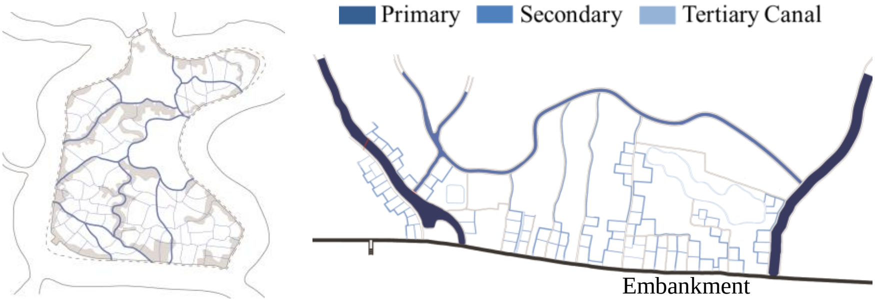

Fig 10: Canal and Drainage, Gabura Union and 7no. Ward, Source: Author.

5.1.2 Phase 2-Return & Resettlement of households and homesteads

After dealing with logged water and curing lands, people will return to the original location of their own from the embankment and also some of the homestead location needs to relocate because of the land acquiring by the govt. to remodel the embankment accordingly.

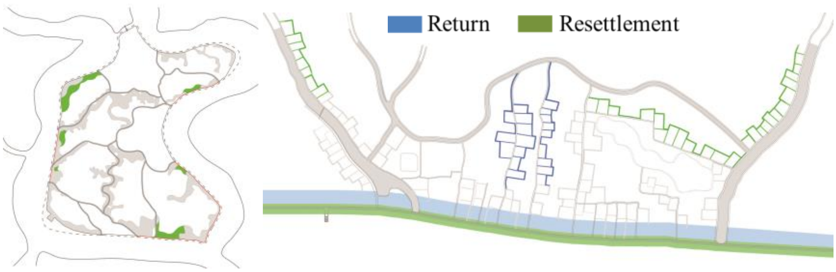

Fig 11: Return & Resettlement, Gabura Union and 7no. Ward, Source: Author.

5.1.3 Phase 3- Development of Embankment

On this stage of development, embankment will be under construction and in some of the places, reconstruction. The present condition of the embankment has to be developed assuring proper measures. Sluice gate provisions and coastal greenbelt beside embankment will further developed with proper maintenance.

Fig 12: Embankment, farm and Agriculture land, Gabura, Source: Author.

5.1.4 Phase 4-Relocating Shrimp firm

After fixing the embankment and settlement, all scattered firms to be relocated accordingly in two common zones which are most vulnerable due to river orientation.

5.1.5 Phase 5-Cultivation Inauguration

After replacing the firm and salinity of land will be decreased and people can start cultivation on these land shown in colour.

6. Conclusion

Starting with the knowing process of conditions which a person can perceive to live on with nature, with higher respect and its came to an end with full of analysis, researches, practices etc. And all these were compiled and summarized in a compatible scale which can be a resource for any further approach to the relevant study or practice.

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THE FACTORS CONTRIBUTING TO DROPOUTS AND INCOMPLETE ACADEMIC STANDING; *A study on Architecture Undergraduates of University of Moratuwa.*

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Abstract

University drop-out is a topic of increasing concern in higher education. Bachelor of Architecture Degree program offered by Department of Architecture, University of Moratuwa demonstrates high drop-out and incompletionrates, which needsto be investigatedwith reference to the causes and parameters. Aligning with the above objective, the current qualitative investigation examinesthree undergraduatesamples representing level I (n =35), level V(n=33) and a group of students (n=26) who have dropped out from the degree course (n=6) or reported to have incomplete academic standing(n=20). Spontaneous and anonymous responses were obtained from level I and V students via two distinct questionnaires on the current level of satisfaction regarding the course with the former and theissues/challenges faced by the latter. Freedom writer’s method was used with 6 dropoutsinitially and reexamined later via structured interviews in comprehending the issue in-depth. Incomplete students were examined via a questionnaire survey.Data was analysed adopting the framework developed by Jordan et al (1994) and Watt and Roessingh (1994).

Push factors were found to have the highest impact on dropouts and incompletions. Pull factors were identified as the second most significant cause followed by falling-out factors. Lack of transparency, unsatisfactory level of student/lecturer interaction, issues related to academic programme, providing feedback, tutoring, assessment, inadequacy of time/breaks given and the lack of a strong student supportive system were revealed to be the significant push factors that lead to drop outs. Personal, family and financial matters were the frequent pull factors while language/communication barrier, students' own negligence and academic disengagement due to long term impact of push/pull factors wereidentified as falling out factors. The study revealed the importance of finding sustainable remedies to above issues in order to create a better learning environment which could empower and retain future undergraduates

until successful completion, aligned with the educational missions of the Department.

Keywords: *Architecture Education, University drop outs, incomplete academic standing.*

1. Introduction

Increasing dropout rates of undergraduates is an alarming issue faced by the higher education sector of Sri Lanka and worldwide. According to data from Higher Education Statistics agency of United Kingdom, 6% of first degree entrants aged under 21 who enrolled in 2013-2014 years did not continue their studies beyond their first year (Havergal, 2016).As highlighted by Barefoot (2004), the high rate of student dropout between the first and second year is a major concern for the majority of US colleges and universities.

Student success rate is regarded as a primary indicator of institutional performance which reflect the overall quality standards of a learning environment. Students persisting to complete their educational goals is a key gauge of student success, and therefore institutional success (Voigtand Hundrieser, 2008). Accordingly, it is an obligation of each and every higher educational institution to commit in establishing conducive learning environments and effective and sustainable student retention programs aligned with their educational missions ensuring student success leading to high rates of completion.

2. Background to research

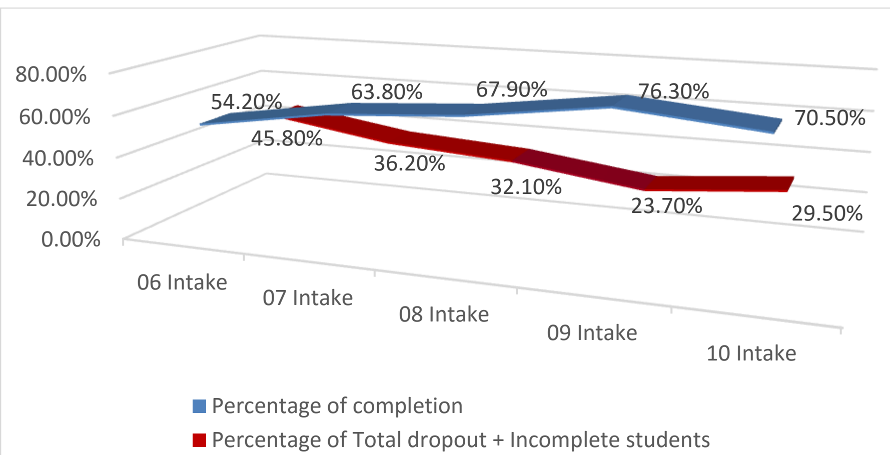


Figure 1: The percentage of completed students Vs incomplete + drop outs of the most recently passed out five consecutive batches.
Source: Undergraduate Studies Division- Faculty of Architecture (2016)

A comparison between the rate of completion against the total percentage of dropouts and students with incomplete academic standing reported in 2006 to 2010 intakes are presented above. As indicated by the statistics of the Undergraduate Studies Division, Department of Architecture has witnessed a gradual decrease of dropouts and incomplete students. It can also be observed that the rate of completion has gradually increased during the recent years. However, the number of students who have dropped out or not completed as a fraction of the total number of students in a batch are alarmingly high; above 2/5 of the batch in 2006 intake and over and above 1/5 in other intakes. Since the first day of enrolment, the quantity of each batch has-been decreased at various stages leading to high incompletion rates by the final year, indicating potential pivotal issues in the overall academic experience of Architecture undergraduates. Accordingly, itis vital to investigate, synthesize and analyze the causes and factors involved in the high incompletion/dropout values of Architecture undergraduates in order to find remedies and mechanisms to increase students' success and completion rates to a satisfactory level.

3. Research Problem:

An institution's success in recruitment ultimately depends on evidence that its students are satisfied, persisting to graduation, and thus receiving value for the investment they and their families are making in higher education (Voigt and Hundrieser, 2008). First of all, an institution should have a proper admission mechanism to attract the best fitting students to follow the relevant degree courses. Once enrolled after a rigorous admission procedure an undergraduate dropping from a degree course or failing to complete within the standard duration is not spontaneous. As defined by Doll, Eslami and Walters (2013), the cause of a student dropping out is often termed as the antecedent of dropout because it refers to the pivotal event which leads to dropout. This is indeed the ultimate result of an accumulative prolonged process taking place in a student's life as an undergraduate in a certain higher education institution. Having alarmingly high incompletion rates in the B. Arch degree course it is vital to probe in to the underlying causes or pivotal events which hinder the students from persisting to completion of their educational goals successfully in the Department of Architecture.

4. Research Objectives

Accordingly, the objective of the current study is to discern, comprehend and analyze diverse impact factors leading to the drop outs and incompletions of undergraduates, specific and unique to the department of Architecture. While identifying the specific issues encountered in the overall academic experience by the selected already dropped out and incomplete students in the department representing the most recent five consecutive years, it is also attempted to study the factors of current first and final year student samples seeking a cross section of the potential parameters of dropout and incompletions.

5. Contributions

The study contributes in identifying institution specific strategies to improve student retention, persistence and its prolonged sustenance until successful graduation of undergraduates. This in return will provide good value for money spent by government on each Architecture undergraduate per a year as well as the investments made by the university and the parents. Further, the study contributes in improving the quality standards to reach the bench marks as set by the educational mission of the department as well as the University as a whole.

In a context where the investigations on dropouts and failures in higher education are limited to the western world the current study claims its novelty by contributing to the above research paradigmre presenting an eastern or rather an Asian context.

6. Theoretical Framework: Review of Literature

Researchers who have investigated on dropouts and failuresof higher education over the years (Fuller, 1927; Dorn, 1993; Jordan, Lara, and McPartland,1994; Short & Fitzsimmons, 2007; Rumberger& Lim, 2008) have revealed diversecauses and parameters. However, providing a comprehensive understanding of the issue in a holistic manner, Jordan et al (1994) have examined the diverse causes of dropouts under aframework having two categories namely; push factors and pull factors(Doll, Eslami and Walters, 2013).

6.1 PUSH FACTORS

As identified by Jordan et al. (1994) a student is pushed out when adverse situations within the institutional environment lead to consequences, ultimately resulting in dropout. These factors mayinclude consequences related totests, attendance and discipline policies; poor behavior (Doll, Eslami and Walters,2013).

6.2 PULL FACTORS

Pull factors can be defined as out-of-school enticements which cause students to put a greater value on something outside of school that may attract or distract them from completing school (Jordan et al.1994 cited in Doll, Eslami and Walters, 2013).These occur when factors, such as financial worries, out-of-school employment, family commitments, or even family changes, such as marriage or childbirth or even illnesses which pull students away from school

(Doll, Eslami and Walters, 2013). These type of factors inside the students divert them from completing school and can be pulled out.

6.3 FALLING OUT FACTORS

Further refining the framework, a third factor called ‘falling out of school’ was introduced by Watt and Roessingh (1994)which refers to the disengagement in students which isneither caused by being pushed by the school nor outside pulling factors (Doll, Eslami and Walters, 2013). As symptoms of falling out, students fail to show significant academic progress and become dispiritedand disheartened with regard to completion of the degree course. This might not necessarily be an active decision, but rather a repercussion of insufficient personal and educational support which highlights a process of dropout whereby the student gradually increases in behaviors of academic disengagement, without being pushed out by the school or enticedby the out of school parameters(Doll, Eslami and Walters, 2013).

These three factors developed by the above two groups of scholars provide an explicit framework tocomprehendthe overall dropout experience.As explained by Doll, Eslami and Walters (2013), since 1950s up 1980s most nationally representative studies in the westpredominantly depicted pull factors as ranking the highest causing dropouts. However most recent research cites push factors as highest overall. Doll et al (2013) further highlight that male students reported the highest rates of push factors while female students reported the highest rates of pull factors.

The current investigation adopts the aforementioned framework jointly developed by Jordan et al. (1994) and Watt and Roessingh (1994)to understand the reasons behind the high dropoutsas well as incompletion rates reported over the last five years by the undergraduates of the Department of Architecture.

7. Research Design

The research was conducted withreference to the undergraduates in the Department of Architecture under three phases referring to three different student groups to comprehend a cross-section of the issue. The research is limited solely to the views, experience and opinions of the students and the opinions of the lecturers and administrators are not considered here. Ensuring validity of the results, the details of the academic standing of all the students investigated were verified with the latest statistics of the Undergraduate Division of the Faculty of Architecture. The research design incorporateda small number of in-depth interviews and a wider questionnaire survey to better comprehend the critical factors of dropouts and incomplete academic standing.

7.1 PHASE I: B. ARCH LEVEL I STUDENTS (FIRST YEAR)

Retention experts have claimed that an institution's ability to demonstrate student success and its ability to attract and recruit new students are intertwined (Pascarella and Terenzini, 2005; and Kuh, et al, 2005). In order for a student to persist a degree course until successful completion, an institute should attract the best fitting candidates. Selecting the students having essentialfundamental skills is crucial when it comes to the degree of Bachelor of Architecture. Accordingly, an aptitude test is conductedannually to select the most eligible 55-60 candidates. The first phase of the current investigation looked in to the views and opinions of the current level one students (2015 intake who have just started semester II) who have entered the university being screened via the aptitude test after following a certain study stream for Advanced level examination. A spontaneousand anonymous questionnaire survey was conducted in the middle of a lecture break on 18th May 2016at 10.00 a. m (n=35). Six closed questions were raised leading to their level of satisfaction about the course halfway throughthe first year (related to A/L subject stream, career dream during A/Ls, level of pre understanding on B. Arch Degree, whether the student enrolled to follow Architecturesacrificing his/her career dream ornot, whether he/she was determined to follow Architecture or not and the current level of satisfaction with reference to the degree course).

7.2 PHASE II: B. ARCH LEVEL V STUDENTS (FINAL YEAR).

Obtaining the views and opinions of the current level five students whohave persisted and sustainedthe courseuntil the final year (80% from the original batch)was recognized to be an effective indicator representing a cross section of potential issues including push, pull and falling out factorsexperienced by them or their batch mates throughout and at present. These student are in the initial stage of their final Comprehensive Design Project (CDP) which is the culmination where they demonstrate all the theoretical and practical knowledge, skills and expertise gained since level one. During the design studio session held on 16th June 2016 around 10.00 a. m students were spontaneously asked to anonymously write down the five most crucial problems encountered by them as an undergraduate (n=33).

7.3. PHASE III: DROPOUTS AND INCOMPLETE UNDERGRADUATES

Complementaryto the undergraduates who have persisted the course, the undergraduates who have dropped out from the degree or missed the original batch due to the incompletion of academic tasksdue to various reasons (failure, inability to attempt end of semester examination or continuous assessment due to physical or mental health conditions, financial constraints, punishments…ect) were explored as the core objective of the investigation in phase three (from intakes 2009-2013). While the dropouts are permanently out of the course, the students who have missed the originally registered batch as their academic task is incomplete will have to leave the schedule of the current academic year to which they have registered temporarily, until the academic task is achieved in a subsequent year. These students are supposed to have completely different psychological responses(disillusioned and frustrated) due to his /her condition compared to the students who have succeed. Accordingly the feedback obtained from phaseII is used to balance out the subjectivity of the responses of phase III.

As an initial step, 6 nos of undergraduates who have dropped out from the course at various stages were given a blank diary following the freedom writers' methodology(Gruwell, 1999and LaGravenese, 2007) in order for them to freely express the reasons behind for a period of two weeks. These writings were carefully scrutinized by the investigatorsforming a firm basis to the design of the questionnaire and the structured interview. The questionnaire survey was conducted with undergraduates having incomplete academic standing (n=20).Being dropped out permanently from the University system, aforementioned 6 subjects were reexamined in-depth via structured interviews in order to explore and unearth the most genuine reasons behind.

The findings of the three phased investigation were analyzed and synthesized in order to identify the department specific significantparameters of dropouts and incompletions.

8. Findings and Analysis

8.1 FINDINGS - PHASE I

Out of 35 B.Arch level I subjects tested, a majority of 68.6% have followed maths as the A/L study stream while 17.1% and 14.3% have followed Bio Science and Arts respectively. However only 48.6% were reported to have satisfactory pre-awareness regarding the nature of the B. Arch course while the awareness of others' were either neutral (42.9%), unsatisfactory (5.7%) or extremely unsatisfactory (2,9%). They demonstrated to have diverse career dreams. Being an engineer (25.7%) was found to be the most dominant career ambition. Only 20% of them were determined to become an Architect as their future career who may supposedly sustain until completion. 57.1% students reported that they had to sacrifice their career by getting enrolled to follow Architecture. However demonstrating a greater level of adoptability after completing their first semester as an undergraduate it was revealed that 80% students are satisfied (22.9% -extremely satisfied, 57.1% - satisfied) about being enrolled to follow Architecture at the current situation. Only 20% demonstrated to be in a neutral, uncertain and undecided position supposedly having potential for future dropouts. Retention research identifies undecided students as being highly dropout-prone (Voigt and Hundrieser, 2008).

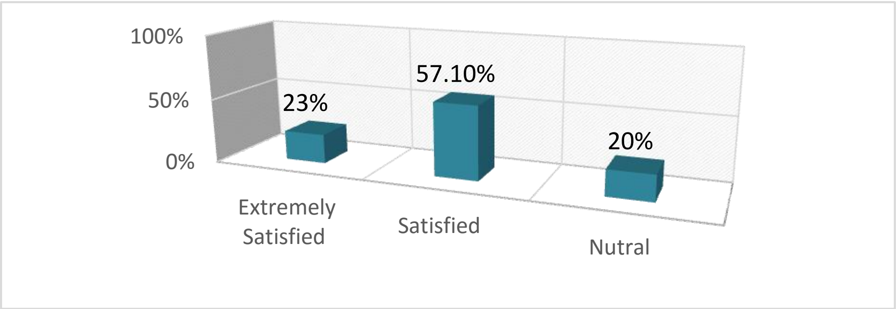
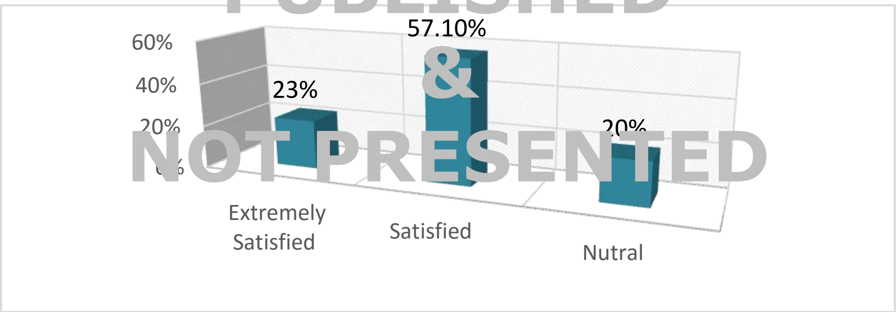


Figure 2: The level of satisfaction of B. Arch Level I students after completing semester one.



8.2 FINDINGS- PHASE II

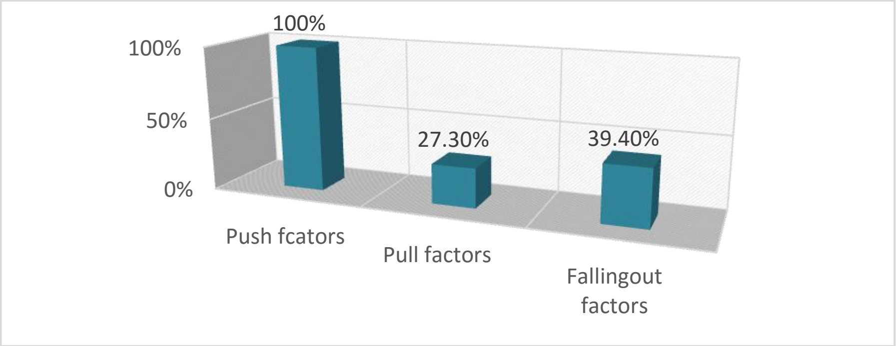


Figure 3: Percentage of potential push pull and falling-out factors exposed by level V undergraduates.

100% of the undergraduates of level V highlighted issues falling in to the basket of push factors of the institute. Dissatisfaction about the manner as to how the programme has been conducted, providing feedback, in adequacy of time given for designing/creativity, the process of crit assessment and the lack of breaks /vacations were the most emphasized issues. 27% subjects highlighted on the pull factors, predominantly economic problems; earning money for the family, learning while working and family commitments. Language or communication problem (ESL), working/designing at a slow pace and feeling of disengagement due to prolonged exposure to push or pull factors; feel tired, fed-up, sleepy, exhausted were significant comments from the 39% undergraduates who highlighted falling out factors.

8.3 FINDINGS-PHASE III

8.3.1 Reasons behind Dropouts:

Both push and pull factors were found to equally dominate as triggering reasonsbehind a majority ofdropouts (83.3%). Lack of transparency in academic activities, unsatisfactory level of student/lecturer interaction, disappointments related to past experiences as an undergraduate; favoritism, issues related to teaching, tutoring, providing feedback, assessment and academic programme, inadequacy of time given and thelack of a student support systemin terms of academic as well as personal matters were revealed to be the main push factors that lead to drop outs.

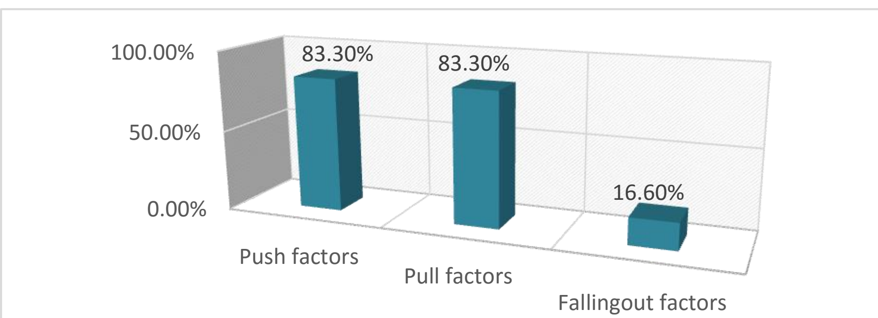


Figure 4: Percentage of push pull and falling-out factors of behind dropouts.

Poor economic background, family problems and earning while working were the major pull factors identified (83.3%).Some of the students werefound to dropout (n=3) as a combination of push and pull factors. In fact the sample included the student who obtained the highest mark for the aptitude test of a particular year whose career ambition was to become an Architect. She haddropped out due to a combined effect of push and pull factors. Falling-out factors (16.6%) were found to have the least impact on dropouts. One student was found to have dropped due to falling out factors caused as an accumulation of the long-term impact of both push and pull factors.

Most of the students who dropped were found to demonstrate lack of pre-awareness regarding B. Arch (66.7%) and most of them have entered to the university either under the influence of parents or simply to obtain a degree from a state university with no specific career ambition relevant to the field (83.3%). Not being used to the university culture which requiresinteraction with the opposite gender for academic activities was found to be another challenge.

8.3.2 Reasons behind incomplete academic standing:

Parallel to the dropouts, push factors have become significant in case of incomplete students. For instance, only 15% students were satisfied regarding the lecturers of the department (unsatisfactory: 50% and neutral: 35%). The lecturers' level of supportiveness in resolving studentmatterswas ratedas unsatisfactory by 55% students (satisfactory: 15%and neutral: 30%). Level of impartiality of lecturersbeing unsatisfactory for 60%(satisfactory only for 10%, neutral: 30%) was identified as another critical issue. Only 45% of studentswere satisfied about the lectures' effectiveness. (Extremely unsatisfactory: 5%, unsatisfactory: 5% and neutral: 45%). Effectiveness of tutoring sessions were rated as neutral (55%) by a majority (satisfactory: 30%, unsatisfactory: 15%). Level of appreciation given based on the work done was unsatisfactory for 50%(satisfactory: 20%, neutral: 30%). A vast majority(80%) agreed that time allocated to improve/develop after each tutoring session is unsatisfactory. Only 30% were satisfied about the existing assessment methods (unsatisfactory: 20% and neutral: 50%) while only 25% were satisfied about the transparency of assessment (unsatisfactory: 55% and neutral: 30%). 70% were found to be unsatisfied about the level of transparency of the academic programme (satisfactory: 10% and neutral: 20%).Overall rating for administration was unsatisfactory by 50%, neutral by 30% and satisfactory only by 15%.

However 60% agreed that the method of delivering lectures (Extremely unsatisfactory: 5%, unsatisfactory: 15% and neutral: 20%) and the relevance of course materials are satisfactory (unsatisfactory: 25% and neutral: 55%). lecturer's knowledge, competency and confidence on the subject matter was rated by a majority (75%) as satisfactory (neutral: 15%. unsatisfactory: 10 %). 55% of the students rated the contribution of peers as satisfactory (neutral: 30%, unsatisfactory:15%). Significantly, ragging was not identified by anyone as a push factor (0%). Research supervision was identified to be in a satisfactory level by a majority of 65% (unsatisfactory: 15%, neutral: 20%).

Pull factors too were found to contribute immensely; family matters(85%; sick/old parents, parents separated, commitment to the family as the only responsible person) and personal matters (75%) were found to have contributed to the incomplete status of students. Language (ESL) and communication barrier (90%), slow pace of academic/design work (70%) and own negligence of students (40%) were identifies as falling-out factors.

Gender (Females:65%, male: 35%) was identified as significant to cause incomplete academic standing.Female students were found to have a hightendency of not completing academic tasks over males. As revealed by their feedback, having to complete the characteristic heavy academic workload of the Architecture Degree course alone with less or no support by male students, lack of interaction with peer groups and seniors, less physical strength compared to males and encountering physical and psychologicaldifficulties in fulfilling academic tasks due to periodic biological conditions(menstruation) have a major role to play in this regard.

Hometown being within the Colombo city limits or outstations (outstation: 75%, Colombo based: 25%) was found as being significant. A majority of student who have failed to complete are from outstations. A/L stream followed was revealed as another parameter of incompletion. Students who have done Mathematics are in a better position than the other streams in terms of perseverance (Bio Science: 40%, Arts:40% and Maths: 20%).The objective behind getting enrolled for B. Arch (influence of parents, teachers / obtaining degree from a state university: 75%, Child hood career ambition: 25%)and place of accommodation (boarding place: 65%, home /relatives' home: 15%, hostel: 0% other 20%) were identified as the other significant parameters of incomplete academic standing.

However, fear and reluctance in providing genuine responses in terms of the issues related to the academic experience was evident by a large percentage of neutral or rather undecided responses given by incomplete subjects as they have to stay within the department until they complete the academic tasks in a subsequent year.

9. Conclusion

Aligning with the findings of most recent research as cited in Doll, Eslami and Walters, (2013),push factorswere found to have the highest impact ondropoutsand incompletions of B.Arch degree course. Pull factors were identified as the second most significant reason behind followed by falling-outfactors. It was also seen that some of the dropouts have been caused as a combined effect of push and pull factors.The study revealed the importance of finding remedies to above in order to create a better learning environment which could retain and sustain future undergraduates which in turn leads to the success of the Department of Architecture and the University as a whole.

Identifying mechanisms to provide explicitpre-awarenessregarding the nature and challenges of the course before getting enrolled discouraging the dropout-prone candidates anddetermining the best fitting intake undergraduate profile including the aptitude, passion and endurance are found as preliminary measures vital in increasing retention and success rates. As explicated by Tinto (1993), the higher the quality of the institution, the higher the retention and graduation rates in return. Accordingly, once enrolled, taking the up to date quality assurance measuresat all possible levels in order to create the conducive academicenvironment to produce the bestgraduates fitting the exit profile defined by theeducational mission of the department will be essential.Undertaking an institutional reform process focusing on the identified department specific push factors is recommended. Obtaining regular feedback from students throughout the degree program on the overall teaching, learning and assessment experienceand makingcorresponding improvements is highly recommended in this regard. Strengthening the student support system including academic and personal counselling is suggested to reduce the impact of pull and falling out factors.

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RESILIENT ENVIRONMENTS VS. RESILIENT ARCHITECTS: *Creativity, Practice and Education*

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Abstract
Within the paradigm of "Resilient Built-environments", in order for Architecture to be resilient, "Resilience" should be identified as an essential component of the Architect's notion of creativity. In much simpler terms, "Resilient Built-Environment" should necessarily be a by-product of the "Resilient Architect". The inherent influence of individualistic notions of creativity upon the practice had intensified the dichotomy between Theory and Practice, unless the notion of "Resilience" is identified as an integral component of the Architect's notion of creativity. Analysing the architectural position is an ideal way of understanding the Architect's notion of creativity, therefore,in exploring the notion of "Resilience" and the "Resilient Architect" within the Sri Lankan platform, the Architectural Positions of two renowned Architects; Geoffrey Bawa and Valentine Gunasekara were explored and analysed. The Architectural Positions of both the architects asserted specific rules and methodologies adopted within the process of problem solving that had subsequently led to a traceable language/pattern within their Architecture. The dominance of such rules within the practice could be detrimental to adaptation of theories/notions, such as "Resilience" and the formation of the "Resilient Architect", unless methodologies itself are flexible, robust, despite rigidity, or else the notion of "Resilience" should exist in the form of a methodological rule.

Keywords: *Resilience, Theory, Practice, Creativity, Architectural Position*

1. Introduction: Sustainability and Resilience
"Sustainability", casted in the crucible of ecology, remained the 'protagonist' within the integral political movement concerned with the protection of the environment, for the past 45 years or more. It taught us all about Reduce, Reuse, Re-Cycle, Up-Cycle, and many other theories and conceptions throughout the decades, and presently, with the consolidation of the concept of "Adaptability" into the sustainable movement, the epithet of the "protagonist"

is shifted from sustainability to the notion of "Resilience", within the realm of architecture, thus, The Resilient-Built Environment.

Despite these repeated plays of words, concepts and positions, very little or no credible application of these theorems can be seen in regions where such interventions are mostly relevant and required: the so-called economically developing parts of the world. Over the past few decades, countries commonly attributed as developing economies have experienced drastic increases in population numbers, subsequent expansion to their urban realm, proliferation of informal labour markets, compartmentalization of wealth, and an unprecedented rise in environmental disasters – from floods and landslides to typhoons and Tsunamis. Sri Lanka is no exception. The human, physical and environmental costs of such devastations have been magnanimous in scale and atrocious in impact. Yet, the response from professional spheres – particularly architects - towards finding credible solutions to these burning challenges of our times has been far from the ideal. This begs the question whether the real problem lies in our inability to formulate strategies, theories and frameworks to 'resist' the environmental – and social – degradation, or in the confines of the way design thinking, approaches and ethos are cultivated and executed within the practice of architecture despite of the understanding and acknowledgement of the need to apply aforementioned theorems in real-world conditions.

2. Resilience to Adaptation - The Resilient Design

In order to explore this apparent distance between the 'theory of resilience' and the 'practice of resilience', one must first inquire the etymological meanings, which scaffold this inflating discourse on 'Resilient Environments'.

The scientific definition of Resilience explains it as 'the ability of a substance or object to spring back into shape; elasticity or the capacity to recover quickly from difficulties; or toughness'. Therefore, the interpretation of the notion of Resilience within the realm of Architecture is imperative to the distinction of definitive parameters of relevance.

As the director of Built Environment Policy at AIA, Rachel Minnery(2015) says:

> In our effort to be more resilient as individuals, families, businesses, and communities, architects will need to carefully plan buildings, select products, and design systems that are easily adaptable to changing needs, holistic in acknowledging adjacencies and regional impacts, and finally see the environment as their client inasmuch as they see their paying patron as their client.

According to Minnery's above position,"Resilience to Adaptation" approach avoids the exploitation of the notion of 'Resilience', in its sheer conception and eliminates possibilities of becoming one of pure idealismwithin the realm of the Built Environment, with its interpretation under the parameters of “Adaptability”. Thus, in both theoretical and practical premises, “Resilience” could be conceived as the particular attribute of a built environment that sustains, withstands pressure; stresses and forces, most essentially, through adaptation.

Such reflections on the notion of Resilient Built Environments promote – Adaptability as an in-built, invisible armouras opposed to exposure and vulnerability.

Elasticity /Flexibility, Graceful adaptation are amongst imperative connotations that convey the same idea as the notion of “Adaptability”. In a similar perspective, these connotations could be identified, explored and utilized as essential design principles within the creation of the Resilient Design, thus, the formation of “Resilient Built Environments.

2.1 RESILIENCE AS RESOLUTION

Within the realm of Architecture, concept of adaptability inherently holds the notion of Resilience accountable to its entire outer construction; social, cultural, economic, environmental surrounding, in much simpler terms, the very ground it stands upon. The resilient Design is one that is responsive towards social, cultural, economic, environmental and technical problems, pressures and limitations, similarly, in a slightly diverse perspective, one that holds the capacity; necessary to ‘adapt’ to various pressures, limitations and possibilities of the built environment, without compromising its expected performance, neither socially nor economically, environmentally or technologically.

Thus, the Resilient Built Environment transpires as a Resolution, which is robust and flexible; well rooted to its ground and to the entire outer construction, sustaining itself through the certainty of ‘Change and Transformation’.Resilience articulates the danger of solving problems in isolation. The inclusion and consideration of important social, cultural, economic, environmental and technical factors of the outer construction is imperative to the creation of the Resilient Design.

> Resilient design strives for environmental, social, and economic sustainability with the ability to adapt to known and unknown risks and vulnerabilities. (Minnery, 2015)

3. Resilience: The Architectural Response

What cannot be grasped often transcends into the oblivion, in the eyes of the humans, and remains oblivious.Unless, the Oblivion, is of wholesomeness and clarity, as believed by famous English author and poet, Richard Le Gallienne; a state which exemplifies the beginning of wisdom. Oblivion in that sense is a virtue to be nurtured, often visited and cultivated by creators. On the contrary,Oblivion formed as a consequence of the continuous “obliviousness” towards entities that cannot be grasped or comprehended,becomes more of a comfort zone for the creator, thus, confining him to a specific set of rules and procedures. Seldom, will the creator put an effort to tread beyond these self-incarcerations and confinements. Such Rigidity is detrimental to creativity and nevertheless hinders the formation and growth of theperceptive, resilient creator - within the architectural discourse, The Resilient Architect.

With *time*, the materialization of ansensitive, fragile and a non-resilient creatoris transpired, feeding himself the vital truism of the obvious, pushing himself, more and more, towards the oblivion, thus, distancing and detaching himself, from the realities of the entire outer construction, which is the very ground he stands upon and the environment that surrounds him. In such circumstances, the tendency of the resultant creations to be robust, ability to withstand pressure and gracefully adapt to change is comparatively low, effectively contributing to the existence ofsensitive,fragile, and non-Resilient Built Environments.

In his seminal bookComplexity and Contradiction in Architecture, Robert Venturi(1977) raises similar concerns about architecture being increasingly excluded from the complexity, experiences and needs of the environment that surrounds it.

> Rationalizations for simplification are still current, however, though subtler than the early arguments. They are expansions of Mies van der Rohe's magnificent paradox, "less is more." Paul Rudolph has clearly stated the implications of Mies' point of view: "All problems can never be solved…. Indeed it is a characteristic of the twentieth century that architects are highly selective in determining which problems they want to solve. Mies, for instance, makes wonderful buildings only because he ignores many aspects of a building. If he solved more problems, his buildings would be far less potent"" The doctrine "less is more" bemoans complexity and justifies exclusion for expressive purposes. It does, indeed, permit the architect to be "highly selective in determining which problems [he wants] to solve." But if the architect must be "committed to his particular way of seeing the universe," such a commitment surely means that the architect determines how problems should be solved, not that he can determine which of the problems he will solve.(Venturi, 1977, pp. 16-17)

Architects being highly selective in determining which problems to solve is a clear indication of the obliviousness towards certain problems and their extreme comfort within a particular compass, thus, the reluctance to explore and venture into diverse platforms within the realm of architecture.

Venturi's arguments confer upon anautopoietic nature of the architects relentlessly attempting to maintain identity and organization.

Through his text, he claims that architects being*committed to a particular way of seeing the universe*– Own Position/Notion of creativityis deterministic of *how problems should be solved*- the way of problem solving but should not be deterministic of which problems will be solved. While justifying the former, Venturi criticises the latter for separating architecture from the experience of life and the needs of society.

Thus, the question arises if being oblivious to certain problems and being deterministic of which problems to be solved is also a part of an architect's "particular way of seeing the universe – Notion of creativity" as well.

Autopoiesis Theory offers an intelligible answer within its explanation upon Autopoietic closure in living systems, in a similarly but a slightly diverse perspective. As conferred by Wolfgang Jonas(2007):

> Autopoiesis characterises the self-referential logic of self-(reproducing) systems… living systems are organizationally closed, i.e. without any input or output of control information. Operations only refer to themselves and the system's internal states… A system cannot enter into interactions that are not specified in the pattern of relations that define its organization. In the sense, the system's environment is a part of itself. The theory of autopoiesis thus admits that systems can be recognized as having "environments" but insists that relations with are internally determined; systems can only evolve only along with self-generated paths.

Venturi's explanation on the impact of Architect's commitment to a particular way of seeing the universe upon the determination of the way of problem solving and the enlightenment offered by the concept of Autopoietic closure in regard to the living systems' relations with the environment are internally determined and that systems could only evolve along self-generated paths, though two diverse knowledge sources,both accentuateupon the dominance of the 'Individual Characteristic" of the creator.

4. Hardcore – The Individual Characteristic

While the common logic and rationale is derived out of consciousness, most ideas that occur as insights or inspiration in the mental faculty are left aside without robust reasoning for their occurrences and existence. "Hardcore" is the core of an individual which has a direct influence upon all ideas, decisions and actions of a person. Derived of consciousness or unconsciousness, the hardcore has a saying upon each action of the creative process.

The hardcore includes of all basic codes that is connected and related in a particular way or pattern in the construction of self.

What we essentially pick up from the external/outer construction, from what surrounds us are highly influenced and affected by the hardcore. What is oblivious and what will be retrieved by the individual from capturing are the ones that do not relate to his hardcore. Same phenomenon is conferred within the concept of autopoietic closure in living systems as ‘relations with the environment are internally determined’, in other terms, ‘The Hardcore’. These specific relations/matters will not have specific codes in the hardcore of an individual, hence, will not be a part of the internal construction, thus forms, what Venturi confers upon as “the particular way of seeing the universe”.

5. Architectural Position

An architect develops his notion of creativity over a long period of time with practice. In most instances, the creations of an architect depict a particular approach or a certain way of achieving creativity, which will be eventually recognized as one’s personal style or identity within the field of architecture. This steady and established way of achieving creativity is explained as the architectural position of an architect and the position has a direct connection with the hardcore of the architect.

Thus, the principles, the rules, the ways and patterns of achieving creativity would be essentially based upon the hardcore as well. Therefore, the architectural position would be an ideal way to observe and analyze an architect’s notion of creativity.

British Architect and Teacher, Royston Landau explaining the architectural position,
“A position can result from different theoretical perspectives, but also from different disciplines (psychology, philosophy of mind, epistemology etc.). Of key importance are the concepts of belief, intention and action, out of which I have given most attention to the problem of what produces action, while being aware that beliefs and intentions are evident in the action.” (Landau, 1984)

6. The Programme of Action

Explaining the position of an architect, RoystonLandau diverts his interest and attention to the intellectual component that are being transmitted and converted into *actions*. He further emphasizes the subjective and personal nature of the matter by referring to it as *‘Individual action’*. These individual actions are the source of a programme, thus “The programme of action”. According to Landau, this programme of action is what eventually constitutes the position of an architect as well.

In his paper on British Architecture; The Culture of Architecture: A Histography of the Current Discourse, Landau introduces Imre Lakatos, A

Hungarian philosopher of mathematics and science, who proposed a logical framework for the concept of programme. Though he used this framework within the domain of science and scientific knowledge, Landau had successfully applied it into the domain of Architecture, for the position analysis of architects.

Moving ahead, Lakatos's *programme* is of two key components:

- Hardcore
- Heuristics

6.1. HARDCORE (THE HEART OF THE PROGRAMME)

The hardcore of the programme of actions, also known as the heart of the programme, differs from the Hardcore of the creative individual. At this instance, the reader is confronted with *two types of Hardcore*, where one represents the *Hardcore of the creative individual* (*the big "H"*)and the other represents *the Hardcore of the programme*.

The Hardcore of the programme (the little "H"), are the beliefs and intentions which are most critical to the programme that rejecting those means abandoning the programme and thus commencing a new investigation.
Ever since all actions, beliefs and intentions of the creative individual is rooted and based upon the Hardcore, it would be accurate in hypothesizing that *the little "H" is a byproduct of the big "H".*

6.2 HEURISTICS (THE METHODOLOGICAL RULES)

The heuristics are the other key component of the programme of action. Lakatos explains the heuristics as the methodological rules and introduces the two classes of heuristics:

- Positive heuristic
- Negative Heuristic

6.2.1 Positive Heuristics

Positive Heuristics depicts the operational rules of the programme of action.
The necessary operational strategies in design will steer the wheel to the expected direction and guide a designer to focus on a particular approach that is true to his or her belief system(The hardcore or the big "H"), thereby overcoming the diversity of irrelevant possibilities.

As explained by Landau(1984), the positive heuristics are the rules of the programme that contribute to the establishment of a formal language, peculiar and distinctive of the architect. The formal language will be a clear depiction of the architect's notion of creativity, thus the architectural position.

6.2.2 Negative Heuristics

Whilst the positive heuristics avoid all irrelevant possibilities and leaves the designer with the operational rules that aid in guiding the programme to the expected outcome, the negative heuristics instruct the designer, never to tamper with the Hardcore (the little "H"). As explained by Landau (1984), tampering the Hardcore means abandoning the programme.

The influence of methodological rules of an Architect's Programme of Action upon his Architectural Response is depicted below in (Figure 1).

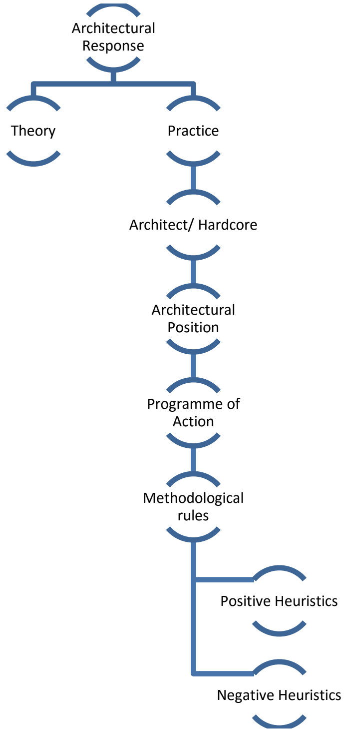

Figure1, Analytical Method of Architectural Response

6.3 *HEURISTICS VS. RESILIENCE*

In correlation to the key theoretical premise, 'Resilience to Adaptability', question arises, if the formation of Heuristics; Positive and Negative as pre-determined rules within the programme of action, inherently oblivious to multiplicity, may regulate and restrict 'Adaptability'. Unless, these specific pre-determined rules are Resilient; flexible, adaptable and robust, works in favour of enhancing multiplicity, providing the architect with adequate ammunition in adopting new ways of problem solving and practicing across a variety of platforms.

According to Venturi(1977), unless “Resilience” falls under ‘the particular way of seeing the universe’, in other terms, as an essential component of the Hardcore and the notion of creativity, or as the autopoietic theory confers, If not ‘internally determined’, Positive Heuristics or pre-determined rules becoming flexible, adaptable and robust is an impossible scenario.
But then, the question arises, can rules ever become flexible? Aren’t they inherently rigid? Within the architectural discourse, the formation of heuristics cannot be completely disregarded, as heuristics form the programme of action, thus the analysis of an architect’s architectural position had become a possibility, offering a substantial scientific means of exploring the notion of creativity of the architect as a creative individual.

Therefore, it would be accurate to state that within the paradigm of “Resilient Built-environments”, in order for Architecture to be resilient, “Resilience” should be identified as an essential component of the Hardcore, Architect’s notion of creativity.

7. Resilience as a Notion of Creativity: ‘Way of Seeing’ to ‘Way of Problem Solving’

Once the notion of “Resilience” becomes an integral component of the Architect’s notion of creativity, it will inevitably become an intrinsic, inherent constituent of his way of problem solving, making its way to the architect’s programme of action/Architectural Position. Thus, the formation of Resilience as an “Architectural Response”.

The key argument formulated within the first phase of the conversation connotes ‘Resilience’ to ‘Adaptability’ as a principle approach to be utilized within the creation of the resilient design. Drawing the connection, ‘Resilience’ as an integral component of the ‘notion of creativity’, invariably implies the need for Adaptable thinking for ‘creativity’. In similar terms,it evokes the need for ‘Adaptable ways of seeing’, inherently resulting in ‘Adaptable ways of problem solving’,which in-turn defines the creator’s notion of creativity.

8. Resilience vs. Reality

Distressed by the atrocities of environmental disasters, the present moment critically demands architects to find credible resolutions for the real-world conditions, than ever before.

Though the prerequisite is such, the individualistic notions of creativity, architectural positions, formulation of Positive Heuristics within the architect’s programme of actions, seem to over-power the demand for the formulation of ‘resilience’ as an architectural response. These two propositions are certainly at a crossroads, pulling themselves at opposite directions, at the same time, in which, the heuristics of the architect’s programme of action struggles to prevent the ocean of anomalies and never to tamper with the “Little ‘H’” – Hardcore- The Heart of the Programme, thus, making the architect oblivious to the notion of resilience, as an anomaly, preventing the formulation of theorems and frameworks that “resist’ environmental – and social – degradation.

As conferred within the introduction, the above phenomenon could be the reason that heightens the inability of the architects in formulating the notion of resilience as an architectural response, confines Design thinking and promotes the cultivation and execution of architectural ethos within the practice of architecture that are oblivious to the demand for credible resolutions for the real-world conditions.

9. The Sri Lankan Platform

These conditions could not get more real than it is at the present moment for the developing economies due to economic instability and limited access to precautions and resources -in comparison with the developed countries. Sri Lanka, holds no exception, positioning itself under the category of developing economies. As conferred within the introduction itself, the recent floods, landslides, and the Tsunami occurred few years ago provides adequate precedents to consider the notion of “resilience” as an architectural response within the Sri Lankan architectural platform, specifically within the practice of architecture, as theories had already been established decades back, yet, the practice remains incapable of providing architectural resolutions that “resist”.

10.Research methodology

In exploring the over-powering nature of Heuristics within the architect’s programme of action; essentially Positive Heuristics as operational rules that contribute to the establishment of a formal language, the concept of stylistic consistency within Sri Lankan platform, the Architectural Positions of two renowned architects of the field Architect Geoffrey Bawa and Architect Valentine Gunasekara were analysed. The analysis will be explanatory of two diverse ways of achieving creativity, diverse architectural positions and thus two diverse notions of creativity.

Ordering of space and form – and their subsequent tectonic and social manifestation - comprise the fundamental vocabulary of an architectural design program. More specifically, spatial ordering, technological definition and social response can be considered as the three critical areas, which determine the morphological organization of architectural form and space. Moving from the above hypothesis, the study had used three areas of compositional analysis in evaluating the specific architectural programs of the selected practitioners.

- Ordering systems: plan, section, elevation
- Mass and trabeation: the tectonic organization
- Real and virtual: broader social obligations

Ever since, the purpose is to explore the over-powering individualistic notions upon creativity within the practice of architecture that obscures the ability of the architect to create architecture that 'resist' and formulate the notion of resilience as an architectural response, the architectural positions of the above two architects would be explored through the analysis of their traceable stylistic consistency within the programme of actions. The case study analysis depicted below will only confer only upon the Positive Heuristics (as a manifestation of the stylistic consistency/formal language), under the two areas of Ordering systems and Mass and Trabeation.

10.1 ORDERING SYSTEMS: PLAN, SECTION, ELEVATION

This concerns with elements – and principles – that serve the organization of the building's spatial layout and formal volumes. These ordering principles can be seen as visual devices that allow diverse forms and spaces of a building to co-exist perceptually and conceptually within an ordered and unified whole.

Themanner in which spaces are arranged can clarify their relative importance and functional or symbolic role in a building's organization; organizational principles are used to formalize this relationship among the forms and spaces, and established a perceived order (or disorder) – and meaning – in architectural composition. The subsequent symbiotic relationship of form and space can be evaluated by analysing the building's two-dimensional documentation: i.e., plans, sections and elevations.

10.2 MASS AND TRABEATION: THE TECTONIC ORGANIZATION

This concerns with elements – and principals – that serve the organization of the building's constructional logic. The term 'tectonic' is first coined by Frampton (2002) to elaborate the poetic manifestation of a building's technological environment. The terms 'mass' and 'trabeation', on the other hand, are loosely based on Edward Ford (2003)'s elucidation of construction in to two types of approaches: monolithic and layered. 'Monolithic' construction refers to the conceptualization of building as a load-bearing mass, whereas 'layered' connotes with a process of building which follows incremental layering of building systems around a load-bearing frame (trabeation). The compositional principles designers pursue to transform these constructional strategies to reflect specific architectural and ‘poetic’ readings of buildings were discussed under this theme.

11.Case Study Findings

As shown in (Table 1), the Positive Heuristics of Architect Geoffrey Bawa and Valentine Gunasekara are a clear manifestation of the influence of individualistic notion of creativity upon the practice. With such power-play from the aspect of individualistic notions, the accuracy of the aforementioned statement; within the paradigm of “Resilient Built-environments”, in order for Architecture to be resilient, “Resilience” should be identified as an essential component of the Hardcore, Architect’s notion of creativity, is thus, Reaffirmed.

Due to this scenario, the notion of “Resilience” is still being conferred upon in many platforms in general, and within this particular platform, it is being conferred under the theme of “Building the future – Sustainable and Resilient Built-Environments”, whereas, the future cannot be more visible than it is at the present. It is high time the devoted focus and commitment towards theory could be distributed in a balanced approach that inherent impact of individualistic notions of creativity, programme of action and architectural positions within the practice, should not be disregarded or considered trivial within the formulation of theories.

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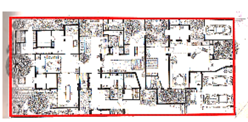
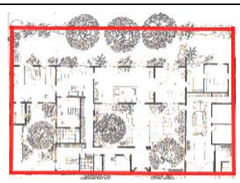
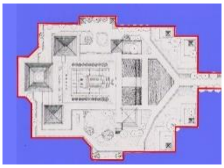
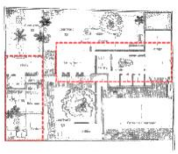
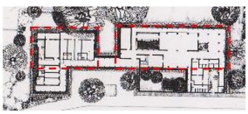
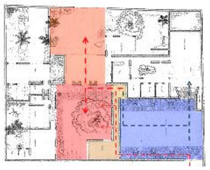
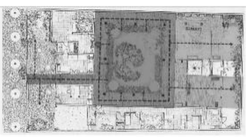
Table 1- Positive Heuristics – Architect Geoffrey Bawa & Architect Valentine Gunasekara

Positive Heuristics	Ordering Systems	Architect Geoffrey Bawa	Architect Valentine Gunasekara
		• Creation of a definite physical boundary • The composition of Pavilions • Experiential route • The Combinatorial Space • The play of solid and Void	• The Curvaceous Form • The Free Space • The Vertical Space

	Mass & Trabeation	• The Breathing Wall • The Cantilevered Section Form • The Extended structural frame • The Concrete Portal frame • The Colonnade	• Structural Expressionism • The Poetic Form • Geometric Fenestrations • The play of light and shadow • Modular Construction • Deconstruction of Structure

Above mentioned Positive Heuristics of Architect Geoffrey Bawa and Architect Valentine Gunasekara were identified and derived by analysing at least **five cases** which depict each Positive Heuristic. Samples of each analysis are portrayed by (Table 2) and (Table 3) below.

Table 2- Analysis of Positive Heuristics – Architect Geoffrey Bawa (sample)

		Case 01	Case 02	Case 03
Ordering Systems	**PH 01:** Creation of a definite physical **boundary**	 The 33rd Lane	 Stanley De Saram House	 New Parliamentary Complex
	PH02: Composition of Pavilions	 W.H. Fernando House	 Ena De Silva House	 The Madurai Club: India
	PH 03: Experiential Route	 W.H. Fernando House	 A.S.H. De Silva House	 Ena De Silva House

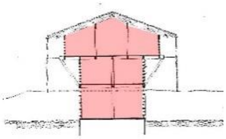
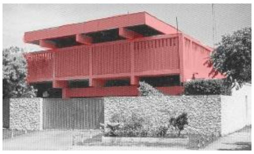
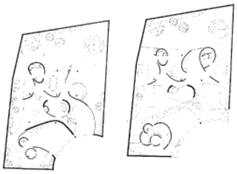
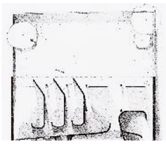
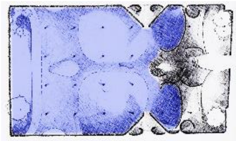
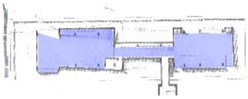
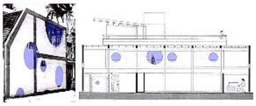
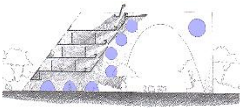
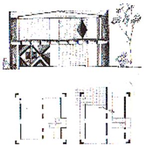
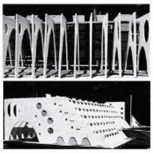
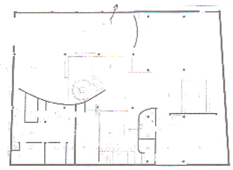
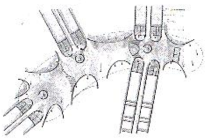
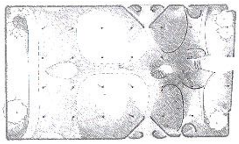
Mass and Trabeation	**PH 06:** The Breathing Wall	 St. Thomas's Preparatory School	 Bishop's College	 Steel Corporation Offices
	PH 07: The Cantilevered Sectional Form	 YahapathEndera Farm School	 Steel Corporation	 Benthota Beach Hotel
	PH 08: The Extended Structural Frame	 N U Jayewardena House	 Madurai Boys' Town India	 Bishop's College

Table 3- Analysis of Positive Heuristics –Architect Valentine Gunasekara (sample)

Positive Heuristics (PH)		Case 01	Case 02	Case 03
Ordering Systems	PH 01: The Curvaceous Form	 Mahendrarajah House	 V.J.H. Gunasekara house	 Tewatte Chapel
	PH 02: The Free Space	 Illangakoon House	 Borella Montessori	 Galle Bishop's House
	PH 03: The Vertical Space	 Mahendrarajah House: Section	 Tharmaratne House: Section	 Galle Bishop's house chapel: Section

Mass and Tabulation	PH 06: Geometric Fenestrations			
	PH 08: Modular Construction			
	PH 09: Deconstruction of Structure			

12. Resilience: Theory vs. Practice

Explicit or tacit, found in books or in the backburner of a person's mind, whether in the state of an abstract cognition of the psychomotor, theory or derived out of practice, despites its origins, knowledge is Knowledge and falls under preordained constituents that forms the universal wisdom.

Within the realm of Architecture, Theory has been in criticism for many decades due to its abstractness and territorialisation of practice, in contrary, practice cannot be accumulated into specific parameters of a theory and is inevitably, highly influenced by individualistic architectural positions of the practitioners. On the other hand, "practice" is beingcriticised for its obliviousness towards theory. Amalgamation of theory into practice and practice into theory, could be a possible resolution inmitigating the tension between abstraction and application as two distant entities. If not perceived as two disintegrated, distant realms, rather as descents of one another; theory which becomes practice and practice which becomes theory, could become a possibility. No doubt that both could operate independently from one another and still be considered as knowledge, but creating 'knowledge' that act as a conduit in bridging the gap between Theory and Practice, two solitary components of knowledge in isolation (Theory and Practice) would be the real challenge. One might not have to reinvent the wheel in doing so, rather a diverse perception or a novel interpretation of the existing knowledge could be helpful. With that thought, Architectural Education could certainly play a vital role in forming the conduits that bridges the gap.

“Rigorous professional practitioners solve well-formed instrumental problems by applying [both] theory and technique”(Schon, 1983, p. 3)

Schon’s statement above vividly explains the possibility of a combinatory approach, where practitioners could combine theory with their individualistic techniques in problem solving whilst Jan L. A. van de Snepscheut confers upon the obliviousness of theory makers towards application and practice, where practice is highly influenced by individualistic positions.

“In theory, there is no difference between theory and practice. But, in practice, there is.”(Jan L. A. van de Snepscheut, 2015)

The realm of architecture is very much a creative domain that the diversity of individualistic notions of creativity, architectural positions and problem solving techniques cannot be disregarded. The transition or the transformation of a theory into a resolution or an Architectural response, is highly dependent upon individualistic architectural positions and would only occur as long as the theory does not tamper the pre-determined set of rules, the programme of Action /the Architectural Position, in other terms, the comfort zone of the architect.

> The ability to design and to be conscious about this (i.e. to be retrospective and projective regarding one’s own position in the surrounding world) seems to be the essential human characteristic, distinguishing us from the rest of the living world. The construction of models of the human position and ability of acting in relation to nature is one of the essential and unresolved challenges of modernity. (Jonas, 2007)

Jonas’s words clearly articulates the inevitable influence of the inner construction; as the ‘own position in the surrounding world’- upon design – as the creative act. He further professes it as the ‘essential human characteristic’ and confers upon the importance of design which is generated out of the equilibrium of human position and the ability of acting in relation to the nature, the surroundings, rather the entire outer construction. Thus, whereas the built environment is concerned, the unresolved challenges of modernity would be to ‘design’ at an equilibrium, whichmitigates the dichotomy between the outer construction (social, cultural, economic, and environmental) and the inner construction – (one’s own position, architectural position, and notion of creativity). Finding the ‘equilibrium’ in the first place, would be a challenge itself. Though seems to be the challenge, it could be perceived as a resolution for the dichotomy between Theory and Practice and the disregard of theoretical notions such as “resilience” as an Architectural Response for the real-world conditions.

Evaluating such behaviour of real-world Architectural Responses and finding strategies to overcome the subsequent disparity between Theory and Practice, however, cannot be entirely practice based. Professions rely on higher training and educational institutions, to establish and renew the bases of practical and intellectual knowledge that the new generations of practitioners will have to acquire. If so, then the objective of the Academia of Architecture and the entire Architectural Education system could be the aforementioned challenge itself; Restructuring itself as a vestibule for the students in facilitating the process of finding their own equilibrium and succouring the emergence of knowledge that act as conduits in bridging the gap between Architectural Theory and Practice.

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ENERGY SERVICE PRACTICES TOWARDS ESCO CONCEPT IN SRI LANKA: A LITERATURE REVIEW AND PRELIMINARY INVESTIGATION

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Abstract
Energy conservation in built environment has been taken reasonable attention in global energy dilemma. However, uncertainty of expected performance achievement of energy conservation project is become an increasing threat. "Energy Service Company" (ESCO) stands as a one such solution which provides successful energy project. Hence, this study investigates the existing energy service practices in Sri Lanka and possibility of adopting ESCO concept for energy conservation in Sri Lanka. This paper is based on literature review and preliminary investigation followed by nine (9) experts in energy industry which was used to discover the characteristics of existing practices of energy service in Sri Lanka, and way forward actions from current energy service practices towards ESCO Concept in Sri Lanka. Findings prove that, current practice of energy services can be categorized as Energy Audit Service, Energy Efficient Improvement Service, Technology service and Energy Supply Service Practitioners. Further, findings conclude that none of existing energy service model reached to the level of ESCO concept to attain the real benefit from energy conservation project and practicing of ESCO concept may be more favourable to the energy service industry in Sri Lanka. Therefore, this research highlights the way forward actions such as guaranteed saving model, energy performance contract and financing model for the development from current status, to the level of ESCO concept.

Keywords: *Energy Conservation, ESCO Concept, Energy Service*

1. Introduction
"Energy" has become a critical success factor for overall development of the key sectors in a country and the progress is synonymous with continuous quest of the energy in many forms (Kalaiselvam and Parameshwaran, 2014). However, scarcity of the primary energy resources confines the adaptability of energy for future development in distinctive industries (Kalaiselvam et al., 2014). Many countries are progressively confronting the energy crisis with ever-increasing energy demand (SLSEA, 2010).

Energy crisis is a one of the daunting challenge faced by Sri Lanka (SLSEA, 2010). Consequently, there was unscheduled power interruptions were taken place in recent past as a result of electrical energy crisis (Fazal, 2014). Even though Sri Lanka was envisaged with crisis in energy more recently, it is become more dare for industries to find solutions towards energy conservation (Fazal, 2014). Perera et al. (2008) noted that energy management has become a cost effective success factor for achieving critical energy conservation targets.

However, Energy conservation and management broadly focused on the planning and implementation of energy efficient projects (SLSEA, 2010). Thereby, many more energy management approaches are emerged as separate entities (Sorrell, 2007). According to Dotty and Turner (2012) ESCO is a one such approach that emerged in order to obtain favorable opportunities from the energy market.

ESCO is a concept which goes beyond the conventional energy services by providing complete energy service through bearing entire risk of energy performance achievement (Bureau of Energy Efficiency [BEE], 2010). Many researches revealed the complete energy project as a project, which runs over design stage to installation and maintenance stage along with comprehensive finance package.

The lack of ESCO model for guaranteed return and safeguard performance risks, limits the adoption of energy conservation project in high energy intensive buildings in Sri Lanka. There is therefore a need to identify the applicability of ESCO concept to Sri Lankan energy service industry, which is to identify the visible gap prevailing in existing energy service industry to reach to the concept of ESCO. Accordingly, the study focuses to identify the specific indicators of ESCO concept as one of cost effective and risk sharing energy service approach and gaps to the existing energy service approaches to bridge more complete and successful energy projects in Sri Lanka. Furthermore, the study consists with four sections presents comprehensive literature review, research methodology, research findings, and conclusions respectively.

2. Literature Review

2.1 THE ENERGY SERVICE

A strong collaboration is existing among different phases of a complete energy project which is from designing stage to installation, commissioning and maintenance stage (Bertoldi et al., 2006). Moreover, energy services includes numerous facets under various disciplines such as energy audit, energy analysis and consultation, design and installation, operation and maintenance, energy performance evaluation, energy supply, energy efficient equipment supply and property management (Bertoldi et al., 2006; Sorrell, 2007).

It is apparent that different trade associations are involved as energy service providing companies in delivering those numerous activities. Castro and Roper (2009) stated that energy service providers based on their activities is challenging the success of the energy projects since most of the service providers are limited to consultation and energy auditing services. Further, Sorrell (2007) stated that most of energy service providers are not affording a complete energy project to the client to ascertain the real benefit from the project. According to Hannon and Bolton (2015), a company specialist with a coherent knowledge in all the energy service activities of a complete energy project is an advantage to the client. ESCO is a cost effective approach to energy service providers who provides complete energy project and practicing energy service as their core business.

2.2. THE CONCEPT OF ESCO

Despite the economic conditions, the concept of ESCO was spread among developed countries as well as the developing countries (Ren et al., 2011). According to Ren et al., (2011), the ESCO concept was emerged in United States in early 1970 as a solution to the energy crisis. Furthermore, the concept was successfully spread in European countries with the stable and strong economics of scale (Fang et al., 2012). In contrast, Hannon and Bolton (2015) revealed that evidence obtain from recent past proved that most developing countries endeavor to add value to energy projects through ESCO concept.

Stuart et al. (2014) defined ESCO as a company that provides energy efficiency-related and other value-added services and for which performance contracting is a core part of its energy-efficiency services business. However, Sorrell (2007) noted that comprehensive and complete energy services offered by ESCOs consisted with energy information and analysis, energy audits, installation, control systems, operation and maintenance of equipment, performance measurement and verification with competitive finance package. Furthermore, Bertoldi et al. (2006) stated that guaranteeing the achievement of energy performance and arranging the finance for the project are key initiatives, which differentiate the ESCOs from conventional energy service providers. Moreover, ESCOs accomplish their remuneration targets as percentage of savings, which remove burden of service charge from the client (Lee et al., 2015). Since revenue subsists on the savings, the survival of the ESCO depends on the success of the energy efficient project (Lee et al., 2015). Therefore, ESCO assist to manage the risk of energy project is a vital aspect, which transferred all the project related risk from client side to ESCO. In contrast, Lee et al. (2013) mentioned that higher the risk of the project, the performance achievement is becoming more unrealistic.

According to Deng et al. (2015), long contract period assist to subtract the risks associated with the energy project. Furthermore, comprehensive energy performance agreements between the client and the ESCO preserve ESCO business from associated risks (Lee et al., 2013). Zhang et al. (2014) stated that the ESCOs are driven in the past two decades through the energy service agreements by providing innovative solution for adaptation of energy measures and green technology in the built environment.

2.3. ENERGY SERVICE AGREEMENTS USED BY ESCO

The process of agreement begins after conducting preliminary energy audit and allowed ESCO as well as the client to concern on services to the depth (Dotty & Turner, 2014). In general, the most common structures for the energy service agreements are identified as energy performance contracts (EPC) and energy supply contracts (ESC) (Lee et al., 2015).

EPC is arranged around the secondary energy conservation measures, while ESC is arranged around primary energy supply measures (Sorrell, 2007). According to Bertoldia et al. (2006), the energy contracts exhibit a framework for the ESCO project, which consist crucial elements for successful project. Accordingly, Baechler and Webster (2011) demonstrate that the key elements which has to be undertaken during development and implementation of energy service agreements include, Investment grade energy audits Project scope development, Engineering and design, Financing options, Development of measurement and verification protocols, Equipment selection and purchasing, Construction management, Commissioning, Project documentation, Training owner’s operating staff, Guarantee of savings through ongoing monitoring and verification activities, Operations and maintenance of equipment.

2.4. ESCO FINANCING MODELS

Hannon (2012) highlighted the fact that success and the continuation of the ESCO depends on positive features of finance models offered at the project. Okay et al. (2008) classified the finance model of ESCOs as guaranteed saving model and Shared saving model. Table 1 compare and contrasts the characteristics of guaranteed saving model and shared saving model.

Table 1: Shared Saving Model and Guaranteed Saving Model

Shared Saving Model	**Guaranteed Saving Model**
ESCO endures the entire finance requirement of the project (Robinson et al., 2015).	Client fulfills the financial requirement of the project through a fixed debt of third party financial intermediate (Peng *et al.*, 2012)
ESCOs ensure the sufficient level of performance achievement and saving targets in order to cover their cost of project (Peng et al., 2012)	ESCO guarantee the sufficient level of performance achievement in order to cover the client debt through savings and assists to obtain debt from third party (Peng et al., 2012).
Client is free from the burden of performance achievement of the energy project (Peng et al., 2012).	Client is free from the burden of performance achievement of the energy project (Peng et al., 2012).
There is no need of reliable guaranteed saving agreement since ESCO bears the cost of the project (Bertoldia et al., 2006).	There is a need of reliable guaranteed saving agreement which augment confidence between ESCO and client (Bertoldia et al., 2006).
Client obligations directs only for the business risk while ESCO obliged for finance risk and performance risk of energy project (Robinson et al. 2015)	Client obligations directs through both business and credit risk of the project. Thus, ESCO responsible for the clients’ credit risk in case of shortfalls in project savings (Robinson et *al.* 2015).

Having considered the above literature review, this study was focused to answer to the following three questions,

1. What are the current practices of energy services in Sri Lanka?
2. What are the critical aspects to be considered in transferring from current status to the ESCO concept?
3. What are the benefits of implementing ESCO concept in Sri Lanka?

3. Research Methodology

Research process is a developed plan to carry out the study by investigating the question, collect information, designing a method of collection and fix on the way of analyzing information to achieve the substantial outcome (Hibbert *et al.*, 2010). Therefore, research process of this study consists of a literature review, data collection as preliminary investigation with energy experts and data analysis to draw the outcome.

The literature review emphasized the ESCO concept in broader view to identify the crucial aspects of the concept such as energy service agreements and finance models used by ESCOs.

This research was subjected to a qualitative research approach by having considered the nature of the study to do a preliminary investigation on energy service practices in Sri Lanka. Nine (09) experts in Energy Management field who are well aware on ESCO concept were interviewed to gather information on the existing energy service industry in Sri Lanka. Furthermore, the nine interviews were used to explore way forward from current energy service practices in Sri Lanka towards ESCO concept. The number of interviews conducted was limited to nine (09) due to saturation of data and specially due to lack of experts in energy service field who are well aware on ESCO concept. Interviews were carried out with energy service professionals, who have border view of ESCO concept and energy services with over 12 years of experience in energy industry in Sri Lanka.

This research carried out content analysis as the technique for analyzing data. Further, QSR.NVivo software was used to analyze the data which assist to develop a code-based structure through the findings of the preliminary investigation.

4. Findings of the preliminary Investigation

This section discussed the findings of the study covering the current practice of energy services in Sri Lanka. Hence, way forward from current energy service practices in Sri Lanka towards ESCO concept, and substantial benefits of implementing the ESCO concept in Sri Lanka.

4.1 CURRENT PRACTICE OF ENERGY SERVICES IN SRI LANKA

All the experts, who are having a broader view of energy service practices in Sri Lanka stated that most of the Sri Lankan energy projects are limited to energy audit and consultancy services which address the energy conservation opportunities and mechanism to the client, while client needs to be carried out the energy project by themselves by coordinating all the financial, equipment, technical and other resources. Experts noted that this company structure as energy audit service providing structure.

Further, as per the experts, very few companies have structured as energy efficient improvement companies. Four (04) experts emphasised that this company structure moved towards the direction of ESCO but still not at a level to classify as an ESCO. Further to the findings, it is not wide enough to provide financial and other resource requirements which to provide a total energy solution to the client.

Further, it is also noted that some technology providing companies are acting as energy services providers in Sri Lanka. According to experts, energy efficient lighting solutions, variable speed drives, energy management systems, building management systems, soft starts, energy efficient motors, and pumps are the most common technologies supplied by those companies. In contrast, five (05) experts highlighted that there are few energy supply service providing companies established in Sri Lanka. Further, highlighted the facts that most of the primary energy suppliers are utilizes renewable energy such as biomass to capture the market.

In summary, all the experts structured that Sri Lanka is still not practicing the ESCO concept as energy service model. Therefore the current practice of the energy services in Sri Lanka can be categorized in to four main sections as,

- Energy Audit Service Providers
- Energy Efficient Improvement Service Providers
- Technology Service Providers
- Energy Supply Service Providers

4.2 WAY FORWARD FROM CURRENT ENERGY SERVICE PRACTICES IN SRI LANKA TOWARDS ESCO CONCEPT

According to experts, concept of ESCO is a universally recognized concept which includes unique finance models to attract the customer on energy conservation. As per the interview findings, common practice of the Sri Lankan energy service industry is highlighted as; user deploys company funds to pay for energy Service Company while services are also limited to energy audit, design and consulting works. Integrated services declared at the universal ESCO concept is not followed by the Sri Lankan energy industry and ESCO is a concept which stands above the existing energy service practices of Sri Lanka.

Figure 1 illustrates the current energy service practices in Sri Lanka. Further, it highlights way forward actions from current energy service practices in Sri Lanka towards ESCO concept.

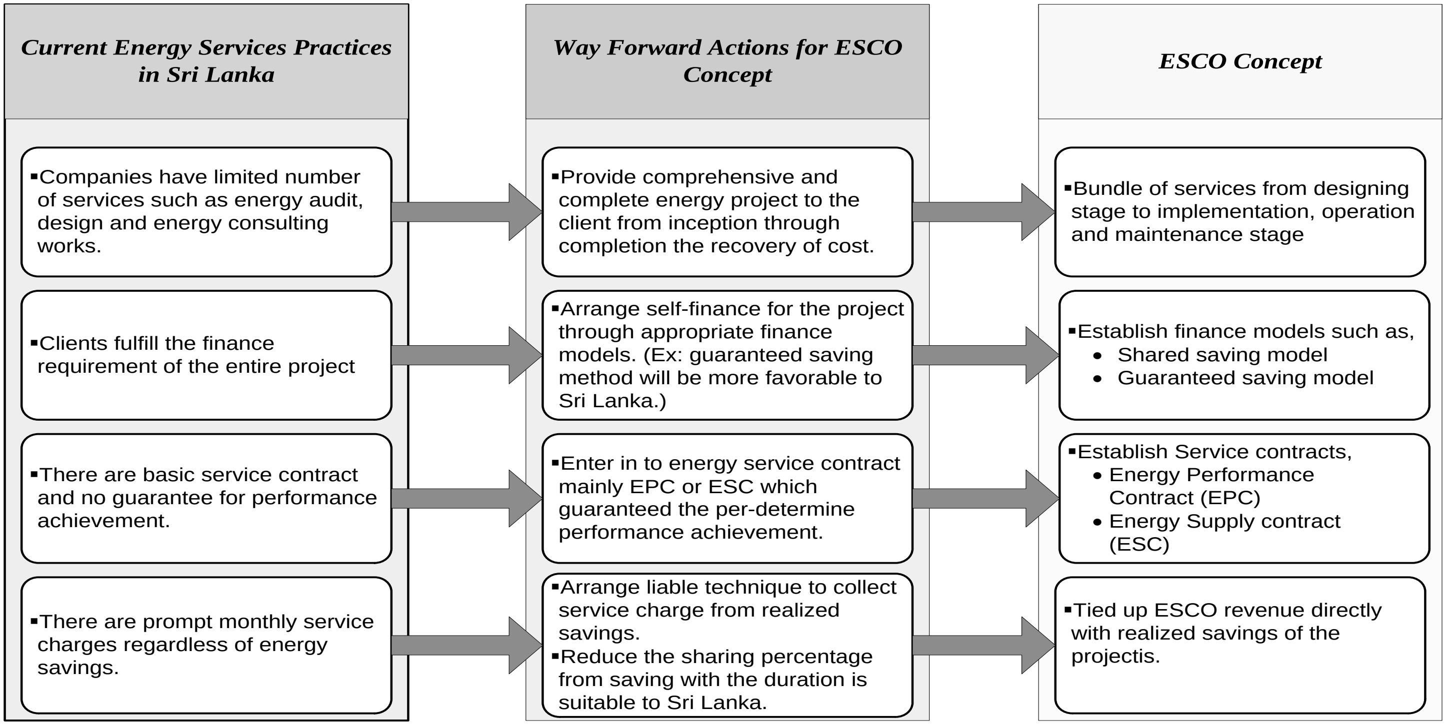

Figure 1: Way Forward Actions from Current Energy Service Practices towards ESCO Concept in Sri Lanka

The first column of the figure shows the current energy service practices in Sri Lanka. Second column illustrates the way forward actions from current energy service practices in Sri Lanka towards ESCO concept and the third column presents the ESCO Concept.

Furthermore, the first point of columns emphasised the fact that to being an ESCO needs bundle of services, which grants numerous facets of the energy project. It is also identified operational capacities of existing energy services companies should be improved to deliver comprehensive energy audit, identifying possible energy conservation opportunities, feasibility studies, designing most appropriate solutions, implementing solutions, maintaining relationship with suppliers and client organisations, monitoring the implemented system, carrying out the operation and maintenance activities throughout the contact period. In carrying out the aforementioned tasks, company has to be maintaining resourceful human workforce.

Further to the findings, the second point of columns emphasised the fact that arranging finance for the project. As a developing country, Sri Lankan energy service companies may not capable for self-funding for projects to follow the shared saving finance model, which is to be a full pledge ESCO. Therefore, Guaranteed the funding is more appropriate for country like Sri Lanka. It is also identified the importance of government support in obtaining funding from the banks. Further, Government can aid to make model more realistic by delivering loans at favorable interest which motivate client to attain loan for the energy project.

Further, the third point of columns emphasised the facts that need to be consider in developing a successful energy services contract in Sri Lanka. It is revealed that energy contract should cover the feasibility stage, implementing stage and measurement and verification stage of the project. Further to findings, EPC include the client information, project baseline, and measurement and verification protocols used, saving share, financial terms, and Legal terms. It is further noted that EPC be able to act as a negotiation tool since it comprises with audits, warranty, financial and payment terms, dispute resolution, good faith, termination, governing law, obligations and responsibilities.

The third point of columns emphasised the facts that method of collecting revenue for the company. According to experts, clients are willing to go for energy conservation only they perceive any monitory value from the energy project. Therefore, revenue percentage from saving should be varying with the duration of the project to create more favorable opportunities to client. Hence, the revenue percentage from saving should be flexible with the energy system of the Sri Lanka which generally classified as 80% from the saving for ESCO and 20% from the saving for client.

Six (06) of experts emphasised the factors need to be consider in achieving realistic performance as mutual trust of operational staff of client organization, stability of the client organization structure, environment conditions, Social factors, economical factors, realistic baseline values, to name few. However, three (03) experts revealed that those factors significantly affect to the energy demand, which will change the normal routines of the client organisation and impact to the performance realization.

Furthermore, all the experts stated that the ESCO concept is suitable to the Sri Lankan built environment even it is not 100% practice in Sri Lanka due to many barriers in the area of financial, economic and technical. Findings assert that the need of this concept may arise in the near future with the crisis of energy consumption in the built environment.

4.3 BENEFITS OF IMPLEMENTING THE ESCO CONCEPT IN SRI LANKA

The study highlights number of prevailing benefits by implementing the ESCO concept in Sri Lanka. According to experts, arranging finance in cost effective way emphasize the ESCOs from the other service providers. Six (06) experts emphasized that finance models offered by the ESCOs are incurred almost zero cost to the client when the project is completed successfully. Further, experts added that, there can be a growth of energy conservation in Sri Lanka as a result of client being able to transfer significant risk to the ESCO through the agreement. Four (04) experts stated that "zero risk to the client" as an observable fact that ESCO facilitate to the client. It is also revealed that the client can more concern on core activities is a benefit that is gained from outsourcing the energy conservation activities for ESCO. As per the all expert, after the implementation of designs as per the contract, ESCOs are providing training to the in-house staff. It is revealed that, achieving predetermined performance of the project is highly depends on the user contribution. Hence sharing the required knowledge with client staff is must for a successful project. Therefore, sharing knowledge is highlighting benefit which adds value to the client organization. Furthermore, all the experts noted that that efficient project offered by ESCO dilute the risks entail with project and make beneficial to the both parties.

5. Conclusions And Recommendations

Energy has become a largest deficient resource in the world with emerging industrialized activities. Energy services industry play a vital role in delivering this energy management requirement. ESCO is a concept which can be adopt by an energy service provider to gain substantial benefits by providing comprehensive energy project in cost effective and risk free manner.

The preliminary investigation proved that Sri Lanka is lacking on the comprehensive energy service such as ESCO. Furthermore, study categorized the existing energy service providers as energy audit service providers, energy efficient improvement service providers, technology providers and energy supply service provider. Further, key findings highlighted Way forward from current energy service practices in Sri Lanka towards ESCO concept as,

- Provide comprehensive and complete energy project from design stage to implementation stage
- Arrange self-finance through appropriate finance models
- Enter into energy service contract which guaranteed the per- determine performance achievement and
- Arrange liable technique to collect service charge from realized savings of the energy project

Furthermore, the study highlighted the number of prevailing benefits which client can obtain such as

- Risk management: Zero risk to the client
- Cost effectiveness
- knowledge sharing
- More concentrate on core business
- Increase the efficiency of the energy project

Energy conservation has been a practical solution to scarcity of energy in near future. ESCO concept is a comprehensive business model which incorporates a high standard of energy service. Thus, adhering to the concept of ESCO could lead to optimize the performance in energy system in Sri Lanka.

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BIOMIMETIC STRATEGIES FOR CLIMATE CHANGE ADAPTATION IN THE BUILT ENVIRONMENT- A LITERATURE REVIEW

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Abstract
Out of the numerous challenges facing mankind globally, the impact of climate change poses more threat. These impacts include sea-level rise, more frequent floods from heavy rainfall and notably among others, intense droughts. Despite the United Nations anchored events and conferences geared towards tackling climate change, little success has been recorded till date. Biomimicry, a novel science and method that studies nature’s models and then emulates their forms, processes, and strategies offer a sustainable approach to this menace of climate change. It also has the potential to offer efficient alternatives to the human activities that contribute to the depletion and pollution of the environment. Hence, the objective of this paper is to evaluate and present the potential of biomimicry in adapting to climate change in the built environment. An extant literature review was conducted on biomimicry and its roles in tackling climate change through mitigation and adaptation. The result explores Biomimetic innovations and applications with their potential to sustainably combat the menace of climate change if adopted. This study is expected to refocus human efforts towards biomimicry where it is believed that nature, during its 3.8 billion years of existence has evolved with highly efficient processes and systems, with the potential to produce solutions to the environmental challenges facing mankind, especially climate change.

Keywords: *Biomimicry; built environment; climate change; greenhouse gas; nature.*

1. INTRODUCTION
Of the numerous global problems facing humanity, climate change is frequently quoted as the most disastrous menace, though in diverse and uncertain ways (Wolf et al., 2009). In the progress towards industrialisation and urbanisation, statistics has shown that human activities contribute heavily towards environmental degradation and pollution. The importance of plants and equipment in the delivery of infrastructural project objectives increases on a daily basis (Idoro, 2012), all in a bid to match and sustain the growth. However, the fuel and energy used to power these plants and the resulting

exhausts/emissions negatively impact the environment. Today, the use of fossil fuels is paramount to heat and power homes as it is convenient using oil, coal and natural gas for meeting our energy needs (Cotgrave & Riley, 2013). These are done without a conscious consideration for the environment, the resultant effect been the rapid increase in the atmospheric concentration of pollutants.

The level of atmospheric concentrations of greenhouse gases (GHGs) are already well above pre-industrial levels and are forecasted to continue rising significantly (Huq & Grubb, 2003). The increase in GHGs within the atmosphere is changing the manner in which radiation is transmitted within the atmosphere resulting in global warming (Etkin & Ho, 2007). Carbon dioxide (CO_2), among several other pollutants, is known to be the primary GHG that has contributed to recent climate change and its emission as a result of human activities (USEPA, 2016). It has been discovered that buildings are major emitters of other non-CO_2 GHG emissions such as halocarbons, chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs) as a result of their use for cooling, refrigeration, fire suppression, and in the case of halocarbons, insulation materials (Pearce et al., 2012). Also, respiratory health problems, headaches, dizziness, irritation of the eyes, nose and throat and other illness are notably caused by these other non-CO_2 GHG emissions. Other impacts also include sea-level rise, changes in storm paths and frequency, more frequent floods from heavy rainfall and among others, intense droughts leading to food shortages etc. (Arain, 2011, Pearce et al., 2012).

As affirmed by Zari (2010), policies and actions to combat GHG emissions must expand rapidly as the impacts of climate change bites and increases. It is, however, noteworthy that, during nature’s years of evolution, it has evolved highly efficient systems and strategies with the potential to prompt solutions to many of the challenges we now grapple with today (Hargroves & Smith, 2006). By responding to its need and proffering strategies that work, natural systems advances (El-Zeiny, 2012) and sustains itself over the long haul. For 3.8 billion years, 10-30 million species have learned to do everything humans want to do, without guzzling fossil fuels, polluting the planet, or mortgaging the common future of generations to come (Strategic Direction, 2008). CO_2 removal from the atmosphere by the photosynthesis of plants and the absorption of CO_2 for pH level reduction by the oceans (Cotgrave & Riley, 2013) are few of the highly successful strategies found in nature. This discovery has therefore birthed an era whereby humans consult nature, studying their forms, processes, systems and strategies to solve problems. Biomimicry, the term describing this practice, will be construed in this study. In light of the conclusions reached, a long-term biomimetic solution is proposed thereby utilising the synergy of strategies found in nature with respect to tackling climate change.

2. THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE (UNFCCC)

At the Rio Earth Summit in 1992, countries agreed to an international treaty, the United Nations Framework Convention on Climate Change (UNFCCC). The UNFCCC is a framework for international cooperation to combat climate change by limiting average global temperature increases and the resulting climate change, and adapting to the inexorable consequences (UNFCCC, 2014).

Climate change is a global large-scale and long-term subject full of uncertainties (Wang, 2008). Regardless of the stance held by individuals, societies or governments on the sorts or immensity of change occurring, an important consideration is the changing nature of change itself: its pace is quickening; its intensity increasing; its symptoms are more obvious; the consequences and severity of change are more evident; and it is fomenting additional and more ferocious change (Edgeman & Wu, 2015). The primary objective of the UNFCCC, as stated in Article 2 is mitigation leading to ‘‘… stabilisation of GHG concentrations in the atmosphere ….’’, but within a time frame that allows ‘‘…ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner’’ (UNFCCC, 2014; Duguma et al., 2014). Although, adaptation and abatement/mitigation of GHGs emissions are both set out in the UNFCCC as responses to anthropogenic climate change, a dichotomy between the two as policy approaches has emerged as one of the most striking features of the discussion on how to respond (Schipper, 2006).

3. ADAPTATION AND MITIGATION RESPONSES TO CLIMATE CHANGE

The duo of mitigation and adaptation has been recognised as being responses to the issue of climate change, as most of the scientific analysis and literature to date has tended to treat them as separate domains, with very little overlap (Huq & Grubb, 2003; Duguma et al., 2014). While mitigation focuses on the source of climate change, adaptation addresses its consequences (Schipper, 2006). The relationship between them is such that, in theory, the more mitigation that takes place, the less adaptation will be needed, and vice versa (Huq & Grubb, 2003). The visible effect of mitigation is not usually immediate, just as the impact of climate change seen now is as a result of long years of accumulated atmospheric concentrations of GHGs and other causal agents. However, adaptation emerged as the only viable option for furthering climate change policy due to delays in the implementation of the Kyoto Protocol (Schipper, 2006). On the other hand, Adaptation deals with enhancing the adaptive capacity and/or reducing vulnerability to climate change impacts while also taking advantage of the positive opportunities resulting from climate change, bearing in mind that impacts cannot be avoided (Wilbanks et al., 2007; Duguma et al., 2014). It is therefore recognised that, since mitigation is streamlined to following regulations and making conscious changes in production, transport, and other service industries, adaptation will not be an optional action (Schipper, 2006). The synergies between adaptation and mitigation reactions to climate change should be highly effective and efficient considering the expanse of the impacts till date. The adoption of biomimicry thinking through the use of nature principles is more than needed in other to proffer adaptation measures to climate change.

4. OVERVIEW OF BIOMIMICRY

Coming from the combination of Greek words; *bios* (life) and *mī́mēsis* (imitation), biomimicry literally means life imitation or the imitation of life (Reed, 2003; Pronk et al., 2008; De Pauw et al., 2010; Arnarson, 2011; Gamage & Hyde, 2012; Murr, 2015). Biomimicry *(bi•o•mim•ic•ry)* studies nature's models and then emulates their forms, process, systems and strategies to solve human problems in a sustainable manner. Multiple terms such as bionics, biomimetics, biognosis and bio-inspired design are also used to describe this practice of learning from nature and emulating its systems (Wilson, 2008; Vincent, 2009; Gamage & Hyde, 2012). Biomimicry is currently gaining overwhelming significance as a global movement in design for environmentally conscious sustainable development that often stimulates creative innovations and solutions (Papanek, 1995; Benyus, 1997; Vogel, 1998; Vincent, 2006; Zari, 2007; Gamage & Hyde, 2012). Al Amin and Taleb (2016) believes that biomimicry as an approach has the potential to solve human challenges due to the fact that other organisms in nature face, or have faced many of such challenges we face as humans and were able to overcome them. No doubt, biomimicry is the best path to a better and sustainable future for mankind as it hopes to solve the problems created by the uncontrolled global growth of industrialisation and the exploitation of natural resources (Rinaldi, 2007).

5. BIOMIMICRY RESPONSE TO CLIMATE CHANGE IN THE BUILT ENVIRONMENT

In combating the menace of climate change, looking to highly adaptable plants/animals or ones that survive in extreme climates and examining the qualities of ecosystems that enable them to thrive successfully, may offer potential avenues to follow (Zari, 2008). Nature has been found to be a master in dealing with chaos, complexity, and unpredictability. Learning from the processes, systems, and strategies at work in nature can be adopted, providing both mitigative and adaptive responses. Successful research and development from nature's over 3.8billion years of evolution has resulted in finding what works with the results found to be sustainable, efficient, functional and aesthetically pleasing as well. For example, before the industrial boom, the atmospheric concentration of CO_2 remained steady as the continuous exchange of CO_2 between the atmosphere, oceans, and land keeps a balance. Professional innovators, designers, and researchers are now heading outside to see how species have managed to survive all these years (Benyus, 2011) after been humbled and inspired by the flora, fauna or an entire ecosystem's modus operandi. It is, therefore, imperative for us to humbly look unto nature as model, mentor and measure in other to find numerous and sustainable solutions to the challenges facing mankind, one of which is climate change amongst many others.

5.1 BIOMIMICRY ADAPTIVE RESPONSE TO CLIMATE CHANGE

The ability of organisms to change certain parameters and characteristics in response to a range of chemical, mechanical and environmental conditions provides endless opportunities and ideas for humans (Lurie-Luke, 2014) in adapting to climate change. These are ideas and innovations found to be capable of responding reversibly to changes within their surrounding environment while successfully adapting and surviving in the long-term. Biomimicry offers an adaptive measure to the menace of climate change by responding to direct impacts of climate change and systemic improvement of the built environment (Zari, 2008; Zari, 2010). This can be achieved through the adoption of the adaptive strategies engaged by nature for more than its 3.8 billion years of existence.

5.1.1 Responding to direct impacts of climate change

Nature has developed highly ordered architectures, complex morphologies, and structures capable of multi-functionality or diverse applications (Kumar & Kim, 2016), after evolving over billions of years. These are features which have enabled them reduced their susceptibility or increased their resiliency to the fast changing environmental situations (harsh or mild) for sustenance and survival. There are arrays of organisms and ecosystems that effectively manage overheating, air pollution, erosion, drought and high winds (Zari, 2010), amongst the several results of climate change. Different combating forces (chemical, physical, and functional) acting on natural biological systems (plants, animals, and other organisms) in the environment can be considered as actions, and their adaptability to these forces by several unique mechanisms can be considered as the direct reaction necessary for survival (Malshe et al., 2013).

For example, the scaly pangolin inspired Nicholas Grimshaw and Partners in their design for the Waterloo International Terminal in England. The glass panels, which some say resembles a pinecone, emulates the flexible scale arrangement of the pangolin thereby making the structure respond to changes in air pressure due to trains arrivals and departures (Goss, 2009). Another example is the proposal of a unique desalination plant called *Teatro del Agua* in the Canary Islands by Grimshaw Architects, in collaboration with Charles Paton of Seawater Greenhouse. Teatro del Agua is a building projected to be self-sufficient in water with a large surplus that can be transferred to neighbouring buildings and landscapes (Zari, 2010). The Namib desert beetle's survival in the extreme desert condition where there is minimal rainfall but short infrequent morning fogs inspired this proposal. The beetle (stenocara) is able to capture moisture from the swift moving fog that passes over it, by artfully tilting its body into the wind enabling water condensation, forming droplets on the hydrophobic-hydrophilic rough surface on its back which later roll into the mouth (Goss, 2009). Teatro del Agua emulates this process by passing seawater over a series of evaporative grilles, leaving salt behind while the moist air touches the cool pipes, condensation occurring and clean water trickles down the outside of the pipes to be collected for use (Zari, 2008).

The above-listed examples are few of the innovations inspired by the application of biomimicry thinking that are applicable in the built environment. With the impacts of climate change now felt through its resultant drought, air pollution and over-heating amongst others, embracing biomimicry holistically offers a sustainable array of options. Despite been an emerging and novel field, biomimicry no doubt is the superlative passage to a sustainable and more desirable future for humankind (Rinaldi, 2007).

5.1.2 Systemic improvement of the built environment

The day-to-day climate is beyond our immediate control, but the built environment is able to reduce its own impact on long-term climate change by utilising sustainable materials and enhanced design to significantly influence the climatic behaviour and sustainability of our buildings (Beddoes & Booth, 2012). Although ecosystems are typically resilient and many are able to move through massive changes while still supporting organisms to survive, the ability of ecosystems to adapt to the rapid changes that may become apparent through climate change is largely unknown (Zari, 2008). However, the ability of our buildings to emulate the natural processes and function like an ecosystem in its creation, use and maintenance has the potential to be part of a resilient and regenerative built environment (Zari & Storey, 2007). For instance, the floating Ecopolis, otherwise known as the Lilypad is a design concept by architect Vincent Callebaut for a completely self-sufficient floating city intended to address housing the inevitable tide of displaced people that could arise as oceans swell under global warming (Rao, 2014). "The floating structure is directly inspired by the highly ribbed leave of the great lilypad of Amazonia Victoria Regia which increased 250 times, an aquatic plant from the family of

Nympheas with exceptional plasticity. The double skin is made of polyester fibres covered by a layer of titanium dioxide ($Ti0_2$) like an anatase which by reacting to ultraviolet rays enable the absorbing of atmospheric pollution by the photocatalytic effect. Entirely auto-sufficient, Lilypad takes up the four main challenges launched by a climatological study of the Organisation for Economic Cooperation and Development (OECD) in March 2008; which include, climate, biodiversity, water, and health. It reached a positive energetic balance with zero CO_2 emission by the integration of all the renewable energies (solar, thermal and photovoltaic energies, wind energy, hydraulic, tidal power station, osmotic energies, phytol purification, and biomass) producing thus durably more energy that it consumes. True biotope entirely recyclable, this floating Ecopolis tends thus towards the positive eco-accountancy of the building in the oceanic ecosystems by producing and softening itself, the oxygen and the electricity, by recycling the CO_2 and the waste, through purifying and softening biologically the used waters and by integrating ecological niches, aquaculture fields and biotic corridors on and under its body to meet its own food needs" (Vincent Callebaut Architect, 2016).

6. LESSONS LEARNT

With the rising population of mankind as evident in most countries around the world, coupled with rapid urbanisation, the negative environmental impacts of human activities are now evident, especially the issue of climate change which has received global attention. Mitigation and adaptation are the two widely recognised concepts with the potent panacea to the global challenge of climate change. While mitigation aim at both decreasing the energy consumption of buildings and limiting GHGs emissions, adaptation on its part refer to the mitigation of the consequences of natural hazards taking root in prevention and protection concepts (Salagnac, 2011). The basic of biomimicry is that, during its 3.8 billion years of research and development, nature has evolved highly efficient systems and processes, which can produce solutions to many of the waste, resource efficiency and other environmental problems that human cope with today (Ásgeirsdóttir, 2013). Whereas, man has been after utilising natural resources for his benefits and welfare which has been accompanied by an imbalance in nature, the introduction of various pollutants into the atmospheric sphere and damaging of the environment (Zarghami & Abad, 2015). Rao (2014) also affirmed that under this new order of sustainability, buildings, outdoor art and other manmade structures would function like trees, meadows, flora and fauna, capturing, cleaning and storing rainwater; converting sunlight to energy and carbon dioxide to oxygen; protecting soil from erosion; disseminating seedlings; and eliminating waste. Adapting to climate change, this study shows the potential of biomimicry to offer solutions in a sustainable manner (Zari, 2008; Zari, 2010). Biomimicry can be used in birthing novel inventions and innovations (Okuyucu, 2015), that will optimise the adaptive capacity of the built environment to the global challenge of climate change

7. CONCLUSION

The human environment is a swathe of mostly activities that contribute immensely to the atmospheric concentration of GHGs. While population and urban surge are on the increase, it is imperative to find ways of cushioning the effect of the resultant climate change both through adaptation as one of the strategies put forward by UNFCCC and other researchers. This should, therefore, involve finding methods to replace the use of fossil fuels, reduction in carbon footprint, discouraging consumption of natural resources and subsequently minimising the generation of waste amongst others. Hence, this study reveals the biomimetic approaches to climate change adaptation. The study result further explores few biomimetic innovations and applications with their potential to sustainably adapt to the menace of climate change when embraced.

Biomimicry has presented an adaptive path to tackling the menace of climate change in a sustainable way. It has also presented methods of replacing the use of fossil fuels with contemporary sunlight and other renewable energy sources while heralding an era of novel innovations that deals with the environmental issues facing mankind. Since replacing the use of fossil fuels will lower the atmospheric concentration of GHGs and prevent the release of additional pollutants, biomimicry examples presented in this study has shown the potential of offering ways to address the excessive release of GHGs into the atmosphere. However, significant time, funding and collaboration between biologists, designers and innovators need to be adopted and encouraged in order to develop more of such technologies. This study has shown the ability of biomimicry to intercept rainfall thereby reducing the risk of flooding, limit overheating, sequester carbon to offset CO2 emissions and overall, improve human wellbeing and the environment. It is also important to note that biomimicry will protect and support ecosystem services which are known to have aided good air quality for the human environment.

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BLIND SENSE OF PLACE
A sensory ethnographic study on parameters of optimal design

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Abstract

Built environment needs to be inclusive addressing all the people who are in different sensory capacities. The current research study was focused on Architecture for visually impaired. The objectives of this qualitative investigation were to explore the nature of blind sensual perception and identify the parameters of blind's sense of place leading to optimal design.The research was conducted, with a sample of visually impaired children (n=13, age = 16-22, male: 7 and female: 6) who are students of Rathmalana school for the blind. A sensory ethnography study was adopted to identify the nature of perception and the parameters of most preferred and least preferred spaces of the school premises. Data analysis was done through Nvivo 11 program. The blind sensual perception considering the order of prioritization of sensory modalities was identified as; haptic perception (35 %), light perception (27%), auditory perception (19%), olfactory perception (11%) and visual perception (8%) respectively. Sense of comfort (46%), and sense freedom (31%) were identified as the predominant psychological parameters leading to optimal sense of place perceived by visually impaired while safety (8%), rhythm (8%), privacy (3%) and sense of belongingness (4%) were identified as secondary factors. Being in harmony with the elements of natural landscape, cross ventilation, artificial ventilation and lighting in a conducive level were revealed as favorable characteristics. Glare, noise, irregular rhythm in vertical circulation (risers and treads of thestaircase) and lack of safety in textural design elements were identified as the unfavorable characteristics of least preferred places. This investigation revealed the importance of transcending beyond the bias of vision and designing inclusive built environments addressing haptic perception incorporating textural effects of materials, ventilation, sound, smell and lighting leading to optimal design conducive for visually impaired.

Key Words: *Blindness; Senses; Perception;Sense of place;Inclusive*

1. Introduction

Architecture is predominantly considered as a visual experience in common practice. Time to time there had been are action against this visual bias within the Architectural discipline. Rasmussen (1962) explained that people assess the quality of space, matter, and scale using multiple senses so that our experience of Architecture is multi-sensory in nature. According to Pallasmaa (2005), we join with the world not because of sight, but because of the rest of other senses.

Visually impaired people are a particular category in a society which cannot be neglected or marginalized. Individuals who are blind give meaning to the places based on their experiences, emotions, memories, imaginations and intentions. Accordingly, the blind perception can add a new spectrum or essence into the field of Architecture.Individuals who are visually impaired pay more attention to the other senses and as a result, they perceive the space and experience it's sense of place in a different way. Vermeersch and Heylighen (2004) supported this concept with their research findings by confirming that people who are visually impaired perceive the built environment, relying on tactile, haptic, auditory, and olfactory perceptions.

Several researchers in the contemporary global research arena have emphasized the necessity of inclusive environments which addresses the people with different sensory capacities. Current preliminary investigation looks into the means of creating inclusive environments for thevisually impaired community with reference to local contextaddressing a current, relevant issue related to the field of architecture.The research has three specific goals to achieve as mentioned below.

- Exploring the nature of perception of space with the use ofdifferent senses by people with visual impairments.
- Exploring relevant sense of place concepts with reference to individualswith visual impairments
- To find out design strategiesto manipulatesensual perceptions and sense of place concepts in creating conducive built environments for visually impaired people.

The focus of the current researchwas mainly limited to a specific group and a context. The scope is limited to the children who are visually impaired, and it is not taken into account all ranges of the visual impaired population. The context is also limited to blind school,Rathmalana. Accordingly, these research findings cannot be generalized to a larger group or context.

Due to the nature of the research question, the study was limited to a qualitative research approach. The research was carried out respecting and giving careful attention to ethical considerations.The studywas limited to a small sample (n=13) due to time constraints and to cause less disturbance to the academic schedules in the school.As an ethical principle, the photographs of research participants were not included in the report to secure the identity of research subjects.

2. Literature Review

Our experience of Architecture is multisensory in nature: we assess the quality of space, matter, and scale using multiple senses (Rasmussen, 1962).

2.1 BLINDNESS

Many decades ago blindness was related to the darkness which equated with evil, stupidity, sin, and weakness (Jernigan, 1969). Highly criticizing the social view on blindness at that time,Jernigan (1969)stated that the primitive conditions of jungle and cave are gone, but the ignorant attitudes about blindness remain.

In general terms, blindness is a lack of vision. It may also refer to theloss of vision which cannot be corrected with glasses or contact lenses. Partial blindness can be introduced as having a very limited view. Having complete blindness, a personcannot see anything and do not see thelight. Visual impairment is a term which experts use to describe any vision loss, whether it is partial blindness or complete blindness. As per the statistics of WHO (2016), worldwidevisually impaired population is about 285 million out of which39 millionare blind, and 246 million have low vision. When it comes to the situation in Srilankan context, 200,000 people are believed to be blind out of 20 million of the whole population. Another 400,000 are having low vision(Statistics, 2001).

2.2 SENSES AND PERCEPTION

Sensescan be introduced as physiological capacities of organisms. They help to provide data for perception.Perception refers to the interpretation of what we take in through our senses (Weiten, 2013).Human body have five basic senses; sight, hearing, touch, smell, taste out of which vision plays the prime role in obtaining reliable information of the world.In the absence of vision, individuals who are visually impaired greatly rely on other remaining senses.

2.3 NOTIONS OF SPACE AND PLACE

As explained by Tuan (1997), space is more abstract than the place and whenspace is felt thoroughly and become familiar to the perceiver, it becomes a place. As further elaborated by Tuan (1997) ‘space’ and ‘place’ both require each other for an explanation. He points out that if one thinks of space as a movement, then the place is a “pause” and this way each pause in the movement will allow space to become a place. It shows that space can become a place through experience. Derived with the experience of space, the notion of asense of place can be defined as a feeling towards a place. It is the emotional relationship between people and places whichdepend on human engagement (Tuan, 1997).

As explained by Relph (1976), thespirit of place exists outside of us while thefeeling of the place lies inside us. According to Relph’s conception, thespirit of theplace lies in the strong characteristics of the environment and sense of place lies upon the human cognitions.

According to Bloomer and Moore (1977), sense of place is derived from the sensual body-centered perception and it is the beginning of all Architecture. Within the scope of this research,the principle focus will be the blind’s sense of place. When it comes to the blind’s sense of place, the material environment remains the same while cognitive factors influence in a significantly different manner based on the sensation and perception conceptions of people with visual impairments.

2.4 MULTI-SENSORY ARCHITECTURE

Pallasmaa (2005) brings out a new perspective of multi-sensory Architecture. Architecture can be considered as the art of reconciliation between human beings and the world. Senses act as the mediators in that process(Pallasmaa,2005). The concept of ‘Multi-sensory’ does not exclude the visual phenomenon although it includes all the sensory attention into Architecture. A multitude of architects have given attention to this approach; the Jewish Museum in Berlin, Germany, designed by Architect Daniel Libeskind, is a vibrant example wheremulti-sensory architecture has been achieved.The Swiss Pavilion, Germany, by Peter Zumthor, is a building designed to demonstrate acoustic qualities naturally (Zumthor, 2010). Carlo Scarpa and Alvar Alto are Architects who not only designed buildings appealing to the eye, but also their work explores the haptic perception. Their composition of material usage has enriched the haptic quality within built environments (Sona & Nair, 2014).Multisensory design approach does include not only buildings. This method can be used even through thestages ofdesign development in order to communicate with clients with deviating sensory capacities (Vermeersch,Heylighen, 2004).

2.4.1 Universal Design

Universal design is a popular, emerging movement in the world which recognizes that thewidest range of people should get access to the built environment, products and communication (Hanson, 2016). Going in line with this notion, the current research probes into the parameters of optimal design for visually impaired.

3. RESEARCH METHODOLOGY

This qualitativeinvestigation adopted sensory ethnography(Pink, 2011)which is a methodology that is appropriate for social research and interventions which helps in understandingthe feelings of inhabitants of particular social contexts, spaces, and places and in turn how they make meanings, act, and react in response to sensory experiences. Sensory ethnography builds anunderstanding of how people's 'multisensorial' experience of place (i.e. touch, taste, smell, sight, sound, movement, and so on) shapes their experience,subsequent behaviors and dispositions (Sunderland et al, 2012).

3.1.1 case study

The research principally focuses on how visually impaired children perceive their built environment. Accordingly,the criteria for the case study was to identify a place dedicated for blind children where the children are studying residing in the same environment. Hessen and Heylighen (2012) have conducted a similar kind of a research at a school for the blind. There are 13 residential schools for children with visualimpairments in Srilanka. Among them, Rathmalana school for the blind was selected to conduct the research due to accessibility, urban context and the resources available.

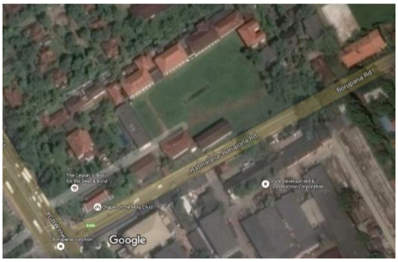


Figure 1, Perspective view of Rathmalana school for the blind

Figure 2, Location of Rathmalana school for the blind

3.1.1.1 Research Sample

The research sample consisted of 13 research subjects who are blind (n=13, age = 16-22, male: 7 and female: 6).Research sample has been selected considering the consent of research participants, proportionate balance interms of different vision status, less variation in age and knowledge level, thebalance of gender proportions and with less disturbance to students' academic schedules.

3.2 RESEARCH PROCESS

As graphically represented below, this research evolved and developed through an in-depth research process which consisted of stages of the preliminary, pilot and research study while gaining discipline, knowledge, training, practice in the process of investigation during four months.

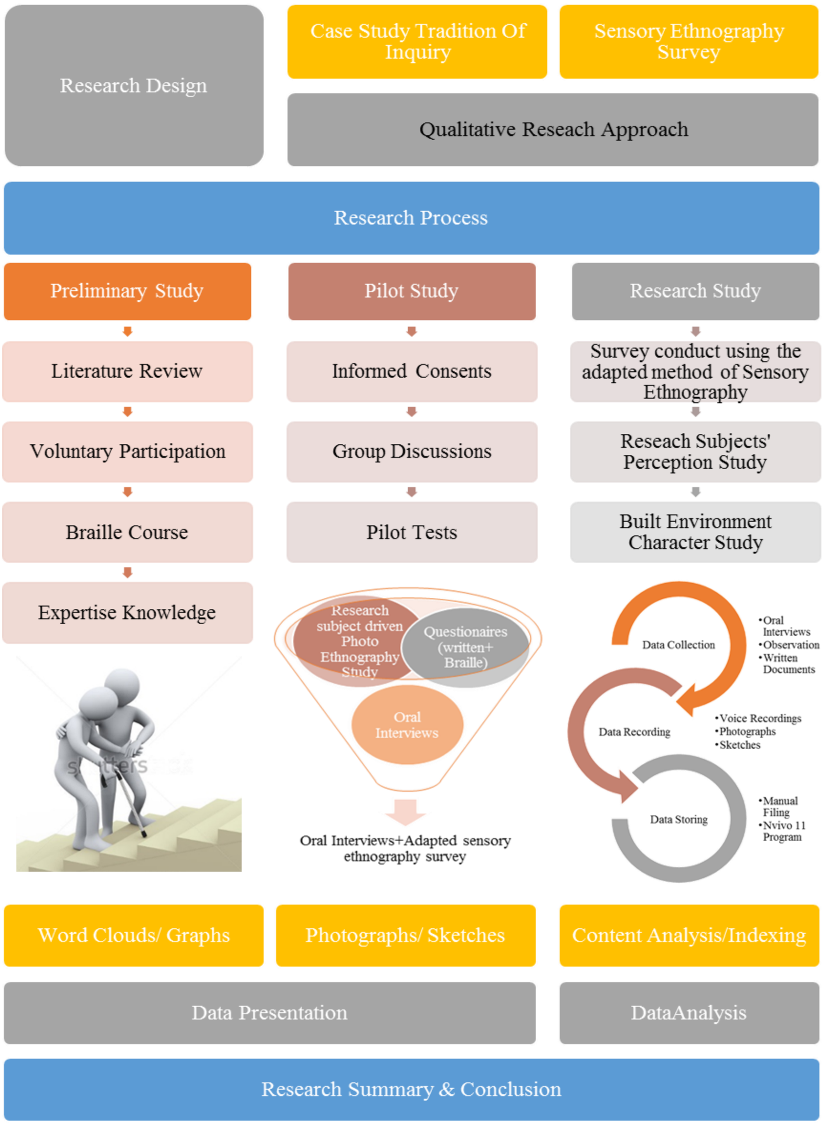


Figure 0, Summary of research Process

The Sensory Ethnography method (Pink, 2011; Herssens & Heylighen, 2012) was adapted to conduct the investigation. Research participants (n=13) were invited to participate in a group discussion at the onset of the study in order to enlighten them regarding the research plan. It was also attempted to obtain thegeneral opinion about their living environment within the school premises with special reference to buildings/spaces. Each subject was asked to give a guiding tour around the school environment afterward. Throughout that tour, each subject was invited to guide the investigator to their most favored and least favored places while explaining the reasons behind their perceptions.

Data was collected via oral interviews (n=13) consisted of open- ended questions which took place simultaneously with the guiding tour. As clarified by Keats (2000), interviewing technique applied for visually impaired should strongly rely on verbal communication. Engaging in an awareness program on visual impairment helped the investigator to develop necessary skills and competence to conduct the interview accordingly. The observations relevant to each research subject were recorded then and there while taking part in the guiding tour via taking down notes, sketches, and photographs by the investigator.

Nvivo 11 program and manual filing method were adapted to store data during the research process. This study has incorporated Nvivo 11 program for data analysis as well. The method of coding analysis (Keats, 2000) has been adapted and the analyzed data were presented using word clouds generated using Nvivo 11 to graphically represent big ideas in the content (Ramlo, 2011). By adopting word clouds it was expected to communicate the summary of findings effectively to the reader compared to a graph/chart.

Research subjects' responses were observed and analyzed to recognize the nature of the sensory perception of visually impaired. Based on their favorable and unfavorable responses and actions with reference to the spaces of the school premises reported during the study tour, the most favored places and disfavored unpopular places were identified to study the corresponding spatial attributes. Corresponding sense of place themes was derived based on the meanings and ideologies reportedby the research participants with reference to those placesidentified. The findings were analyzed in order find out the characteristics of favored places vs disfavored places supported with a site analysis synthesizing notes, photographs, sketches and the comments of research participants.

The findings and conclusions of this research have contributed in comprehending the parameters leading to optimal design for visually impaired.

4. FINDINGS& ANALYSIS

The significant findings came out of the interviews conducted simultaneously with the sensory ethnographic study represented below.

4.1 FINDING 1- HIERARCHY OF SENSORY PERCEPTION

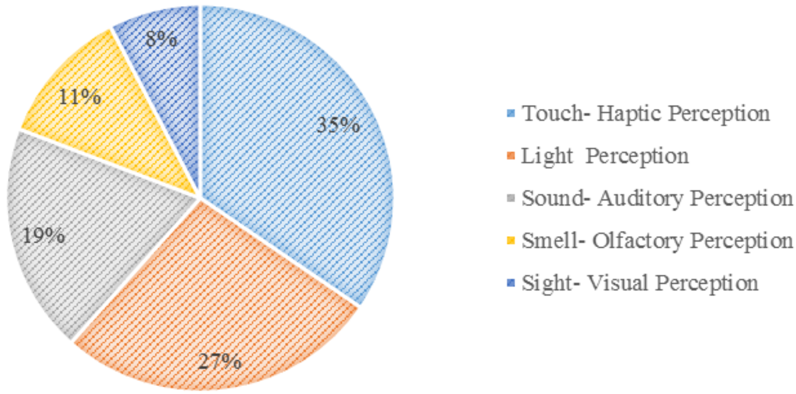
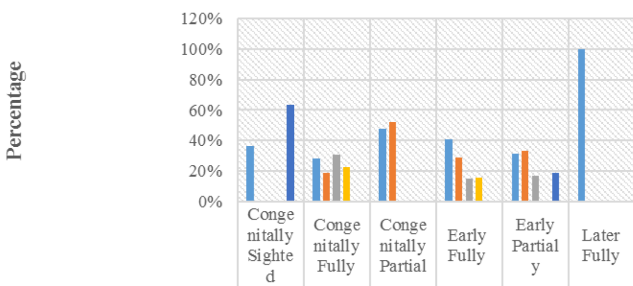


Figure 0,Sensual perception ratio of visually impaired

It seems clear from the evidence that children who are visually impaired experience the space based on a hierarchical order ;the sensation of touch; haptic perception (35%), light (27%), sound (19%), smell (11%) and sight (8%). This perception variation depends on the degree and the onset age of visual impairment.



	Congenitally Sighted	Congenitally Fully	Congenitally Partial	Early Fully	Early Partially	Later Fully
Touch -Haptic Perception	37%	28%	48%	41%	31%	100%
Light Perception	0%	19%	52%	29%	33%	0%
Sound- Auditory perception	0%	31%	0%	15%	17%	0%
Smell- Olfactory Perception	0%	23%	0%	15%	0%	0%
Sight-Visual Perception	63%	0%	0%	0%	19%	0%

Figure 5,Summary of finding: Perception vs. status of blindness.

The haptic perception was the common perception type which applies to all the vision categories.Need of the incorporation of haptic perception into the built environment was the major key idea which revealed with the summary of perception type vs. status of blindness.

4.2 FINDING 2- SENSE OF PLACE CONCEPTS

Children with visual impairments have given meanings into spaceswith their emotions, feelings, and thoughts so that those spaces have become places forthem. Notions of asense of comfort and freedom were found to predominate amongst the sense of place concepts that derived based on the perception of blind subjects.

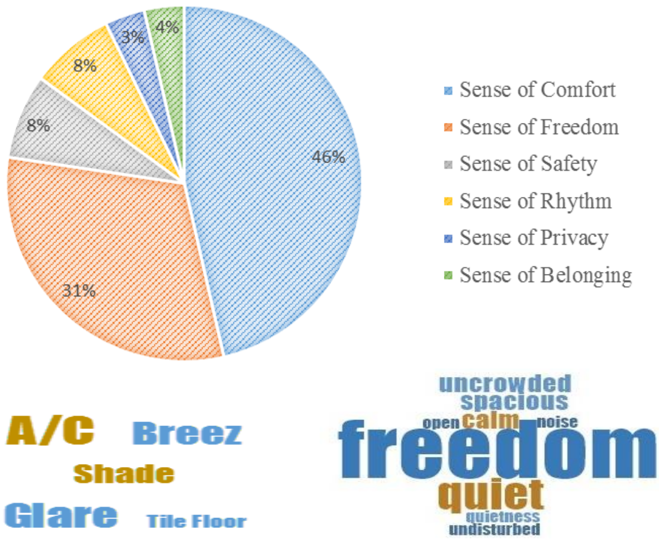


Figure 6, Emerged sense of place concepts

The blind's sensual perception considering the order of prioritization of sensory modalities was identified as; haptic perception (35 %), light perception (27%), auditory perception (19%), olfactory perception (11%) and visual perception (8%) respectively. Sense of comfort (46%), and sense freedom (31%) were identified as the predominant psychological parameters leading to optimal sense of place perceived by visually impaired while safety (8%), rhythm (8%), privacy (3%) and sense of belongingness (4%) were identified as secondary factors.

These concepts reflect the psychological needs of the children who are visually impaired. It clearly indicates the fact that physical environment can directly influence the psychology of blind individuals signifying the importance of inclusive environments. The concept of sense of comfort derived based on the physical attributes of the environment is found to affect the physiological comfort of the blind subjects. According to the view of Jackson (1961), learning the skillful use of a cane can make much difference in the sense of freedom. Tuan(1997) strengthened this concept by arguing that a setting is spacious if it allows one to move freely. It is surprising to reveal that considerable percentage (31%) of children who are visually impaired seek freedom within built environment. Society has created a dependency attitude regarding people who are being blind and has tried to project that attitude over blind individuals. Children who are blind experience the space with a mentality of dependency. Literally,these research findings point out that visually impaired individuals require a barrier-free environment where they can behave independently.These concepts are more or less important because each of them carries a meaning or a feeling which has developed by childrenwho are visually impaired over a period of time with the experience of built environment. Further, research data exposedthat the students who were there in the school for an extended period were found to have a variety of sense of place concepts than the ones who stayed for a short period.

	Congenitally Sighted	Congenitally Fully	Congenitally Partially	Early Fully	Early Partially	Later Fully
Sense of Comfort	100%	36%	50%	37%	50%	100%
Sense of Freedom		36%	50%	37%	25%	
Sense of Safety		9%		13%		
Sense of Rhythm		9%		13%		
Sense of Privacy		9%				
Sense of Belonging					25%	

Figure 7, Sense of Place Vs. Vision Status

As depicted in thefigure below, thegender of the research subjects was revealed as a parameter of asense of place concepts.The sense of comfort and sense of freedom were perceived by the both gender types. While females were concerned on asense of rhythm, males were in need of asense of safety, privacy, and belongingness.

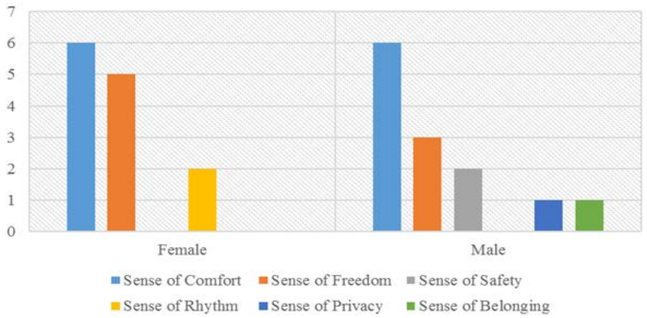


Figure 8, ense of place concepts vs. gender

Being in harmony with the elements of natural landscape, cross ventilation, artificial ventilation and lighting in a conducive level were revealed as favorable characteristics. Glare, noise, irregular rhythm in vertical circulation (;risers and treads of the staircase) and lack of safety in textural design elements were identified as the unfavorable characteristics of least preferred places.

4.3 FINDING 3- PARAMETER FOR AN OPTIMAL DESIGN

It is certain that the manipulation of built environment plays a significant effect on the perception of the children who are visually impaired. Following parameters have been identified by the research as conducive to creating optimal environments for blind.

Places blended with natural surroundings and layout oriented for cross ventilation : Natural environment possesses the qualities of freedom and harmony. The direction of the cool breeze can help to locate, identify and differentiate a place from another. Natural wind flow within a building can be manipulated with contrast in spatial volumes, openings, and built form.

Mechanically ventilated spaces: This parameter can be strengthened with the statement by Hescong(1979) that thermal environment can be felt through the skin with tactile changes which meets the body. The thermal environment can be highly moderated with mechanical air conditioning.

Building orientation considering the sun path direction: As stated byTuan(1997) blind people are found to use the sun to help them find their way. Further refining this statement, the current research revealed that many visually impaired children are sensitive and irritated by the sun’s glare to a certain extent.This issue can be addressed considering the orientation of the building.

Well-lit places than dark places : Individuals who are having low vision can benefit greatly in well-lit places.

Spaces considered on olfactory perception : The presence of a specific smell can define a given location. This idea can be incorporated into the built environment by means of landscape approach; planting flower plants, bushes, and trees which give a variety of fragrance.Other than the natural landscaping approach it can achieve in the interiorswith the material usage.

Safety Concerned spaces: Fingertips of children who are visually impaired have naturally become sensitive to gain haptic perception. They tend to find and verify places touching the wall surfaces. Damaged surfaces can harm and injure the sensitive fingertips of children who are visually impaired since they do not know the threat of the site;broken windows, rusted grills…ect. Maintenance of places and elements often can ensure the safety of children.

Usage of building elements thatenable asense of touch- haptic perception: Haptic design quality can be gained with textural differences of materials. Individuals who are visually impaired can sense even a subtle difference in a texture since they have predominantly adapted to gain perception through touch.Haptic quality can be enhanced with the usage of different textural objects. When there is a transition of space, it is vital to inform the blind individuals in advanced that they are about to move into a different place. This can be effectively achieved with the textural variation of the floor.The echoing quality of material also can enrich the haptic quality in built environment.

5. CONCLUSION & FUTURE DIRECTIONS

The study was initiated with the research question: visual bias in architecture since architecture is considered predominantly as a visual experience in common practice. It is hypothesized that the built environment needs to be inclusive addressing all the people who are in different sensory capacities. The current research study was focused on Architecture for visually impaired.

Identifying the nature of blind sensual perception and the beneficial characteristics of environments to be perceived by blindswhich can lead towards optimal design was the main objectives of thisresearch.

The research was conducted, with a sample of visually impaired children (n=13, age = 16-22, male: 7 and female: 6) who are students of Rathmalana school for the blind. A sensory ethnography study was adopted to identify the nature of perception and the parameters of most preferred and least preferred spaces of the school premises.

The research findings clearly depict that the blind sense of place is different from the way how sighted perceive the built environment. Most of the elegant features, beauty, and aestheticsadmired by the sighted people in the built environment would not catch the attention of blind individuals.This investigation revealed the importance of transcending beyond the bias of vision and designing inclusive built environments addressing haptic perception incorporating textural effects of materials, ventilation, sound, smell and lighting leading to optimal design conducive for visually impaired.

This study encourages the architects and designers, to develop optimal design strategies for an inclusive built environment. That approach can efficiently provide the people with visual impaired to use their built environment without any barriers. The study could be further expanded taking the limitation of the current research intoconsiderations covering a much larger sample size with visually impaired subjects of diverse age categoriesand with reference to a wide range of case studies in order to generalize the findings to a larger population.

6. ACKNOWLEDGEMENT

Writing a dissertation is like a journey through a unlighted tunnel towards the light.
It was dark in the beginning. Unless guidance was not there, I would not reach this far towards the light…I acknowledge, with gratitude, towards, administration and the staff of Department of Architecture, University of Moratuwa, Dissertation supervisor, Dr. (Mrs). Anishka Hettiarachchi for her dedicated encouragement,guidance and patience throughout the process,Research Co-ordinator Dr. Shaleeni Coorey, Year Co-ordinator Dr. Narein Pererafor guidance, Ann Heylighen, Research Professor KU Leuven, Department of Architecture for sending full research papers which were very relevant to my study, Ms. Kumuduni – the vice principal of the Rathmalana blind school and the staff for support and guidance provided throughout the field research work, Mrs. Hewage -the coordinator of the NIE braille program and the staff for their training and support, all the research participants and my family, friends, and colleagues.

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UNDERSTANDING THE FACTORS CONTRIBUTING IN THE FORMATION OF CANOPY LEVEL URBAN HEAT ISLAND – A CASE STUDY OF NAGPUR CITY

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Abstract
Many Indian cities are today facing issues like overcrowding, deteriorating air quality, overloaded infrastructure and increase in air temperature, which directly affect comfort level and quality of life of residents. Central Indian city of Nagpur is no exception to this phenomenon. Current research work involves understanding & investigation of factors contributing to development of urban canopy level heat island in the city of Nagpur. It also involves finding out the temperature distribution patterns within urban canyons, by recording and analyzing field data. As most of the human activities occur in this layer, the comfort level of residents is directly affected by any increase in temperature in this zone. The paper discusses a correlation between ambient air temperature and variables of canyons such as vegetation, height-width ratio of buildings and streets, materials of horizontal and vertical surfaces, colors of surfaces & type of land use; and analyzes variation in air temperature in different parts of the city of Nagpur during summer. The results might prove useful for developing more resilient built environment not only for city of Nagpur, but also for other cities in south Asia with similar characteristics.

Keywords: *Urban heat island, Canopy layer, Vegetation, Height-width ratio, Materials*

1. INTRODUCTION:
Urbanizations had brought many challenges like depleting natural resources, quality of air, water, climate change and increase in global temperature and changes in cities. An increased rate of urbanization also results in high growth rate of vehicular population, residential and commercial complexes and industries. This causes significant changes in land-use land-cover (LULC) pattern and increase in anthropogenic heat emissions *(M.Mohan 2012)*. In Indian cities, the natural landscapes are changing very fast and being replaced

by structures at the cost of open-spaces and vegetation. The built-up and paved surfaces act as obstacles for the proper dissipation of heat energy to the surrounding environment due to their higher heat absorption and retention capacities. Because of this, air temperature in urban areas is observed to be more than that in surrounding open areas. This is referred to as Urban Heat Island(UHI) effect. The intensity of UHI effect is also observed to be directly related to the degree of urbanization *(Oke 1987, Santamouris 2001).*This research work involves understanding of factors contributing to development of urban canopy level heat island in the city of Nagpur and finding out the temperature distribution patterns within urban canyons.

2. URBAN CANOPY LAYER HEAT ISLAND :

Oke (1976) describes urban atmosphere as one having two distinct layers - urban boundary layer and urban canopy layer. The Urban boundary layer (UBL) is overall atmospheric system that extends for many kilometers above the cities and whose characteristics are partially determined by the city below. The Urban canopy layer (UCL) or urban canopy is layer of atmosphere where most life occurs - i.e. from the ground level up to mean height of roofs, where Incoming solar radiations are gradually absorbed and specific conditions of air temperature and humidity may exist, which are different from those prevailing in the surrounding space.

The Urban heat island (UHI) is typically presented as a temperature difference between the air temperature within the urban areas and that measured in a rural or open area outside the urban settlement (ΔTu).The intensity of a heat island depends on many factors like population density, size and morphology (physical structure) of the city. Major causes leading to formation of urban heat island include:

- Reduced vegetation in the urban areas.
- Heat absorbing properties of materials used in urban settings
- Urban geometry
- Anthropogenic heat in the form of heat emitted by air conditioners, engines of vehicles etc.

Climatic effects of urbanization are strongly felt in the urban canopy. *Oke (1976)* stresses that the urban canopy is a micro-scale concept i.e. the specific climatic condition within the canopy is the result of its immediate surroundings such as land-use, land-cover, building materials, geometry, percentage of vegetation, color of the buildings etc. and any changes in these parameters can modify the local ambient climate. Thus meteorological condition within the urban canopy is much localized. Due to varying height of buildings, upper boundary of urban canopy often varies from one location to other. Even human comfort and energy use of buildings are affected by the local climatic conditions within the urban canopy.

An Urban Canyon is defined as 3-dimensional space bounded by a street and the buildings that abut the street; within an urban canopy. The air circulation and temperature distribution within the urban canyons are significant for the energy consumption of the buildings (Santamouris, 2001) as well as for human comfort. Most of the UHI studies are therefore focused on the energy balance in the urban canyon, the temperature distribution of the air and of the surfaces and the air circulation in the urban canyon.

Temperature Distribution within Urban Canyon:

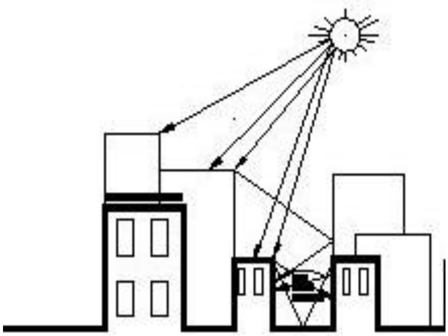


Fig 1 Urban Canyon

The temperature distribution in the urban canyon is greatly affected by the urban energy balance. The energy balance consists of all the exchanges of energy as well energy added by human activities i.e. anthropogenic heat. In urban canyons, most of the solar radiation strikes on roofs and on vertical walls of the buildings and very small portion reach the ground. Solar radiation falling on the vertical wall is partly reflected mostly towards other walls of buildings in close proximity and is partly absorbed at wall surfaces. This initiates the process of radiation reflecting back and forth a number of times between the walls of different buildings. As a result of this, small part of solar radiation falling on wall gets reflected upward to sky, while most it absorbed by walls of the buildings and is slowly released back to atmosphere in the evening and during night hours. The rate of radiant heat loss to sky depends on sky-view factor, which is a geometrical concept that describes the fraction of the overlying hemisphere occupied by the sky(*Oke, 1981*). Therefore radiant heat loss within the urban canopy is smaller than the radiant heat loss from open area where sky-view factor is more.

Urban canyon is therefore a very useful unit for investigation in the urban heat island study and helps in understanding the air temperature changes in urban

areas. Magnitude of urban heat island over a city and within the street canyon can be studied by recording and observing air temperature distribution within the street canyon. There are different methodologies used by various researchers to study urban heat island.

Many researchers have used either Remote sensing technique or field data analysis method. Field data can be gathered either by ground transect or fixed point monitoring method.

Previous studies show that there is existence of urban heat island in city of Nagpur. All earlier studies investigate the influence of Land-use, land-cover changes on air temperature at spatial level.

Aim of Present Study:

The Current Research focuses on the study of canopy level urban heat island of Nagpur city to understand the temperature distribution in urban canyons. The study aims to investigate factors which are responsible for rise in temperature within the canyons. This paper presents statistical correlation between ambient air temperature & variables of canyon such as vegetation and material of surface, color of surface, land use etc.

Study Area

Nagpur is one of the best known cities of central India located in state of Maharashtra. It acquired historical importance from 18th century after its founder Gond King BakhtBuland Shah made it Capital of his kingdom. Nagpur originated in the eastern part known as Mahal and later spread to now south central part of Sitabuldi.

Mahal is the traditional city centre of Nagpur & is of historical importance. This part of the town grew organically in the beginning.

Fig 2 Map of India
Source:maps of India.com

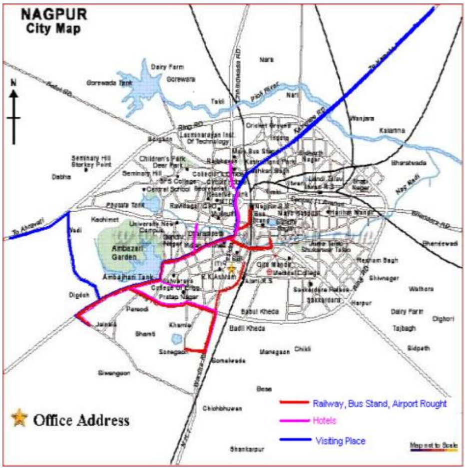


Fig.3 Map Of Nagpur
Source:maps of India.com

The present scenario of Nagpur city indicates that it is developing in all directions. The urban pattern of Nagpur reveals its transformation from an old congested city form to planned development.

Climate of Nagpur: Nagpur witnesses a very hot and dry summer from March to May. Well distributed rainfall occurs during the southwest monsoon from June to September, while period from October to November is the post monsoon season. Winter is cool and dry from December to February. During summer, temperature ranges from maximum 47º C to minimum 29º C and in winter ranges from maximum of 30º C to minimum of 10º C. Average rainfall is about 45inches (1150 mm). Relative Humidity is about 90% during monsoons and around 20% in the summer. Winds are generally light to moderate, with some increase in the speed in the later part of the summer season and the monsoons.*(Source: Indian Meteorological Department Regional Center at Nagpur Airport)*

3. RESEARCH METHODOLOGY:

Numerous earlier studies have indicated that the land use / land cover (LULC) has most significant influence on urban climate. Based on spatial organization of city, it was therefore decided to consider Land use Land cover as the main variable influencing the urban climate in the city. In the present research, fixed point monitoring stations were located in areas with different land use / land cover patterns, for recording temperature and humidity. The data collected during different seasons was then statistically analyzed to understand contribution of different parameters in UHI of Canopy layer.

3.1 Criteria for selection of measurement sites: Following criteria were used for selecting study area and locations of monitoring stations in different parts of city:

1) Study areas should be representative of different types of LULC patterns existing in city
2) Study area should represent a wide range of urban morphologies.
3) Study area should have uniform surface cover, structure, material and human activities.
4) Study area should not have much variation in temperature within a zone of influence of 100m x 100m.

Field study was carried out in selected zones; which were delineated by using satellite thermal image of Nagpur City and LULC classifications.

3.2Satellite Image: -Surface temperature distribution over a city can be observed in a Satellite Thermal Image, which shows the surface radiant temperature–primarily of roofs and roads. Satellite image obtained from MRSAC (Ref.Fig.4) shows areas with a High, Moderate, and Low temperature within the city; from which, the heat pockets within the city can be identified.

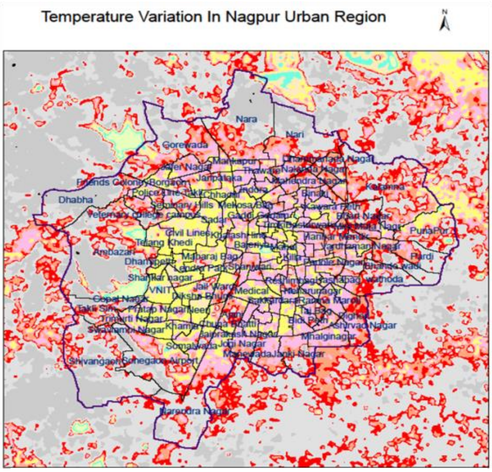


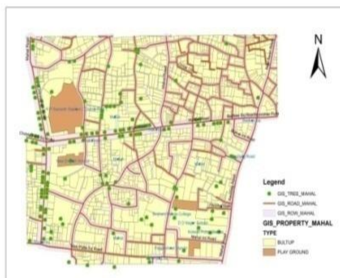
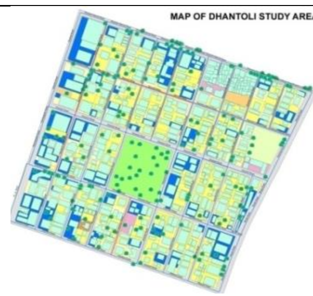
Fig. 4 Satellite Thermal Image
Source: Maharashtra Remote Sensing & Application Centre, (MRSAC) Nagpur

As there is a relationship between air temperature and surface temperature, we can use this image to identify representative zones from which temperature could be recorded. For this research Satellite Thermal Image of Nagpur obtained by LANDSAT 8 TIRS Band -10 on 13th April 2013 was used. The image was procured from Maharashtra Remote Sensing and Application Centre, Nagpur (Ref.Fig. 4).

3.3 Descriptions of Study Areas :

As discussed, study areas were selected by correlating satellite image with land-use land-cover classification. Land use consisting of different classes – i.e. residential and commercial activities was used to delineate study areas along with different land covers such as paved area, open area and green surfaces. Land use land cover classification was based on built-up area, building density, and green & open area coverage. Built-up area was further sub-classified on the basis of built-up density into following categories: High density, Medium density and low density. Based on these, following areas were selected (Refer Table 1):

Table 1 (Selected Study Areas)

Area	General Description	Image
Mahal	The oldest part of Nagpur located on the eastern side. This area can be called as of compact (attached or very close set buildings) low-rise and midrise buildings with a few open spaces and narrow lanes of organic pattern and few trees. **Landuse**- Mixed **Land cover** is mostly paved. **Tree cover:7%** **Construction materials:** Bricks, cement plasters, cement concrete. Population density is 700-850 pph. Built-up density is 77dwph.	
Dhan-toli	Well planned area with open spaces and parks&gridiron pattern of roads. This area consists of open arrangement of midrise detached buildings (3-9stories) with few low-rise buildings. **Land-use:** mixed. **Land cover:**Percentage of pervious land is less. **Tree cover : 16%** **Construction material:** Brickwith cement plaster and concrete. Population density is 221 pph. Built up density :60dwph	
Dhara-mpeth	It is situated in the Westside of Nagpur. Medium dense Built up area.This area has combination of open arrangement of midrise detached buildings (3 to 9 stories) and compact low-rise buildings with few trees. **Land-use:** mixed. **Land-cover:** predominantly impervious (road surfaces), but small patches of pervious area also exist. **Tree cover :14%** Population density is 292 pph Built-up density : 55dwph	

Shank-ar Nagar	Well planned colony with Parks, Playgrounds and Residences. It is a purely residential area, surrounded by big patch of farmland. This area can be termed as open area with low rise buildings (1-3stories). **Landuse**– Residential. **Land cover:** The Percentage of pervious land-cover is relatively higher. **Tree cover:**25% **Construction materials:**bricks, cement plasters and concrete. Population density is 125 pph .Built-up density: 25dwph	

3.4 Location &other Details of identified Urban Canyons:

To study urban heat island at canopy level, three street canyons were selected from each study area mentioned above (Ref. Table 2). Out of these three, one street canyon was commercial while other two were residential. In order to monitor and record air temperatures within the canyons, fixed point measurement method was used. No. of monitoring points varied as per the canyon length.

Table-2 Street Canyons where measurements were taken

Area	**Street No.**	**Length of Road**	**Width of the Road**	**H/W**	**Orientation**	**Land use**	**Road Material**
Mahal	1	90m	6m	2.25	NE_SW	Resi	Concrete
	2	486m	17.5m	1.06	E-W	Comm	Asphalt
	3	90m	9m	1.8	N-S	Resi	Asphalt
Dhan-toli	1	165	6m	2.5	N-S	Resi	Asphalt
	2	435m	10m	2.1	N-S	Mixed	Asphalt
	3	288 m	10m	1.35	NW-SE	Resi	Asphalt
Dhara-mpeth	1	285m	4.5m	2	E-W	Mixed	Asphalt
	2	968m	24m	0.75	NW-SE	Comm	Concrete
	3	478m	9m	1.66	N-S	Resi	Asphalt
Shankar Nagar	1	140m	7.5m	1.2	N-S	Resi	Asphalt
	2	118m	9m	1	N-S	Resid	Asphalt

3.5 Fixed Stations& Measuring Instruments:-

Field measurements of Air temperature and relative humidity within the street canyons were taken and recorded by the HTC wireless data logger. The data logger is designed with a high accuracy temperature and humidity sensor, providing fast response and stability. Hand held Kusam-meco infrared thermometer Model IRL-300 was used to measure the horizontal and vertical surface temperatures. Positions of field measurement stations were identified by GPS instruments. All the instruments were calibrated before the experiments.

The air temperature & humidity measuring instruments were installed at a height of about 1.5 m to 2.0 m above ground level as per WMO guidelines. Measurement of Air temperature, relative humidity and temperature for surface material were recorded during the summer season in the month of May 2015. Temperatures were recorded at all monitoring points in all four areas on the same day simultaneously at 3 hours intervals from morning 9 am to 10pm in night. These timings were considered for analysis because humans are more active during these periods. During this period of survey, sky was clear and winds were calm. Wind speed was very low at 0.4 to 0.8m/s , and therefore has not been considered for analysis in this study.
Other important variables which affect Air temperature within canyon – i.e. i) building heights, ii) orientation and width of streets, iii) urban vegetation & iv) type of material used in buildings were documented by visual survey. Effect of anthropogenic heat on air temperature in canyons was beyond the scope of this study. The Weather Data was obtained from Regional Meteorological Centre, Govt. of India, located at Nagpur Airport.

3.6 Calculations for UHI Intensity :-

Urban heat island intensity is calculated as a difference between the maximum urban temperature and nearby rural area temperature. As rightly pointed out by *stewart and oke,* the classification of field sites as conventionally "urban or rural" has become especially difficult in regions where both cities and country sides are densely populated and land uses are intensely mixed. City of Nagpur is also expanding in all four directions with urban influence, and it is very difficult to find rural site very near to Nagpur. Therefore in the present research, UHI Intensity has been calculated as difference of the temperature at a given study area location and the temperature recorded by meteorological station at Nagpur Airport (baseline temperature) at the same time. The intra-urban UHI intensity has been calculated as difference between temperature at a given study area location and the lowermost temperature recorded at the same time amongst all stations within the same study area.

The main objective of field work and data collection was to investigate factors which are responsible for rise in temperature within the street canyon. The data collected through surveys was then analyzed by using statistical tools. To define the relationship between temperature (as an indicator of UHI) and other variables commonly observed in the urban canyon (as an indicator of urban morphology) the correlation analysis was carried out. In this analysis, temperature is taken as dependent variable and other variables such as extent of vegetation, (building)height/(road)width ratio of canyon, material of horizontal and vertical surfaces, density of built-up as independent variables.

4. Results and Discussions:

4.1 UHI &Variation in Local Climate

The intra-urban heat island intensity (UHI) at canopy level in the three study areas of Mahal, Dhantoli & Dharampeth was calculated as difference in the average temperature in each of these study areas and the observed temperature at that hour at Shankar Nagar, which was found to be lowest amongst all the 4study areas.

It was observed that in Mahal, which is old part of the city & has high built-up density, had highest ambient air temperature amongst the 4 study areas. Average Intra-Urban heat island intensity in Mahal area for the summer season (May 2015) at three different times– i.e. during noon (12:00 – 15:00 hrs) was 2.8deg C, during evening (16:00 – 19:00 hrs) was 5deg C, and during night (20:00 – 22:00 hrs) was 4.4deg C.

The air temperatures recorded at urban stations in all the 4 study areas varied substantially (Refer Figure 5). The air temperature in areas with high built up density – i.e.. Mahal &Dharampeth was observed to be significantly higher than air temperature in Shankar Nagar, which has low built up density and has large patches of farmland belonging to Agricultural University nearby. This substantial difference in urban heat island intensity or temperature variation within the study areas of Nagpur city indicates that built-up density &local urban characteristics have a strong influence on the urban heat island intensity.

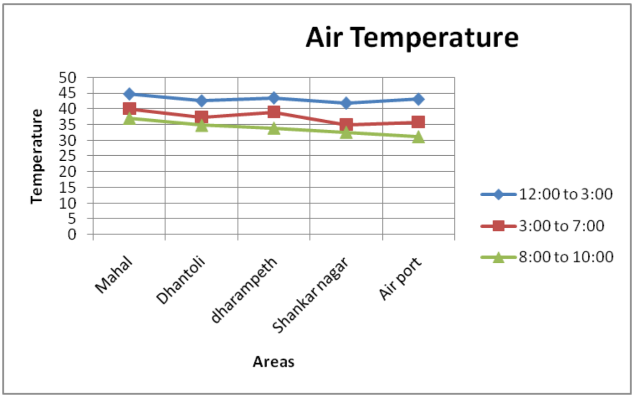


Fig. 5 Recorded Air Temperatures in Different Study Areas

4.2 Relationship of UHI with variables of urban morphology Within canyons

4.2.1 Relationship with H/W ratio of street Canyon:

The study found that during noon, area with lowest H/W ratio of street canyon (1.1, Shankar nagar) recorded lowest temperature (Ref.Table 3 & Fig.6). Dharampeth, which has second lowest H/W ratio of 1.47 recorded second lowest air temperature. Dhantoli, which has highest H/W ratio however recorded lower temperature than the Mahal. This exception might be due to compact and dense morphology of Mahal. During the night time, same trend was observed.

Area	H/W
Mahal	1.7
Dhantoli	1.98
Dharampeth	1.47
ShankarNagar	1.1

Table 3 : Study Areas &Height /Width ratio

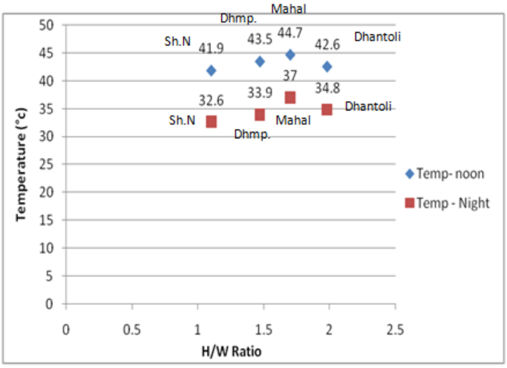


Fig. 6 Graph showing relationship between Air temperature & H/W ratio

The result of this study generally matches with *T.R.Oke's* conclusion that UHI increases with increasing height to width (H/W) ratio of street canyons which he found during the study of *Canyon geometry &the nocturnal urban heat island: comparison of scale model and field observation*.

4.2.2 Relationship with Building Material:

The surface temperature of facades (Vertical) and Streets (horizontal) varied considerably depending upon their exposure to solar radiation. In these study areas, streets were mainly of Asphalt & Concrete and facades were of brick with cement plaster and painted with color. It was found that horizontal surfaces of streets had a high temperature between 50 and 60 deg C in the afternoon. These materials are dense; dark in color (asphalt) with low albedo and therefore absorb more heat than material for facades. Also, due to high angle of the sun in the tropics, much of the shortwave radiation on building facades is probably reflected and absorbed by the street surfaces, which increases the temperature of surface (Nichol 1996). Temperatures of facades were found to be less than surface temperatures of horizontal surfaces (Ref. Fig.7 & 8).The difference was much more pronounced during noon, and gradually reduced during evening and night time. This was because of orientation of facade and light color of the facades (i.e. high albedo).

Fig.7 Horizontal surface temp

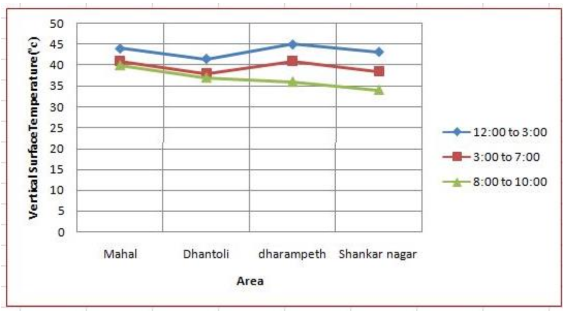


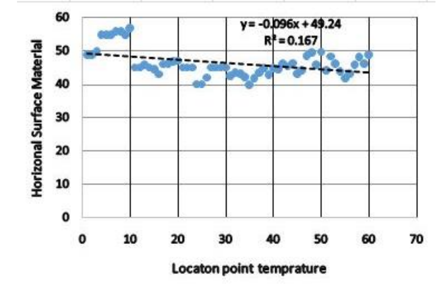
Fig. 8 Vertical surface temp.

The horizontal surfaces (streets) and vertical surfaces (facades) were always observed to be warmer than air temperature in canyon – both during daytime & night time.

4.2.3 Co-relation between Surface temperature & air temperature:

In all four study areas i.e. Shankarnagar, Dharampeth, Dhantoli & Mahal, during noon (12:00 to 15:00 hrs) , there was strong relationship between material surface temperature of horizontal and vertical surfaces and air temperature in canyon (Ref. Fig. 9 & 10 for Mahal area. Similar graphs were generated for other study areas, too).With increase in surface temperature, the air temperature also increased. This was due to absorption of solar radiation by both surfaces and air.

Similarly, during the night (8 pm to 10 pm), it was observed that within the street canyons of study areas of Mahal, Dhantoli and Dharampeth, there was a positive correlation between horizontal and vertical material surface temperature & air temperature - i.e. ambient air temperature increased when temperature of material of horizontal and vertical surfaces had also increased. This was because these materials absorbed solar radiation during day and re-radiated the stored heat during nights, warming ambient air temperature *(svenson and eliasson 2002).*



Mahal Fig.9 Relation Between Air & Horizontal surface temperature

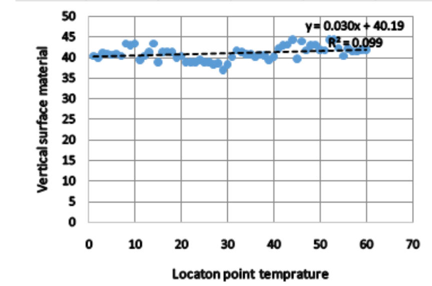


Fig.10 Relation Between Air & Vertical surface temperature

In Shankar nagar, which is low rise& low built-up density area there was no significant correlation between material surface temperature &air temperature and during night. This is because the absorbed solar radiation by surfaces gets dissipated very fast due to low height/width ratio and higher extent of vegetation, as compared to other study areas.

4.2.4 Relationship with vegetation:

Various forms of greenery which exists in study area are gardens, trees along the road sides, and trees, shrubs, lawns within individual house lots. Their

percentage varies from 7 to 25 (Ref. table 1). In all the canyons of four study areas, it was found that air temperature increases when percentage of vegetation within the canyons is less. For example, in case of Mahal where extent of vegetation within the canyon is less than 10 percent, the air temperature was higher when compared with the canyons of other study area. This trend was also observed within Shankar Nagar area. Out of two canyons in this area, where percentage of vegetation is differed, air temperature in canyon with higher percentage of vegetation was lower by0.9 deg C than other canyon with lower percentage of vegetation.

4.3Analysis of data

Multiple regressions are being carried out to predict a single variable from a number of independent variables, which contributes most to the formation of canopy level urban heat island in city of Nagpur. From the analysis so far, it is emerging that contribution of building material within the street canyons is most significant factor.

CONCLUSION:

The study proves the presence of canopy level urban heat island in the city of Nagpur through fixed point measurement. Results showed a maximum Intra-urban UHI intensity of 2.8 deg C (in selected study areas of Mahal, Dhantoli, Dharampeth& Shankar Nagar) during the noon(12:00 to 15:00 hrs). The Intensity of UHI was 1.7º C w.r.t. air temperatures recorded at Meteorological station at Nagpur Airport. During night (20:00 to 22:00 hrs) the maximum Intra-urban UHI was found to be 4.4deg C and UHI w.r.t. air temperatures recorded at Meteorological station at Nagpur Airport was found to be 5.8º C.

The intra urban variation in air temperature is related to urban built-up density, materials of horizontal and vertical surfaces and vegetation.

The main aim of this research was to investigate factors which are most significantly responsible for rise in temperature within street canyons. Ongoing analysis of data using multiple regression techniques indicates that building materials play most significant role in raising the temperature within the street canyons in city of Nagpur.

This study could contribute positively in framing of urban design guidelines for developing more resilient built environment for Nagpur city, and in mitigating intensity of UHI in near future.

FORMATION OF CANOPY LEVEL URBAN HEAT ISLAND - A CASE STUDY OF NAGPUR CITY

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DISASTER RESILIENT HOUSING OF ASSAM: A CASE STUDY

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Abstract
The Assam Valley along the mighty river Brahmaputra located in the North Eastern part of India is one of the most vulnerable locations in the country. It is prone to natural disasters namely floods, landslide and earthquake being in seismic zone 5. The state of Assam faces serious challenges to settlements particularly the housing, both urban and rural. According to the Assam State Disaster Management Authority, 600 villages have got submerged and over 3 lakh people affected in the year 2015.This paper examines three types of indigenous settlements in Assam to understand the traditional pattern of resilient housing in rural settlements considering areas prone to annual flooding and also with consideration for frequent earthquakes. It then presents conceptual reimagining from the study for developing a model resilient urban settlement without compromising on modern livability and safety. A demonstrative model executed in the urban capital city of Guwahati is presented as an ideal model for bringing resilience to vulnerable urban areas.

Keywords: *Disaster, earthquakes, floods, indigenous settlements, resilient.*

1. Introduction
Good traditional practices in building construction practice are being ignored today and are looked down upon as the 'houses of the poor'. Many traditional built typologies have got erased in the course of time due to lack of support by expert and the government. There is an urgent need to establish that disaster resilient development are possible to build using available skills, techniques and materials that fulfill modern lifestyle and current aspiration.

Due to changing aspirations, affordability and availability, RCC plus brick use in buildings is an increasing trend which form a large part of the rural and urban built environment of the India's north eastern state of Assam. This study aims to highlight the potential of indigenous building practices suitable for a disaster resilient development for the vulnerable state of Assam, very often distressed by natural disasters.

2. Methodology

The hazard profile of the State of Assam is studied followed by a brief building typology study by selecting five built forms form twenty seven vulnerable districts of the region. A total of seven building typologies were identified in the typology study of which three indigenous building typology is discussed in detail to establish its potential towards disaster resilient development. The study is concluded by a demonstrative model executed in the urban capital city of Guwahati, presented as a model for bringing resilience to vulnerable urban areas.

3. Context

Assam is situated in the north eastern part of the sub-continent India, at the foothills of the Himalayas. It is the largest state among the seven northeastern states. Commonly known as the gateway to the North East, the state is connected to the mainland by a narrow corridor in West Bengal that runs for 56 km below the foothills of Bhutan and Sikkim. According to Census 2011 Assam has a population of 3, 11, 69,272 and area of 78,433 sq. km. [1]

4. Geographical Location

The state of Assam mostly a Valley is an important geographic location of North East India which connects the other eastern States with the rest of India. It is situated between 89°5´ to 96°1´ East longitude and 24°3´ to 27°58´ North Latitude and is surrounded by hills on all three sides. The State shares international boundaries with the Kingdom of Bhutan in the North and Bangladesh to its west. [2]

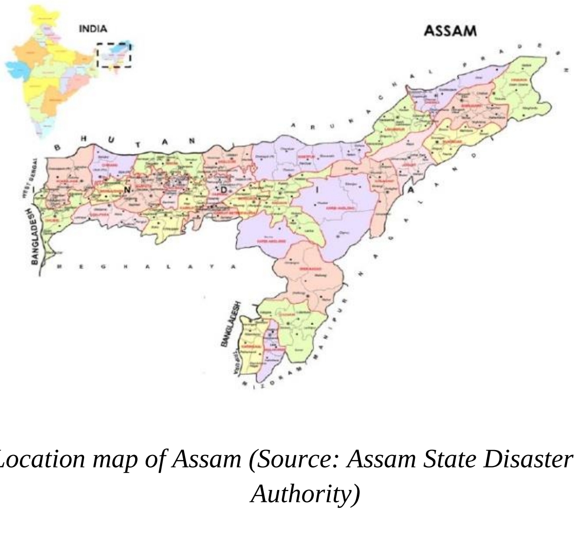

Figure 1 Location map of Assam (Source: Assam State Disaster Management Authority)

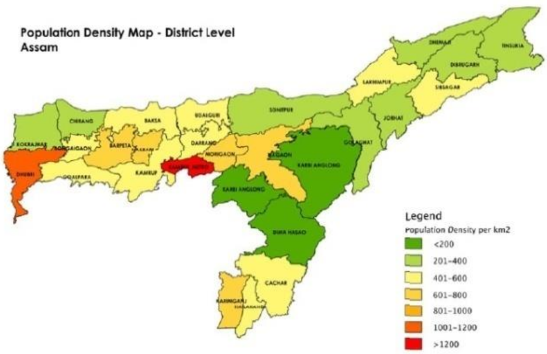

Figure 2 Map Showing Population Density of the 27 districts of Assam (Source: Assam State Disaster Management Authority)

5. Demography

Assam is the 14th largest state in India. Assam is divided into 27 districts. As per 2011 census Nagaon district is the highest populated district of Assam and Dima Hasao is the least populated district. Kamrup Metropolitan district is having highest urban population and Chirang district the least, Fig 2 shows the population density across the twenty seven districts of Assam. [3]

6. Topography

Assam has uneven topography consisting of hills, plains and rivers shown in Fig.3. The Brahmaputra basin covers an area of 70,634 sq. km out of 78,433 sq. km within Assam. About 7800 sq. km of Assam is covered by North Cachar Hills and Barak river Basin. A narrow corridor runs through the foothills of the Himalayas that connects the State with West Bengal. [4]

The topography has majorly three units, they are

1. Karbi Plateau
2. North Cachar Hills and Barali Range
3. Brahmaputra Valley and Barak Valley

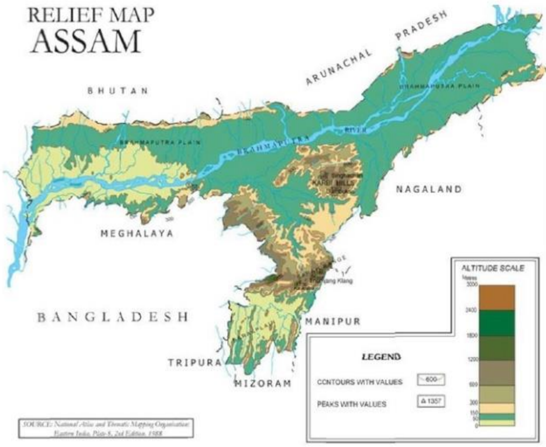

Figure 3 Map showing Topography of Assam. (Source: online.assam.gov.in/web/guest/topography of Assam)

7. Geology, Major Rivers and Soil Type

Geomorphic Studies indicate that the river Brahmaputra is older than the Himalayas. The river with steep gorges and rapids in Arunachal Pradesh entering Assam it becomes a braided river 16km wide with tributaries. It further creates a flood plain known as the Brahmaputra Valley about 80-100 km wide and 1000 km long. In the south the Barak River flows through the Cachar District with a 40-50 km wide valley and enters Bangladesh with its river Surma.

Due to the complex geomorphology and topography as seen in Fig.4 different types of soils are found across the State. The high fertility of Soil and good water resources makes it suitable for Agriculture, however Soil erosion is one of the major problems in Assam. Twenty districts of the Brahmaputra Valley and the Cachar district consists of younger alluvial Soil especially on the banks of the river Brahmaputra and the Barak. Foothills of the Himalayas consists of Sandy Soil whereas districts of Karbi Anglong, Dima Hasao and North Cachar consists of red loamy and red sandy soil which is less fertile compared to the fertile soil of the river basin.[4]

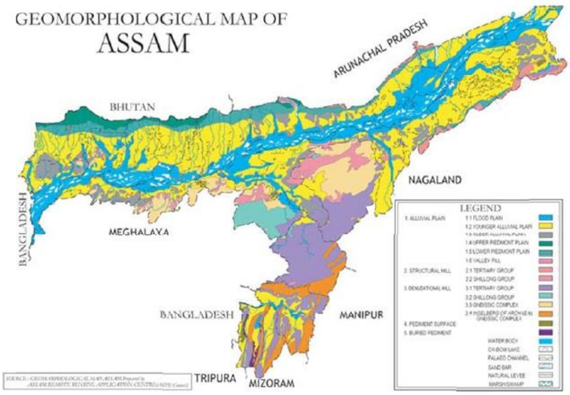

Figure 4 Map of Assam showing Geomorphological condition (Source: Assam State Disaster Management Authority)

8. Climate, Temperature and Rainfall:

Assam has four seasons in a year and is characterized by extreme humidity. The weather is hot and humid summers (May-August) and dry and cold winters (October-February). During winters there are instances of rainfall, fog and Cloudy weather due to the obstruction of the South west wind by the Himalayas. The average temperature is moderate about 29°C in the hottest month of August and the average winter temperature is 16°C. Though rainfall is an annual feature the effect of Monsoon is greatly felt from June to September. Rainfall in Assam is very heavy with average rainfall of 2262.95mm which is close to places with highest rainfall around the world. Rainfall often leads to destructive floods of the flood plains and raises the occurrence of urban flood.

9. Natural Hazard Profile of Assam

The unique geo climatic condition of the region make Assam very prone to natural disasters like Earthquake, Flood and Landslide. Heavy rainfall often leads to flood, river bank erosion, landslide and other environmental catastrophes frequently. The effects of Natural disasters is discussed in details as follows: [4]

9.*1. Earthquakes*

Due to the collision of the Indian Plate with the Eurasian Plate, the Himalayan Region has emerged as one of the seismically active regions of the world resulting in many disastrous earthquakes in the past and in recent times. Many active faults like the Himalayan Frontal Thrust, Main boundary thrust and the main central thrust exist in the Region. The entire state falls under Seismic

Zone 5 as in the map Fig.5, the most vulnerable Seismic Zone. Twelve major earthquakes have occurred in the region in the last 100 years and occasional quakes of 5 in Richter scale every four months. Figure 5 shows the Seismic Zone Map of India 2002.

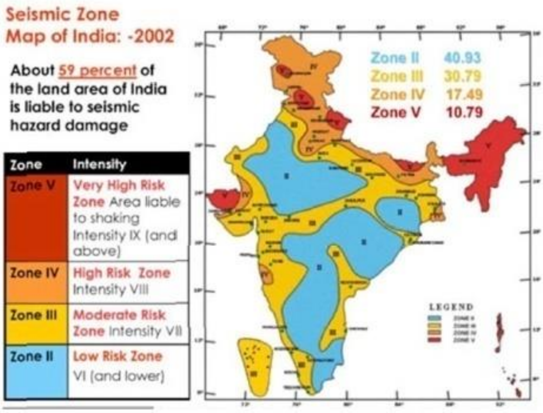

Figure 5 Seismic Map of India 2002

9.2 Flood:

The River Brahmaputra is one of the largest rivers in the world. Every year the river Brahmaputra and its tributaries creates major destruction of resources by flood and soil erosion. Flood in the region occur due to a variety of causes such as.

- Heavy Rainfall in short space of time.
- Storm
- Aggravation of Riverbed
- Encroachment in the flood plains
- Degradation of catchment area in the form of deforestation
- Lack of Proper Control of Land use
- Illegal development on wetlands

From the Figure 6 it is clearly seen that except the *Dima Hasao* and *Karbi Anglong* Area which are mostly Hilly the rest of the 25 Districts in the plains and valleys are greatly affected by Flood. According to the flood damage data published by the Assam State Disaster Management Authority the effects of Flood on damage to people and infrastructure is an annual feature which brings great economic loss to the State. [4]

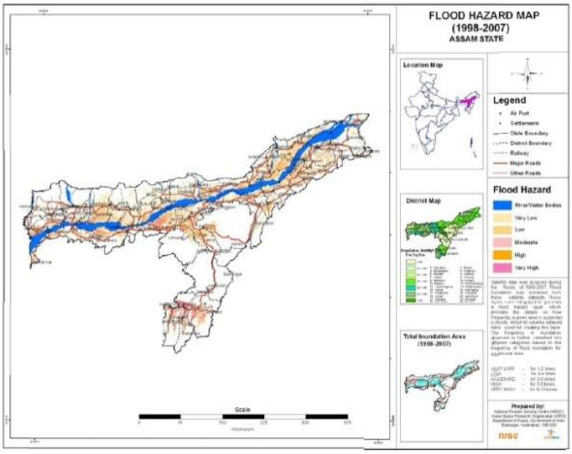

Figure 6 Flood Hazard Map of Assam (Source: Assam State Disaster Management Authority)

9.3 Land Slide

Land slide in the recent years is primarily induced by human activity. The urban areas, particularly the capital city of Guwahati is greatly affected by occurrence of landslides. The hills of the City are coated with a thick layer of immature soil with low permeability which naturally become prone to land slide during heavy rains during monsoons. Lack of proper land use development plan and unauthorized rapid growth of settlement on the hills are said to be the root cause of most of the landslide and the effect of it is seen in the frequent instances of landslides in the city. [3]

10. Build Typology in the State of Assam

From the study of the Hazard Profile of the State we realize that the state is highly vulnerable to natural disasters mostly floods and earthquake. The effects of floods and earthquake specially effect the human dwellings be it residential or of public use. A brief study of dwelling typology study is made by selecting five built forms form twenty seven vulnerable districts of the region. A total of seven building typologies were identified in the typology study of which t hree typologies mostly indigenous to the region are found to be resilient in nature and therefore is studied in detail. Findings from the typology study is applied further in the development of a model urban dwelling.

10.1. *Dwelling Typology in Rural Areas*

Figure 7View of Diphu Village, Karbi Anglong Assam (Source: Assam State Disaster Management Training Project)

Traditional Rural Housing Typology generally consists of a homestead with a cluster of rooms arranged around an open courtyard and surrounded by betel-nut trees, plain tall trees, bamboos and vegetable gardens. The whole premise is surrounded by a Bamboo fencing. The several spaces in the dwelling consists of a front yard (chotal), the living room as a block with no shared wall, the bedroom, the kitchen block and the shed. A prayer room and a granary (bhoral) is observed in the homestead which is mostly constructed using Bamboo or ikra weed wattle and daub technique. Most of the dwellings doesn't have windows but jalis instead as openings.

10.2 *Dwelling Typology in Urban Areas*

Figure 8 Street View of Silchar Town of Cachar District Source: Author

In Towns and Urban Areas houses of traditional style made with bamboo is often used by the economically weaker section of the people. Majority of the

houses in the urban areas are either cement plastered burnt brick walls with profile sheets roofing and or RCC. Though small towns still have individual compound with the house the flat culture is rapidly growing at a large scale.

The buildings in urban areas have not kept any conformity to each other, the absence of local level zoning and building regulation has left the construction activity mostly as the disposal of individual with limited advice from any professional. Almost all major towns have multi-storied buildings in the town centre or the market areas which house shops on the ground floor and other commercial activity and sometimes residence on the upper floors. Thus in the urban areas we see mixed use buildings both old and new class two and class one buildings.

10.3. *Identified Building Typology*

10.3.1. Typology 1

House on Bamboo Stilts with ikra/ woven bamboo wattle and daub walls thatched hipped roof with Wooden Frame Structure

The house on stilts is a common feature among many places in North East. In Assam Missing Community of the Dhemaji District in the Northern part of the State is known for this type of houses, majorly as a response to the regular floods in Dhemaji.

Figure 9Building Typology 1 Source: Author, Assam State Disaster Management Training Program

Architectural Design and Detail:

The structure is based on two grids of columns, occupying a rectangular shape in plan with a room a verandah in front. One grid of Bamboo columns supports the floor, the other support the roof. The distance between the rows varies from 1.35m to 1.8m. The verandah infront is around 2.42m deep and 4.3m wide. The enclosed room is around 6.95m deep and 4.3 m wide. There are no windows and only one door through the verandah. The gap between the bamboo walls and the thatched roof provides ventilation. The raised platform is accessed by a ladder which is often carved out of a single tree trunk, these trunk ladder is a peculiar feature of such dwellings observed across the similar houses.

Construction and Structural System:

The main structural system consists of bamboo frame structure with hipped roof. The roof under structure consists of wooden truss covered with local grass thatch. Bamboo beams and columns support the structure.

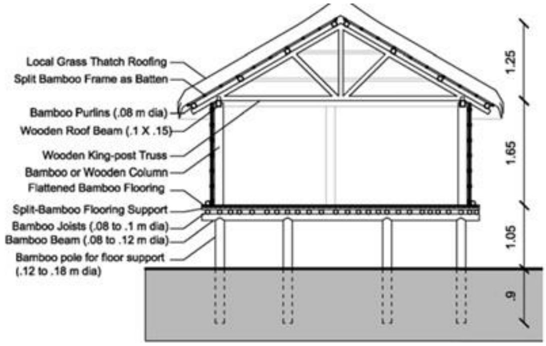

Figure 10Measure drawing of a typical Bamboo House on Stilts

Foundation:

Traditional way construction is not seen to have strong foundation. The bamboo columns are directly inserted in to the ground not more than two feet deep.

Floor:

The floor is created by spanning a layer of Bamboo joists on top of the bamboo beams with a layer of thin bamboo made by opening out a pole of bamboo placed across the joists.

Walls:

Walls are usually made of woven bamboo or ikra weed mostly plastered with lime or nowadays with cement mortar.

Roof:

The locally available thatched is neatly tied to the purlins of the central support of the wooden kingpost.

<u>Performance during Natural Hazard</u>

Earthquake: The regular geometry in plan, light weight structure and separate supports for floor and roof make these structures safe in earthquakes. Since the walls are independent of structure and tied at regular intervals with timber frame and built with lightweight materials like mud plater woven ikra/bamboo make these walls flexible during earthquake. The strong and flexible wooden joinery also help the structure to resist earthquake forces. Since the structure is built on independent stilts, the earthquake damage is at minimum level. Usually, the workmanship and joinery details are worked out well, minimizing the damage. Though the structure shows good performance during earthquakes there are possibilities of damage due to poor condition of natural material like decay of bamboo poles due to direct connection to soil, joinery of bamboo pole to beam.

Flood: The high plinth and thick thatch roof provides protection to the structure. However flood waters can pose threat due to its flow causing scouring and some horizontal thrust at the base of the structure, if the bamboo stilts and columns supporting the structure are weakened due to decay the structure may collapse. Shallow foundation and subsequent exposure of the foundation to the frequent floods is a possible threat.

10.3.2. Typology 2

Assam type Building –Wooden Frame with cement plastered Ikra/ Bamboo woven walls and CGI roof

Commonly known as "Assam Type House" these typology is generally used in dwelling units. Performance of Assam Type houses have been very good in several past Earthquakes in the region. However the houses are vulnerable to fire because of use of untreated wood based materials. In this type of construction walls are independent of the structural members resulting in variations with infill wall material. These are found in both rural and urban areas, but not in practice anymore in urban area.

Figure 11 View of a Typical 'Assam Type House'

Architectural Design and Detail:

Buildings of these typology are geometrically regular in plan. These are rectangular in plan and verandah along its length on one side. Other variations in the plan are observed in the form of perpendicular extension of the spaces to form an L shaped or C shaped plan. Plan is divided into a regular grid with position of columns along the grid and doors and windows placed centrally in between the columns. These houses are mostly single storied without any provision for location of overhead tank.

Construction and Structural:
The main structural systems consists of wooden frame structure supporting four way slope wooden truss with CGI roof. The load of roof is transferred to wooden beam (9cmx9cm) and then to wooden columns (12cmx12cm).

Foundation:
The light weight structure is often built on 60-90cm deep isolated concrete footings of size 16cmx16cm. The wooden column is anchored to the concrete footing by bolting it to 15-20 cm projected metal strip inserted while casting foundation.

Wall:
Infill walls are half brick thick brick wall in cement mortar joint till sill level and timber frame woven bamboo/ ikra cement plastered wall above sill level.

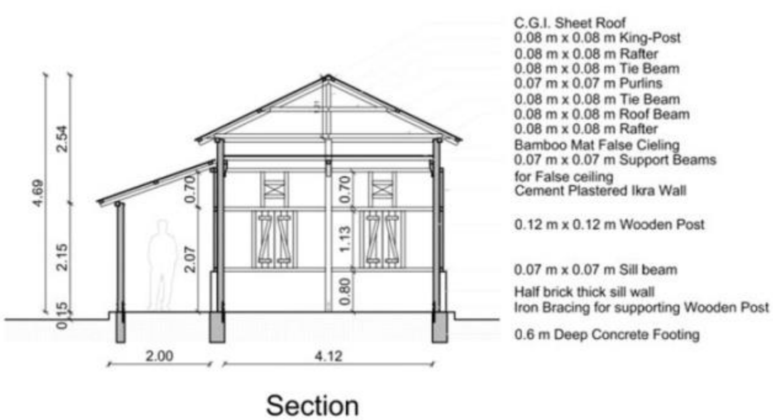

Figure 12 Typical Section of an Assam Type House

Roof:
The structure of the roof is king post truss type made out of wood.

Performance during Natural Hazard

Earthquake:

The regular geometry in plan, light weight roof and walls make these very safe in earthquakes. Since the walls are independent of the structure and tied at regular intervals with timber frame and built with lightweight materials like mud/cement plastered woven ikra/bamboo, make these walls flexible during earthquake shaking. The burnt brick with cement mortar till sill level can develop some cracks, or fail in earthquake shaking, but as these are independent of the structure, there is not much damage to the structure and it can be easily damaged.

Floods:

In the absence of cement plastered plinth the flood water can cause damage to the plinth. In the absence of brick wall above plinth level the flood water can damage the bamboo/ikra walls, however this can be repaired at nominal cost when the flood water gets receded.

10.3.3. Typology 3

House on RCC Stilts, RCC columns with RCC and burnt brick in cement mortar in fill walls and CGI sheet pitched roof with wooden under structure.

This house is a modern version of traditional stilt house very commonly built in the recent times. The Bamboo stilts for supporting the floor and the roof structure are replaced by RCC frame structure, keep in terms with use of new conventional materials. It is a new typology that is being implemented in the flood prone areas of the State. It is observed that communities that were traditionally not building the stilt houses are also opting for this typology due to it flood resistant performance.

Architectural Design and Detail:

The structure shows resemblance to the traditional construction however at a little bigger scale. The grid of 6x4 RCC columns placed at regular distances support the raised floor. The same columns continue till roof level to support the roof.

Construction and Structural Syste

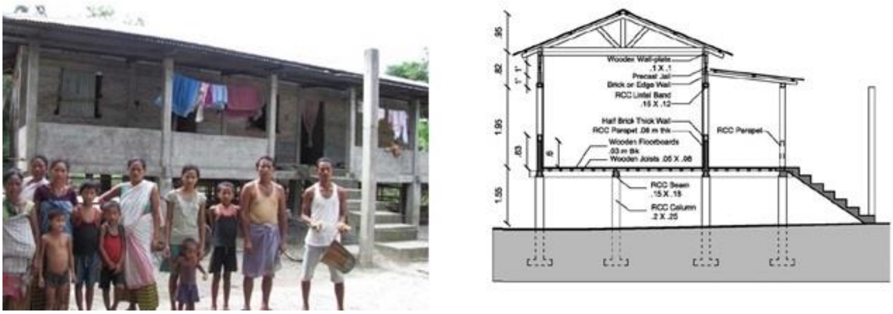

Figure 13 Typical RCC framed house on Stilts

The main structural system consist of the RCC frame with hipped roof. The external walls are made of RCC till sill level. Continuous lintel band is present all across the rooms

Foundation:
The structural RCC columns are supported on 0.6x0.6m isolated RCC footing with 0.9m depth.

Floor:
The floor is created by spanning wooden joists on top of floor beams along the width of the structure.

Workmanship
RCC:
There is no engineering input in RCC design and detailing. The amount and placement of steel for RCC work poses some concern for construction quality.

Wood and Bamboo:
Very good quality joinery detail and finish in both wood and bamboo.

<u>Performance during Natural Hazard</u>

Earthquakes:
The RCC frame provides enough support for the structure. The traditional flexibility of wood and bamboo is compromised due to heavy RCC use. The main problem is the amount and detail of reinforcement within RCC.
Floods: RCC footing of 1m depth withstands nominal flood and water logging. The high floor level provides enough protection to the superstructure.

11. Recommendations
Based on the findings and Conclusion of the Typology Study the following recommendation towards a disaster resilient can be made:

A model residence in the city of Guwahati, Assam can become a model for resilient typology built with the merits of the traditional buildings.

Architectural Design and Detail:

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Figure 14Residence in the City of Guwahati built on RCC stilts and Bamboo superstructure. Source: Author, Residence Designed for Mr. Dilip Narzary at Guwahati Assam by Ar. Kankana in the year 2015

The structure shows resemblance to the traditional construction however at an urban area with all modern amenities and comfort of city life. The grid of 6x4 RCC columns placed at regular distances support the raised floor. Engineered joints are used to make the superstructure in Bamboo frame with Bamboo double wall plastered technique to ensure thermal comfort.

Construction and Structural System:
The main structural system consist of the RCC columns further becomes a framed bamboo superstructure with profile roof. The external walls are made of woven bamboo and the internal walls are bamboo-Crete.

Foundation:
The structural RCC columns are supported on 0.9x0.9m isolated RCC footing with 1.2m depth.

Floor:
The floor is created by spanning woven bamboo splits covered with a layer of chicken mesh and then finished with vitrified tiles.

Wall:
Walls are made of two layers of bamboo woven with a Ferro cement compound wall plaster.

RCC: The structure is engineered to minimize the extensive use of RCC thus limiting wastage and cost of material.

Wood and Bamboo:
Very good quality joinery detail and finish in bamboo which has both aesthetic and comfort value because of its natural properties.

Performance during Natural Hazard

Earthquakes:
The RCC frame provides enough support for the structure. The traditional flexibility of bamboo is maintained by optimizing RCC use.

Floods:
RCC footing of 2m depth withstands urban flood and water logging. The high floor level provides enough protection to the superstructure.

12. Conclusion: Change in trend of Construction

A change is observed towards building with bricks and RCC, instead of traditional materials. Though Assam type houses are not built today the construction practice derives a lot of feature from the older houses. At times RCC is used to build entire wall and flat slabs for roofs replacing the sloped CGI sheet roof. Due to changing aspiration, availability, and affordability, RCC and brick use in buildings is an increasing trend. Such constructions form large part of rural and semi urban built-form in Assam, which is rapidly growing in number, making many buildings vulnerable at a very fast pace. Good traditional practice that are disaster resilient are ignored. Therefore they are rapidly being pushed out of favor by people. These need to be promoted and supported as viable and useful practices due to their environment friendly nature, affordability, and availability of materials and skills. It needs to include that disaster resilient houses are possible to build using available skills, techniques and materials that fulfill people's requirement of modern lifestyle and aspiration.

12.1 Acknowledgement:
The typology Study of the State of Assam was made by Author Kankana Narayan Dev, assigned as Project Officer Assam State Disaster Management Training Project under PIC and Tata Institute of Social Sciences 2012-2014. A sincere thanks to Mr. Dilip Narzary from Guwahati who supported the construction of his residence as a model modern building made on traditional principles.

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AN EXAMINATION OF THE SOCIO-CULTURAL RESPONSIVENESS OF URBAN DESIGN INITIATIVES IN THE CONTEXT OF SRI LANKA
SPECIAL REFERENCE TO GANDHI PARK IN BATTICALOA CITY

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Abstract:
Planners and designers create spaces for people. However, in most instances, the modern urban design interventions are criticized for their inability to address the ground conditions. These interventions appear out of context when they are placed in the real ground situation. This is mainly due to the lack of responsiveness of the design to the socio-cultural conditions of the particular location. Therefore, the aim of this research is to explore the above mentioned critique through a local case study. This research analyses whether the designers have considered the socio-cultural setting and values of the people of Batticaloa city when they designed the Gandhi Park in the middle of the town center. This research was conducted through participatory and non-participatory observations, Photographic surveys, interviews and discussions with those who use the Park. The aim was to find out what kind of social and cultural responsiveness reflects through this park, how the design elements support the park to function, and examine whether those values, needs and aspirations of the people have been taken into the consideration in designing this park. The methodology of this research is based on comparative and narrative analysis. The study reveals that the socio-cultural values, lifestyles of people and local attitudes were not taken into consideration at the design stage. As a result users are compelled to change their attitudes according to the design.

Keywords: *Socio-cultural responsiveness, Users, Park, Values, Local Attitudes*

1. Introduction
This research demonstrates that the current urban design projects barely take into account neither the socio-cultural characteristics nor the aspirations of the local people. Urban Design is considered as a tool that is applied to elevate the identity of a city. Also, Urban Design initiatives require a high level of

imagination and creativity. However, most of the times it has been found that de-sign does not harmonise with the ground conditions. Although this is a wider critique in the present day, there are no systematic and scientific researches done in the context of Sri Lanka. This research attempts to systematically study a design project in in order to find out to what extent the present day critique is valid. The pioneering work of Jane Jacobs (1962) states that the aesthetic concerns of urban design is not wrong, but it should not only be about the physical form. The real aesthetic quality in design has to consider the social and cultural diversity. A place has its own evolution pattern. The cultural characteristics are rooted in its evolution pattern. This gives a place its own identity and character. Urban design initiatives should support this whole process and should elevate the qualities of the place. According to Lawson (2009), the problems that are attempted to be addressed in urban de-sign projects are either entirely internal to the system or may be linked with some external factor not under the designer's control. Therefore, understanding the real problem is vital. Designers should not work on their imagination or imposed problems. The realization that the purpose and function of design is crucial will ultimately help designers to come up with designs that are better suited to the context. The objective of this research is to examine the popular criticism that contemporary Urban Design projects have failed in terms of their socio-cultural responsiveness and in order to explore this critique, Batticaloa Ghandi Park is taken as the case study.

2. Literature Review

2.1 **CRITIQUES ON MODERN URBAN DESIGN**

2.1.1 *Critique on Modern Urban Design based on the approach*

Gordon Cullen's "The Concise Townscape", first published in 1961, probably had the greatest influence on a many urban designers. Cullen examined the traditional artistic approach to city design. He created the concept of "serial vision" which de-fines the urban landscape as a series of related spaces. His aesthetic approach to the designing of the picturesque urban quarters enriched the vocabulary of urban designers.

2.1.2 *Critique on Modern Urban Design based on understanding*

2.1.2.1 *Understanding Based on Livability*

Jon Lang (1994) says that "urban design concerns with social and environmental context. The concerns of social and environment returns the focus of urban design to create a better city. Urban design is an effort of designers who apply knowledge about the environment and people to the creation of livable, enjoyable, and even inspiring built environments. Thus, Jon Lang emphasizes that urban design must take a user-oriented approach to achieve a higher quality of life in human settlements. In his book 'Urban Design: The American Experience' he says that "urban design experience from the beginning of the "City Beautiful" concept and it provides attention to developments and developments also gain an understanding of how the environment is experienced by people based on particular city's architectural and urban design".

2.1.2.2 *Understanding Based on Aesthetics Experience*

Meanwhile the another author Kolb says that "From a perspective of aesthetics, creating architecture and urban design as coding and experiencing them as decoding seems quite flawed. Even if experiencing was reduced to some kind of decoding, it would be problematic for an architect to predict the meanings that the buildings will have when experienced against certain particular contexts". (Kolb,1990). Thus, Kolb simply says that experiencing the urban design by people, is in the hands of the architect or the urban designer. Experiencing the urban design means the aesthetics of the particular area should be socio-culturally responsive. On the other hand it could fail to give meaning to that place or city through the urban design initiative.

2.1.3 *Critique on Modern Urban Design based on the Projects*

Most of the Urban Design initiatives seem to look like artificial projects and those projects or initiatives do not fit with reality. The vision created by the Architect should be natural and it should connect with the people's aspirations. (Appleyard,1979).

However Taylor (1998) has stated that "Plans thus became more flexible, but at the same time the artistic socio-cultural dimension was left out. The systems view of planning with quantitative methods is usually referred to as rather anti-aesthetic, but in most of the urban design plans are proposed as an environmental aesthetic concept. In planning urban design projects with aesthetic art it should be critically examined. However, most of the designer's having of possibility that opening up of superior and professional taste cultures also not be so easy to allow responsiveness of socio-culture of urban design. (Taylor,1998)

Roger Scruton (1979) says that "During the modernity and post- modernity, the architects have become the sole authority of their so-called works that pay no attention to the physical, social and cultural contexts. Their intentions of establishing a personal style and their followers aiming to continue that in order to be someone like that celebrated figure have completely ignored the society.

3. The methods and techniques for the study

- Unstructured Interviewing
- Interview with the designers
- Direct observation
- Gather information through field observation and photographs
- Narrative Analysis
- Comparative analysis

4. Analysis and Findings

Batticaloa Gandhi Park is located in Batticaloa town center. Schools, Transport Hubs, Dutch Fort, Library, Main Post Office, Municipal Council, Court, Tourist Information Center and Cargills food city are some of the places located close to the Gandhi Park area. Activity patterns were studied in order to grasp it's complexity with regard of actors, location, their processes, and the structure within which these activities are carried out at the Gandhi Park and its surroundings. Many of the activities at the Gandhi Park are due to its location and this location is connected with many other public places.

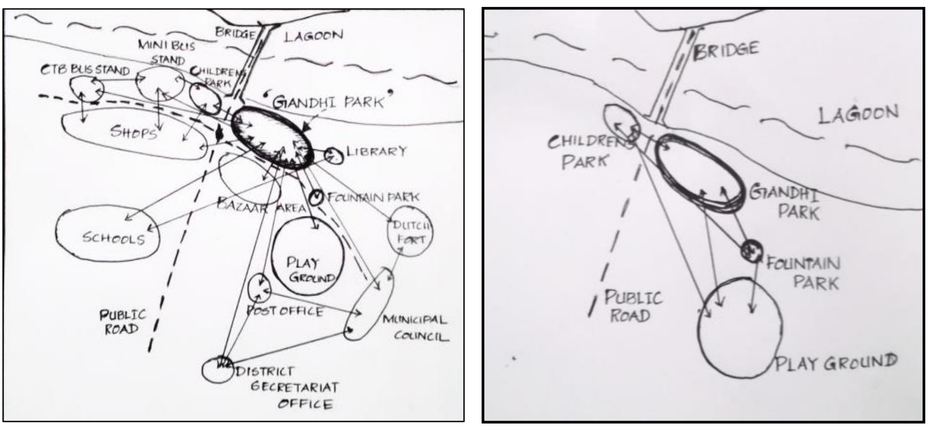


Figure 1, Sketch of connectivity of Gandhi Park and its surrounding (Source: Compiled by Author)

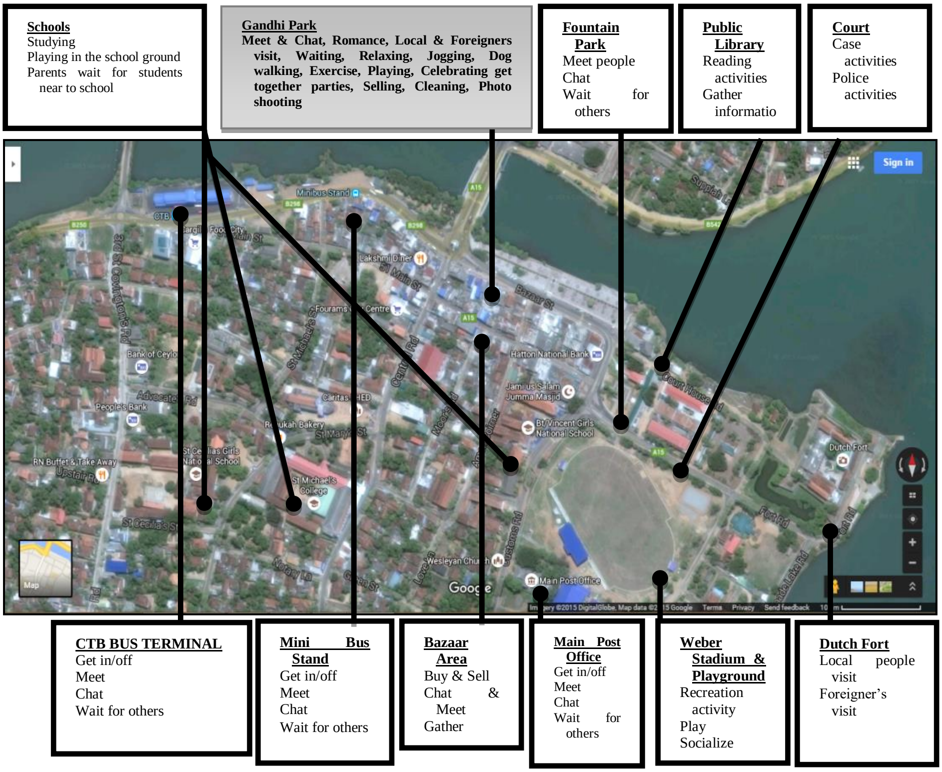


Figure 2: Activity Pattern of Gandhi Park surrounding (Source: Compiled by Author)

4.1 SOCIAL RESPONSIVENESS OF THE GANDHI PARK

- *Park promotes community interaction*

The Gandhi Park should give a sense of place and it should reflect the social identity of Batticaloa. In Batticaloa people have a habit of sitting on the ground, chat with relatives, friends and neighbors. Most of the kids also have a habit of doing their work by sitting on mats. Most of the people like to chat in groups create their own space and regularly use that space to chat and meet. Although the people in Batticoloa spread their mats under the trees to be in the shade, we cannot see this arrangement at Gandhi Park. The seating arrangement at the park is suitable only for those who like to sit alone. There is no way to sit as a group and chat. Even most of the stone benches, two sides of the Gandhi Park are placed in linear form; some of the stone benches have been placed under the trees and only two or three persons can sit on a bench. People can't even sit on the ground at Gandhi Park.

Figure 3: Batticaloa people using mats to sit (Source: Compiled by Author)

When questioned designer defended the seating arrangements follows.“We designed the seating arrangement in this park to provide visual linkages to the lagoon.”- Eng. P. Achchuthan, Batticaloa Municipal Council. Meanwhile Archt. Asoka Pali Wijeratne said ‘‘Gandhi Park is acceptable as a park for me. I am not sure whether it is socially acceptable to the community. In day time the park is so hot and there are not enough trees for shade. Mostly it is suitable for people from the west for enjoying the sunlight”

Even though there are some critiques, the seating arrangement has enhanced the lagoon view.

The next point is that there are no anti-social activities taking place happen in this Gandhi Park area. Gandhi Park is not fenced and it is open to the street and people can see what is happening inside the Park’ and there are some guards supervising this park.

The supervisor of the Gandhi Park said a lot about the safety at Gandhi Park. He said that “In my opinion, development of this park is very beneficial to the people. This park functions from early morning to l night. Since this is named as Gandhi Park we have respect his principles. We are taking every precaution to keep this park safe and peaceful. Here we do not allow anything that is harmful to our culture and society. We close the park at 9.30 pm in order to avoid unnecessary activities happening in this park as safeguarding the socio-cultural values is very important for the good image of the park”-S.Kannan, Gandhi Park Supervisor, Batticaloa Municipal Council-

Table 1.People have visited alone or with others in the park

With any one (%)	Weekday	Weekend
Alone	15%	4%
With others	85%	96%

(Source: Survey done by the Author)

20 people selected randomly were asked how they came to the park and 17 people said they come with others and 3 people said they come alone.

"Eyes on the Street" theory which was developed by Jacobs argues that increased street traffic, day and night, not only help communities flourish socially and economically, but also acts as a self-policing which deters crime and anti-social behaviour. When designing the spaces for people that particular urban space should not encourage anti-social activities. Throughout the urban park should be a safe place for people. In Gandhi Park also there is no possibility to have any anti-social activities. It closes at 9.30 pm and nobody can enter into the park after that.

- *Place for a social event*

This Gandhi Park is used for several purposes. Many social events take place in this Park. The social events can be photo shootings, hungers strikes, awareness pro-grams, school events, art competitions as well as get together parties. Gandhi is famous for 'Ahimsa' and in Batticaloa there is a belief that if a 'picketing' or a 'hunger strike is carried out in front of the Gandhi Statue it would be successful. So the Gandhi Statue also enhances the social events.

Many photo shootings happen in this Gandhi Park because of its aesthetic appearance attracts photographers as well as people to Gandhi Park. There is not enough space and similar aesthetic quality is available in other parks or places. As mentioned earlier the Gandhi Park attracts a lot of social events, but in some of the important cultural festivals are not taking place here due to some drawbacks in the design of the Gandhi Park.

According to Batticaloa Development Plan (2014) it says there are 91% people are Tamils and 70% of the people are Hindus. So most of the Tamils dominate the Batticaloa and they sustain the unique socio culture of Batticaloa. Tamils of Batticoloa celebrates their festivals in open space with their parents, friends, neighbours and relatives. Mostly Tamils participate in celebrating festivals, such as Thai Pongal festival, which is celebrated on January 14th or 15th; on a large open space. People create their own space and arrange according to the direction and they start their Pongal works. In Tamil New Year also most of the cultural games are conducted in large open space like playground and paddy field area. There are no restrictions on access to those places and the physical elements of those places encourages this kind of cultural events. Urban design is meant for people. When designing spaces designers should consider all aspects and behaviours. Urban design should cater to these kinds of cultural festivals. But in Gandhi Park there is no possibility to have these kinds of cultural functions. It just used only for recreation purposes like exercise, jogging, sitting, standing, dog walking, selling, romancing and celebrating small parties. These are not reflecting and giving meaning to Batticaloa socio-culture.

Figure 4: Batticaloa people celebrating Thaipongal festival (Source: Compiled by Author)

4.2 CULTURAL RESPONSIVENESS OF GANDHI PARK

- *Preservation of historical landmarks*

The significant landmarks of the historic events of Batticaloa are preserved in Gandhi Park and the predominant feature here is the ‘Gandhi Statue’. It reflects the Tamil culture and is indicative of the Gandhi influence in Batticaloa. There is a belief among Batticaloa people; that if any picketing to be successful they must do it in front of the Gandhi Statue. And Gandhi is famous for ‘Ahimsa’. Gandhi Park got its name because of the statue and it gives an identity to the park as well as to the whole area. There is another statue located in the corner of the Gandhi Park near the Batticaloa Gate. This statue is built to the memory of the late Reverend ‘William Ault’. He volunteered to serve as Wesleyan Methodist Missionary with noble and pure motives.

Layout of Significant Landmarks of Batticaloa Gandhi Park

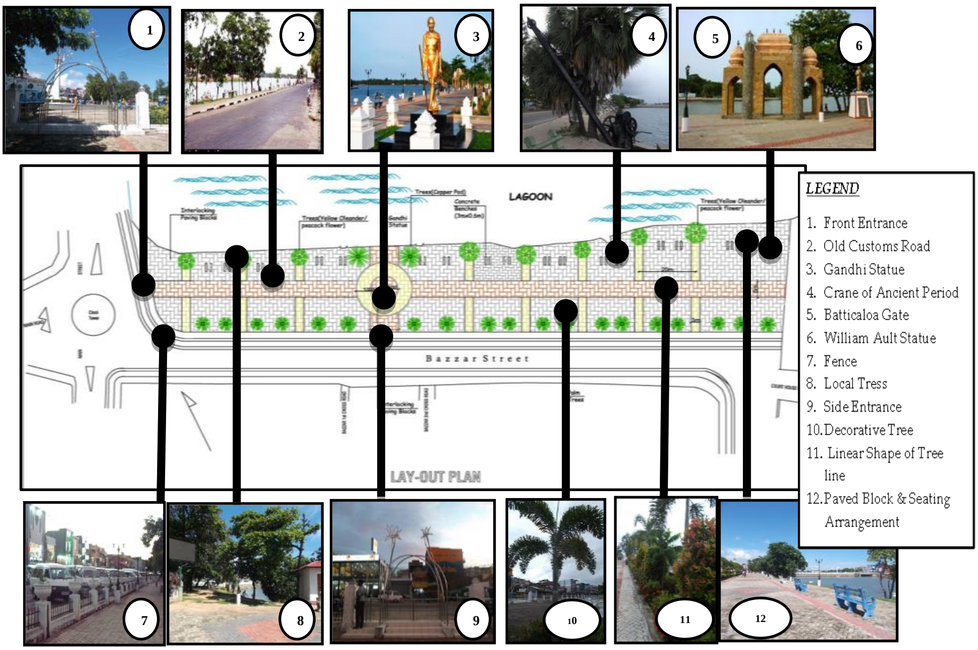


Figure 5:Layout of significant landmarks of Batticaloa Gandhi Park (Source: Compiled by Author)

Later he became the bearer of Methodism to the Eastern parts of Sri Lanka. He was the pioneer of education in Batticaloa region. There is ancient equipment which was used in an earlier period for loading and unloading activities. There was a harbor in this place and this crane was used at that time. This is a precious historical monument which is 300 years old. Batticaloa Gate which is in the Gandhi Park consists of the traditional art of Batticaloa. It reflects the historic architectural style of Batticaloa. The traditional art representation of the Batticaloa traditional dance which can be called as "NAATU KOOTHU" in Tamil also locates in Gandhi Park. There was a road known as Customs Road, which functioned from an early period and supporting the activities of the old Harbor, which was located at the end of the Gandhi Park area. Even at the designing stage there was a protest from the people against the closing of the Customs Road. However the Gandhi Park project was implemented successfully and the road is now paved with concrete blocks. Now people use this as a walking path.

- *Sitting arrangement and structure*

Most of the people in Batticaloa like to sit under small huts and have conversations. Even most of the urban spaces in Batticaloa can be seen some kind of small huts. These structures are cool and comfortable reflects the culture. The small kids like to sit under the trees and they like to play with sand. But in Gandhi Park there is no sitting arrangement. There is a big issue in deigning places for people. Designers are not considering the cultural beliefs, norms and traditions. Designers should create spaces for people. If the designer, considers all the cultural aspects that particular urban design will definitely give a cultural sense for local people as well for foreigners. People always like to have their cultural values in each and every design. Therefore these elements should be taken in to consideration in the proper manner. Otherwise the urban design will be alien to the particular locality.

- *Water bodies*

In Batticaloa; people worship the water as God. In most of temples there is a pond. And they do Pooja to the pond. Mostly in Kovil festival (Tamil: Kovil Thiruvila) times most people take a bath and engage in religious activities. Generally these kinds of the places reflect the cultural responsiveness. At the Gandhi Park there is a Lagoon, located nearby, but it doesn't function very well. There is an absence of the sense of cultural value. Park only enhances the visual linkage to the lagoon and gives a certain level of relaxation. The urban part is only used for activities such as relaxation, doing exercise, chatting, etc. But it is not culturally responsive to the city. The Batticaloa Lagoon is connected with socio cultural values. Even people see this water body as their God. The livelihood of the fisher community depends on this water body. But this park fails to bring out the sense of cultural value.

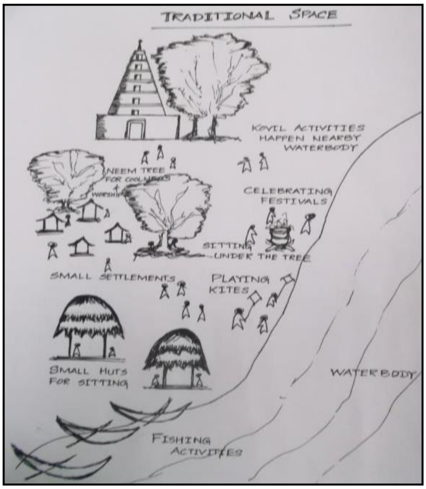
- *Symbols*

Batticaloa has its own identity and use the ‘MERMAID’ symbol in all urban places. Batticaloa is famous for ‘Singing Fish’. Fisher community perceives the sea as their God. So the sea and the mermaid have a close relationship with Batticaloa social culture. Mermaid design can be seen at the entrance to the Batticaloa town, at Main roundabouts, Clock Tower, and the Railway Station.

Figure 6: Mermaid designs which are located in several locations (Source: Compiled by Author)

However, at the Gandhi Park there is no mermaid design. Is Gandhi Park trying to change the identity of Batticaloa? Two entrances of the park are designed like a lotus. The designer has said that it was designed that way because basically lotus is meant for peace. But not giving any recognition to the mermaid symbol which gives the unique identity of Batticaloa is questionable. Thus, it appears this modern urban design is trying to change the unique cultural identity and traditional elements of Batticoloa.

4.3 SKETCH OF TRADITIONAL SPACE IN BATTICALOA AND PROVIDED SPACE IN GANDHI PARK



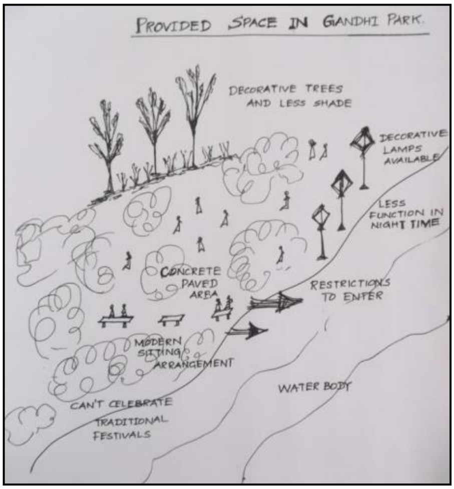


Figure 7: Sketch of traditional space *Figure 8: Sketch of provided space*
(Source: Sketches drawn by the Author)

4.4 CONCLUSION OF ANALYSIS

There is a wider critique of modern design that it's not sociocultural responsive to the local context. But in some extent Gandhi Park provides some benefits to people. It does not reflect the socio cultural environment in its design. Most of the people appreciate the Gandhi Park design and it functions well. But people always try to create their own spaces to do their activities. The westernized design elements do not suit the local context.

Urban designers should think that they are creating sustainable urban spaces for people and they should consider whether to change the unique sociocultural character and the identity of the place or keep as it is. When designing places for people preserving the unique identity is the most important thing. Taking into consideration the sociocultural values of a particular area will help to develop a more sustainable urban design.

5. Conclusion

The objective of this study was to understand the sociocultural responsiveness of urban design initiatives in the Sri Lankan context. Gandhi Park located in Batticoloa was selected as the case study. Urban design is an innovative concept and different users give different meanings for urban designs. The selected case study is an urban park and a significant public space. It provides activities for local people and tourists, as well as opportunities for social interaction and connection, social inclusion, mingling of different cultures, and building a sense of local community it is a focal point for community rebuilding and development. The urban park congregations a series of functions, it is usually a place can fulfil people’s needs and satisfy their expectations and urban park should has a concentration of space for social functions such as walk, stop, meet, chat, play, sell, buy, celebrate parties, observe others, eat rest, wait and enjoy. Urban Park as urban design in Sri Lanka cannot be restricted within space anywhere. The Batticaloa Gandhi Park is one of good example of that. It has connections with streets beyond the public buildings. This created people to have more connections with Gandhi Park and its surroundings.

With this analysis we may ask, to what extent the urban designs are socio-culturally responsive? When designing the spaces for people most of the designers have failed to consider the people’s needs and aspirations. As a result, most of the urban designs became failures. Although Batticaloa Gandhi Park; functions very well, to some extent it does not reflect the socio-cultural environment. As mentioned earlier in the analysis people of, Batticaloa have their own tradition, cultural values, beliefs, behaviors and unique identity. Even their own spaces reflect the sociocultural responsiveness which cannot be seen in Gandhi Park. The reason is the design elements do not fit and the restrictions does not allow the people to behave as they wish. If the space is designed according to the people’s wishes definitely the urban design will be responsive to the city. But in modern urban designs most of the designers adopt the western cultural designs. When the designs are implemented it does not go with the local context. Even the design elements of sitting arrangement, lighting, paved walking paths, green do not reflect the local sociocultural characteristics.

Modern urban designers are trying to change the local identity and character of the place by not considering the cultural values. As an example each and every city has its symbols which help to reflect their identity and even that single element has a lot of meaning. . In modern urban designers are not giving priority to the use of those symbols in urban designs. They are trying to introduce new symbols which do not fit to the particular local context. Those symbols seem so alien to the local people. It does not give any sense to the place.

The results of this study will help the urban designers and town planners and other relevant professionals to understand the needs and aspirations of the local people when designing the urban spaces for people. Most of the people are attached to their social life and cultural values. Therefore the designers should take into consideration the socio-cultural values of the people and the city when creating urban designs for people.

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PLANNING AND DESIGNING PUBLIC OPEN SPACES AS A STRATEGY FOR DISASTER RESILIENT CITIES: A REVIEW OF LITERATURE

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Abstract:
Public open spaces are often used as a mode to make cities sustainable from all its three counts; economic, environmental and social. Most of contemporary urban planners, designers, and landscape architects use the public open spaces as a mode to increase the urban quality of life, improve aesthetic attractiveness, improve the environmental health, growth of economy, and to increase the walkability, liveability and vitality of a city which direct towards the sustainability. However, sustainable development should also encompass the enhancements of disaster resilience. Yet, the use of public open spaces as a strategy for disaster resilience, still remains largely unrehearsed when planning and designing sustainable cities. Accordingly, the aim of this paper is to emphasize the need of planning and designing public open spaces with a focus on disaster resilience; as an agent of recovery, to provide essential life support, as a primary place to rescue and for shelters and potential for adaptive response. Further, this ongoing research study analyses the current literature and presents the significance of combination of disaster management strategies with urban planning and designing strategies in order to make cities resilience to disasters. Finally, the analysis suggests a framework to plan and design public open spaces for sustainable disaster resilience cities, proposing set of concepts; loose space concept, Urban Sponge Park, Network of Open Spaces, which can be potentially used when planning and designing public open spaces for disaster resilient cities.

Keywords: *Disaster Resilience cities, Public Open Spaces, Sustainable Development, Urban Designing, Urban Planning*

1. Introduction

Cities contain significant amount of people, infrastructure, amenities and modern facilities. Pelling (2012) describes, cities as the engines of economic growth, an integrated system linked with consumption and production, a source of livelihood, a stock of accumulated assets, and a political and cultural arena.

Hence, any adverse effect to a city means, adverse effect to significant number of people, infrastructure, amenities and modern facilities and engines of economic growth of a country.

This reflection is even more significant, in the global urban context. Global urbanization trend pattern establishes, that there is population increase and increase of human migration towards cities, most commonly for reasons such as jobs, education and new lifestyle. Therefore, urban areas will contain increasingly large proportion of world's population. Confirming this, Zhang (2015) state the percentage of urban population in 2014 is 54% and this will increase up to 72% by 2050.

This rapid population growth together with rapid urbanization, create significant challenges to both natural and built environment in cities, including more pressure on land and services resulting inadequate resource management, settlements in hazard prone areas, lack of capacities, unclear mandated for DRR at local level and decline of ecosystems and so on (UNISDR, 2012). These challenges increases the exposure of the city dwellers to natural disasters. As a result, most of the cities in the world which contain large proportion of people, are at risk from the effects of climate change and natural disasters. For instance, Huq, Kovats et al. (2007) states many cities in Africa are at risk from sea-level rise and storm surges (e.g. Banjul, Lagos and Alexandria) and many of the world largest cities in Asia are at risk of flood inundation (e.g. flood plain of major rivers the Ganges–Brahmaputra, the Mekong and the Yangtze). Therefore, it is increasingly important to plan and design these cities with a focus on 'disaster resilience'.

Further, Malalgoda, et al. (2013) state that unplanned cities and urbanisation can be one of the major challenges ahead to create a disaster resilience built environment in cities. However, León and March (2014) emphasize, urban planning and designing can play a vital role in making cities resilience through its ability to incorporate multi-dimensional aspects affecting disaster risk reduction. Adding to this, UNISDR (2012) states that strategic planning and design of spatial elements and their influence on the natural and built environment are directives of city's capacity to absorb and recover from the effect disasters. Accordingly, it can be understood that, planning and designing can play a significant role when increasing cities' resilience to disasters.

Further, to enhance the disaster resilience through planning and designing interventions, the focus can be given on different spatial elements of a city such as buildings, parks, playgrounds, streets, and infrastructure. Public open space is one of the key spatial elements which can play an important role in cities.

However, the role of public open spaces to enhance the cities' resilience specially, encouraging adoptive response after a disaster, still remains as a largely uncovered area (Hossain, 2014). Accordingly, this research paper main focuses on identifying potential uses of public open spaces for disaster resilience and to identify the planning and designing interventions that can be used to harness these identified potentials.

2. Research Method

This paper is based on the findings of a literature analysis, conducted to evaluate the state of the art in the subject area which was carried out as part of an ongoing PhD research study. Accordingly, the literature was critically evaluated to synthesis the findings. In order to ensure that the literature review is complete and comprehensive the researcher has critically reviewed journal papers, book chapters, conference papers as well as local and international reports which discuss the issues in the subject area. At the same time, this literature review has been presented in different national and international audiences where the literature review has been critically examined and modified according to the feedback received.

3. What is a 'Public Open Space'

As this study focuses on the use of public open spaces for disaster resilience, first it is imperative to understand, what is it meant by the term 'Public Open Space'. The term 'Public Open space' was used in 19th century in United Kingdom and United States, when allocating spaces for the improvement of the health and quality of life of the working class people who lived in squalid and congested urban environment (Giles-Corti, Broomhall et al., 2005). According to Swanwick, Dunnett et al. (2003), currently this term is widely used with variety of meanings, ranging from 'green space' (e.g. parks, greenways) to all the types of public spaces counting streets and squares and also private spaces including gardens, courtyards.

The definition of Public open spaces can be found from different standpoints. Woolley (2006) introduced two forms of definitions. One is constructed on primary purpose of allocation which derives from the policy stance. Accordingly, Public Open spaces is positioned in between green space and civic space including Parks and gardens, Natural and semi-natural green space, including urban woodland, Green corridors, Outdoor sports facilities, Amenity green space, playgrounds for children and young people, Allotments, community gardens and urban farms, Cemeteries, disused churchyards and other burial grounds.

The second definition place the Public Open spaces as a space that allows different types of activities encircling necessary, optional and social activities. This includes Parks, Playgrounds, Playing fields and sports grounds, School playgrounds, Streets, City farms, Incidental or 'natural' green spaces. This definition is more towards the users' point of view rather than the purpose of allocation. Two main important points that can be raised from these two definitions are:

1. Public open space can be any space between green space and civic space but has to be used by the public and
2. It should be an outdoor space which is not covered by buildings.

The following categorization of 'Public Space' which was introduced by Carmona (2010), opens up another dimension to this understanding. He categorises the Public space in to three groups based on the accessibility, ownership and use.

1. External Public Space – All spaces between the private landholdings including Public squares, streets, highways, parks, parking lots, stretches of coastline, forests, lakes and rivers etc.
2. Internal Public Space – Various public institutions (e.g. Libraries, museums, town hall) and Public transport facilities (e.g. Bus stations, Train stations)
3. External and internal Quasi Public Space – This means privately owned public spaces such as sports grounds, restaurants, cinemas and shopping malls. Places where legally private and nominally public.

The accessibility and the use, are two main important points for this study which can be identified in this categorization. Accordingly, there can be 'open spaces' within a city but if it is not accessible to the public, that cannot be considered as 'Public Open Space'. Therefore, the 'Public open spaces' should be accessible to public and also should be allocated for public use which was also identified by Woolley's definition.

Accordingly, it can be summarised that the working definition of 'Public Open Space' in this study, is any outdoor space which is accessible to the public and allocated for the public activities, e.g. Public squares, Parks and gardens, Amenity green spaces and coastlines. With this understanding, next section discusses the current use of Public Open Space and potential future use for disaster resilience.

4. The use of Public Open Spaces for Disaster Resilience

Most of the contemporary urban planners and designers, use the Public Open Spaces to make sustainable cities in multiple-dimensions. Public Open spaces are mostly used to improve the scenic amenity and to promote active and passive engagement with the place, benefiting the physical and psychological wellbeing of urban dwellers. Further, these public open spaces are also used to promote social interaction and cohesion. In addition, green public open spaces offer the environmental benefits such as water and air purification, noise and wind filtering and microclimatic comfort. Furthermore, all the above values and functions of Public Open spaces directly and indirectly contribute to the economic growth of cities.

However, Vargas-Moreno, Meece et al. (2014) highlights that Public Open spaces have the potential to act proactive manner, contributing multi-scale within the entire city to solve the current and future problems and issues. At the same time, as discussed before, the need to enhance the cities' resilience to disasters, is an increasingly important and one of the key proactive approaches for sustainable cities. However, the current planning and designing lens has not been fully utilized to look at the use of public open spaces for disaster resilience.

Confirming this, Hossain (2014) state that the role of public open spaces in increasing cities' resilience to disasters, has not been fully discovered yet. Consequently, this paper attempts to analyse the current literature which discusses the potential uses of Public Open space as a strategy for disaster resilience cities and establishes the research gap, through the discussion on current problems and issues of harnessing these potentials. Accordingly, the literature analysis reveals that the public open spaces in a city have the potential to contribute three main stages in disaster management; emergency evacuation, recovery and mitigation.

4.1 EMERGENCY RESPONSE AND RECOVERY

The potential use of Public Open Spaces for emergency response and recovery, is mostly discussed in the literature related to earthquakes and Tsunami events. With a major contribution, Allan and Bryant (2010), analyse critical role of public open spaces in an earthquake event: case study in San Francisco, Northern California. This study reveals that, after the earthquake, parks and playgrounds in the city were mainly used as safer places to gather, shelters, to build low cost cabins and sometimes the sloping land of some parks became inconvenient to build the camps. Moreover, this analysis discloses that after a major earthquake, city's open spaces become the 'second city' providing simple to multifaceted services such as gathering, sheltering, distribution of goods and service, temporary inhabitation and commemoration. Accordingly, it can be identified, the importance of having different typologies of open spaces (small squares to parks) contributing different functions of emergency management and recovery and also the importance of consideration on connectivity among those Spaces with a potential to act as a ‘second city’.

Conversely, Fuentes and Tastes (2015) emphasize the significance of connectivity between the public open spaces in a city, through the consideration on linkage between open space, resilience and urban design as an integral way to plan and design resilient cities. Further, their research on earthquake and tsunami in Chile 2010; Case study on San Pedro de La Paz, recommend the need of designing open space network contributing to urban resilience. Further, this study recommends to take account of open spaces as an urban asset for seismic events under the resilience framework.

Adding to this argument, León and March (2014) demonstrate that, along with the connectivity, the consideration need to be given on three other factors, when using public open space as a tool for ‘rapid resilience’. This study was undertaken with a special focus on tsunami prone coastal urban communities and the findings reveal that Open spaces and streets need to be planned and designed with a focus on Tsunami evacuation providing safe assembly spaces, basic emergency services and utilities, such as first aids, fresh water, electricity, and communication. Further, they emphasize that, along with the accessibility and connectivity, public open spaces need to be planned and designed with adequate location, capacity and terrain qualities for Tsunami prone coastal urban communities. Accordingly, it can be understood that these factors such as accessibility, connectivity and terrain qualities, may vary according to the type of the disaster, yet there is a significant potential of using public open spaces for emergency evacuation and recovery after a disaster. Furthermore, it is imperative to harness this potential when increasing cities’ resilience to disasters.

4.2 DISASTER MITIGATION

Apart from emergency management and recovery, the literature analysis explores the potential use of public open spaces to mitigate the impacts of natural hazards. Currently, this usage has been identified mostly in flood risk mitigation strategies and has included to flood risk management frameworks. Confirming this, Burby and French (1981) and White and Richards (2007) state that flood prone areas need to be protected from future development and the most common way to do this, is to keep the flood-prone areas for open space purposes.

However, most of these discussions merely recommend to preserve the hazard prone lands as open spaces and lack of consideration is given to understand the practical implementation of this strategy to cities. As a solution, these flood-prone areas can be converted to public open spaces with designated uses. Confirming this, Kubal, Haase et al., (2009) state that preserved land in flood prone areas can potentially be converted to public open spaces promoting wildlife habitat and recreational activities. This can be a vital solution to get the highest and best use of land in rapidly urbanizing areas and at the same time, as a strategy for disaster resilience.

This notion is correspondingly applicable to most of the other types of hazards. For instance, the research discussions on minimizing the effect of Tsunami, suggest to demarcate the development setback line through the integration of land use maps and Tsunami hazard maps (Amarathunga, Haigh et al., 2015) and then to use the protected areas for open spaces. In supporting this view, Ardekani and Hosseini (2012) propose that these preserved areas from development setbacks, have the potential to be used for agriculture, open-space or scenic amenity. Accordingly, it can be understood that in a city, hazard prone area have the potential to be converted to Public Open Spaces contributing to disaster mitigation and also to the everyday use of the city.

5. Discussion: Necessity of Planning and Designing Inputs

Above discussion revealed the potential role of public open space as a strategy to make disaster resilience cities, as a facilitator for emergency evacuation, as an agent of recovery and as a strategy for disaster mitigation. However, these potentials cannot be effectively harnessed without considering the practical implementation side of it. Accordingly, this section is focused towards the current issues and problems of using Public Open Spaces for disaster resilience in cities. Further, the researcher propose set of the potential strategies that can be used to overcome these problems through a literature analysis on potential concepts, theories and practices of urban planning and urban designing.

5.1 PLAN FOR EVERYDAY USE

As it was identified, the public open spaces have the potential to be used for emergency evacuation and recovery in disaster situations and can act as an essential life support in an event of emergency. In practice, most of the recovery planners identify the open spaces as a component of the natural environment under emergency management plan but not as a part of the built environment. However, as Allan and Bryant (2010) point out, if these open spaces are planned and designed for the only purpose of emergency planning and recovery without having any connection with everyday life of the city, these places will become isolated in long run and result to have unstructured open spaces which are not physically prepared and not identified by the public in an event emergency. Further, this is not practical in a city where the rapid urbanization is taking place and not rather compatible with sustainable city concept.

As a solution, these open spaces can be planned and designed as ‘public open spaces’ in a way to function well in both emergency and non-emergency time. Confirming this, Allan and Bryant (2010) highlight that the emergency management plans and recovery plans become more effective when it is aligned with everyday life of the city through urban planning and designing strategies. León and March (2014) further confirm the necessity of planning and designing public open spaces to function well, during both emergency and non-emergency times through their study on Tsunami rapid resilience. Accordingly, it can be understood that, for the effective use of public open space as a strategy for emergency recovery and mitigation, it needs to be planned and designed, aligned with everyday life of the cities.

5.2 NETWORK OF PUBLIC OPEN SPACES

The literature analysis identified that, connectivity is one of the main factors which effects for the effective use of Public Open Spaces in emergency management and recovery. At the same time, it has been discussed that, after a disaster, city’s open spaces have the potential to act as a ‘second city’ contributing simple to complex services such as gathering, sheltering, distribution of goods and service and temporary inhabitation etc. Further, Allan and Bryant (2010) suggest that the successful integration of recovery planning and urban design, facilitate to look at city’s open spaces as a ‘second city’ with network of open spaces. In supporting this view, Fuentes and Tastes (2015) further confirms the idea of design public open space network for the urban resilience. Accordingly, this discussion emphasize the importance of planning and designing a network of Public open spaces contributing both urban resilience and disaster resilience.

At the same time, urban planners and designers demonstrate the benefits of having interconnected Public open spaces system in cities. Confirming this, Rogers and Sukolratanametee (2009) state that integrated network of parks and open space can promote the walkability, promote the interlinked recreational facilities, beneficial for neighbourhood designs and can be used to facilitate the sense of community. Further, Carmona (2010) says network of open spaces linked with green corridors integrate the natural and the built environment which is a key to create cities sustainable environment. Accordingly, it can be understood that, designing a network of Public open spaces have the potential to facilitate both disaster resilience, urban resilience and sustainable cities.

However, this need to be done in line with the fact of design for everyday life of city which was discussed at the previous section.

At the same time, it was identified the need of different typologies of open spaces contributing to different functions of disaster aftermath. This factor can be amalgamate with the planning concept of having variety of Public Open spaces contributing variety of needs of the city. As Thompson (2002) state, the diversity of public open spaces and their individual characters invite different uses and contribute the city's functionality, vitality and sustainability. Further, Carmona (2010) states that the external public open spaces provide life breath to the cities by adding recreational opportunities, venues for special events, wildlife habitats and opportunities for the movement of the people. Accordingly, it can be understood that planning and designing network of public open spaces focusing both disaster resilience and sustainable cities should also encompass the notion of different typologies of spaces contributing different functions of the city and as well as the factors of disaster resilience framework.

5.3 LOOSE SPACE

However, Planning and designing different typologies of public Open spaces to function well in both emergency and non-emergency situation, is not a simple task. For instance, planning and designing for everyday life may include the factors such as seating facilities, promote walkability, space for cycling, space for different recreational activities and children play areas, green spaces and so on. Further, as it was discussed, planning for disaster resilience may include facilitating emergency evacuation, sheltering, first aid and so on. Therefore, in order to function well in both of these situations, the identified public open spaces need to be planned and designed in a flexible manner allowing variety of uses.

However, addressing multiple objectives, the elements of 'Loose-fit' concept can be potentially used to plan and design public open spaces allowing variety of functions. The studies of Franck and Stevens (2013) explore that 'Loose-Fit' environments are not planned and designed for the specific tighten use. It is more unregulated, loose, open-ended and the user will decide the use of the space, rather than following the decisions of the urban planner or designer. In supporting this view, Thompson (2002) state, "Found" spaces often serve people's wide range of needs in ways that designed spaces do not. Applying the same theory, if the Public Open spaces can be planned and designed as a 'Loose space' offering the sense of freedom to the user, that Space have the potential to function well in both everyday life and in disaster situation.

5.4 MITIGATION AND URBAN SPONGE PARK

Most of the literature findings which discuss the use of open spaces to mitigate the disaster impact, consider the open spaces as a conservation and preservation strategy but not as an asset to the city. As an example, Burby and French (1981) and White and Richards (2007) state that most common way of protecting flood prone area, is preserve the flood-prone area as open space. It was also discussed that these preserved land have the potential to be used as Public spaces. Moving another step forward, Drake and Kim (2011) introduce the concept of Urban Sponge Park which marries the storm water engineering, urban design, and urban habitat concepts. Using this concept, they converted a large marshy wetland area in Gowanus, in to a new site for large residential development. Under this master plan, the parks were designed as a working landscape, proposing strategies to divert excess storm water run-off for use in the public park along the canal, thus reducing the load into the sewer system. Likewise, this concept of urban sponge park have the potential to be used to achieve multiple objectives including liveable cities which are physically feasible, environmentally sustainable and disaster resilience built environments.

Further, the potential conversion of hazard prone areas to public open spaces does not mean an additional development in vulnerable areas, but it should be planned and designed to make the use of hazard-prone areas safer to the community and wise use of the space in cities. Accordingly, this discussion shows the potential of planning and designing urban hazard prone areas as Public open spaces addressing multiple objectives incorporating sustainability, disaster resilience, liveable community, protecting open space or wildlife habitat, enhancing economic vitality, and promoting social equity, and benefiting to future generation.

6. Conclusion

This paper has offered an overview of the use of public open space as a key spatial element to enhance the disaster resilience in cities by mean of a critical analysis and synthesis of literature. Further, this study attempts to deliver the message, that current planning and designing focus on public open spaces should not be limited to the factors such as increasing scenic beauty, improving the environmental health, economic growth, increasing the walkability, liveability and vitality of a city and creating sustainable cities. Nevertheless, the focus should also be expanded towards the disaster resilience as an emerging need of sustainable cities.

Accordingly, the literature analysis first discusses the potential uses of Public Open spaces as a facilitator for emergency evacuation, as an agent of recovery and as a strategy for mitigation. Further, the discussion section points out the current issues and problems associated with harnessing these potential uses. Finally, this paper suggest the potential planning and design interventions that can be incorporated when using public open spaces for disaster resilience cities. In conclusion, the factors which have been discussed in this paper can be framed as follows (Figure 1), as a preliminary framework to plan and design public open spaces for sustainable disaster resilience cities.

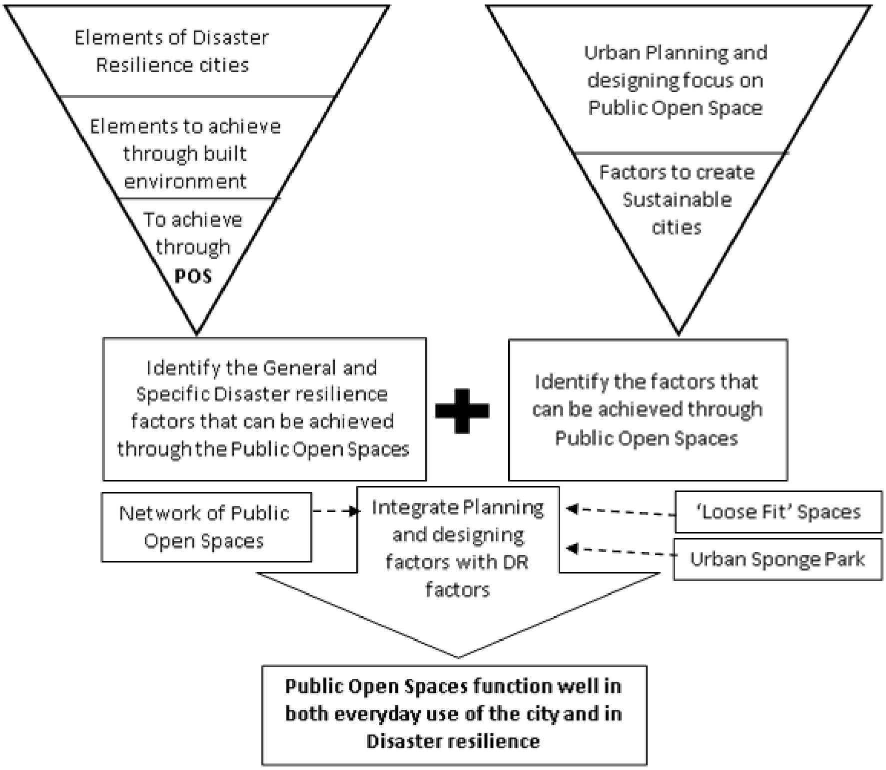

Figure 1, Framework to plan and design public open spaces for sustainable disaster resilience cities

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CREATING BREATHING SPACES WITHIN THE EXISTING FABRIC OF OLD CITIES

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Abstract
Humans constantly endeavour to redesign the habitat they live in to provide more comfort, ease, and better living conditions. However, in attempts to maximize this comfort, the basic needs and necessities of the space are lost and we end up improvising the same. Historically, settlements were always surrounded by large spans of forests and farms, providing ample open spaces. However, short sighted design, owing to rapid urbanisation, has led to a paucity of such open spaces in modern cities. The problem is particularly severe in case of the core areas of Indian cities which are characterised by attached houses - individual building units sharing a common wall and terraces accessible from adjoining premises. However, the attached houses present a unique opportunity to convert the intriguing pattern of terraces in to urban green areas and public spaces. This paper proposes a design and implementation for such terrace open spaces in old cores of Indian cities.

Keyword: *Old cities, Connected terraces, Breathing spaces*

1. Introduction

Cities have generally outgrown from the core areas. But, in India, as the cities sprawl, developments and policies usually focus only on newly merged areas. These new developments are well planned and provided with better infrastructure and amenities contemplating needs of the day. On the other hand the neglected city centres in the oldest parts of the cities, have started decaying. They have become concrete jungles plagued with homes to congestion, overcrowding, pollution and hence poor quality of living. The tightly packed attached housing in the city centres occupying every inch of space leave no opportunity even for neighbourhood level public spaces. City centres are also characterised by multiple factors such as involvement of multiple stakeholders, high land values, heritage structures, ownership issues, and political interests; hence they are difficult to intervene. Deependra Prashad and P Narkhede

(2010) have also addressed similar problems of old cities in their works New Architecture and Urbanism: Development of Indian Traditions and Revitalisation of old core of Pune with special emphasis on housing.

Revitalization is imbibing new life and vitality in old, deprived and derelict urban areas. It brings back new life to the city by stimulating various economic, socio-cultural, physical and environmental activities. As far as building stock is concerned, revitalization strategies aim at upgrading living conditions ensuring the maintenance of the property. Revitalization does not necessarily mean entire demolition and redevelopment. It is just improvement in the existing conditions by changing certain aspects of neighbourhood which is in state of despair.

Conservation of the unique old fabric of the core, yet making available facilities to meet the needs of today in the pace of urbanization is a big challenge! Hence this study focuses on how one of the issues regarding lack of open spaces could be tackled and proposes strategies for its revitalization.

1.1. RESEARCH PROBLEM

The tightly packed attached housing in the city centres means that it is impossible to pool land to create public parks or gardens. At the same time, the intriguing pattern formed by the settlements in the core city also presents an opportunity in the form of connected terraces. Therefore, there is a need to look at the existing structure and typology of terraces to analyse if they fulfil the needs of open/green spaces if transformed accordingly.

1.2. RESEARCH OBJECTIVE

The objective of this research is to assess if terraces in the core city areas can be translated to open and green spaces.

1.3. RESEARCH METHODOLOGY

The following chart gives a glimpse of the methodology used for conducting the research work. Research Questions were identified and a methodology was devised to answer every question as seen in the chart below.

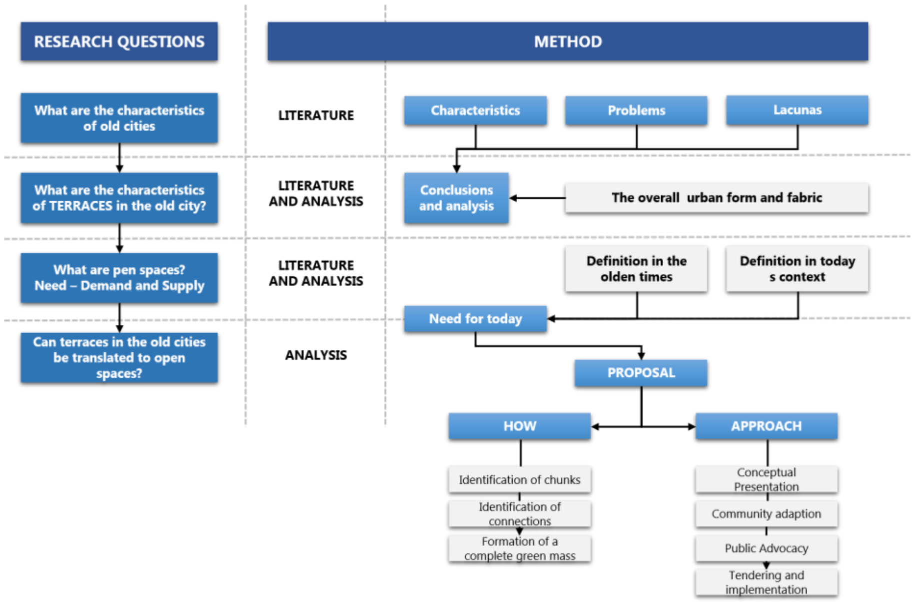

Figure 15: Research methodology followed for conducting the research

2. THE OLD CITIES

India today, is known for its rich culture and heritage that has been in existence for centuries. Every state, every city, every street has a story to tell about its past, and this story is effortlessly told by the ancient structures which it contains.

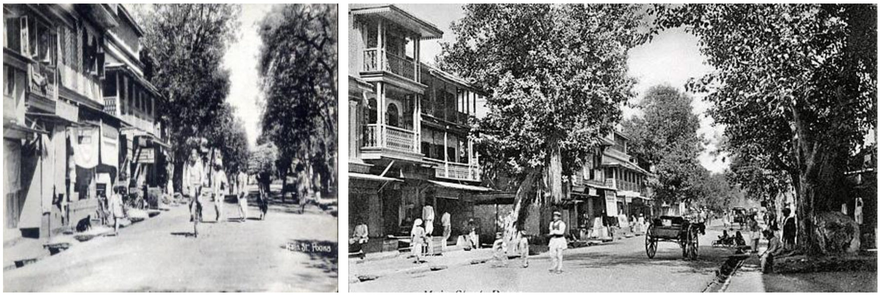

Figure 16: Some glimpses of the core city during olden times

At the same time, it is true that it is very difficult to see generality in towns, because towns in India are a world in themselves. Besides that, in general the towns are unique individually with their own set of concerns that no two cities can be categorised together. Nevertheless similarities are observed in organisational patterns and characteristics.

In context of the core areas, the closely packed structures sharing the same walls and often the front yards or internal spaces signified social interaction, united joint families, and a healthy and secure community living. The urban form of the settlements here, is like a maze of two or three storied structures, placed along narrow lanes and pathways with little or nil open community space. (Shinde, 2012-13)

2.1. EFFECTS OF URBANIZATION

Most cities have a core area which gives an identity by way of its architecture or activities it caters to. Without doubt, they are a critical part of legacies. But at the same time, a common man easily tends to side line this historical importance when it comes to personal or basic needs. The purpose for which they were built may not satisfy or cater to the needs of today. Urbanization favours this very fact and people tend to ignore the traditional way of living lured by westernization and the promises of comfort that comes along with it.

Figure 17: The existing prevailing condition in the old cities

With the growing population, increase in traffic and congestion, the already constrained older core areas of the cities have become the most un liveable spaces. In contrast, newly developed areas have planned gardens or green spaces or at least setbacks between the buildings to breathe through. But old cities with openings on just 2 road sides have limited ventilation. At the same time, these are also spaces with least green cover. (Khadpekar & Rao, 2008)

2.2. THE TERRACES

Buildings in core cities, in spite of being individual houses most often share a common wall. There isn't a huge difference amongst height either, which varies in a range of two to three storeys. This automatically leads to easy access across terraces. Some houses had deliberate connections in terms of staircases to climb from one place to another while most others were differentiated by parapets. This accessibility is very profoundly showcased in various Hollywood and Bollywood films.

The terraces were and are still used by women of the house for kitchen work (drying spices, grains, *papad*, making pickles, etc.); though the present day use has significantly decreased with the chaining economic markets. The terraces were also used for sleeping during summers when temperatures soared. This habit also declined with the age of air conditioners and lack of interaction and communication between neighbours. Only festivals like Uttarayan or Diwali make the complete use of the potential of these spaces. Otherwise they remain underutilised for throughout the year.

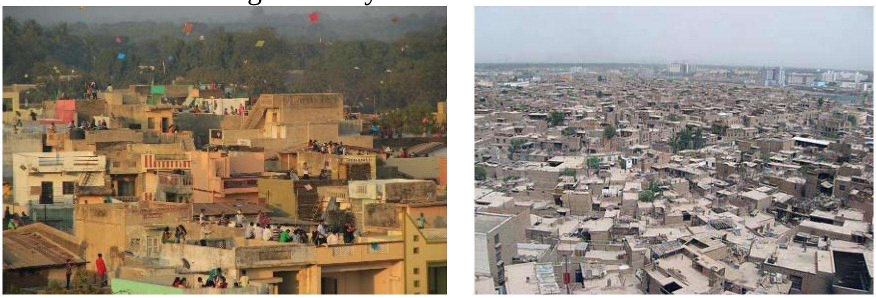

Figure 18: The unique pattern created by the upper layer of the settlements in the core cities.

3. PUBLIC SPACES

Public spaces are fundamental features of any city. They are spaces used for entertainment, leisure or relaxation. They are the living rooms, gardens and corridors of urban areas. They serve to extend small living spaces and provide areas for social interaction and economic activities, which improves the development and desirability of a community.

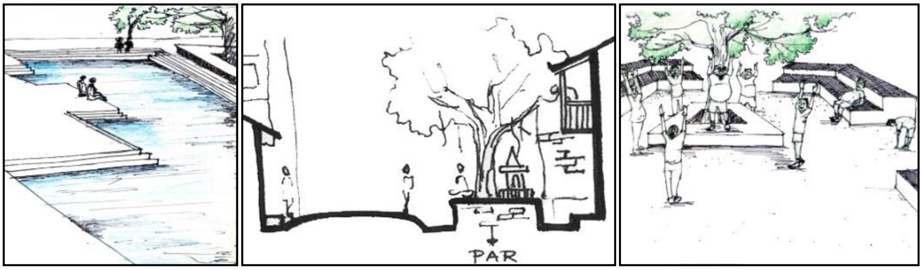

Figure 19: The different public spaces that existed during ancient times

Upto 19th century, public places were the external living space like *katas*, *taalims*, *ghats* and *pars*. Small places like sit outs under a tree, common hand pumps / stand posts, *verandahs* or front yards acted as public spaces that then existed which sought leisure and interaction. *Talims* were mainly built for exercising. *Paars* functioned like a village square, where there would be a raised platform around venerable tree with a small shrine beneath. *Ghats* were built along the river mostly near the temples. The space between individual buildings became the *kattas*. These spaces of the old days have also been illustrated by A Deo (2007) in his work Old city revitalization: Case study of Pune, Ahmedabad.

On the surface, it’s easy to look at great public places and see them as nothing more than well-designed physical locations. But beneath the surface, these places can be so much more. They are locations where community comes alive, where bonds among neighbours are strengthened and where a sense of belonging is fostered. They are locations that spark economic development and drive environmental sustainability.

Despite their importance, public spaces are often poorly integrated or neglected in planning and urban development. However, more and more research suggests that investing in them can create prosperous, liveable, and equitable cities in developing countries. The lack of provisions for public spaces hampers economic activities, pollutes the environment, and reduces social stability and security. Public spaces should be considered a basic service, with the same priority as transport, water and sanitation which communities often primarily focus their resources on. (Khadpekar & Rao, 2008)

Public spaces could also to a great extent be merged with greening of urban spaces. Green Infrastructure can be broadly defined as a strategically planned network of high quality natural and semi-natural areas with other environmental features, which is designed and managed to deliver a wide range of ecosystem services and protect biodiversity in both rural and urban settings. The green cover as prescribed for any city should be at least 33% of its landuse but the chart below shows Indian cities lie nowhere even closer. At the same time, old city areas with an even higher density of built mass show no signs of green vegetation.

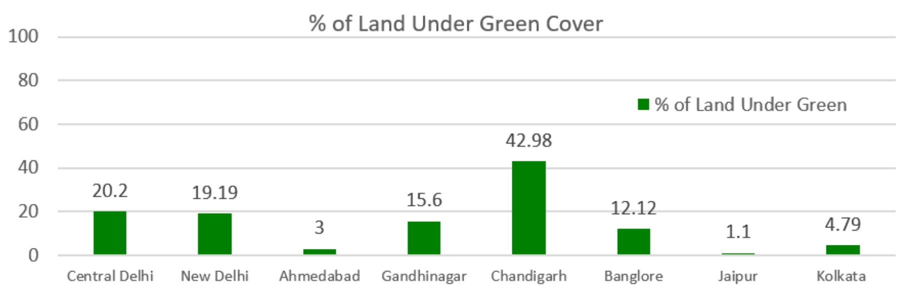

Figure 20: Percentage of green cover across different cities in India

With the realisation of depleting green cover, first mentioned as early as in the 19th century, the term “urban forestry” got introduced. But it is almost after decades that potential and substantial role in making cities more liveable and sustainable in the long-term has been recognized. Hence, the need to not only provide public spaces, but also green vegetation to add on to the environmental quality of the space.

4. TRANSLATING OLD CITY TERRACES TO PUBLIC SPACES

Revitalizing the core city areas, yet conserving the unique existing fabric but at the same time maintaining its functionality in terms of both the present and the future is the need for today!

The urban form of the old cities has a very interesting layer on the top made by interconnecting adjoining spaces. The varying heights of these spaces adds on to the character with an additional element of surprise and curiosity. One small terrace may not even size up to a perimeter of 100m. But, by connecting terraces the opportunity of enhancing the utilizable spaces increases manifolds.

The idea is hence to identify chunks of attached or connected terraces and deliberately convert them to terrace gardens. The interconnections could be made in terms of vertical elements like stairs and ramps. Spaces sharing similar heights could be levelled to a certain extent to achieve larger spaces which could act as lawns or gardens. Smaller terraces could be clubbed together to achieve decent amphi theatres while others could have covered sit outs/gazebos. Trees could be planted at intervals to provide enough shade, but at the same time letting in enough sunlight such that routine works remain unhampered. The parapets could be treated separately as barricades of flower beds or even creepers falling down creating a green wall for the built mass below.

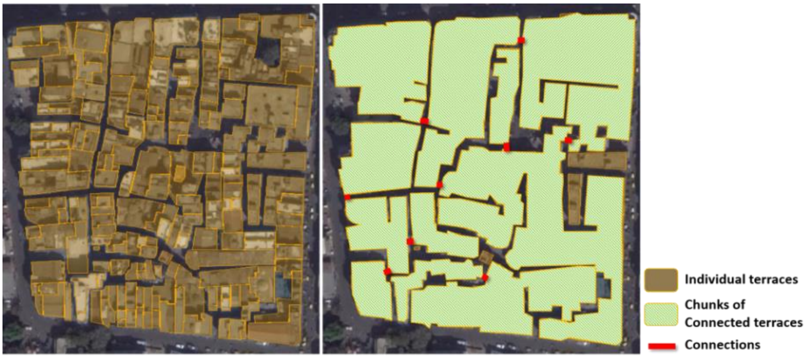

Figure 21: Formation of a green network using existing individual terraces

After an initial phase of developing such individual chunks, small bridges could be constructed between them. This would help connect the whole area into one green network instead of smaller units accessible to one and all.

Figure 22: Before and After images to depict how the exist urban form could be revitalized. The images shown below are purely conceptual and largely only to depict the whole mass that could be developed. The proposed green space would include a mix of paved/unpaved/green areas along with sit outs, steps, amphi theatres, trees, shrubs and plotted plants.

4.1. ADVANTAGES

Ar. Le Corbusier in his five elements of new architecture talks about the roof garden, restoring, supposedly, the area of ground covered by the house.

The whole idea could help maximise the capability of the building in a sustainable way. Greening of roofs would enhance micro climate and in addition to the social and economic benefits of reducing energy and CO2 consumptions, buildings with highly visible greenery are profitable not only for its owners and residents but also for the community, inspiring and encouraging people in cities to install more greenery onto their buildings. Rooftop vegetation minimises heat gain into the building and reduces heat island effects in the city; facilitates birds and butterflies controls rainwater run-off; acts as an absorbent of city sounds; creates an attractive look; and on an overall count, conserves energy. The green roofs can also help in rainwater harvesting in such a way that the rainwater collected can be used for landscaping and for other purposes within the premises.

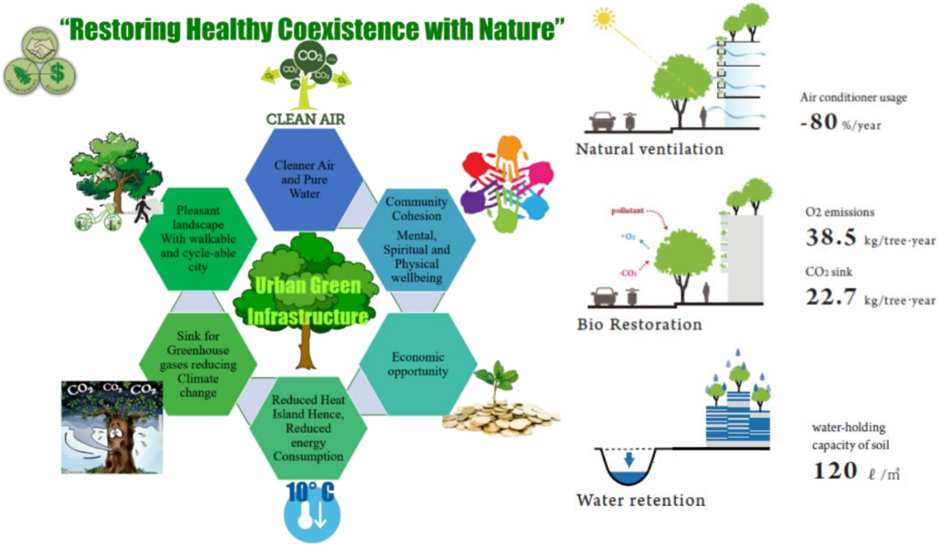

Figure 23: Advantages of urban green and green roofs (Sawa)

The next stage would be to understand how these terrace gardens could actually be constructed. It would be important to especially understand the technical aspects of what would be a typical cross section, what would be the multiple layers involved such that the built mass below is not affected, what kind of trees and plants should be planted and what would be their effects on the micro climate of the surrounding. It would be important to study works of certain architects and urban designers who specialize or deal with terrace gardens. For example, Ar. Hidetoshi Sawa, Ar. Young Il Lee, Ar. Chitra Vishwanath.

Though the scope of this study does not include the above mentioned technical details, some studies have been described in the section below.

House for Trees, Ho Chi Minh City, Tan Binh District has been designed by Ar. Hidetoshi Sawa. The house is like a prototype for construction of terrace gardens for surrounding structures to stand up. The photographs below give a glimpse of the structure with certain images explaining its construction techniques.

Figure 24: Case of House for trees, Hidetoshi Sawa (Sawa)

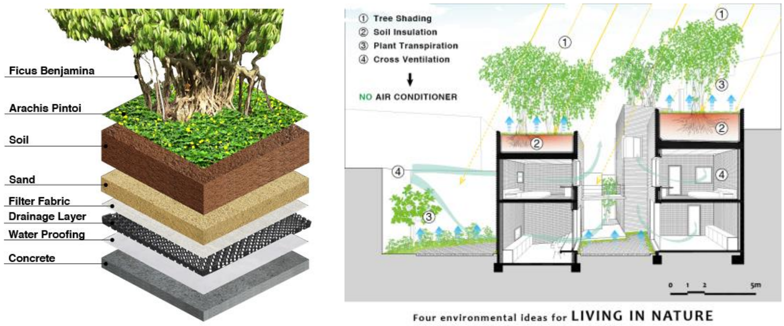

Figure 25: A typical cross section required for plantation on roof tops. (Sawa)

Ar. Chitra Vishwanath also talks about unutilized boring terraces that could be utilized for urban farming. She has replicated the same in her own house. Exploring ecological architecture, she talks about a similar concept in her term "smart roof" for green terraces in the city of Bangalore.

The High Line in New York built on an elevated disused section of railroad is also a good example for converting dead spaces into a greenway.

4.2. CHALLENGES AND APPROACH REQUIRED

Vertical gardens as an idea has only been experimented on individual buildings. Urban greening is being practiced these days, but old cities still remain untouched. When there is so much scarcity of land availability on ground, vertical gardens in the form of chunks of open spaces could help increasing green cover of the city.

It would be necessary to follow an appropriate method of dealing with implementation of the proposal as it requires intervention in brown field areas involving multiple stakeholders and private owners. In the initial stage, a conceptual presentation could be drafted explaining the design and technicalities of the proposal. Alongside, terraces of public and commercial buildings could be selected to set examples of how terraces could be revamped. Having set a prototype, the second stage would be discussing the proposal with the existing residents of the locality to encourage them from doing the same. The core cities having a large percentage of dilapidated buildings very regularly have new construction taking place; this would rather be favourable for the proposal. Owners of these buildings could be given incentives to open up their terraces for public use, and buildings could be designed to take the additional load. Existing buildings structurally weak could have basic renovation done to accommodate seating areas, potted plants and things alike.

Once such chunks of terraces get formed, connections in terms of bridges could be identified to join them leading to the formation of a complete network of public space for the area!

The scope of this paper is limited to the idea of terracing at the conceptual level and hence does not discuss the concerns that would arise during execution and implementation. The major questions that would need to be addresses are - who would do it? Whose spaces would be taken up? Would they be open for both the residents and outsiders? How to control access of strangers or miscreants in adjoining private properties? Other challenges would include willingness and approval of people, security concerns and structural issues (as the existing built mass may or may not be able to take so much of an extra load). Also, with varying heights of buildings, a critical design intervention would be making the network universally accessible.

5. Conclusion

Our world today needs an anchorage of the past and an insight for the future. As time passes the present will become the past and the future which is talked about every now and then will become the present. The future can be achieved the way we want to. It is up to us to choose to cherish the past in the present and know that the structure we spend our time in, will still be an enchanted part of our lives in the future.

The design proposed here is an attempt to honour the past in terms of forms and expressions, familiarize with the present in terms of functionality for today's world and appeal the future keeping its relevance intact and hence become timeless by design. This design provides secured breathing spaces which will remain unhindered through the passage of time regardless of the changes which will take place in the society. When every public space and structure settles in as an inconspicuous part of our daily life, these spaces would promise to be a fresh and new part of daily routine. New things come and seldom is it realized when the new turns into old. But these spaces promise to stay evergreen through generations to come. In the crowded hustle-bustle of the old city, it promises to be a new place of peace – a place to breathe!

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FACILITIES MANAGER’S ROLE AT THE DIFFERENT STAGES OF FACILITY LIFECYCLE IN SRI LANKA

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Abstract:
Facilities Management (FM) is a comprehensive approach for building management. Many researchers highlighted that facilities manager should not be restricted to the operational stage. Hence, the role of a facilities manager can be structured throughout the facility lifecycle. However, there is a lack of a study on the facilities manager’srole during different stages of the facility lifecycle. Therefore, this research aims to investigate the role of a facilities manager at the different stages of a facility lifecycle. The study used the systematic eight (08) stages defined in RIBA Plan of Work 2013 as a basis for investigating the role of a facilities manager at different stages of facility lifecycle.The study followed qualitative research approach.A literature review and expert opinion survey was carried out to investigate the facilities manager’s involvement at the different stages of RIBA Plan of Work 2013. Content analysis was used to analyse the gathered data.Findings reveal that preparation of maintenance, energy and building management strategies as the foremost undertakings of a facilities manager at Concept Design stage. Moreover, at Developed Design and Technical Design stages facilities manager is responsible towards advising on value engineering process and getting planning permissions. Furthermore, facilities manager at Handover and In Use stages attends for technical trainings onbuilding services and portfolio management.

Keywords: *Facilities Management, Facilities Manager’s Role, Facility Lifecycle,RIBA Plan of Work 2013*

1. Introduction

The design and construction phases of a building lifecycle is often dominated by the project team which consists with various stakeholders including client, contractors, architects, consultants and engineers (Chitkara, 1998). However, the dominance inoperation stage is usually driven by afacilities manager to enhance the useful lifespan of the facility(Lewis and Payant, 2007).Hence, Shah (2008) argued that the role of afacilities manager is important throughout the building lifecycle to effectively manage the facility.

Development of buildings is basically being relied on the needs of the business to create a work setup that is supportive in enhancing the core business functions (Alexander, 2000). Consequently, during the inception of building construction, the business requirements of the client are presented to the design team via a client's brief (Bezelga and Brandon, 2006).According to Atkin and Brooks (2009) facilities manager has the exact capacity of knowledge on identifying a supportive environmentin preparing the client's brief
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Further, Felten et al. (2009) mentioned that the involvement of a facilities manager throughout the construction process is vital in confirmation of data consistency through to the operation and maintenance phase. Furthermore, the construction cost is only regarded during decision making in design and construction phases and such decisions often not fully deem the maintenance requirement of the facility (Dunston and Williamson, 1999). Therefore, as stated by Chanter and Swallow (2008) the scope of Facilities Management (FM) has put a substantial footing for the management of buildings where any single maintenance management cannot be conducted without a facilities manager.Moreover, Bosch and Pearce (2003) and Pitt et al. (2009) stated thatdeployment of a Facilities Manager during the planning, designing and construction stages have significant and positive impact for ensuring the sustainable strategies.Facilities manager facilitates planning, designing and construction, and managing any type of facility, which encompasses the building services are focused towards the attainment of strategic business objectives (Alexander, 2000; Hendrickson and Au, 2008).

However,there is lack ofstudies in identifying the involvement of a facilities manager at different stages offacility lifecycle. There is therefore a need to investigatethe facilities manager's involvement at different stages of facility lifecycle.The RIBA Plan of Work 2013, organizes the lifecycle of a building including preparation of client's brief, designing and construction, and operation and maintenance into eight (08) systematic stages (RIBA, 2013). Therefore, this study used eight (08) systematic stages defined by RIBA Plan of Work 2013 as a basis to investigate the involvement of a facilities manager at different stages of a facility lifecycle. The four (04) sections below presents comprehensive literature review, research methodology, research findings, and conclusions and recommendations respectively.

2. Literature Review

A robust collaboration among eachbuilding lifecycle stageis existing that begins from early planning to deconstruction stage of the facility (Bribian et al., 2009). Decisions made at the planning stages will drastically influence to the performance of the building during the operation stage of the facility (Petersen and Svendsen, 2010). Consequently, the requirement of making precise decisions at each stage is vital to enhance the efficiency and effectivenessthroughout the building lifespan. The whole building lifecycle has been laid into eight (08) principal stage by RIBA (2013) as Strategic Definition, Preparation and Brief, Concept Design, Developed Design, Technical Design, Construction, Handover and Close Out, and In Use stage.
RIBA plan of works was first developed in the year of 1963 and thereafter, the plan of works was amended and issued in the respective years of 1967, 1973, 1998, 2007 and 2013 to cope with the developments in the construction industry (Architecture, 2013).Therefore, with the evolution of RIBA Plan of Work, the RIBA plan of Work 2013 has become an important step for the construction process map which introduces with new changes(Architecture, 2013).

It was identifiedthe involvement of various professionals throughout project lifecycle in carrying different project tasks. As specified by RIBA (2013), the professionals who involve at different stages consist client advisers,project lead, architect, lead designer, civil, structural and building services engineers, construction lead, contract administrator, quantity surveyor and health and safety adviser. However, in previous research studies the involvement of a facilities manager throughout the lifecycle is less investigated.

The scope of FM has gradually become a significant practice in any organization where the efficiency of that organization is in conjunction with the built environment in which it functions (Amaratunga et al., 2000). Achieving an effectual facility that can be easily operate, maintain, and manage is the foremost focus under the field of FM (Enoma, 2005).

IFMA (2016) defines FM as "a profession that encompasses multiple disciplines to ensure functionality of the built environment by integrating people, place, process and technology".Furthermore, IFMA (2016) has identified eleven (11) core competency areas of a facilities manager related to(a)communication, (b)emergency preparedness and business continuity, (c) environmental stewardship and sustainability, (d) finance and business, (e) human factors, (f) leadership and strategy, (g) operations and maintenance, (h) project management, (i) quality, (j) real estate and property management and

(k) technology. Further, Tay and Ooi (2001) emphasize that, the term FM covers comprehensive range of activities under several disciplines for the achievement of successful facility.

The efforts of a facilities manager should involve with all designing, construction and, operation and maintenance phases of the building lifecycle (Lewis and Payant, 2007). Therefore, the role of facilities manager spreads across extremely wide range of activities throughout whole building lifecycle.Moreover, according to the findings of Felten et al. (2009) the collaboration of FM throughout the planning, designing and construction phases of the building lifecycle grants the following benefits.

- Reduce the time required for the building commissioning process
- Reduce the costs related in building operation and maintenance while increasing the productivity of users through the creation of the of more need-oriented utilization of the building
- Clearly define the provision of authority and responsibility required for FM planning
- Concern on user at the initial stages will optimize the quality of the building along with the cost of construction
- Deeply evaluate the all FM related concepts
- Concern on the user as a customer with specific needs
- Consider the possible changes during over the time of use through a construction related evaluation
- Coordination of information between construction operation phases

Strategic Definition stage copes with recognizing the business case of the client in respect to the potential project (CIOB, 2002). Whilst, Fewings (2013) revealed that identifying the business case involves in defining the objectives of the client in the perspective of particular project at the inception stage. Further Langston et al. (2008) argued thatfacilities manager at the inception stage is responsible for making decisions with justifications which are being relied upon the client’s objectives.The Preparation and Brief stage vitally involves in initializing the project brief and the objectives of the project (RIBA, 2013). Whereas, facilities manager should play a critical role in establishing the client’s need with respect to the preparation of initial project brief (RICS, 2015).

At the Concept Design stage, an initial concept design together with outline proposals for building structure and services are established to derive different natures for the particular project at the completion (RIBA, 2013). These outline proposals are developed in order to obtain an optimal output as per the necessaries stipulated in the briefing stage (Jawdeh and Wood, 2010). Whereas, preparation of alternative proposals is one of the technical competencies of a facilities manager at building design stage (RICS, 2015).Moreover, the operation and maintenance of such designed and installed building services is a vital aspect, which emerges during the role of facilities manager (Yik et al., 2010).

The design development phase engages in solidifying the design concepts that are derived from the earlier Concept Design stage (Paddon, 2014). Moreover, in the Developed Design phase, the design of the project is further refined and the stage further involves in the preparation of plans and details referring to construction, specifying the arrangement of space and defining all the building services of the project (Jawdeh and Wood, 2010).As argued by Singh et al. (1999) the collaboration of the roleof a facilities manager with the design team is significant to provide concern on health and safety, space arrangement, accessibility and maintenance aspects.However, Jawdeh and Wood (2010) explicated that one of the foremost issues confronted by the facilities managers during this stage is the lack of designers' interest towards the aspects in the occupancy phase and the ignorance of the role of facilities manager.

The Technical Design stage involves in characterizing the specifications which is required for the construction purposes (Jawdeh and Wood, 2010). Moreover, Tunstall (2006) stated that this stage is incorporated with the specialist design efforts for the building structure, building service systems including for the electrical and mechanical systems. Whereas, RICS (2015) highlighted the importance of understanding the technical design by a facilities manager, to deliver a facility with holistic FM solutions. Furthermore, RIBA (2013) revealed that the technical design of the project should necessarily be collaborated with the FM-related strategies including the indoor environmental quality, fire safety and building control strategy.

The building construction stage involves the process of assembling materials to actual execution of the design into a building (Merritt and Ricketts, 2001). According, to RICS (2015) the involvement of a facilities manager during the construction is paramount to ensure the construction quality. Moreover, as-constructed information is crucial for a facilities managertowards future operation and maintenance practices (Liu et al., 1994). Once the building construction is completed, commissioning of systems and equipment are undertaken to encompass the performance or the reliability are retained as designed (Wu and Issa, 2012). Further to Akin et al. (2004), after the completion of commissioning, the facility is ready for occupancy. Therefore, commissioning has become a key concern towards the operation and maintenance phase of a building (Wang et al., 2013). As identified by Lewis and Payant (2007) the dominance of operation and maintenance activities are with the facilities manager. Thereby the role of a facilities manager is significant at the building commissioning stage.

The performance of a building is usually being relied on the effectiveness of operation and maintenance activities conducted on building services (Lai andYik, 2007). Further, Lai et al. (2008) pointed out that effective operation and maintenance during the facilityoperation stage is crucial in encompassing the satisfied level of performance of the building. Whereas Shah (2008) emphasized that operation and maintenance management as one of the fundamental job roles in the arena of FM.

By reviewing the above literature, this study was focused to investigate the current practices of a facilities manager, ideal roles of a facilities manager, legal aspects to be considered by a facilities manager and challenges to be faced by the facilities manager in carrying out the job role at different stages of RIBA Plan of Work 2013.

3. Research Methodology

A plan that directs the study from research problem to the conclusion, which is consisted with research approach and research techniques can be identified as a research design (Tan, 2002; Polonsky and Waller, 2011). Consequently, the research design of this research comprised with a literature review, expert opinion survey and data analysis.

The research was subjected to a qualitative research approach as the study vitally deals with in-depth information. Collection of in-depth information from FM experts were limited to eight (08) due to less availability of FM experts who have experience from planning to post construction stage. Purposive sampling technique was used as the sampling criteria for the selection of FM experts.

A comprehensive literature review was carried out to review the role of Facilities Manager and the stages of the RIBA plan of work 2013 whichwas assisted to develop an interview guideline for data collection. An expert opinion survey was carried out to investigate the current practices of facilities manager, ideal roles of facilities manager, legal aspect to be considered by a facilities manager and challenges to be faced by the facilities manager at different stages ofRIBA plan of work 2013. Content analysis with the aid of QSR NVivo 11 was utilized to analysed thegathered data. The final outcome of the research can be used as a guide to practice the role of Facilities Manager throughout the building lifecycle.

4. Research Findings

The findings of the research study covering the areas of current practice of facilities manager, ideal role of facilities manager,legal aspect to be considered by a facilities manager and challenges to be faced by facilities manager at the different stages stipulated in the RIBA plan of work 2013 are presented in this section of the study.

4.1. STRATEGIC DEFINITION STAGE

As stated by all experts, facilities manager currently involves during this stage to make the decision on whether to refurbish or expand the existing building or to execute a new construction projectto assist the business requirements while raltionalisingthe decisions. Further to the experts,facilities manger’s ideal role involves advising the top management on cost effective development option, space and building modification requirements and best source of funding.

In carrying out the tasks at this stage, facilities manager has to be considered on the planning and development regulations due to the stage involves selecting the development option.Convincing the client on best development option based on the existing legal considerations and real time FM related strategies are often challengeable to the facilities manager at the strategic definition stage.

4.2. PREPARATION AND BRIEF STAGE

Research findings highlighted that currently less number of facilities managers having the practical experience in briefing the client’s need with respect to the client’s brief preparation. However, it was noted that briefing the client’s exact need to the design team as the fundamental role of facilities manager at this stage. Further to the experts, the ideal practices of facilities manager involves engaging for feasibility analysis, selecting the best source of funding, advising the client on energy management, sustainability, and operation and maintenance targets. In addition, planning and development regulations, land and property law, and health and safety regulations are highlighted as the main legal aspects to be considered by the facilities manager while carrying the tasks at the preparation and brief stage. Furthermore, convincing the top management to allocate the required amount of fund to execute the new project is challengeable to the facilities manager at this stage.

4.3. CONCEPT DESIGN STAGE

According six experts, the current role of facilities manager involves providing the inputs on operation and maintenance implications and selecting the most appropriate design option out of the different outline proposals. However, experts stated the importance of the role of facilities manager in preparation of FM strategies such as indoor environmental quality strategy, fire safety strategy, health and safety strategy, energy management strategy, operation and maintenance, and building control strategy.Further, facilities manager has to be vigilant on the environmental regulations, planning and development laws and health and safety regulations to conduct the practices during the concept design stage. Moreover, it was found that convincing the design team about the importance of incorporating FM strategies to the design is a confronting task for a facilities manager during the Concept Design stage.

4.4. DEVELOPED DESIGN STAGE

Findings asserts that currently facilities manager having the significant practice of providing value engineering inputs to the proposed facility and advising the client and design team on maintainability, building information and building control systems.In addition, the facilities manager should carry out a performance evaluation on the proposed building. Further, FM strategies should be reviewed by the facilities manager to update them with design variations. While conducting the different FM tasks at this stage, facilities manager has to be thorough on several standards such as American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) standards,British Standards (BS). Further, it was identified the significance of considering the waste management regulations, fire safety and health and safety regulations at the developed design stage. As noted by six (06) experts, similar to the previous stage, facilities manager has to face challenging circumstances when convincing the design team to incorporate FM strategies into the design.

4.5. TECHNICAL DESIGN STAGE

Seven (07) experts highlighted that few number of facilities managers having the experience in reviewing the technical design to confirm compliance with regulatory requirements. However, it was noted that reviewing the technical design to ensure the compliance as a key role of facilities manager at this stage. Moreover, facilities manager should work on to get planning permission from relevant local authorities such as Municipal Councils, Urban Development Authorities. Further,it is important to advice the client to select the sub-contractors at the technical design stage.Accordingly, to carry out the FM practices at this stage, it is vital to adhere with the local and international guidelines and standards such as Sri Lanka Standards, ASHRAE, BS,International Electrotechnical Commission standards to name few. Further, experts highlighted thatfacilities manager has to make some complicated decisions with technical designers when there are circumstances such as system over designing or under designing issues which is the most challengeable task during the Technical Design stage.

4.6. CONSTRUCTION STAGE

All the experts agreed that facilities manager’s current involvement during this stage is to monitor the construction progress on behalf of the client. In addition, it was found that ensuring the site safety, coordinating the public community to handle complaints due to nuisancefrom construction works as the ideal roles that has to be played by the facilities manager. Moreover, dealing with the public community to handle complaints is the most challengeable task for a facilities manager during the Construction stage. Furthermore, facilities manager should monitor the quality, cost, extra works and variations of the construction and should organize utility supplyto the site on behalf of client. While practicing the functions at construction stage it is paramount to ensure the requirements of environmental law and health and safety regulations with respect to construction works.

4.7. HANDOVER AND CLOSE OUT STAGE

All experts stated that facilities manager currently involves at this stage to prepare handing over documents and to attend technical trainings conducted by service providers. Moreover, experts noted that facilities manager engages for testing and commissioning activities carried out at the handover stage.Further to the findings, the ideal duties of facilities manager includes inspecting defects in the constructed facility and gathering operation and maintenance manuals, as built drawings, testing and commissioning reports before to commence the facility operations. Furthermore, six (06) experts highlighted the significance of facilities manager’s involvement at this stage to review the collateral warranties from supplier/ contractors, to coordinate the services provider for facility maintenance and to cross check the assets with the asset registry prior to accept them under facilities manager’s stewardship. Further, all experts emphasized that facilities manager having a paramount duty at this stage with respect to the legal aspects of ensuring whether parties have met the contractual obligations and should thorough on the terms and conditions relevant to the defects liability period of the constructed building. Further, poor corporation and poor documentation practices of contractors will create critical concerns for the duties of a facilities manager during this stage.

4.8. IN USE STAGE

As stated by eight (08) experts facilities managers currently practicing most of the FM functions at the In use stage. Hence, the role of facilities manager is there to ensure highly supportive environment to accomplish the core business objectives. Accordingly, tasks of a facilities manager at this stage involves operation and maintenance of building services, structure and infrastructure, water conservation, energy management, building performance evaluation, waste management, occupational health and safety management, and handling building control systems. Apart from the aforementioned duties, facilities manager has to confirm risk free operation, ensure effective and efficient resource usage and carry out post occupancy evaluation at this stage.As noted by seven (07) experts facilities manager should knowledgeable in the areas of contract law and procurement guidelines as facilities manager has to often enter into the contracts with various vendors and service providers to conduct duties at the In Use stage. In addition, experts emphasized that insurance law is paramount with the facilities manager's duty of risksminimization due to unforeseen situations. Further, as per the previous stages, facilities manager should fulfilthe legal requirements relating to environmental law, fire safety and, health and safety regulations during the facility operations. Moreover, the experts revealed that handling the issues due to variation of end users' level of satisfaction, suppliers' issues, issues due to low fund allocation for FM department as the main challenges, which has to be faced by a facilities manager during the In Use stage.

5. Conclusions and Recommendations

The scope of duties of a facilities manager cannot be limited to the operation stage of the building lifecycle. Therefore, FM efforts should be comprehensively addressed throughout each lifecycle stage to attain a facility that is incisive with the core business requirements. The lifecycle of a facility is clearly specified in the RIBA Plan of Work 2013 which addresses the lifespan from Strategic Definition to In Use stage. Hence, RIBA Plan of Work 2013 was used in this study to investigate the facilities manager's involvement at different building lifecycle stages.

According to the findings, it was identified that the responsibilities of a facilities manager at Strategic Definition stage involves advising the top management on cost effective development option and, space and building modification requirements. During the Preparation and brief, Concept Design and, Developed Design stages facilities manager should advise the client on energy management and sustainability targets, maintenance implications, building control and building information systems, and value engineering methods for the proposed facility. Further, findings revealed that getting planning permissions from local authorities and attending for technical trainings as a vital functions of a facilities manager at Technical design and Handover stages. In addition, it was found that the fundamental responsibilities of a facilities manager at In Use stage involves efficient and effective management of building services to provide supportive environment towards the core business functions.

Thereby, facilities manager's involvement throughout the whole building lifecycle systematically guides the efficiency and effectiveness of the building performancetowards achievement of ultimate business goals by creating the most suited built environment for business operations.

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TRANSFORMATION OF HISTORIC BUILDINGS: A STUDY OF ARCHITECTURAL DETAILS AS REPRESENTATIONS OF CONSTRUCTION AND MEANING

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Abstract:
Generally, building details are understood as constructional representations, thus referring to their materials, joints and systems. But clever architectural detailing is often embedded with semantic meanings - in addition to constructional objectives - especially with respect to the building's 'part to whole' inter-relationship between its systems of construction, its compositional vocabulary, and its thematic investigations. Therefore details - as both 'representations of meaning' and as 'representations of construction' - hold a greater responsibility in transmitting the building's character, value and performance.

This research is a critical examination on subversive changes that regularly happens to original detail representations when historic buildings are transformed into modern programs. Both the notion and tectonics of 'architectural details' are re-read through the research, framing its inquiry on the hypothesis that the conservation – and the subsequent transformation – of a building may consist neither the original nor the modern detail: it is often a hybridization of both historical and modern ideas. To evaluate this hypothesis - and to verify subsequent representational changes of architectural details - a research framework is outlined, a theoretical position is arrived at, and three recent Sri Lankan experiences of the conservation and re-use of historical buildings are assessed.

The study concludes that the building detail transformation in the selected case study scenarios is a failure from an architectural point of view, as there is very little intellectual understanding behind the process. Subsequently, the research brings out the poor architectural intervention within such building transformation processes, and argues that more desirable techniques were not adequately explored, either by design or by default. This research therefore, is an effort to reverse the current approach to re-designing the re-use of historic buildings, and aims to project an alternative discourse on architectural details and detailing in such context.

Keywords: *details, historic building transformation, detail hybridization, meaning representation, construction representation*

1.0 Introduction: The transformation process

Building is not merely a singular artefact: it is a unified articulation among several parts. That part-to-part, part-to-whole and whole-to-part interrelationship makes a building both useable and workable. This larger perception of 'part-whole articulation' - if connotes in to general architectural terms - can simply be termed as the process of 'detailing'. Accordingly, 'detailing' is the driving force behind a building's distinctiveness and performance. The readers' and users' understanding of a building depend on what details demonstrate on its system of construction and meanings of aesthetics.

Depending on the way it details, each and every building has a character or representation of its own. Building and this original representations seem to stand forever, thus we contemplate them as enduring absolutes. But the reality is that they change rapidly with time, and even become obsolete for usage. Some of such buildings are renovated, conserved and re-established as time-tested entities, depending on their flexibility and adaptability. New building details emerge as the subsequent result, even disregarding the original representations.

Indeed, the subsequent results are neither new nor old, yet something immanence. Such correspondence occurrences – which mediates between the binaries of 'new' and 'old' - can be connoted as 'hybridizations'. The hybridized details could still respond to the parental characteristics, having tension with both old and contemporary characteristics or even by creating a totally spontaneous intervention. However, in order to incorporate such intellectual and pragmatic positions of detaining in to specific building interventions - such as the transformation of an old building into a modern program - new paradigms of architectural thinking must be pursued both in academia as well as in practice. More specifically, an intellectual dimension of building must be bought into our analysis of such construction-specific situations.

2.0 Architectural Detail and The notion of 'Hybridization'

According to Louis Khan, "architecture is the thoughtful making of spaces". Notwithstanding, this research looked at a building with a greater perception; beyond spatial planning as well as the mere aesthetics. The broader argument here is that the 'making of space' requires the 'making of building systems' that defines that space, and the 'making of building systems' has all to do with how those systems and parts are joined and detailed. Following Edward Ford's

(2011) interpretation of an ‘architectural detail’, this research infers buildings as both a pragmatic construction and a symbolic abstraction, in order to build up a research position. “*Abstraction is necessary distancing mechanism in any art - a formal arrangement, a plot device, or an idealized shape - to make the fragments of the world, physical or otherwise, into art. …….Animation - abstraction’s opposite - is no less necessary, and if abstraction is about understanding a building, animation is about feeling it*” (Ford, 2011).

The research moves from the position that the notion of an ‘architectural detail’ must be defined within an advanced intellectual paradigm, as opposed to the standard conventional definitions based on its performances (structural, aesthetical and environmental). In such thinking, Ford’s interpretation of a detail as five possible representations - as abstract, as motif, as order, as joint and as autonomous design - develops a better dialog within detail itself, with detail and building, and between the building and its spectators; each of these five definitions of details holds either meaning representations or construction representations. The various applications of these five definitions in the building transformation process can evoke one of three ideas of hybridization: Displacement, Reaction and Fusion. These three possible outcomes of hybridization were adduced from what Nathanssue (2012) has researched and stated.

The following table depicts the study-specific definitions alluded for the five dimensions of the idea of ‘details’ and three dimensions of the idea of ‘hybridization’.

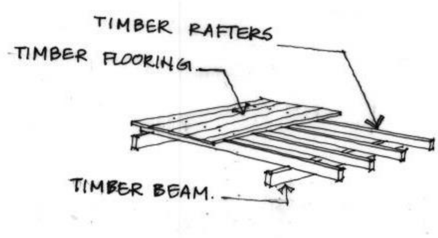
The idea of Architectural Detail	as Abstract	Detail depicts concepts more as a metaphor and symbolic approach than direct express.(not exposing but non exposing detail)
	as Motif	Direct representation of aesthetic over every other image of detailing.(decorations which gives aesthetic appreciation)
	as Order	An external depiction of what is inside as the structure. It is a system of construction; but non-structural. It is a system of ornamentation; but not to be confused with decorations.

	as Joint	These details are to relate one part of a building to another with the purpose of making it a whole
	as Autonomous Design	This detail is contrasting to the other building whole. Look different and do not fit at all. It is highlighted.
The idea of Hybridization	as Displacement	One idea dislocates the other so that the two co-exist in tension
	as Reaction	The two ideas respond to each other and a symbolic relationship emerges
	as Fusion	The two ideas merge so completely to get results as an entirely new idea, with different characteristics from either of its parent ideas

3.0 Constructional representation of the detail

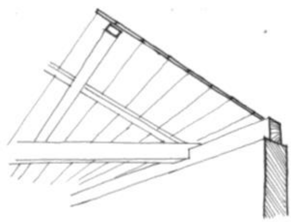
The study delineated a subtle and elusive understanding of the ‘representation’ of details in the selected 'transformed' buildings with respect to ‘then and now’. It identified that the contemporary interference of architectural detail in the process of transforming a historic building into a new program has resulted in representational changes. Four specific - but interconnected - theoretical observations have been identified with regard to how architectural details in such building interventions represent their constructional virtues.

The first observation is that - prior to the respective ‘transformation’ processes - most building details had represented constructional virtues than symbolic meanings. The original timber floor detail at Galle Dutch hospital, for example, has been conceived to resolve a pragmatic constructional requirement of how to support the suspended floor slab at the first floor level. The detail itself is a collection of several wooden parts, and their precise articulation acts as a unified whole; the three layers of timber beams, rafters and paneling form an order that represents the structural logic. The specific connections between timber layers - as well as their association to the wall - form ‘joints’ that make possible the assemblage of the entire organism.



Early construction means of detail
Source: by author

At the Galle Dutch hospital, a range of timber trusses accommodates the roof along the span of walls, supporting the roof structure and subsequently transferring loads to the perimeter walls.

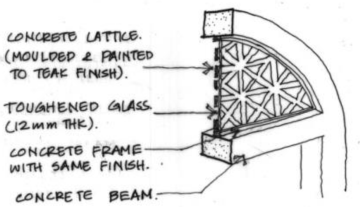


Early construction means of detail
Source: by author

As with the previous example, the primary objective of this detail is indeed constructional: a 'truss' as a collection of timber parts jointing each other and 'a range of trusses' forming the presence of an order represent the constructional logics of the building. These examples reveal situations where details have been devised as an order and as a joint, to articulate parts to parts, and parts to whole; this particular construction idea is predominantly represented through the detail itself.

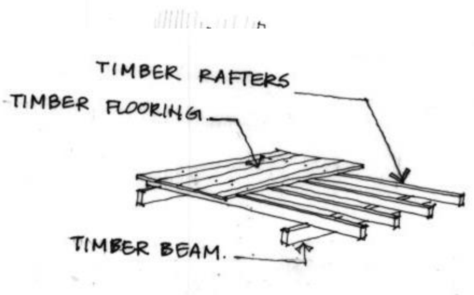
Secondly, during the building 'transformation' process, the original constructional representation tends to be suppressed, concealed or eliminated, subsequently being overlaid by meaning-specific representations, thereby distracting the original construction-specific representations of detailing. In most cases, even though the original construction representation is preserved, they are made to be mute or in tension with a new representation.

The door frame and grill work in Colombo Race course building has been originally done in timber, with their wooden parts and joints representing the pragmatics of construction. Linear timber members that form the trellis-like structure are carefully laid diagonally over each other, forming both ‘an order’ and ‘joints’ that solely represent the respective constructional intelligence. In the ‘reuse’ process, the entire grill work has been removed and replaced with a concrete molding, and colored to resemble a teak stain finish of a timber panel. By doing so, the embedded purity of the original constructional representation has been completely destroyed; there are neither ‘joints’ nor forming of an ‘order’, while the sizes of the diagonal members are also different because the concrete molding cannot achieve the same slenderness as that of a timber section. If one considers the logics of construction, having a concrete molding within a timber framed architrave also brings into question the entire rationale of the new detail; it is simply a motif, which accommodates a mere compositional aspiration.



Concealed construction representation of detail
Source: by author

Roof detailing above the atrium in the Independence Arcade is another example to show that the original constructional representation is suppressed and made to exist in tension with new meaning-specific representations. The original detail had several rafters and reepers articulating at one point, supporting not a joist, but a huge truss. Clay tiles were placed over that structure, and hence the detail was originally a comprehensive hipped roof structure at that point. It could identify as an order and as a joint which represented the constructional logics needed to resolve original constructional situation. In the transformation process, it has been refurbished and added certain opposing values, but keeping some of the original construction representation intact. The additional glass and aluminum exaggerate the detail more as an autonomous design, thus allowing constructional representation to remain suppressed. Hence in this situation, the detail has its own dual representations of meaning and construction; yet the original idea of representation was not acknowledged or realized to give priority. A subversive approach to detail has muted its original constructional representation.

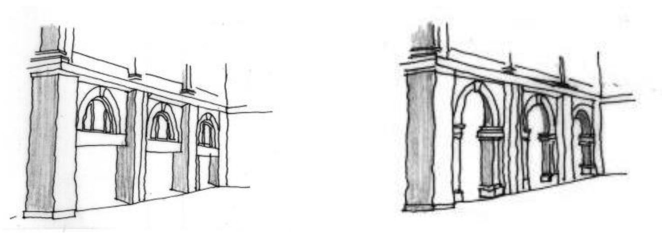


Subversive construction means of detail
Source: by author

Thirdly, even though the original constructions had accommodated parts-to-whole relationship, the new details have failed to respect such sense of totality in constructional representation. In other words, the 'new' has not allowed the original representation to be enhanced by its subsequent detailing.

Same example used above can be used to explain this particular idea as well, where the present expression of the detail is totally different from what was embedded originally. Even though the old building stood as a collective of parts by letting its construction details to be elicited, the new detail gives the impression that it did not precisely understand the original representational objectives. That is why such an explicated constructional detail was ornamented and given different perceptions. The future observers can be easily misguided by these new (and undisciplined) representations as they would read the total building detail without a coherent meaning, but with a fragmented understanding.

Column arch structure detail of colonnaded front façade of Colombo Race course building is another example where the original representation has been unwisely disturbed. Originally, this particular set of the arches were different from the others and represented the building's load bearing system and joints. It clearly could be identified as a constructional representation that contributed to the load-transferring function of the building, yet opposing the aesthetic continuity of the façade's repetitiveness. In the reuse process, that detail was not understood as a constructional mean, but only as a fragmentation to the repetition of the façade. Subsequently, what was deemed as lacking in the aesthetics was treated to restore, but the need of preserving the embedded constructional representation was left behind.



Transformation of detail
Source: by author

Fourthly, there is also a risk in the possible misrepresentation of the construction details in transformed building. This brings up the challenge of using building parts and mechanisms to satisfy the needs for adaptability or flexibility of buildings without suppressing the original representations or generating viable alternatives instead.

Ford (2011) describes the term 'construction' to acknowledge its contribution to a building in two ways: "*as an assembly or as a totality, as a set of parts in a discreet relationship or as a unified organic continuum. We demand not just completeness, but permanence*" (Ford, 2011, p. 227). This idea is a validation to the utterance of construction details, which is to convey a major role in the part-to-whole relationship of a building. Indeed, our understanding of a building - not as parts, but as a whole – depends on the ability of constructional detailing to appear in co-existence. "*We must understand it (construction) as an assembly, as co-dependent parts, as elements in equilibrium, as configuration that has been constructed*...." (Ford, 2011, p. 227). If the building represents construction, then our reading towards it needs to be developed accordingly by responding to the original situation. Elimination, concealment or suppression of construction representation make our understanding of the buildings blunt and weak, and does not direct towards a new understanding based on either of the meanings. It is like you wearing a baggy outfit. Once worn, it may look nice; but there is no explanation or critical relationship to your body's system of parts, joints, mechanism, flexibility, layers or shape.

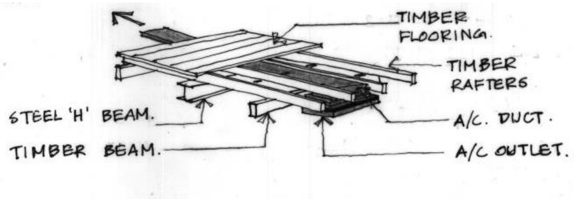
4.0 Semantic representation of the detail

Similar observations can be delineated with regard to how architectural details in selected case study buildings represent their semantic interpretations.

It can be observed that, when original construction representations were transformed into semantic representations in new buildings, they positively or negatively suppress the older representations, thus making the building more of an 'artifact' than an 'agglomeration of parts'. Even though this research does not argue whether this is good or bad, it will nonetheless take the position that buildings should not compromise their ability to function - and be represented - in totality.

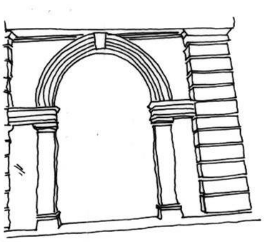
Firstly, with these buildings originally being utilitarian buildings, their predominant representation has not been meaning-specific. But detailing during the transformation process has seemingly attempted to bring out that semantic representation which was concealed before.

The second floor timber deck detail of Galle Dutch hospital was originally a structural element, which merely had a constructional meaning. But the timber-cladded service duct (which was supposed to suppress within the deck), together with the deck detail, demonstrates a more symbolic representation which wasn't there earlier.



New meaning representation of detail
Source: by author

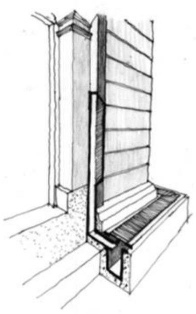
The original representation of the side façade wall detail of Colombo Race course was also meaning-specific, yet demonstrated a disciplined, harmonious implication to the whole building. In the reusing activities, it has been decided to remove the wall at either side of the arch and replace it with glass. By doing so, the detail seemingly terminates abruptly in a subversive manner, thus transforming a 'motif' into an autonomous design.



New meaning representation of detail
Source: by author

The second observation with respect to meaning representations in the case-study buildings is a kind of opposite to the first. It concerns with the fact that the explicit new idea of a detail often proves to be in contrast - or abstract - instead of preserving, transforming, or extracting the original semantic representation. Although the genuine purpose of the abstract detail is to suppress itself and impress old, it has not been a complete success because the semantic representation here has become a byproduct of the combination of both old and new.

In the downpipe details of the Independence Arcade the idea seems to be to hide the services within the motif wall. Otherwise it would have been a subversive implementation. Even though the suppression of ‘the new’ was expected accordingly, the aluminum downpipe itself acts with an opposite sense to suppress ‘the old’ as well. In the end, the duct is an abstraction which misrepresents its identity. By being so, the new semantic representation to the building façade has made to be of dual meaning: a combination of a 'motif' wall and an 'abstract' duct.



New meaning representation of detail
Source: by author

In the timber floor detail of Galle Dutch hospital the effort was to preserve the original representation. It does not furnish a successful attempt and a semantic representation has emerged as a byproduct of that effort. Replacing steel ‘H’ beam is a subversive activity, but it was done to enhance ‘the old'. Finally both the 'construction-specific' historic detail and the modern 'autonomous' design detail simultaneously represent both its construction and meaning. Meaning representation is being supported by both old and new parts in the end.

Thirdly, new details as autonomous design support the genuine requirement of overstating the original semantic representations of old details. But those design implementations are usually not strong enough to make the original withstand. They often fail to act as an exceptional subversive activity that lets the 'old' to maintain its original meaning further.

The roof detailing above the atrium in the Independence Arcade is such an autonomous design, which is subversively placed as not to interrupt the reading of original details. It let old parts to be themselves, and represent the semantic representation of the existed. But, since the detail is not completely new and subversive, the distinction of new meaning from old is hard to define.

It can be argued that a 'semantic representation' is the personal perception of reading a building/detail, whereas 'constructional representation' suggests a common universal way to read a building/detail. According to Ford (2011) it (semantic representation) is an "art of optics" which vary from one to another, yet something mutual at the end.

The comprehensive and generic idea of semantic representation simply relates to the symbolic expression. Coomaraswamy (as cited in Ford, 2011) opposes the idea of symbolic and iconographic art of western tradition by saying, "*in this kind of art no distinction is felt between what a thing 'is' and what it 'signifies'*". Meanwhile, the semantic representation of contemporary details was discussed in general perception by saying, "*most of these narratives are simplifications of reality*". Many are exaggerations, and some completely contradict the structural or constructional reality of the building (Ford, 2011, p. 295). In the local context, these Colonial building's semantic representation is a confusion fallen in between Ford's general, yet universal refinement and Coomaraswamy's philosophical perspective.

5.0 Three forms of hybridization

Results of hybridization with special references to case-study buildings explicit a lot regarding what has happened at present during the transformation of historic buildings to modern programmes. The cases state that only few outcomes have emerged in spite of many other possibilities of hybridization.

'Displacement' is a common outcome in case study buildings, and appears in four times out of nine circumstances. Door frame and Grill detail of Colombo Race Course building explicit how the displacement happens by co-existing two different ideas in tension. In the façade and downpipes detail of the Independence Arcade building, an old motif detail is transformed in to an abstract detail; however, the first idea is not totally eliminated, nevertheless have been dislocated by the new idea. As such, the two ideas co-exist in tension.

'Reaction' is also relatively common in the contemporary applications of detailing in conservation buildings. It appears in three times out of nine results in the case study analysis. For example, the Column-arch structure of Colombo Race course and the timber floor detail of Galle Dutch hospital are hybrid 'reactions' where the old and new ideas respond to each other; the new representation is a symbolic relationship of both old and new.

'Fusion' has the least amount of application out of the selected details analysed for case-study investigation; it has been observed two times only. Roof detailing above the atrium of Arcade is one such cases to be identified as hybrid 'fusion' (this too is not a clear allegory; but tendency is more towards fusion). The two ideas merge so completely and results in an entirely new idea, with different characteristics from either of its parent ideas.

6.0 Towards a better understanding of the building transformation process

Indirectly, details can be referred to as true architectural representatives of buildings. The research could clarify that – during its transformation process – a building is treated, preserved or transformed only depending on how it was understood by the specific design team. Indeed, such understanding of a historic building seemingly lacks capability to comprehend the building's constructional mechanism or organism (beyond the mere aesthetics).

With historic buildings, there seems to be a rooted approach to read them more through their semantic representations, and less through their constructional representations. What most re-designers do is to mute the pure constructional representations of historic buildings and overstate the meaning representations, thus resulting in hybrid 'reaction' or 'displacement' details – either consciously or unconsciously. Fusion - as a hybrid outcome - is paid lesser interest, as re-designers are seemingly reluctant to implement a subversive activity within a historic context.

According to Ford (2011), a clever architectural detailing is always being done with a purpose behind elimination or exaggeration. But modern architectural detailing is understood by the majority only as elimination of unnecessary and necessary small scaled building elements. But either it is elimination or exaggeration of details, they all need to have fair justifications to do so. As Ford states, eliminating or suppressing the details is like removing the evidence that was there to prove the weight, assembly of parts, resist for the weather, and functional requirements of a building. Instead, the building would be a weightless, immaterial, solid bulk then, but may not practically work properly. This research argues that – during the conservation/transformation process –

building details that do not mute their explication are essential to transmit the embedded idea of the original building.

Reading the buildings correctly, understanding their traditional representations and transforming them with the original idea preserved must indeed be pursed for better building conservation projects. Building expressions would be more preserved - and would acquire more value - if the re-formation solutions emerge not by default, but by design. Depending on the findings of the case study analysis, it is able to postulate that the design actions so far have been nothing but default solutions.

Even though 'displacement' and 'reaction' respond to original parental characteristics of details, they rarely carry the virtues of the original detail meant to be preserved. This research suggests taking a turn and paying more attention towards ‘fusion’ as a hybridization strategy in detailing buildings, which seek to be transformed from old to new. Fusion is a result of modern abstractions or subversive activities. Accordingly, the research suggests the possibility of using an opposing factor (subversive action) to preserve the tradition. Those autonomous designs on one hand proceeds the transformation, and on the other hand grasp the individual attention. That would allow for the emerged detail to separate old and new clearly as they will be independent from the way they possess their constructional and semantic objectives.

The main reason for new building details to present isolated ‘patching-up’ solutions - than evaluating such detailing as a substantial part of the building whole - is that the most detail solutions are derived not by design but by default. This research calls for the need to reverse that approach and affirm to read buildings with a broader understanding of what they demonstrate, both constructional-wise and semantically. The study believes that imparting such approaches and attitudes to detailing is only possible if a proper dialog about the building conservation/transformation process is generated both in academia and practice.

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CAN ACTOR NETWORK THEORY BE USED IN UNDERSTANDING PLANNING PROCESSES?

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Abstract:
Planning systems and practices – including plan preparation and implementation- are often comprise of different actors. The engagement of planning professionals in the planning process is not always static. At all levels, different actors play different roles in the planning process. The design and implementation of any planning process effectively, requires an understanding of the complexity of that process and its related networks. This paper proposes a means of mapping the network of resettlement process and housing delivery system in a selected resettlement scheme, applying the Actor Network Theory (ANT). ANT was introduced by Bruno Latour and Michal Callon in 1990s and it treats equally all human and non-human actors and their relationships in a network. Accordingly, the current research considers legal frameworks, policies, acts and laws as non-human actors within the same network where human actors exist. Utilizing a resettlement community in Anuradhapura as a case study, this research focuses on the flow of information between different actors related to the planning process. Different field based approaches were used to trace such flows of relationships between humans and non-human actors in the resettlement planning process. The application of actor network mapping analysis reveals the influence of different human and non-human actors in shaping and reshaping the planning process in plan preparation and implementation.

Keywords: *Actor Network Theory, Urban Informality, Resettlement, Non-Human Actor, Human Actors*

1. Introduction

Actor Network Theory has been used by different scholars to understand processes of innovation and knowledge-creation where non-human actors dominating subject areas like science, technology, and media. But it was not well experienced in planning practices where most of the non-human actors such as laws and legal procedures play a significant role.

With the failure of the linear model in planning in and around the twentieth century, the planning community developed new models of planning. The need of integrating different voices, across the public and private sectors, in the planning practice was recognized for effective action. Non-recognition of the most deprived and powerless people in the planning process breeds dissatisfaction among people. This thread of discussion has provided a rich vein of understanding on how to rethink the planning process in terms of relationships between people and different acts, laws, amendments and how to manage those relationships collaboratively. Critiques have further deepened the understanding by emphasizing the enduring nature of power relations and conflicts within these networks and the difficulty of achieving predefined-planning objectives. Absence of a strong integrated approach to understand those complex planning procedures made the planning process exist uncovered.

In such a background Actor–Network Theory (ANT) has been considered to be of relevance in understanding the planning practice (Boelens, 2010; Doak and Rydin, 2010.) Such studies pose difficult questions for public policy, particularly in relation to settlement planning. The rapid changes in environment, and. the emerging socio-technical studies makes it more complicated. Thus, planning organizations, authorities and planners within them are grappling with a new range of problems, new technologies and new sets of knowledge (Davoudi and Strange. 2008). Not only the emergence of new technology but also the emergence of different policy documents within planning domains has given an opportunity for ANT to explore on planning problems. ANT seems preferably suited to understand a case in which technological systems and environmental change are major preoccupations. With its emphasis on the lack of any sharp boundary between social and the natural worlds, ANT offers an analytic power over existing planning theories and formal planning practices. The current study explores the usefulness of ANT in understanding complex planning processes by taking a specific resettlement planning process in Mihindupura. The basic concepts and theories explained in the following section will be helpful in understanding the ANT in related to the planning process, where many researchers have slipped off.

2. Literature review

ANT contributes to the planning studies by addressing to the critical question of whether physical materiality and micro actors in a network had any reality or validity in planning practice. It encourages understanding the planning practice as a totality of what may lead to expose new findings in the real ground level planning. In response to this situation, ANT understands the mutual co-existence of the social and material elements identified as ‘actors’. ANT defines an actor as “(a)ny element which bends space around itself, makes other elements dependent upon itself and translates their will into the language of its own" (Callon and Latour 1981). It is based on three central principles. They are the existence of radical relationship between elements, generalized symmetry (between social and material actors) and the importance of association between these actors as a way of achieving change.

Latour (2005) has clarified that, in terms of ANT, the network is a 'method' not a 'thing' 'out there' to be discovered. ANT is based on understanding the dynamic ways in which relationships between different actors are negotiated. Latour is reluctant to use the metaphor of 'network'. According to him, the word 'network' tends to suggest 'stability' rather than 'flux' (Law, 2009). As Callon (1989) says, 'the actor network should not … be confused with a network linking in some predictable fashion elements that are perfectly well defined and stable, for the entities it is composed of, whether natural or social, could at any moment redefine their identity and mutual relationship.' (p. 93)
According to Murdoch (1998) ANT theorists are interested in how 'socio-material relations are arranged into orders and hierarchies' and how temporarily-stable relationships can deliver an action. Also, according to Callon (1989), network stability does not give the sense of 'perfectly well defined and stable', but rather to consider networks of relationships as either more or less stable, more or less fluid (Murdoch, 1998). As Latour (2004) states, 'Being connected, being interconnected, being heterogeneous, is not enough … really we should say "worknet" instead of "network". It's the work … that should be stressed'

A variety of concepts are used to discuss this work within ANT. For example, 'translation' is one of the key concepts referring to the ways in which network is negotiated. This focus on the tentative and temporary arrangement of relationships may help explain the frequent difficulties by which models of urban development are translated into different environments (Tait and Jenson, 2007). Thus, ANT unpacks the concept of translation into stages of problematization, interessement, enrolment, mobilization and stabilization.

Problematization is when actors identify that there is a need to change relationships within the network. This is usually defined by a human, because humans can communicate a meaning in a way that a non-human cannot, but a non-human often encourages the problematization. For example, this research uses the problematization of resettlement planning. While the problematization is articulated by professional planners, a human, and it is directly related to housing, a non-human. Meanwhile, actors are required to come together around the dominant framing and then engage in specific negotiations within the context of such framing. Such negotiations will end up in arranging all the other actors in a way, the focal actor wants, other actors to be; where focal actors is considered as the dominator of the network. Accordingly, with all the actors that are in an 'interessement' with the focal actor create a stabilized network. Callon (1985) defines 'interessement' as a group of actions by which an entity attempts to impose and stabilize the identity of other actors through its problematization'. For instance according to Callon's study, legal documents and rules and regulations creators in a country expect other actors to 'play a role' ; authorities to support/empower the rules and regulations, politicians to legalize them in the parliament, inhabitants to follow the rules, opponents to revise their arguments etc. The stage that generally comes next is enrolment, where actors are made to accept and perform certain roles. 'Interessement achieves enrolment if it is successful'. In this stage Callon describes how an actor will try to form alliances through 'negotiations, trials and tricks' and the obstacles the actor faces in this process. By enrolling allies, actors can mobilize the resources to sustain their preferred network. Enrolling is a particularly interesting process by which actors constitute other actors in their own agency. Relationships between actors are further defined by intermediaries passing between them (Callon, 1991). Mobilization, the fourth stage of translation maintains commitment to the problematized cause of action. Mobilization can be seen as a test given to the actors to see whether other actors are "true to their words or not". This condition is also applies to the non-human actors as well. When the alliance of the actors in a network is successful, the network can lead to a temporary stabilization. But throughout the process of translation there is the risk of failure or halt at any stage described above. But the translation of the interests of diverse actors, along with their enrollment into stable networks, requires continual chains of translation.

According to Callon (2009) these processes, and their complexities, assumptions and uncertainties, are often hidden within 'black boxes'. Black box is a metaphor that is used in ANT to represent a complex category. According to the ANT, a set of complex actions can be represented by a 'box', since it is generally regular and stable in its functions (Wiener, 1948). Such black-boxes resist the opening up of cumulative processes to a proper negotiation. Rather, such black boxes create areas within networks where relationships between actors are 'taken for granted and unchallenged'. City wide proposals for resettlement planning integrating systems of acquisition, compensation, plan preparation and implementation reveal a tendency to over simplify the complex context of housing delivery in a resettlement planning process. According to Jacobs (2006) traditional geographies have 'black-boxed' the building as an immutable artifact: "they do not integrate the socio-technical processes by which that there-ness materializes: the process of construction and use of the building, the various modes of authorship and ownership, the day-to-day complexities of maintenance and servicing." (p.11) In this context, understanding housing delivery process in a resettlement planning process is a timely need. Further, to elaborate it can be considered as Latour's example of a dance to describe the importance of understanding the translation process in fixed black boxes. Accordingly, when the movement stops, the dance ends but, of course, the actors have been changed, and this is the fundamental scenario that can happen in the planning practice too. Further, Doak and Karadimitriou (2007) characterize the urban (re)development as fluid assemblages, 'as heterogeneous collectivities of people and things, relationally tied to each other over time and space' (p. 221). This research explores the applicability of ANT into a resettlement planning process implemented about 30 years ago.

3. Methodology

3.1. CASE STUDY: RESETTLED COMMUNITY IN MHINDUPURA, ANURADHAPURA, SRI LANKA

Mihindupura, Anuradhapura, Sri Lanka- located 2 km from the present Anuradhapura new town and located between two rivers, Malwathu oya and Halpan ela- is a place where resettled community lived in for the last 25 years this resettlement project was carried out in 1988, under the Anuradhapura scared area plan, when part of the town then was declared as the sacred area to maintain the religious environment in Anuradhapura. Earlier (till 1988), the selected communities in Mihindupura (165 families), were living in Kurunegala junction, Anuradhapura which is 3 km away from the present location. During the resettlement project, people in Kurunegala junction were given three location options –Katukeliyawa, Dewanampiyatissapura and Mihindupura. Out of these three sites Mihindapura was the most preferred site by the people at that time and therefore, Mihindapura was selected for the current study

3.2. METHODS OF DATA COLLECTION AND ANALYSIS

This study follows a qualitative approach, but attempts to analyze the data using network theories. Main data collection methods were archival documentary search, field observations, photography survey, semi structured interviews and focus group discussions. The secondary data was collected from the National Physical Planning Department (NPPD) (Earlier known as the Department of Town & Country Planning), Sri Lanka, Anuradhapura Municipal Council (AMC) (In 1980s, it was an Urban Council) and Wessagiriya Grama Niladhari (GN) (Village administration Division) of Anuradhapura. The archival documentary search was carried out to understand the context and procedures, to review legal provisions and to look for written evidences about the program. Semi structured interviews and focus group discussions were done with the community in Mihindupura and officials from project planning and implementing authorities by then and now people/officials who have a rich understanding on the Anuradhapura Preservation Scheme. The analysis was done by considering two time laps, 1980 to 1990 and 1990 to 2015. During the field study, two questions were asked from the interviewees.- Q1.What are the processes and experiences you went through in moving from Anuradhapura old town to Mihindupura?' (First question refer to the duration I from 1980 to 1990 representing the period where decisions, rules and regulations related to Mihindupura resettlement were taken). Q2. -What are the present experience of the community in Mihindupura?' (Second question refer to the duration II from 1990 to 2015 representing the post resettlement period) Through these questions, by interviewing different groups of people, a complex range of more than 20 human and non-human actors were identified.

4. Results

The resettlement process of Mihindupura, has started with the relocating of people from the Anuradhapura Scared Area boundary to the outer city. With that the key intention of the policy makers was achieved as all the commercial activities were shifted from the immediate vicinity of the Anuradhapura Scared area. Palmer (2014) states that this kind of process consists of with several micro steps and actors, overwhelmed by macro steps but mostly doesn't represent since they are hidden in a stable 'black-box'. According to Callon & Latour (1981, p.299) a macro-actor is by definition no more difficult to examine than a micro-actor. But a macro-actor can be a micro-actor seated on black boxes, a force capable of associating so many other forces that it acts like a 'single man'. According to them, growth of a network is only possible if one can associate long lasting forces and simply existing with them. Hence a macro-actor is at least as simple as a micro-actor since otherwise it couldn't have become bigger. But by tracing actually functioning worknets and asking the aforesaid two questions, the interest is to open the 'black-box' and identify the micro actors hidden beside the macro-actors: to visualize the resettlement process in detail.

4.1 ANT MAPPING INSIDE THE 'BLACK BOX'

To commence a tracing of the flow of resettlement planning process starts by opening the black boxes available. The networks were established employing the ANT definition of an actor as "any element which bends space around itself, makes other elements dependent upon itself and translates their will into the language of its own" (Callon and Latour 1981 p. 286). The information gathered under the two main questions were compiled and brought into one diagram in order to visualize the actors that emerged in different planning stages.

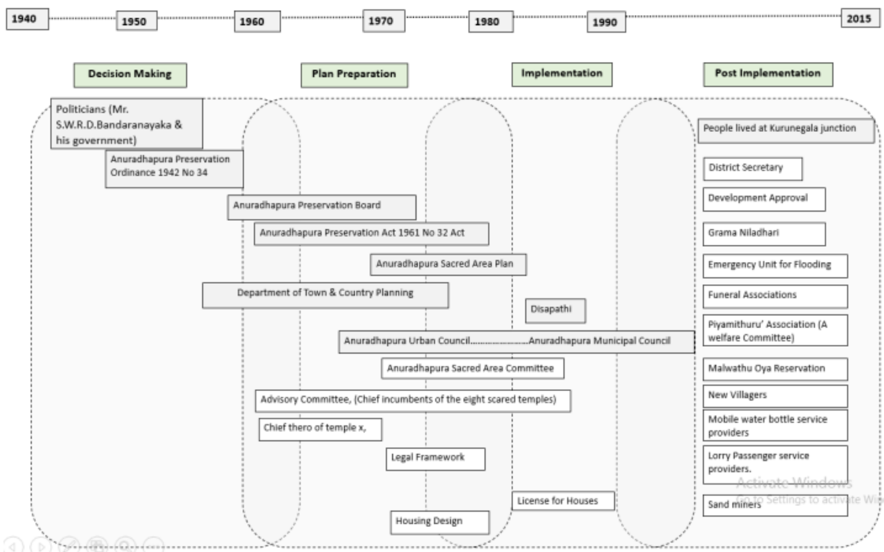

Figure 2, Opened 'Black Box' -Resettlement Planning Process for Mihindupura Resettlement Scheme (Source: Compiled by the authors)

As highlighted, the research refers to all the actors attached to the worknet at the real ground. By, opening the black box two interesting findings could be observed in the worknet in Mihindupura resettlement scheme. Initial observation is the existence of informal actors within the formal planning process of Mihindupura resettlement such as chief incumbents of the eight sacred temples. The second observation is that, during the post implementation period there is an increase in the number of actors such as different community based associations who are supposed to influence the formal planning process. Overall, these identified actors outweigh the actors who have emerged away from the formal planning process. The non-human actors such as policy documents including rules and regulations enhance the complexity of the functional worknet of Mihindupura resettlement scheme. Apparently, the opened black box is not as simple as what is in the documents. This complexity can be further elaborated employing the five stages of translation process, as interpreted in the ANT. According to the concept of translation of ANT, the politicians (Mr. S.W.R.D Bandaranayake and his government) has started the process of problematization, emphasizing the need of keeping Anuradhapura Sacred Area separately from a busy environment."…Anuradhapura town was located around Sri Maha Bodhiya (Sacred tree)..by 1940s the ancient ruins were not preserved and they are out of the eyes of the rulers… fish, vegetable stalls and other trading activities around Ruwanweli Maha Seya (Stupa) make the devotees depressed…”. (Anuradhapura preservation scheme report, 1996, p.5)

In order to achieve the aforesaid problematization, the group of politicians including Mr. S.W.R.D. Bandaranayake had attempted to impose and stabilize the identity of other actors, by introducing legal documents such as Anuradhapura Preservation Ordinance No.34 of 1942, Anuradhapura Preservation Board Act No 32 of 1961, Legal Framework for Mihindupura etc. As Callon, states such rules and regulation creators in a country expect other actors to ‘play a (particular) role’. After introducing this process the group of people who have an interest, enrolled in a network to achieve their target make their interest a success. According to the information provided by the ‘black box’ the planning decision making process for Mihindupura resettlement scheme was initiated in 1940s. In order to achieve this identified problematization, established by the Bandaranayake government at that time, the ‘group of interest’ establish the Anuradhapura Preservation Board to implement the designed Sacred Area plan for Anuradhapura. But at the stage of enrollment the ‘group of interest’ found that the commitment to the problematization caused by assigned groups of interest such as Anuradhapura Preservation Board are not ‘true to their words’. But if Anuradhapura Preservation Board was successful, it can be considered as a position where the network move to a temporary stabilization. Instead, after enrollment of the actors in interest the network emphasized the need of re-shaping the network by mobilizing the alliance of actors. In this case, the Preservation Committee was disbanded and a new committees called Anuradhapura Scared Area Committee and an Advisory Committee consisting of chief incumbents of the eight scared temples of Anuradhapura, was established. The process of translation come came to a halt and started to implement the plans of resettlement by 1980s. Therefore with the support of many other actors such as Department of Town and Country Planning (Present National Physical Planning Department), Disapathi (GA), Anuradhapura Urban Council (AUC) the plan came into operation in terms of resettlement programmes. According to the translation process explained in the theory of ANT, this situation can be identified as an example for a stage where a temporary stabilization happen in the process of resettlement planning.

As per the information gathered through surveys for the aforesaid two questions, the process of resettlement extends over years following the process of translation mentioned in the ANT. But ANT does not explain “why” or "how" a network takes the form that it does. Thus, further to elaborate the resettlement process of Mihindupura the research employs the Social Network Analysis (SNA) to define the roles played by different actors in the traced map of translation from 1940s to 1980s. Such roles of an actor can vary from a focal actor who dominates the entire network, to an actor who plays the role of a gatekeeper in negotiating things between two or more actors. Degree and Betweeness measures are employed to identify the characters of the actors of the traced network and also to find whether the actor is focal or not. In degree of a network represents the number of incoming edges into a node. Out-degree of a network refers to a number of outgoing edges originating from a node. When this in-out composite value is taken, it calculates the total connection of a node. For example, this gives how many connections (ties) a particular actor in the network, is having with other actors in the same network. Accordingly, the focal actor of a network has the highest degree value and represents the dominator of the network. It aligns other actors to make the interest of the focal actor to be realistic. In this study, in and out degrees were studied separately, while only the composite degree diagrams are presented in the paper.

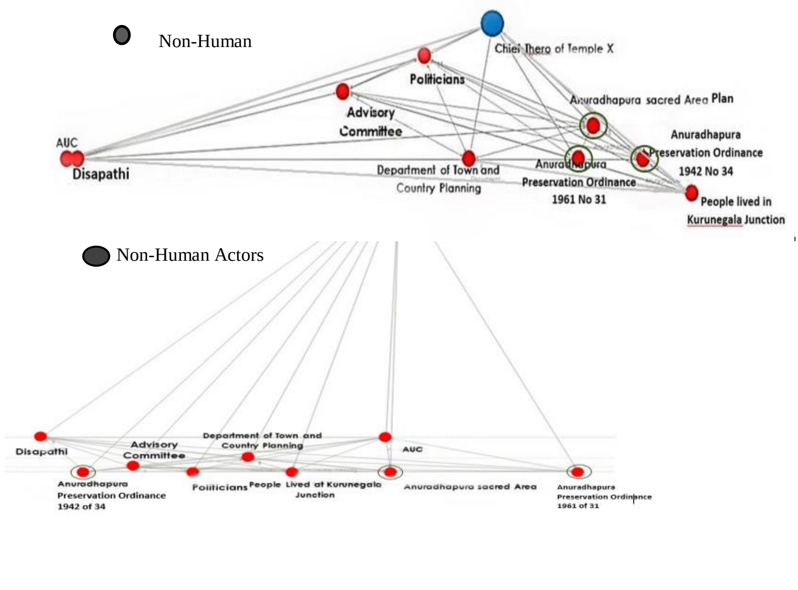

Figure 3, Degree (In and Out) Centrality (1980-1990)

(Source: Compiled by the authors using UCINET software)

Betweeness of a network identify the mediator of the network. Mediator plays the role of a gatekeeper in a network. Obligatory Passage Point (OPP) referred to a situation that has to occur for all the actors to be able to achieve their interests as defined by the focal actor.Accordingly, in the above diagram, Thero has the highest number of ties towards and outwards. But he was not within the formal planning process by that time. Instead, he has relationships with all the other actors in the network. From the people who lived in Kurunegala Junction to Politicians, Thero has a well spread network. The ties in between the chief incumbent and the other actors do not represent the existence of formal relationships. Thus, the findings of the ANT expose the existence of actors who are not in the formal planning process and most importantly such actors play the role of the focal actor with the highest connections among all the actors. For instance being an actor in the formal planning process, Disapathi (Government Agent) had only five direct connections (ties). But the Thero who is not within the formal planning process has eight direct connections (ties). Thus, the Thero has become the FA of the network. Further he was in the middle of most of the networks. Eventually, the identified relocation sites were Mihindupura (Shanthi Villages), Dewanampiyatissapura (Shanthi Villages) and Puranagammana Villages. From these three locations people were given the opportunity to select the preferred place. In providing houses the Committee provided them a design with one living room and two bedrooms. In addition they were given with Rs. 25,000 as a motivational grant by the Ministry of Housing Development Authority. After completion of the project the Sacred Area Committee handed over the responsibility of this scheme to Anuradhapura Urban Council.

Although the resettlement planning process proceeded smoothly, according to the process of translation it could have failed or halted at any of the stages described above. The information in the ‘opened black box’, from 1940s to 1980s reveals that the planning process continues, providing examples for the translation concept of Callon and Latour. After the establishment of the Anuradhapura Preservation Board and preparation of the Anuradhapura Sacred Area Plan the process halted for a period. But it is a temporary stabilization and continued from 1980s by creating a new problematization. With these observations, it was identified that the group of interest such as Anuradhapura Preservation Board are not ‘true to their words’. According to Callon, in such a situation a mobilization in the same network can happen to reform the network to meet the interests. That’s how the Anuradhapura Scared Area Committee was established.

Afterwards, with the corporation of Ministries of Policy Planning, Housing and Construction and Highways, the Department of Town & Country Planning accelerated the process of resettlement programme under the Scared Area Plan. Providing examples for the failures in linear planning models at the stage of post implementation, new actors emerged when it came to the post implementation period. With the emergence of such human actors, the roles played by both human and non-human actors changed in the stage II.

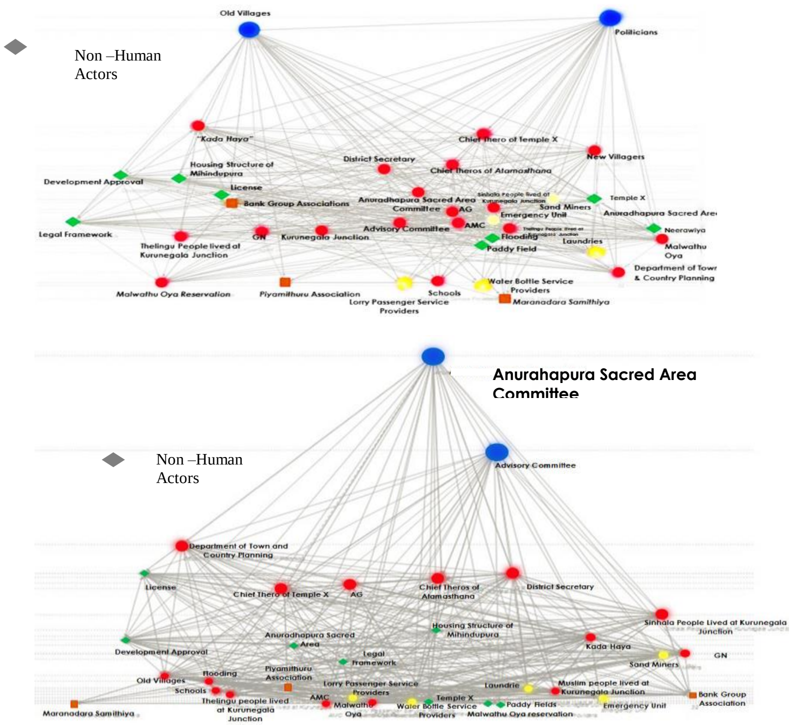

Figure 4, Degree (In and Out) Centrality (1990-2015)
(*Source: Compiled by the authors using UCINET software)*

Above diagrams it reveals that the focal actor has changed into old villagers who were resettled from Kurunegala junction few years a back has become the focal actor. These actors were the Obligatory Passage Points in the duration I who were called as ‘people lived in Kurunegala’ in the first diagram. This can be related to the local political ties that they developed during the last 25 years. Accordingly, people and politicians who represent the village, have the highest interaction level with all the actors in the network. The old villagers (community who were resettled from Annuradhapura) and the politicians of the area have developed direct connections with new villagers who have moved recently to Mihindupura, District Secretary, Grama Niladhari, and Group Associations. Like the human actors, the non-human actors such as license, housing design for the resettlement schemes, development approvals have become the intermediaries of the network by obtaining the highest values of betweeness. Most of the non-human actors in the network play an intermediary role. According to Rydin (2012), to understand how the networks are formed, negotiated and potentially stabilized, it is necessary to consider how these actors operate in relation to each other, how they enroll each other into the network and the role that intermediaries play in bringing actors together and defining their relationships. Thus, the research exposes two important aspects of planning. Initially it emphasize the failure in applying linear formal planning models and processes in planning practice. The research also reveals how planning policy documents are important in mediating and defining the ties among different actors engaged in plan making and implementation.

5. Discussion and Conclusion

Although no firm definition is bought up, the major argument of this paper based on ANT emphasize that the planning process cannot be pre-determined and it is always supported by a process of translation and thereby the findings of the current research support work of Murdoch (1998) and Latour (2004). Initiating from the stage of problematization, the planning process extends through enrolling the actors who are in interest to solve the problem. Also the focal actor mobilizes the other actors who are not true to the words on the way to stabilization of the worknet. This process discovers the instable and the dynamic nature of the planning worknets, since they keep on changing. ANT discovers the process of planning in terms of its five key stages. More or less in many contexts policy documents are used to safeguard the formal planning process, pre-defined by some of the expertise. The policy documents are not to fix the people to a pre-defined set of rules. Further, the research employs SNA and centrality measures to understand the findings of the research. The interpretation of ANT does not express a strict process to understand complex planning processes. The current study findings have shown planning processes can be better understood when ANT incorporates Social Network Analysis. This is an interesting finding. Infact, it could be elevated to being one of, if not the key contribution, that this research makes. As per the findings of the analysis intermediaries plays the role of gatekeepers. According to the concept of betweeness, the actors who are playing intermediary roles are often qualified with negotiations and translations. Thus, the research highlights the necessity of understanding policy documents with possible amendments and up-to-date changes in order to meet the aspirations of the people (Doak and Karadimitriou, 2007). If not, people themselves negotiate the provisions in the acts and laws to make their lives comfortable as happened at Mihindupura.

Throughout the process of planning, laws and regulations are at the zenith and any activity against the law is called as ‘illegal’. But the ANT findings reveal that laws and regulations are not the most prominent focal actors in the planning process, instead they are negotiators. To our knowledge this has not been discussed in previous literature and therefore, this finding can be recognized as a key contribution to our knowledge of understanding complex planning processes. Building on this point, the planning process should not be driven by the laws and regulations, but by the actors who need to recognize other actors and believe in them. Therefore, the research exposes the disjuncture between the uses of law with its actual role Mihindupura community is trying to make themselves comfortable by negotiating the given rules; and using their relationships and associations using personal contacts as the key mode of communication. Application of ANT for Mihindupura reveals that the planned resettlement is driven not only by the plans and regulations but also through the actors away from the legal procedures. Thus, it is necessary to understand the role of planning policy documents in a worknet rather than trying to switch all the actors into a predefined network through policy documents including acts, laws and legal frameworks. Thus, planning process cannot be understood as a fixed process, which delivers fixed outcomes.

In previous studies that have examined actor networks have failed to analyse the role of non-human actors in a planning process where human actors interact and active. It is commonly believed that the legal documents are the bases of the planning procedures when it comes to practice. The findings of the research, however, establishes an argument that legal documents are always the negotiator in a network where human actors move and function. Thus, rather analysing the planning procedures along with social network analysis or ANT, combination of both the theories will deliver a more comprehensive and accurate responses. Understanding planning process is not simple and it has no clear-cut paths and edges. The collaborative approach of using theories and analysis together helps to produce a more holistic picture of planning process in a particular context forgiving the limitations of ANT.

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INTEGRADED COASTAL ZONE MANAGEMENT (ICZM) IN THE MEDITERRANEAN: LOCAL PRACTICES AND IMPEDIMENTS TO IMPEMENTATION

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Abstract:
This article refers to the analysis of "gaps" between institutional frameworks and implementation of actions for the integrated management of the Mediterranean coastal zones and focuses on the local level, dealing particularly with case studies in Mediterranean municipalities, as part of the Mare Nostrum Project. The primary objective of the project - funded by the European Neighbourhood and Partnership Instrument of Cross Border Cooperation in the Mediterranean Programme - is to contribute in the improvement of policy implementation procedures referred to ICZM along the Mediterranean coast, at local, national and cross border level, and in the integration of coastal zone policies to the wider socio-economic and spatial policies. Identifying and analyzing existing legal and institutional tools for spatial planning and ICZM in the case studies carry out this objective. In general, the case studies indicate that local authorities recognize the high importance of coastal zone in urban development and environmental protection. Nevertheless, in all cases, local authorities focus on planning procedures, which are designed to streamline development, while often impairing the public's right to be aware of, and participate in the planning process. If a "bottom up" approach is considered to be essential, public participation procedures should be upgraded and reinforced.

Keywords: *Coastal zone management, urban planning, cross-border cooperation, coastal areas, implementation gap.*

1. Introduction

Article 4.3(e) of the Barcelona Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean, requests the Contracting Parties to promote the integrated management of the coastal zones, taking into account the protection of areas of ecological and landscape interest and the rational use of natural resources. In 2008 a Protocol was developed to provide a common framework for the implementation of the above. Despite the signing of the Protocol, the widespread degradation of the Mediterranean coast continues, due to pollution, and uncontrolled residential, tourist, and recreational development. In parallel, the ICZM Protocol is poorly implemented by member states, while numerous stakeholders with overlapping responsibilities and low level of understanding and cooperation are involved in its implementation on local, regional, national, and cross border level.

This article is based on research conducted for the Mare Nostrum Project (2015). The primary objective of the project is to contribute in improving policy implementation procedures referred to ICZM along the Mediterranean coast at local, national and cross border level in order to complete the integration of coastal zone policies to the wider socio-economic and spatial policies while increasing its resilience to natural and man-made hazards. Identifying and analyzing existing legal and institutional means that are available for the implementation of spatial planning and ICZM to participants from Israel, Greece, Malta and Spain carry out this objective. Coastal planning and management tools are treated as instruments that are embedded in the broader legal, institutional, administrative and economic framework. The phased program and method might facilitate the realistic implementation of ICZM within and across national borders in the Mediterranean.

2. Methodology

The first stage of the methodological framework was the identification of the case study areas for every participating country. The actual factors for the selection were the need to cover different case areas as type of coastal environment (urban, rural, port, etc.), and the necessity to include cases with potential of cross-border cooperation (MARE NOSTRUM Project, 2015). According to these factors, the case studies selected were:

- The issue of illegal constructions in the coasts and the Delta area of Evros River, in the Municipality of Alexandroupolis in Greece.
- The definition of a setback zone of a coastal neighbourhood in the Municipality of Kavala in Greece.
- The improvement of accessibility and potential for public uses of the coastal area of the Municipality of Haifa in Israel.
- The urban regeneration of the area of the Port of Valetta in Malta.
- The restoration and upgrading of the natural environment in the Albufera coastal area, south of Valencia, in Spain.
- The land use management of the bay area in the city of Alicante, in Spain.

The second stage focused on gathering the necessary and available information of each case study (MARE NOSTRUM Project, 2015). The collection had two goals:

A. Create an inventory of relevant conditions for the local study areas, including environmental, socio-demographic, economic, administrative, legal and institutional data, as well as information about situations of geopolitical conflict, if there were any. A set of templates was selected as a tool for this purpose.

B. Complete an opinion survey among local stakeholders, decision makers and relevant actors concerning ICZM issues in their areas. An open questionnaire was selected as a tool for this purpose.

The opinion survey was proved to be very significant, given that it investigated the degree of understanding of the respondents regarding ICZM issues at the local level. This was used as a starting point of reference in the case studies, in relation to which, improvements or stagnation was assessed in ICZM practices in the duration of Mare Nostrum project. In addition to this, the identification of existing gaps between legislation, regulations, and policies at the local level from the one side, and the supranational initiatives (EU directives, protocols etc.,) from the other side, was also facilitated in the survey (MARE NOSTRUM Project, 2015).

The outcomes of the survey greatly helped in shaping up the complete “pictures” of the case studies described below, and were, in turn, significant inputs for the formulation of the conclusions.

3. The Case Studies

3.1. ILLEGAL CONSTRUCTION IN EVROS DELTA PROTECTED ZONE (ALEXANDROUPOLIS, GREECE)

The Evros Delta is a protected natural park in northeastern Greece, at the borders with Turkey. Administratively it is part of the Municipality of Alexandroupolis, and belongs to the Region of East Macedonia and Thrace. The municipality has a population of 60.000 inhabitants. The Delta area is 378 sq. km, and the coastline length is 65 km. Most of its area is agricultural land (86,2%) with 12,5% forest land and 1,3% urban land (rural communities). The coastal zone setback is at 100 m. in this protected area, although generally, in Greek seashores, it is legally specified to be 50 m. Finally, the ICZM policy implementing institutions at a local scale are the Decentralized Administration of Macedonia & Thrace, which is the regional branch of the central government, the Regional Authority of East Macedonia & Thrace, the Alexandroupolis Municipality, the Alexandroupolis Port Authority S.A., and the Evros Delta National Park Management Agency.

Concerning the Alexandroupolis case study, the dispute between environmental preservation and illegal constructions used for recreation, fishing and hunting, has been a hot issue for the last 15 years. Legislation particularly focusing on Evros Delta is a Joint Ministerial Decree on the National Park (Greek Ministry of Environment, Spatial Planning and Public Works et a., 2007). It allows no constructions or private establishments and activities of any kind, and it provides for the immediate demolition of the constructions. The same provisions for constructions of this type, are also provided in legislation concerning urban and regional planning at the national level (laws 2508/97 and 2742/99), and in their implementations at the local level (the Regional Spatial Framework of the Region of East Macedonia and Thrace, currently under revision, and the Master Plan of the Municipality of Alexandroupolis, currently under preparation), both being legally binding.

Informal meetings and demonstrations of the owners of the illegal huts were of strong influence to the local authorities. Consequently, no hut was demolished, the fines issued for illegal constructions were never paid, and initiatives for the environmental-friendly transformation of the area, included in the Regional Operation Programme, were never implemented.

3.2. DISPUTE CONCERNING SEASHORE BOUNDARIES AND SETBACK LINE IN COASTAL NEIGHBOURHOOD (KAVALA, GREECE)

The city of Kavala is a port in North Eastern Greece. It is part of the Region of East Macedonia and Thrace, and it is the seat of the Municipality of Kavala. The population of the city is 65.000 inhabitants, its area is 40 sq. km, and the coastline length is 35 km. In terms of land uses, 45% of the municipal area is urban, 15 % agricultural, 2 % forest, 2 % mining, 1 % archeological, 0,2 % military, 2 % industrial, 2 % transportation, and 2 % tourism. The coastal zone setback, as mentioned in the previous case, is legally specified at 50 m., but the delineation of the setback is made with a non scientific and outdated method, which raises disputes. The main local policy implementing institutions, related to ICZM, are the Decentralized Administration of Macedonia & Thrace, the Regional Authority of East Macedonia & Thrace, the Kavala Municipality, and the Kavala Port Authority S.A.

In Kavala, there are several legal disputes between property owners and the state, on the exact definition of the shoreline and the coastal zone setback line (shoreline and beach). Legally, the issue is being dealt in the law on coasts and beaches (L. 2971/2001) (Greek Ministry of Environment, Spatial Planning and Public Works, 2001) and also in two plans prescribed by national legislation concerning urban and regional planning (Spatial Framework of the Region of East Macedonia and Thrace, currently under revision, and the Master Plan of the Municipality of Kavala, recently approved. The above two plans are prescribed by laws 2508/97 and 2942/99). According to them, the houses of the residents of the particular neighbourhood are located inside the coastal zone, and thus, they do not have legal status, with all the accruing consequences (fines, demolition). In this case, the lack of a scientifically documented method for the determination of the boundaries of the zones of seashore and beach in the existing legislation created the implementation gap.

As far as public participation is concerned, public consultation took place during the preparation processes of the Master Plans, the City Plans, and the Action Plans of the municipalities for both Greek cases. In practice, though -with the exception of administrative departments of related interests- there was no substantial, active participation of the local population, unless the specific plan or project or activity, directly affected private properties. The public's role in general, was consultative and never decisive.

3.3. THE SOUTHERN SEASHORE AND COASTAL NEIGHBOURHOOD (HAIFA, ISRAEL)

The city of Haifa is a significant port in the Mediterranean side of Israel. In administrative terms, it comprises the Municipality of Haifa. The area of the coastal neighbourhoods of the southern seashore –which constitutes the Haifa case study- is 2,88 sq. km, its population reaches 13.790 inhabitants, and the coastline length is 9 km. All the study area is urban, of which 10% is protected area, and 10% hosts military installations and compounds. The coastal zone setback is legally specified at 300 m., and -according to national legislation- coastal areas are public, or property of the State. The main policy implementing institution at a local scale, related to ICZM, is the Municipality of Haifa.

In Haifa, the pressure for development of the Haifa coastline is balanced against the identified need to preserve the coastal ecological systems and facilitate public access to the coast for recreation. Related legislation is the Coastal Environment Protection Law (Ministry of the Environment of Israel, 2004), the National Outline Plan 13 (Israel's National Planning and Building Council, and Amendment 3 to it, approved at 2007). Local Authorities Law (Israeli Parliament, 2008) grants enforcement powers to inspectors of local authorities on issues covered by the law and on issues not covered by local by-laws (Haifa Municipality does not yet have authorized inspectors). The District and Haifa Outline Plans are the main urban planning tools that incorporate the guidelines of the National Outline Plan 13, and its amendment, marking the coastal zone, providing protection to the coastal environment and aiming to preserve public access and open spaces at the seafront. For decades, the limited access of the coastal neighbourhoods to the seashore, together with a non-integrated development approach, for long prescribed by previous sectorial Development Plans for the coastal zone, resulted in gradually increased separation of the coastal zone from the rest of the city. Since the mid-1990's, the adopted legal instruments have been increasingly oriented toward natural and historical preservation, opening up of the coastline, removing illegal constructions and increasing public access to the sea. In the 2000's, plans were made to redefine the functional area of the Haifa port and move parts of it northward, aiming at opening up large swathes of the coastline as an open public promenade.

In terms of public involvement, the approval process for the National Outline Plan (NOP) requires public notification, and this enables minor public participation through submitting objections in writing, with the planning board reviewing them.

Finally, the factor of cross-border cooperation is being taken into consideration mainly regarding cultural activities, and it is not extended to other issues, mainly due to the political situation,

3.4. GRAND HARBOUR & MARSAMXETT HARBOUR CASES (VALETTA, MALTA)

The city of Valetta is the capital and the main –and unique- port system in Malta. Administratively, it is a unique phenomenon, since Valetta covers most of the national territory and the administrative levels are national (national government, national laws and policies), regional (no administrative unit, but Local Plans that cover regions), and municipal (local councils). The case study focuses on Malta's Grand Harbour and Marsamxett Harbour, with an area of 15,1 sq. km, and population of 68.264 inhabitants. The coastline length is 32 km. Half of the study area is urban, 10% agricultural, 5% protected heritage, 5% archeological sites, 20% industrial, 10% transportation, and 15% tourism (urban land uses overlap with protected heritage ones and archaeological sites). The coastal zone setback is not specified. The main policy implementing institutions at the local scale, are the Office of the Prime Minister, the Ministry for Sustainable Development, the Environment and Climate Change, the Ministry for Tourism, the Ministry for Infrastructure and Transport, Malta Environment and Planning Authority (MEPA), Malta Tourism Authority (MTA), Transport Malta, and Local councils (Valletta, Floriana, Marsa, Paola, Isla, Bormla, Birgu, Kalkara, Pietà, Msida, Gżira, Ta' Xbiex and Sliema).

In the Grand Harbour area, tourism and industrial development pressures negatively affect its historical significance. The competing, and often conflicting land use pressures are dealt by the Development Planning Act (Maltese State, 1992), which introduced the Structure Plan (Ministry of the Environment and Infrastructure of Malta, 1990) as the main legally binding instrument for spatial planning and development control, and the Environment and Development Planning Act (Maltese State, 2010).

The latter, in turn, introduces the Strategic Plan for the Environment and Development (SPED), which is the successor of the Structure Plan. The enforcement units of the Maltese Authorities of the Environment and Planning, and of Tourism, act in order to maintain all legal procedures. In fact, though, most of these actions fail to be effective. Also, Local Plans together with detailed specializations through Subject Plans, Action Plans, Environment and Development Briefs, and Supplementary Planning Guidance documents cover the case study area in terms of planning (Malta Environment and Planning Authority, 2002).

The Structure Plan highlights the importance of an active role of media, NGOs, local councils, official bodies, experts and the general public in planning, as well as their uninhibited access to information. All meetings of the Environment and Planning Commissions and the Environment and Planning Review Tribunal are open to the public and all decisions are accessible to the public. Nevertheless, the ambiguity of certain legal provisions has led to conflicts over the level of public involvement in public consultations and the assessment of development applications.

3.5. SEAFRONT OF «LA ALBUFERA» (VALENCIA, SPAIN)

The seafront of La Albufera is a protected natural park in the area of Valencia in Spain. The population of the area is 4.472 inhabitants, its area is 9,25 sq. km, and the coastline length is 13,5 km. In terms of land uses, 8% of the study area is urban, 13% agricultural, 49% is forest land, 8% is occupied by tourist activities and installations, and 22% comprises of other uses. 92% of the area is protected natural heritage. The coastal zone setback is in general 100 meters wide with occasional exceptions (Pinedo) where the protection area is 20 meters wide. The main, policy implementing, local institutions, related to ICZM, are the Governing Board of L'Albufera Natural Park (consultative body), the L'Albufera Natural Park Executive Board (management body), and the Cooperation Agreement for the implementation of infrastructure activities in L'Albufera area, signed in May 1994, by the Valencia Regional Government and the Ministry of Public Works, Transportation and Environment (MOPTMA).

Concerning L'Albufera case study, the up to recently intense recreational use of the seafront is in conflict with the environmental importance of the area. The conflicting land use pressures are aimed to be dealt by the National Law 2/2013 on the protection and sustainable use of the coastline (Spanish Government, 2013), and locally by the National Park declaration decree issued by the Region (Regional Authority of Valencia, 1986), the Regional Law 4/2004 on Territorial Planning and Landscape Protection (Regional Authority of Valencia, 2004), and a Municipal bylaw on the use of Valencia's beaches and adjacent areas (Valencia City Council, 2010). The Valencia Regional Authority protected the natural resources of the case study area through decrees (Decree 89/1986, Decree 71/1993, Decree 96/1995, Decree 259/2004) and set up three local plans (the Special Plan for the Protection of the Local Environment, the Natural Resources Management Plan, and the Use and Management Master Plan) and two boards (L'Albufera Natural Park Executive and Governing Boards) with wide representation, in order to better manage the area. As part of the urban planning procedures, the Valencia Region Territorial Strategy, which is non-binding, is mainly focusing on the coast.

3.6. BAY OF ALICANTE CASE (ALICANTE, SPAIN)

Alicante is a port city in southeastern Spain, south of Valencia. The case study focuses on Alicante Bay, a coastal area of the city. The population of Alicante Bay is 27.486 inhabitants, in an area of 4,5 sq. km. The coastline length is 9 km. In terms of land uses, 76,5% of the study area is urban with no special protection, 20% is urban protected heritage, 2,5% archeological sites, and 1% is covered by transportation infrastructure. The coastal zone setback is in general 20 m., with occasional exceptions for greater protection where it is set to 100 m. The main policy implementing institutions at a local scale, are the Valencian Regional Government, the Department of Infrastructures, Territory, and Environment (General Subdirectorate of Ports, Airports and Coast) and the Municipality of Alicante, through the Cooperation Agreement on integrated actions in the Bay of Alicante, signed on 5 November 2010.

Regarding the Alicante Bay case study, a complex situation characterizes the area and makes it difficult to deal with, with conflicting land uses and stakeholders' competing interests. Infrastructures and real estate developments barely left any open space in the bay, while the Regional Authority is currently making an attempt to control the situation, as part of the urban planning procedures (through the Regional Law 4/2004 on Territorial Planning and Landscape Protection [Region of Valencia, 2004], and the Valencia Region Territorial Strategy). The planning arsenal is completed by the Alicante General Municipal Urban Development Plan -a non-binding and not yet approved planning tool-, and the Municipal Ordinance for Beaches and Coves. Furthermore, all administrative levels of the area signed the General Protocol on Integrated Actions in the North Bay of the Municipality of Alicante, in a cooperative effort to address the issue, through the function of three committees, on technical, coordination and public information issues.

The Territorial and Landscape Participation Board acts as a direct channel for public intervention, with the obligation to organize public participation processes for plans and projects with significant impact on the landscape. Public participation has taken place mostly within the processes of environmental assessment and urban planning. However, there is no ICZM oriented mechanisms or channels for public participation in the study area due to the general lack of tradition in public participation processes in the region.

7. Conclusions

In the analysis of ICZM in the Mediterranean, the initial aim of the selection of case studies was to cover a wide range of issues, different types of coastal environment, and the possibility of cross-border cooperation. The particular case studies succeeded to achieve these goals, while in the issue of cross-border cooperation investigated the restrictions and the limitations of it in the border case studies.

The first step prescribed by the methodology, for identifying a baseline that derives from the instruments and tools used at the local level is already stemming out from the above analysis and Table 1 below. There are practices in coastal management that are common for all the project's partners. In all cases, urban, land use and environmental plans, as well as regulations and strategies are the key instruments for protecting the coastal zone and nature conservation in general, and controlling pollution and degradation of the coastal environment.

All these instruments and tools are established mostly by the State, through laws and institutional frameworks, covering the national level and guiding local authorities to implement and assess. The top down approach is clear. The regional authorities in Spain -with their legal powers after decentralization- are the only exception to the rule. Also, there seem to be some tools with positive impacts on ICZM throughout the planning history of every case, even if some of them were not fully or partially implemented for political reasons. All municipal authorities are dealing with ICZM issues, through equivalent responsible departments and by using urban plans and bylaws as tools for control and enforcement. These issues mostly concern conflicts of land uses or property rights, there is usually a gap between the related legislation and regulations, and their implementation, and the effectiveness of the authorities' involvement is often weak. Finally, the cross – border cooperation parameter seems to be suffering in ICZM, since there are no legal or institutional instruments at the local level, in order to build upon.

The second step concerning the identification of a baseline for the case studies, is through recognizing the impediments to implementation of the previous legal or institutional tools on the local level, and the positive characteristics of ICZM in each case study. A summarization of the above is exhibited in the two tables drown above.

***Table 1**: Positive and negative characteristics of case studies by nation, concerning implementation of ICZM (MARE NOSTRUM, 2015; 2nd Report).*

Impediments to implementation	**Greece**	**Israel**	**Malta**	**Spain**	**On the positive side**	**Greece**	**Israel**	**Malta**	**Spain**
Limited local government powers	V	V	V		Binding local urban planning tools	V (legal)	V (legal)	V	V
Lack of funds and human resources	V	V	V		Active/educated NGOs	V	V	V	V
Inadequate knowledge on ICZM	V		V	V	Active public participation procedures	V	V	V	V
Problematic coordination between stakeholders	V	V	V	V	Fixed setback zone		V		V
Reduced effectiveness of participatory processes	V		V	V	Coastal land = national land	V	V		V
Setback technical determination (+cadastre)	V		V		National ICZM strategy	?		?	?
Problematic law implementation	V	V	V	V	Provisions for law enforcement service/officers		V	V	V
Weak political will	V	V	V	V	Laws at local level				V
Issues of national sovereignty	V								
Delay in implementation of planning tools	V	V		V					

In the Greek case studies, a positive factor is that there are legally binding planning documents and tools at the municipal and regional level, acting at the local level, and there are ICZM provisions in spatial planning instruments at the regional level. On the other hand, there is little information about the property rights of coastal land, since the land cadastre in Greece is under preparation, and only a very small part of the land registered is coastal area. Also the registration of land in the land cadastre, and the demarcation of the seashore line are two different and many times conflicting procedures, and there is still no scientific method of defining coastal boundaries. The slow procedures regarding preparation and approval of spatial plans create problems of outdated data and proposals. There are no effective procedures of monitoring the coastal zones, and law enforcement is usually jeopardized by the clientelism of Greek politics. Finally, implementation progress is also jeopardized because of issues of national sovereignty on coasts, seas, and seabed, and related disputes between Greece and neighbouring Turkey.

A major positive factor in the Israeli case study, is the definition of seacoasts as public land. ICZM is included in spatial planning at the municipal level and the most important factor, which facilitates implementation in ICZM issues, is the clearly and unconditionally defined setback zone of the coast. The enforcement of laws and planning regulations by local inspectors is limited, and the bylaws of the municipal councils are usually outdated. The cooperation and coordination of civic departments and organizations on the local level and between levels is frequently difficult, and political clientelism, and weak political will to implement the legislation, are phenomena, which frequently affect ICZM in a negative way. On the other hand, no retroactive force of planning laws offers immunity to past mistakes and illegalities, something that may discourage opportunistic favoritism.

In the case of Malta, the existence of a national ICZM strategy constitutes a positive factor. There is legal provision for the appointment of Enforcement Officers. Nevertheless, Malta’s planning system is characterized as discretionary and of a more political than technical nature. There is limited cooperation and coordination of departments and organizations on the local level, as well as between administrative levels. Local plans are binding but not legally, and in this way they can easily be amended. In addition, clientelism is existent and also encouraged by weak political will for implementation of laws, and loopholes and vagueness in the legal instruments. Finally, the lack of a fully functional land cadastre, providing information on land ownership in the coastal zones, creates great obstacles for the implementation of policy measures.

The Spanish case studies have on the positive side, a national ICZM strategy, as this is the only partner-country that has actually succeeded in the ratification of the ICZM Protocol and its legal substance in 2011. Also, the regional authorities are granted the power of issuing laws and legal documents. The legal and institutional frameworks also provide for the appointment of enforcement officers with a high level of relevant education. Due to these officers the demarcation of the coast is almost complete. Nevertheless, there are still active conflicts between the demarcation and the registration of privately owned coastal land, mainly due to amendments and exceptions being passed in the legislation. The excessive degree of housing development from the ‘60s and ‘70s, which occurred without any monitoring and control measures, still makes the implementations of current legislation, difficult. The Cooperation Protocol signed at 2010 by all levels of administration, was only partially implemented, mainly because of lack of economic resources for ICZM of local authorities.

In general, the case studies indicate that local authorities recognize the high importance of coastal zone in urban development and environmental protection. But even if the coastal areas are legally recognized as public good accessible to all citizens, existing territorial planning and management institutions related to ICZM are improving, and the civil society organizations promoting environmental affairs seems to be strong, there is still no ICZM instrument at the local level. Overlapping jurisdictions and responsibilities on a complex environment, such as the coastal zone, block most coordination channels. The loopholes, the vague definitions, the “grey areas” of local laws and plans, combined with the unwillingness of the local authorities to implement the “unpopular” or “inconvenient” parts of the legislation, their limited knowledge on ICZM, and their poor economic resources for monitoring and enforcement measures for coastal protection, are obstacles preventing the formulation and implementation of sound ICZM policies, as they always leave space for excessive and injurious exploitation of the coasts. In all cases, local authorities focus on planning procedures, which are designed to streamline development, while often impairing the public’s right to be aware of, and participate in the planning process. If a “bottom up” approach is considered to be essential, public participation procedures should be upgraded and reinforced. Finally, cross-border cooperation in the case studies is missing, especially on ICZM issues.

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APPLICATION OF OPEN SOURCE HARDWARE AND SOFTWARE IN ASSESSING THE VARYING LEVELS OF PERCEIVED SAFETY IN CITIES

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Abstract:
Although planning is said to be done targeting the people, plan-making processes in most instances are dominated by top-down approaches, giving very little regard to how people perceive or feel about the cities they live in. The perceptions or 'emotions' urban areas trigger, and how these cause behavioural changes reflect the implications of planning and decision making upon them. Prior studies indicate that environmental factors are capable of triggering affective reactions in people. Thus, throughout the course of this study, it was attempted to understand how environmental factors affected University students' perceptions of safety, which were quantified on the basis of emotions, i.e. the calmness or stress felt, and walking speeds. Data on emotional states were captured in real-time by a technically-sound, low-cost device assembled using Free and Open Source Software and hardware. The study demarcated the areas perceived to be 'safe' and 'un-safe' by people, and ranked them based on their perceived safety. The reasons for this classification were then identified. The results concluded that the factors in the environment affected people's emotional states and walking speeds, as people walked faster in areas regarded as 'unsafe' and slower in areas regarded as 'safe'. The data also explained the difference between the behaviour of males and females, when perceived safety was concerned, during different times of the day. This study introduced the chance to identify unconscious emotional reactions of people, which can be served as useful inputs for urban planning. Furthermore, the study will confirm the value of the real-time sensing device as a tool beyond traditional methods in understanding feelings of safety in environmental settings.

Keywords: *Emotions, Free and Open Source Software (FOSS) and hardware, perceived safety, real-time sensing device*

1. Introduction

People, as users of cities encounter a vast array of environmental qualities belonging to environments of various sorts on a daily basis. These environmental qualities are what contribute to the experiences people undergo in these various environments. Certain environments or places may grab the attention of the users and leave them feeling pleased or delighted, while some others leave the users feeling fearful or unsafe (Nasar, 1998). These feelings instilled within city users can be wholly attributable to the qualities of the particular environments. However, these feelings also depend on a number of dynamic and static contextual factors such as time of the day, gender, age, whom they are with, familiarity of the environment etc. (Ratnayake, 2014)

Methods of quantifying the people's perceptions and feelings in urban areas last boomed in the 1960s with Kevin Lynch's concept of Mental Mapping. This was the closest the planning continuum has ever got to quantifying urban perceptions. However, there is still a scientific lack in the discussion of emotional aspects and their correlation with people's behaviour in planning. In the recent past however, scientific research has been done integrating technical and human sensors in combination with direct feedback from people via real-time participatory communication channels such as social media, to determine what areas give rise to various emotions (Raslan et. al., 2014). Despite such technological advancements, which are financially out-of-reach for third world countries, there still is a lack in the application of the emotional data layer in the field of town planning, particularly with regard to quantifying urban perceptions of areas on various grounds such as being wealthy, modern, safe, lively, active, unique, or family friendly. Although emotion extraction is being done in various other fields in many first world countries using the latest, high-end technologies, there is a lack in technologically sound, yet cost-effective technologies to measure and extract these data for countries like Sri Lanka. Therefore, a financially feasible and technologically accurate device is needed for the purpose of extracting people's perceptions and emotions.

2. Theoretical Background

Environments serve as habitats to many and are expected to fulfil the biological needs of those within it to a certain degree, besides its primary duty of providing refuge. Among the many biological needs of living beings particularly humans, the physiological needs, safety needs, belongingness and love, esteem needs, and self-actualization are eminent (Maslow, 1943). However, recent studies indicate that, out of the above needs, personal safety is a crucial factor of lifestyle options, and is said to be one of the main problems threatening the quality of urban life (Noll, 2000; Park et. al., 2001). This causes people to avoid places that they associate with personal risk. (Keane, 1998;

Riger and Gordon, 1981). Thus, perception of safety in any environment plays an important part in the human interactions with the particular urban environment.

How people perceive cities usually depend on a number of dynamic and static contextual factors. Methods of quantifying the people's perceptions and feelings in urban areas last boomed in the 1960s with Kevin Lynch's concept of Mental Mapping, which was the closest the planning continuum has ever got to quantifying urban perceptions. This approach, which reflects the subjective perception of a person in space, considers only the geometric and behavioural dimension, thereby leaving out the emotional dimension. Lynch's concept, along with several other contemporary concepts has influenced research to be carried out coupling modern and innovative tools with traditional techniques to explore the city in the recent past.

The first to combine data from Global Positioning Systems (GPS), with data from biometric human sensors was the artist Christian Nold (2008), who came up with the concept while working on his art project: Bio Mapping. To practically explore the subject, Nold invented a device that was portable and wearable, which recorded data from two technologies: a simple biometric sensor measuring the GSR (Galvanic Skin Response) and a GPS. The trained sample was then asked to walk around an area predetermined by Nold in order to test their emotional responses to the environments of the particular area. This technical method could be regarded as a sequel to and an automation of the work done by Lynch (1965), which overcame the most prominent drawback of mental mapping: the ability of participants to draw and express their imagination adequately.

Subsequently, several researches went on to attempt to better understand space using novel bottom-up approaches. The use of sensor technologies to understand people's perceptions was one such attempt by Resch et. al (2013). In an approach named "People as Sensors", Resch et. al utilized people as sensors following a previous claim made by Siegele (2010) which stated that that humans have turned out to be excellent sensors themselves. This "People as Sensors" approach represents a model in which not only electronic devices produce data sets, but also where people generate subjective measurements by recording their subjective, individual perceptions or observations (Resch et. al., 2013). The uniqueness of this concept is twofold: firstly, this research provides the first application for "ground-truthing" emotions in near real time in an urban context using the concept of "People as Sensors", and secondly, unlike other research efforts, this approach offers direct feedback to real-world processes in urban management and planning, and will help to detect previously unseen urban patterns. One clear limitation of this methodology in extracting emotions however is their over-reliance on Twitter Tweets, assuming that they are written in-situ (Resch et. al., 2013).

Further, affective perception of people's about their environments, in combination with crowdsourcing approaches was investigated by Klettner (2013). Though, in this approach, there is no real-time sensor technology, real-time visualisations of geo-social networks or social media like Flickr, Twitter, Foursquare, Facebook, etc. was made by Neuhaus (2011). The use of psycho-physiological measurements in urban space, for instance, to map emotions was made by Zeile et al. (2014) or with the help of smartphone data and social media data to get collective human behaviour patterns by Sagl et al. (2012). These new data and information layers can provide additional insights into the development of both the physical and social structures of inherently complex and dynamic urban environments (Resch et al. 2015b, p. 200). In research fields of security, aspects of perception of urban spaces and subjective felt security is getting more and more important. Salesses et al. (2013) examine, how the perception of safety of test persons changes during watching randomised Google Street View image pairs. The ratings were aggregated in a city map and compared with criminal statistics. The methods based on a subjective rating of a statistical situation and the test persons were not in situ. There was no embedding of people, thus, the situative urban context was also not considered.

Despite the success of the previous attempts, there were several inherent limitations of these studies: the methods followed and the equipment involved were extremely costly (Nold, 2008), and the data collection mechanisms were not in real time (Klettner, 2013), did not embed people (Salesses et. al., 2013) or excessively relied on social media posts assuming they were written in-situ (Resch et. al., 2013). As a result, the discussion of emotional dimension and their correlation with people's behaviour in planning, particularly has been essentially less researched.

3. Research Question

Accordingly, this research attempts to answer the following question: whether technically sound yet financially feasible anthropocentric methodologies, combining open source hardware and software are capable of assessing the temporal impacts environmental factors have on pedestrians' feelings of safety.

4. Methodology and Results

4.1. CASE STUDY AREA

A site located in close proximity to the University of Moratuwa (Figure 1) was selected to assess the impacts of environmental factors on pedestrian perception of safety and walking speed. The surrounding of the University has developed a particular notoriety in terms of safety over the past number of years and hence was ideal to assess the levels of safety. In the selected site, a continuous path which has varying environmental characteristics was chosen to observe the people's perception and behaviour as they walk along it.

Figure 1, Case study area (Source: Google Earth (DigitalGlobe image, imagery date 8/2/2015)

4.2. SAMPLE SELECTION

With the University of Moratuwa in the vicinity, it had a vibrant university student population that temporarily resided in the vicinity, who were homogeneous in their age categories, i.e. typically ranged within the ages of 20 to 27 years, the familiarity of their surrounding was relatively akin given their daily commutes from where they were boarded to the university, and with relatively alike ties with the environment, given the fact that all those who are boarded in the vicinity of the university are not from the area, hence perceive the area merely as their place of temporary residence. Thus, a sample size of 50 was selected with 50% of gender diversity.

4.3. METHODOLOGY

The purpose of this study is to assemble a cost effective, yet technically sound open source device, in order to examine the temporal impacts environmental factors have on people's emotional states or perceptions, i.e. how the impacts of environmental factors differ based on the time of the day, particularly on the feeling of safety, and their walking behaviour, particularly, the walking speeds. As the first step, the environmental factors affecting people's sense of safety needed to be determined. These vary from place to place and exist in uncountable numbers. For that, the path which spanned over 2.85kms was divided in to 28 segments, each segment spanning over a 100m. After identifying the 28 road segments, serial vision photographs were captured both during the day and night times for each of these road segments.

After capturing the photographs, a pairwise comparison was carried out for each of the 28 photographs, where a single photo was compared with each other on the basis of which photo the person felt reflected a safer environment than its counterpart. In addition to rating what photograph depicted the safer area, the reasons for their selection too were noted down. This process was carried out for the 378 photo combinations (${}^{n}C_{r}$ = ${}^{28}C_{2}$ = 378) by using test persons, where each test person was to rate photo combinations and give reasons for their selection as to what factors made a photo look safer over the other. These reasons were then used as the basis for determining the environmental factors that existed in the area depicted by the photographs.

The complete list of reasons for selection of a photograph was then summarized, cut short and merged to produce the final list of environmental factors (shown below) that contributed towards an area being perceived as safe or unsafe.

1. Inter-visibility of road segment
2. Street-oriented buildings
3. Frequency of vehicular movements
4. Distribution of places attracting people (such as boutiques, bus halts, public institutions etc.)
5. Lighting conditions during the day and night
6. Dead spaces
7. Distribution of households
8. Frequency of pedestrian movements
9. Hierarchy of roads
10. Physical upkeep of the area

Based on the choices made by the test persons, a win ratio and a loss ratio were calculated for each photograph. A win ratio is a statistical rating that depicted the selection of one photo over the others in relation to its level of safety, whereas the loss ratio depicted the non-selection of a photo over the others in relation to its level of safety. The win (W) and loss (L) ratios of image i with respect to image u are as follows:

$$Q_{i,u} = \frac{10}{3}\left(W_{i,u} + \frac{1}{n_i{}^{w}} \sum_{j_1=1}^{n_i{}^{w}} W_{j_1,u} - \frac{1}{n_i{}^{l}} \sum_{j_2=1}^{n_i{}^{l}} L_{j_2,u} + 1 \right)$$

$$W_{i,u} = w_{i,u} / (w_{i,u} + l_{i,u} + t_{i,u}) \qquad (1)$$

$$L_{i,u} = l_{i,u} / (w_{i,u} + l_{i,u} + t_{i,u}) \qquad (2)$$

Here,

w- the number of times an image was selected over its paired image

l- the number of times that an image was not chosen over its paired image

t- the number of times when an image was chosen as equal to its paired image

(Salesses, Schechtner, & Hidalgo, 2013)

Using these ratios, the Q-score for each image pair i,u was computed as follows:

Here,

n^i_w- the total number of images i was preferred over

n^i_l- the total number of images i was not preferred over, and where the first sum extends over j1, the images that image i was preferred over and the second sum extends over j2, the images that were preferred over i.

(Salesses, Schechtner, & Hidalgo, 2013)

Q-scores, or Quotient Scores, are a statistical representation that determines how well-known or well-liked a specific subject is by surveying a group of respondents to determine their choice and gauge their opinions (Chruscinski, 2011). In the context of this study, Q-scores were used to quantify people’s choices of environments on grounds of perceived safety.

After each pair of photos was compared, then the win ratio, loss ratio and the Q-scores were computed for each of the 28 photos, as shown in table 1 below. A high Q-score meant that the area was perceived to be safe by the majority of the respondents, while a low Q-score meant that the area was perceived as unsafe. Each street segment was then ranked based on its Q score, where rank

1, representing the safest segment, was given to the segment with the highest Q score. Additionally, each street segment was concluded on its safety status: whether the segment was perceived to be 'safe' (if W > L) or 'unsafe' (if W < L).

The same process was then repeated for the data corresponding to the night time.

Then, the final list of environmental factors was evaluated using various methods and techniques (Table 1) in order to rate the factors for each road segment. The rating was done using a Likert scale spanning from 1 to 5, where 5 was given when a particular factor was largely existent and 1, when the factor was almost non-existent.
To monitor the actual behaviour of the users within the environment, with special regard to the 28 segments, the Galvanic Skin Response (GSR) and walking speeds were measured of the 50 test persons.

Table 1, Method of analysis, criteria and their corresponding ratings to rate the cues for each road segment

Factor	**Method of Analysis**	**Criterion**
Inter-visibility of road segment	Axial lines and Partial Isovist Analysis using UCL Depthmap 10	Number of axial lines drawn between two anchor points Lesser the number of lines, greater was the inter-visibility
Street-oriented buildings	Isovist Analysis using UCL Depthmap 10	Area visible along the sides of the road from each of the anchor points, also known as the Isovist Area
Frequency of vehicular movements	Based on author's observations	Observed frequency of vehicular movements
Distribution of places attracting people	Based on author's observations	Number of places attracting public users per road segment as a percentage of total buildings
Lighting conditions during the day	Based on author's observations	Hindrance of illumination by various means such as trees, walls etc.
Lighting conditions during the night	Buffer Analysis using ArcGIS and author's observations	Area illuminated by street lighting
Dead spaces	Based on author's observations	Percentage of road frontage taken up by dead spaces per segment
Distribution of households	Based on author's observations	Number of households as a percentage of total buildings per road segment

Frequency of pedestrian movements	Based on author's observations	Observed frequency of pedestrian movements
Hierarchy of roads	Based on the road class classification as per the National Road Master Plan 2007-2017	Class of the road to which the segment belongs
Physical upkeep of the area	Based on author's observations	Observed upkeep and maintenance of the road segment.

The GSR, which was aimed to capture people's perception of safety, is also known as electro-dermal activity, is a property of the human body that causes variations in the electrical characteristics of the skin. The GSR is said to be varying with the state of sweat glands in the skin. Sweating is controlled by the sympathetic nervous system and skin conductance is an indication of psychological or physiological arousal. Thus, the GSR can be used as a measure of emotional and sympathetic responses (Peuscher, 2012).

For the purpose of measuring the GSR of the test persons, a GSR sensor (Figure 2) was used by attaching the two electrodes of it to the index finger and the middle finger of the user's non-dominant hand. Each of the test persons were then asked to walk along the path, on one side of the road, during the day time and during late evening.

The sensor was then connected to a Dccduino UNO, which is a microcontroller board used for creating interactive electronic objects (Figure 3). The GSR sensor was configured to the Dccduino UNO board, and then personalized by coding in the Arduino.

Figure 2, the GSR Sensor
(Source: Grove – GSR Sensor)

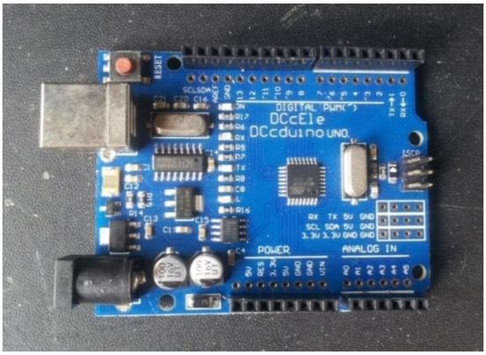

Figure 3, The Dccduino Microcontroller Board (Source: Captured by author)

The GSR sensor readings were captured every 0.2 seconds by the device (Figure 4). For the purpose of refining these readings, only the sensor readings of every second were taken in to account. Then the 'neutral level of arousal' was calculated based on the 'line of best fit'. The difference between the neutral level of arousal and the actual level of arousal was then determined and a conclusion was made as to whether the individual was calm (difference > 0) or stressed (difference < 0) during the particular time. Lastly, the aforementioned difference was averaged to obtain the mean level of arousal for each of the 28 road segments.

To measure the walking speeds of the test persons, a mobile application named Runtastic Pro was used. The main reason behind the selection of this particular mobile application is that this is one of the very few mobile applications in the market that displays the walking speed adjusted by the Naismith's rule. Walking speeds are greatly influenced by the variations in the terrain: people tend to walk slower when climbing a terrain with an upward slope and faster with a downward slope. For the purpose of this study, variations in walking speeds that were caused by the differences in the gradients could not be taken in to account and hence, the walking speeds needed to be adjusted to represent the equivalent speed the person would have travelled at if the terrain was flat. This is called the Naismith's rule. This adjustment was essential as the selected path had massive variations in the terrain.

Time	GSR Reading
1	0.017304
1.2	0.017113
1.4	0.017263
1.6	0.017284
1.8	0.017174
2	0.01669
2.2	0.016663
2.4	0.01782
2.6	0.01771
2.8	0.017179
3	0.017258
3.2	0.01717
3.4	0.017172
3.6	0.017019
3.8	0.017091
4	0.016652
4.2	0.017698
4.4	0.017684
4.6	0.017155
4.8	0.016919
5	0.016885

Time	GSR Reading	Neutral State	Difference	Conclusion	Average Difference
1	0.017303728	0.01670003	-0.0006036976	Stressed	
2	0.016689553	0.01670006	0.0000105071	Calm	
3	0.017258428	0.01670009	-0.0005583378	Stressed	0.0169576451
4	0.016651971	0.01670012	0.0000481494	Calm	
5	0.016884546	0.01670015	-0.0001843964	Stressed	

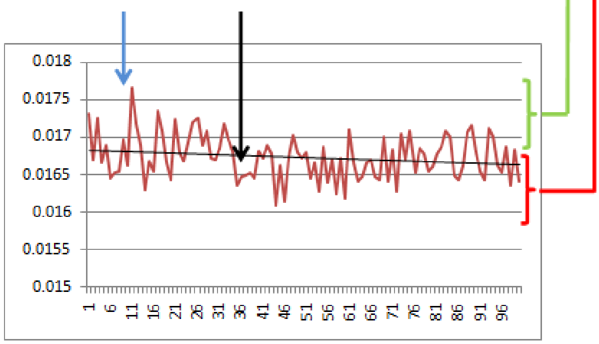

Figure 4, A snippet of the pre-processed sensor readings
(Source: Captured by author based on collected data)

First, the walking tracks of the individuals were exported in the GPX file format and visualized using the Google Earth application. Then, the time taken in seconds to travel from one anchor point to another was gathered. The average walking speed (km/h) too was determined by the GPX tracks and these were later converted to meters per second (m/s). These speeds have been adjusted by the Naismith's rule, as mentioned in the previous paragraph.
After gathering the GSRs and the walking speeds of each of those in the sample for both day and night times, the data were then analysed using various statistical techniques such as Linear Regression analyses, Chi-Squared tests, Independent Sample T Tests, Binary Logistic Regression analyses to infer meaningful conclusions.

5. Findings, Discussion and Conclusion

The study initially demarcated the areas perceived to be 'safe' and 'unsafe' by people, and ranked them based on their perceived safety. The reasons to regard some areas as 'safe' and some as 'unsafe' were then identified. The results of the analysis concluded that the cues in the environment affected people's emotional states and walking speeds, as people walked faster in areas regarded as 'unsafe' and slower in areas regarded as 'safe' (day: $\chi^2(9) = 83.933$, $p < 0.1$, night: χ^2 $(4) = 8.174$, $p < 0.1$). The data also explain the difference between the behaviour of males and females, when perceived safety was concerned, during different times of the day. Men appeared to walk faster than women during the day and the night (day: $t(48) = -7.041$, $p = .000$, night: $t(48) = -5.737$, $p = .000$). However, this does not indicate that the men's perceptions of safety were more significantly influenced by the cues in the environment than that of the women. Both men and women walked faster during the night than during the day (female: $t(48) = -2.555$, $p = .014$, male: $t(48) = -2.268$, $p = .028$). There were no significant differences in the changes in emotional states of males and females, both during the day and night (female: $t(48) = 1.248$, $p = .218$, male: $t(48) = -.784$, $p = .437$). Lastly, the environmental factors or cues affecting the perceived safety during the day ('inter-visibility of road segment' ($p = .101$) and 'physical upkeep' ($p = .118$)) and night ('distribution of places attracting people' ($p = .057$) and 'distribution of households' ($p = .063$)) were identified in order of the significance of their influence.

With the data collection methods widely used in practise at present, it was perceived to be impossible to gather intricate and personal human details such as emotions instantly by most professionals in the field. However, in an ever-so advancing world where technology seemed to have the upper hand, a technological solution seemed the only possibility. As a result, a technologically sound, yet financially feasible device was assembled for the purpose of capturing and recording human emotions, while a mobile phone application captured the changes in the walking speeds. In doing so, the study discarded some of the beliefs held as to the impossibility of quantifying human emotions.

The study initially demarcated the areas perceived to be 'safe' and 'unsafe' by people, and ranked them based on their perceived safety. The reasons to regard some areas as 'safe' and some as 'unsafe' were then identified. The results of the analysis concluded that the factors in the environment affected people's emotional states and walking speeds, as people walked faster in areas regarded as 'unsafe' and slower in areas regarded as 'safe'. The data also explain the difference between the behaviour of males and females, when perceived safety was concerned, during different times of the day. Men appeared to walk faster

than women during the day and the night. However, this does not indicate that the men's perceptions of safety were more significantly influenced by the factors in the environment than that of the women. Both men and women walked faster during the night than during the day. There were no significant differences in the changes in emotional states of males and females, both during the day and night. Lastly, the environmental factors affecting the perceived safety during the day ('inter-visibility of road segment' and 'physical upkeep') and night ('distribution of places attracting people' and 'distribution of households') were identified in order of the significance of their influence.
This study confirms the value of the real-time sensing device as a tool beyond traditional methods in understanding feelings of safety in environmental settings. Methodologies followed by similar preceding studies in detecting human perceptions were extremely costly (Nold, 2008), not in real time (Klettner, 2013), did not embed people (Salesses et. al., 2013) or excessively relied on social media posts assuming they were written in-situ (Resch et. al., 2013). The methodology followed in this study however eliminates all of these shortcomings. The device is open source, and can be assembled by anyone at a cost less than $20. The data on the test people's emotional states and walking speeds were monitored in real time while the test persons were out walking in the study area and embeds people, as the devices were physically attached to their bodies. Further, the study does not rely on social media posts, which can be easily manipulated and may not be posted in-situ by the participants.

Additionally, this study, and the methodology introduced by it offer the chance to identify and analyse unconscious emotional reactions of people, such as the stress caused by travelling through unsafe areas, traffic congestion, high densities of people etc. which can be served as useful inputs for urban planning in devising strategies for the betterment of places. Also, the identification of unconscious decisions, such as increased walking speeds and increased stress levels (indicating the possibility of unsafeness), provide insinuations for planners to understand the city and improve areas that appear to be problematic. Therefore, studying the emotional states and their corresponding behaviour of people in cities, not only provides a new perspective to planning, but also gives due recognition and enables the involvement of the single most important element planning is done for, and has been avoided for decades: the people.

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A COMPARATIVE STUDY OF THE THERMAL PERFORMANCE OF MUD AND BRICK HOUSES IN BANGLADESH

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Abstract
Different building materials respond differently to climatic conditions due to their inherent properties. The thermal properties of building components such as walls, ceiling and floors together determine the energy consumption patterns and comfort conditions in an enclosed space. The aim of this study is to compare the thermal performance of naturally ventilated mud house and brick house, typical in the villages of Bangladesh. The objective is to search for affordable and energy-efficient construction techniques suitable for rural settlements. This is pursued by analyzing mean radiant temperature, Inter-zonal heat gain and comfort level within buildings constructed from traditional and modern materials. The study focus on single storied houses with pitched roof made of CI Sheet and wall materials are traditional mud walls and brick wall with plastered surface. The thermal behavior and comfort, the patterns of energy use of mud wall and brick wall are analyzed, compared and discussed. How a building envelope reacts to outdoor conditions through graphic illustration has been demonstrated and ways in which the research can be extended by the simulations using software has been showed. This research will contribute to the promotion of passive and low energy architecture towards a sustainable future.

Keywords: *Mud house, Brick house, Thermal-performance, Simulation.*

1. Introduction

The traditional houses of Bangladesh are regarded as a good representative of warm humid tropical houses which are adaptable to local climate and well harmonized with local believe and tradition as well as local materials. As the social changes taking place, architecture will play a decisive role in the future development of Bangladesh. Although the society of Bangladesh is still strongly rooted in agriculture, people are getting more educated, privacy and individuality is gaining more importance. The village elite are building in bricks; the government or non-government organisations have buildings made out of brick or concrete; and the same applies to the temples and mosques. The hierarchy of materials is very clear. The perfect home seems to have nothing in common with the traditional house in earth, bamboo or mud.

Traditional built forms of the rural area often includes sound solution for climatic problems. The temperature difference between rural and urban areas is 4K to 5K (Mallick, 1993).According to user experience, traditional houses of Bangladesh are less hot during the daytime, but it becomes comfortable within a short time after sunset. Although these traditional building materials are highly sustainable, people are seeking for materials such as bricks, concrete, and corrugated iron sheets that are supposedly more durable. Therefore, the question arises on how the traditional house of Bangladesh can afford to control natural climate for achieving thermal comfort environment in the indoor space.

2. The context of the study

Bangladesh is located in the tropical monsoon region and its climate is characterised by high temperature, heavy rainfall, often excessive humidity, and fairly marked seasonal variations. From the climatic point of view, three distinct seasons can be recognised in Bangladesh - the cool dry season from November through February, the pre-monsoon hot season from March through May, and the rainy monsoon season which lasts from June through October. In winter there is not usually much fluctuation in temperature which ranges from minimum of 7C-13C to maximum of 24C-31C. The maximum temperature recorded in summer months is 37C although in some places this occasionally rises up to 41C or more (BBS, 2012).

3. Objective

This study compares the thermal performance of mud and brick houses in Bangladesh to show that mud houses are better suited for the naturally ventilated rural houses and provide a comfortable living condition compared to brick walled houses.

4. Methodology

Relevant published documents as well as researches previously conducted on the thermal performance of mud house structure, thermal mass of a building material, the distinct advantages of mud construction in hot- dry climate, traditional mud housing technology of Bangladesh and potential of mud construction in terms of thermal comfort have been extensively studied.

The study comprised of computer modelling, which used known thermal resistance values of the various layers of building materials, to calculate the overall thermal resistance of the system. Hourly values of incident and diffused solar radiation and outdoor temperature were used to simulate hourly temperature, mean radiant temperature and inter-zonal heat gain. The simulations were performed with recorded weather data for Dhaka, Bangladesh. For this purpose the test unit, the mud wall and brick wall buildings was first modelled in ECOTECT, and then thermal properties of the constructional elements were varied in order to measure the effect of these changes on the thermal comfort of the occupants. It should be noted here that for this simulation study, wall thickness was kept constant (50 cm) for all materials. The room was rectangular in size with a length of 27 feet and width of 18 feet, the longer side facing the south side. The roofing system considered is pitch roof of CI sheet and openings are placed on southern and northern walls. All conditions were kept constant except for the wall materials to find out the results. The comfort band is selected between18.0-26.0℃.

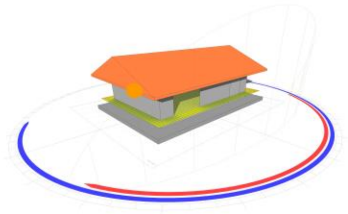

Figure 01, Study model with brick wall

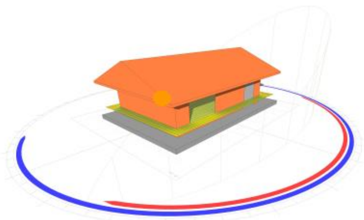

Figure 02, Study model with mud wall

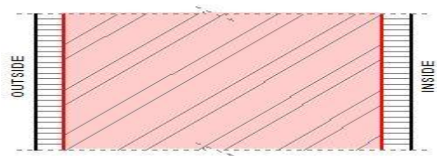

Figure 03, Considered section for brick wall

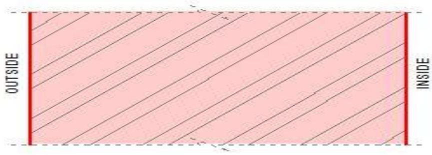

Figure 04, Considered section for mud wall

Field work is conducted with data loggers to find out the actual temperature difference in mud and brick walled house. The data was compared with the simulation results.

5. Literature review

The thermal performance of mud house structure was rarely reported and compared with another type of building (Red brick structure) in the literature. The thermal mass of a building material describes the ability of that material to absorb heat, store, and later release it either outdoor or indoor. Thermal mass can delay heat transfer through the envelope of a building, and help keep the interior cool during the day when the outside temperature is relatively higher (Amos-Abanyie, S., 2012). When thermal mass is exposed to the interior, it absorbs heat from internal sources and dampens the amplitude of the indoor temperature swing (Chenvidyakarn T, 2007).

This is particularly beneficial during warm periods, when the internal heat gains during the day is absorbed, and help to prevent an excessive temperature rise and reduction in the risk of overheating (Yam et al., 2003). A building with high thermal mass has the ability to absorb heat and provide a cooling effect which comes from the difference between the surface (radiant) temperature and that of the internal air. Szokolay (2004) accounts that absorptance/reflectance will strongly influence the solar heat input. Reardon (2010) agrees with Szokolay (2004) by asserting that porous materials with low specific heat exhibit low thermal mass effects. Additionally, good thermal conductivity and high reflectivity are also required for effective passive cooling by thermal mass.

C.V Coffman et al (1980) reported that the mud house construction have natural air conditioning effect because the rooms are cool during day time and warm during night time. The application of mud as wall material was investigated to control room air temperature for buildings by R.J Duffin et al (1981). The most common passive solar building architecture comprises of massive walls to reduce the temperature fluctuations inside a building. The popular mud-houses in Yemen city utilize this effect. The use of mud as building material is of great concerns not only for the people in hot developing countries, but also for those in cold industrialized countries in Europe and America. The engineers from developed countries have realized the special features of mud. The wider use of mud construction has a good reputation in dry and hot places because of its distinct advantages, e.g. the mud habitat suits different weather and geographical conditions as the temperature remains temperate throughout the year inside the mud building (SM. A Eben, 1990). H Algifri et al (1992) compared the thermal behaviour of adobe house with modern concrete house in Yemen and reported the potential of mud as construction material for energy saving in passive houses.

6. Mud construction in Bangladesh

ATHERMAL PERFORMANCE OF MUD AND BRICK HOUSES IN BANGLADESH

Mud construction, along with other alternative materials such as rammed earth and straw bales, are often promoted as ‘sustainable’ building materials. One aspect that makes these materials perceived to be ‘sustainable’ is their embodied energy. If made locally, the embodied energy of rammed earth and mud brick is estimated to be around 0.7 MJ/kg, less than 30% of the embodied energy of clay bricks (2.5 MJ/kg) and less than 20% of the embodied energy of lightweight aerated concrete blocks (3.6 MJ/kg) (Lawson, 1996). On the other hand, the thermal performance of these materials is often overly stated in many publications. Earth walls are claimed as having “superior insulation”, providing “excellent protection from extremes in climate” due to their hefty thickness, thus lowering heating and cooling needs (Austin Green Building Program, 2009).

In Bangladesh, a mud house is one of the traditional housing types that are used in rural areas as well as in the outskirts of small cities. This building type is typically one or two stories and preferably used for single-family housing. The main load bearing system consists of mud walls of 50 cm thickness (Nasir Uddin, 2007), which carry the roof load. Clay tiles, thatch or CI sheets are used as roofing materials. The application of these materials depends on their local availability and the ability of the house owners. According to the findings by Amrita Das and Mohammad Shariful Islam, the plan shape of this type of construction is generally rectangular with lengths between 20-30 ft and widths between10-15 ft (Amrita Das et al., 2007). The main structural elements are mud walls which carry the load of the roofing. The opening area is about 30 percent of the total wall area. However in present time, brick made houses with CI sheets as roofing materials have become popular mode of construction. Due to the fact that brick walls are levelled as more durable, with economic developments in rural areas more people are attracted towards brick houses. But brick walls with CI roofing can cause overheating and uncomfortable living conditions in the climatic context of Bangladesh.

Indigenous material such as mud brick has been widely used in rural areas of Bangladesh for centuries. Mud brick is environmentally friendly. It possesses high thermal capacity and acts as heat sink in extreme weather conditions. Straw which is an agricultural waste can also be used as a building material. Traditionally, it is mixed with clay or soil to produce mud brick. It also possesses good insulation properties. The energy requirement in a building can be reduced to minimum by the application of thermal mass of mud wall. Heat-gain modulation can be achieved by properly using the thermal mass of the building itself in order to absorb and store heat during the daytime hours and release it to the atmosphere after few hours.

7. Data Analysis

For the months of March, July, and December simulations are run on the mentioned model in ECOTECT. The comparative analysis of the findings is discussed below.

7.1. MEAN radiant temperature and Hourly temperature comparisons:

The Mean radiant temperature simulations show the temperature within the selected zone. By comparing with the simulated results, we can determine which material performs well to provide comfortable indoor conditions in a given time of a particular day.

There are three shaded zones and three lines on the hourly temperature graph. The blue shaded zone marks the temperature where the occupants will feel cold, the white zone marks the comfort band of temperature and red shaded zone indicate temperatures where the occupants will feel hot. The blue line represents the outdoor temperature, Brown line shows the temperature of CI roofing and Green line represents indoor temperature.

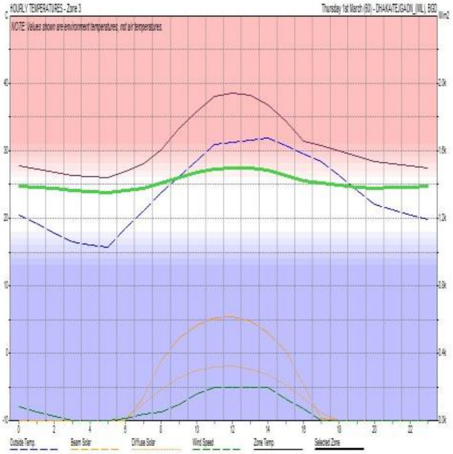

Figure 5, Hourly temperature for mud wall (1st March)

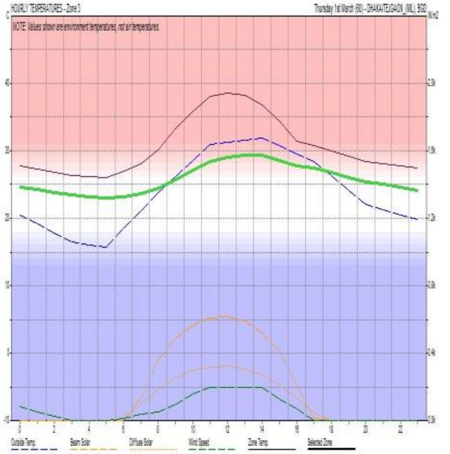

Figure 6, Hourly temperature for brick wall (1st March)

From the mean radiant temperature and hourly temperature graphs, it clearly shows that for the month of March with a mud walled house, the indoor temperature remains less than the outdoor temperature within the comfort range marked by the white shaded zone.

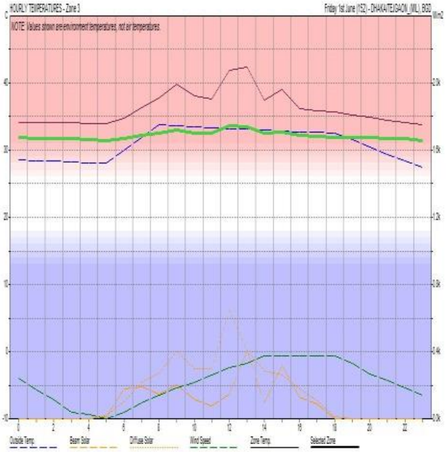

Figure 7, Hourly temperature for mud wall (1st June)

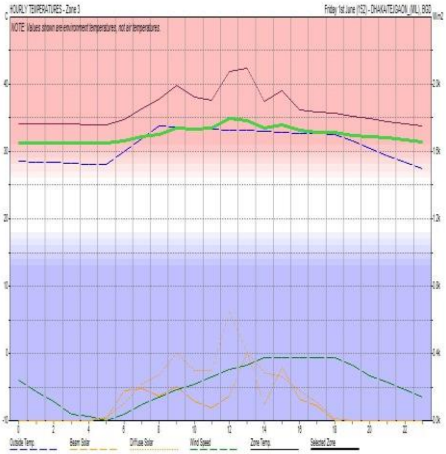

Figure 8, Hourly temperature for brick wall (1st June)

From the mean radiant temperature and hourly temperature graphs, it again shows that for the month of June with a mud walled house, the indoor temperature remains less than the outdoor temperature but for certain time of the day (from 11 am- 2 pm) the indoor temperature exceeds the comfortable range but for the brick walled house, the deviation is much higher.

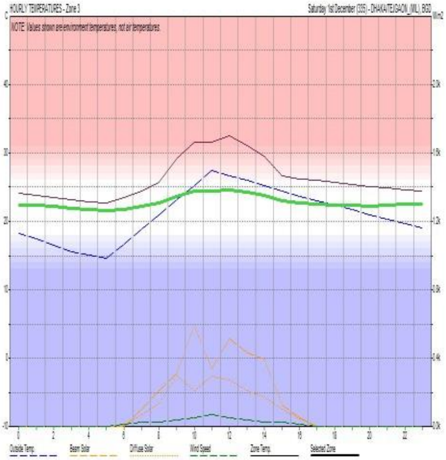

Figure 9, Hourly temperature for mud wall (1st Dec.)

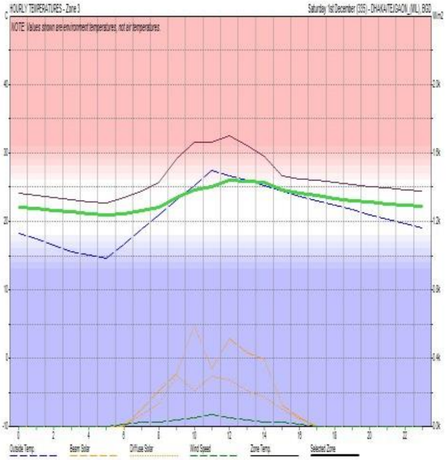

Figure 10, Hourly temperature for brick wall (1st Dec.)

From the above diagrams and graphs, it is seen that both mud walled and brick walled house keeps the indoor temperature within the comfort range. But from the hourly temperature graphs it can be seen that mud walled house shows less variation in internal temperature compared to the brick walled house.

7.2. Temperature in comfort zone:

The thermal comfort range is dependent on various factors like humidity, wind speed; solar radiation and also can vary person to person. Keeping these factors in mind, for 70% humidity and 0.5 m/s wind speed, the comfort band is selected between18.0-26.0℃ (PLEA, 2011). By running comfort simulations in ECOTECT, the following results are obtained.

Mud wall	Brick wall
Operation: Weekdays 00-24, Weekends 00-24. Comfort Band: 18.0 - 26.0℃ In Comfort: 3911 Hrs (44.6%)	Operation: Weekdays 00-24, Weekends 00-24. Comfort Band: 18.0 - 26.0℃ In Comfort: 3625 Hrs (41.4%)

So it shows that the indoor temperature in a mud walled house will remain within comfort range more than that of a brick walled house.

7.3. Passive gains or loses:

The passive heat gain or loses was analysed in ECOTECT to find out how the amount of heat is gained of lost is varied with the change of wall materials.

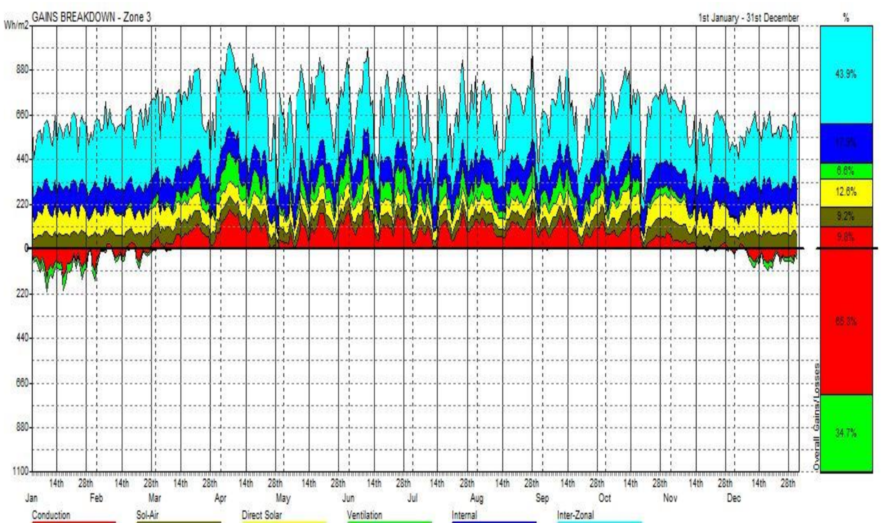

Figure 11, Passive gains or loses graph for mud walled house

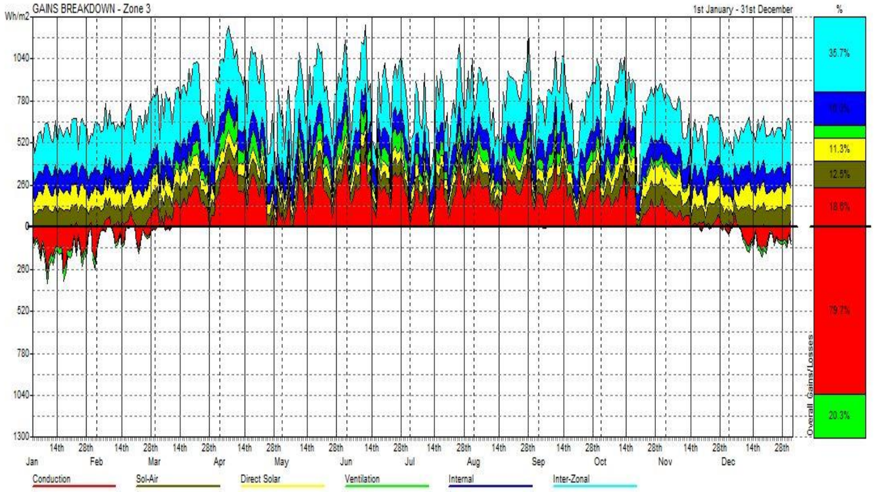

Figure 12, Passive gains or loses graph for brick walled house

From the graphs, it is clearly seen that the amount of passive heat gain is much higher in Brick walled house compared to a Mud walled house.

8. Field investigation

For field investigation, two houses were selected in the same location, adjacent to each other so that nesting conditions remain same. South east inner wall was selected for installing Data loggers in the test rooms for collection of various climatic data.

8.1. Selection of study room:

The selected rooms were similar in size and shape; both had CI roofing under which a ceiling was constructed with bamboo mat. The wall thickness varied in the mud house from 50 cm at the bottom to 20 cm at top portion. The brick wall was 15 cm in thickness. Both houses had openings on east and south walls and had partial shading from trees.

Figure 13, Selected rooms for field investigation (view from east side)

8.2. Installation of Data Loggers:

The data loggers were installed in the test room at two points at a height of 1.8 meter (close to the human height but away from children's reach) from the floor level of the test room (Fig. 14). Loggers were mounted on the wall with the help of hook and loop tape.

Figure 14, Installed Data Logger in Mud house

Figure 15, Installed Data Logger in Brick house

8.3. Field Results:

The recorded data from Data Loggers were compiled and plotted in graph. From the graph, it is seen that the maximum temperature recorded in the mud house was 31.5°C while for brick house it was 33°C.

The maximum temperature recorded in mud house was at 3:06:12 PM, while in brick house it was at 2:17:29 PM which shows a longer time lag for the Mud house. The graph also shows that in Mud house, temperature and humidity fluctuation is less than Brick wall house resulting in a more comfortable living condition.

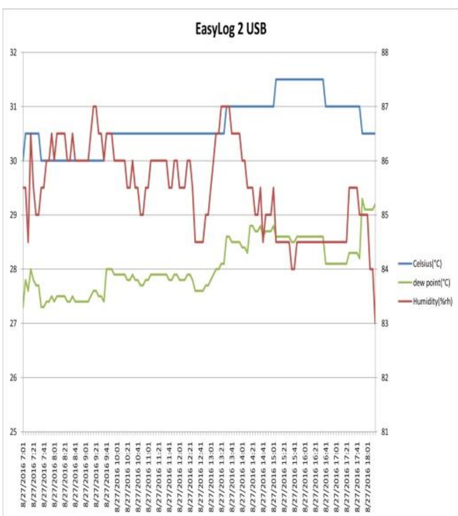

Figure 16, Temperature, RH and Due point in Mud house

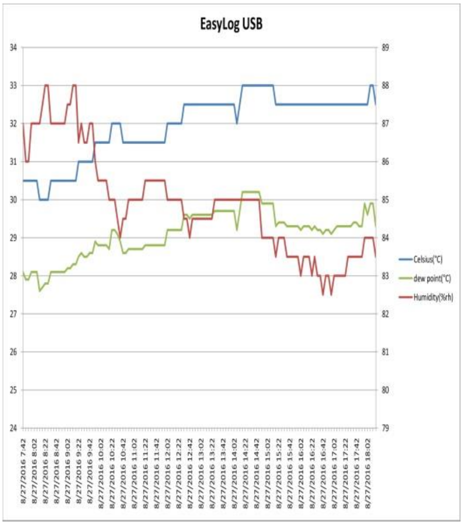

Figure 16, Temperature, RH and Due point in Brick house

9. Findings and remarks:

From simulation, it can be seen that the indoor temperature in a Mud walled house will remain within comfort range more than that of a Brick walled house. The amount of passive heat gain is much higher in Brick walled house compared to a Mud walled house.

From field data, it was observed that Mud house showed lower temperature compared to Brick house. Results show a longer time lag for the Mud house which can reduce cooling loads.

The study was conducted only for houses with CI sheet as roofing. Further studies can be conducted to show the impact of roofing material in the indoor temperature and find out whether the conditions can be further improved in the Mud house with the use of other types of roofing. Lower indoor temperature can result in less consumption of energy and reduce carbon emission. By using Mud or Earth as building material we can promote a sustainable living environment and reduce thermal stress.

10. Conclusion

The comparisons between mud walled and brick walled house reinforced the fact that mud as a building envelope keeps the inside of the hut cooler in summer than outside and warmer than outside in winter in comparison with brick wall. However the cooling effect of these traditional mud houses can be further improved and thermal comfort conditions inside the huts improved by proper design considerations.

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OCCUPANTS' SATISFACTION ON GREEN CERTIFIED FACTORY BUILDINGS IN SRI LANKA

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Abstract:
Factory buildings play an important role in socio-economic environment in Sri Lanka while significantly contributing to the resource consumption. Therefore, the application of green building concept, which ensures the well-being of both human and environment is crucial to this end. While leaving a lighter footprint on the environment, a successful green building should be able to meet the classical building design concerns of economy, utility, durability, and comfort requirements. The occupants' satisfaction also needs to be given a special attention as it directly relates with the occupants' productivity. However, a lack of concern on the occupants' satisfaction can be seen in green factory buildings in Sri Lanka and thus, the research aimed at investigating the occupants' satisfaction and identify the causes for dissatisfaction if any. A semi structured questionnaire survey was conducted among total of 50 occupants selected from five green factory buildings in order to identify their level of satisfaction. The Mean Weighted Rating method was employed for data analysis. The research identified that the satisfaction level of occupants is at a good level though the occupants' dissatisfaction in green factory buildings was mainly caused by difficulties engaged with adjusting the light, room temperature, and room ventilation levels.

Keywords: *Occupants' Satisfaction, Green Buildings, Factory Buildings*

1. Introduction

Green Building concept is a practice of creating and using healthier and more resource-efficient model of construction, renovation, operation, maintenance and demolition (Chan, Qian & Lam, 2009 and Calkins, 2004). According to the United States Green Building Council [USGBC], (2009), green buildings reduce the environmental impact significantly while using energy, water, and other resources efficiently by adopting various sustainable attributes for resource conservation Those attributes are sustainable site conditions, energy consumption, water efficiency, indoor environmental quality, material uses, etc. As Wong and Fan (2013) mentioned, due to global environmental concerns, green building design has become a mainstream building design goal in recent time. In the context of Sri Lanka, the green building concept is quite new but, is rapidly expanding all over different industries while searching for more resource efficient buildings for their usage (Green Building Council Sri Lanka [GBCSL], 2011). Manufacturing industry is one such industry and as a result, a number of green certified factories have been launched in the country.

Even though the green buildings provide many benefits and minimize the negative impact on environment, as per the previous researchers, occupants of some green building are not satisfied with their indoor environment (Leaman & Bordass, 2007). According to Abbaszadeh, Zagreus, Lehrer and Huizenga (2006), while some of the best green factory buildings can rank higher than the best conventional factory buildings, in terms of user experience i.e. comfort, health and productivity, a few of the lowest scoring factory buildings on user experience are also reported as being green. The environmental performance is not the only factor that should be considered in green buildings and occupants' satisfaction also needs to be given a special attention as it directly related with the occupants' productivity. Further, knowing about the satisfaction level of employees is important for the management of the factories to take initiatives to avoid such dissatisfactions. This study therefore, aimed at investigating the occupants' satisfaction level of green certified factory buildings in Sri Lanka.

The paper structure begins with a literature review on green building concept and the determinants of occupants' satisfaction in factory buildings. The paper then presents the methodology adopted for this study and discusses findings on the occupants' satisfaction level under each determinant. Finally, the paper is concluded by summarising the findings.

2. Literature Review

The following section reviews the literature findings gathered through a comprehensive literature survey.

2.1 GREEN BUILDINGS

As mentioned by Kats (2003), "green" or "sustainable" buildings use resources such as energy, water, material and land more efficiently than conventional buildings and contribute to improve occupants' health, comfort and productivity by providing more quality indoor environment. The main characteristic of the green buildings is the change of the built environment by creating energy efficient, healthy and productive buildings that reduces of the negative impacts of buildings on environment (Gou, Prasad and Siu-Yu Lau, 2013).

As Bombugala and Atputharajah (2010) highlights, green buildings reduce carbon emissions by 35%, water usage by 40%, energy usage by 50%, and solid waste by 70%. Similarly, United States General Services Administration [USGSA] (2011) found out that, green buildings have 19% lower aggregate operational costs, 25% of less energy, and 36% of fewer CO_2 emissions. Nevertheless, green buildings should effectively use natural resources within economic means while supporting the health and wellbeing of the occupants (Wilkinson, Reed, & Jailani, 2011).

According to Gou et al. (2013), series of green building rating systems, protocols, guidelines and standards have been initiated in several countries with the green building revolution in past 20 years to fulfill the requirement of evaluating and benchmarking the performance of the buildings. United Kingdom (UK) started the first green rating system in 1990 known as Building Research Establishment Environmental Assessment Method (BREEAM) followed by United State of America (USA) in 1998, with Leadership in Energy and Environment Design (LEED). In addition, some of the other leading green building rating systems described by Isa, Rahman, Sipan, and Hwa (2013) are Building Environmental Assessment Methods (BEAM) – Hong Kong; Comprehensive Assessment System for Building Environmental Efficiency (CASBEE) – Japan; Green Building Label (GBL) – China; Green Star – Australia; Green Mark – Singapore and Green Building Index – Malaysia. Amongst those green rating tools, LEED is the most popular rating tool which provides third party certification of green buildings and its market share is increasing in both US and international arena. GBCSL came into existence as a result of an emerging trend towards applying greener concepts for the built environment in Sri Lanka (GBCSL, 2011). However, a wide use of LEED rating system can be seen in Sri Lankan context as well, due to its international recognition.

2.2 OCCUPANTS' SATISFACTION ON GREEN BUILDINGS

Workspace satisfaction is directly affected to the job satisfaction. Occupants' needs have to be considered for comfort and workspace quality. These factors are very important for physiological and psychological reasons and play a significant economical role (Wagner, Gossauer, Moosmann, Gropp & Leonhart, 2007). The mental satisfaction, clear mind and reduced stress enhanced their concentration on work and it cause to reduce errors made by employees (Samaranayake & Silva, 2010). Moreover, Frontczak, Schiavon, Goins, Arens and Wargocki (2012) explained that much lower self-estimated productivity is reported by the occupants who worked in uncomfortable work environment than those who felt comfortable with the overall environment.

The positive influence of green buildings on the occupants and employee productivity has been reported in the literature. The financial rate of return for productivity increases attributable to green building were shown to be nearly ten times than the energy, water, and other benefits. These financial savings are resulting from reduced absenteeism, improved product quality, increased rates of production and increased sales due to the employee satisfaction on green buildings (Gabe, Greenaway, & Morgan, 2007; Kats, 2003; Romm & Browning, 1994). Moreover, as USGSA (2011) highlighted, the occupant satisfactision on green buildings is 27% of higher than the conventional buildings. Further, this satisfaction is affected by indoor environmental quality which consists with thermal, acoustic, visual, indoor air quality, and by other features such as privacy, cleanliness, and personal control over the internal environment (World Green Building Council, 2013).

However, as stated by some researchers (Kim, Hwang, Lee, & Corser, 2015; Altomonte & Schiavon, 2014), although green buildings have the potential to enhance indoor environmental quality, they often fall short. Further, green certifications do not influence the satisfaction of occupants even though the buildings meet the recommended standards (Prakash, 2005). Some evidences from recent post-occupancy evaluations showed that, the green buildings often not perform to their best and therefore, the occupants' satisfaction is at a low level (Abbaszadeh et al., 2006). A study done by Prakash (2005) found that the occupants often complain about various parameters like day lighting and thermal comfort which directly contribute to better indoor environment quality and which has a positive impact on occupants' satisfaction of productivity and performance (Prakash, 2005). A study done by Ranasinghe, Perera, and Halwatura (2012), concluded that there were occupants who were dissatisfied with acoustic quality, artificial lighting and thermal comfort in green buildings. The, correlation between user satisfaction and the self-estimated job performance affects to the employee productivity (Veitch, Charles, Farley and Newsham., 2007) and therefore identifying the satisfactory level of occupants in green factory building seems essential in order to overcome the drawbacks that can be happened as a result.

2.3 DETERMINANTS OF OCCUPANTS' SATISFACTION ON GREEN FACTORY BUILDINGS

Under the support of Marks & Spencer's eco-initiative, one of the leading companies in Sri Lanka has built the world's first purpose-built green factory for apparel manufacturing and currently, most of other leading apparel manufacturing buildings are being certified as green (Mendis, 2013). The occupants' satisfaction level of the factory buildings should be in a higher level since they incorporate productivity driven business process (Kamaruzzaman &

Sabrani, 2011). Therefore, there is a need of investigating the occupants' satisfaction on green certified factory buildings in Sri Lanka and identify the causes for dissatisfactions to achieve better performance from the green buildings. Before evaluating the occupants' satisfaction level, the identification of determinants of occupants' satisfaction on green certified factory buildings is essential. Thus, following shows the determinants of occupants' satisfaction on green certified factory buildings, identified through a comprehensive literature review.

2.3.1 Thermal comfort

According to Wagner et al. (2007), temperature is considered as an important factor for the general satisfaction in the workplace and it also might affect occupants' productivity. Occupants are more satisfied with the controllable indoor climate and effects of their different inventions strongly influence the satisfaction with thermal indoor conditions. Further, there are design standards such as American Society of Heating Refrigerating and Air-Conditioning Engineers (ASHRAE) and ISO that provide guidance promising comfortable conditions (Levin (2003). Warm climate conditions could be occurred due to inefficient lighting systems. According to ASHRAE Standards (2004), air temperature, mean radiant temperature, air speed, humidity, metabolic rang, clothing insulation are the factors that affect the thermal comfort of occupants.

2.3.2. Indoor air quality

Levin (2003) described that indoor air quality generally consider about the outdoor air ventilation to control concentrations of contaminants indoors. Humidity level has an effect on occurrence of bacteria indoors and it leads to health problems. Chemical contaminants in indoor air cause health problems such as nausea. Individual chemical sensitivity differs from person to person. Therefore, when one person is infected, another one will not be infected. A special system has to be designed for those people but it is impossible to write guidelines for particular situation (Levin, 2003).

2.3.3. Acoustic comfort

According to Altomonte and Schiavon (2013), the noise level in workspace and sound privacy in workspace (ability to have conversations without neighbours overhearing and vice versa) are considered when talking about the acoustic comfort. The main objective of acoustic comfort is to reduce interferences for conversations or disruption of concentration (Levin, 2003). Noise affect to concentration and conversation, and cause health and safety issues such as pain, headache, nausea and permanent hearing loss. Therefore, standards, regulations and guidelines are presented to provide quality indoor environment as well as prevent physiological damage. As per Altomonte and Schiavon (2013), acoustic absorption and acoustic cover techniques are arranged to suck up excessive sound such as sound attenuators.

2.3.4 Visual comfort

As mentioned by Levin (2003), there must be adequate illumination level with enough contrast and accurate colour rendition for reading and other visual task performance. High lighting condition and low lighting condition can cause eye damage, headaches and stress and as a result it will reduce the productivity of occupants. Hirning, Isoardi and Cowling (2014) brought forward the idea that both health and energy benefits can be achieved by controlled use of daylight. Efficient lighting conditions can be provided and work performance and visual comfort can be enhanced by using natural lighting.

2.3.5 Spatial comfort

According to Frontczak et al., (2012), the satisfaction with the amount of space was ranked to be the most important for workspace satisfaction regardless of age group, gender, type of organization, distance of workspace from a window or satisfaction level with workspace. Satisfaction with the amount of space was not related to an approximate evaluation of the amount of space available per person at the work space. As mentioned by Altomonte and Schiavon (2013), amount of space available for individual work and storage, level of visual privacy, ease of interaction with co-workers, comfort of office furnishings (chair, desk, computer, equipment, etc.), ability to adjust furniture to meet employees' needs as well as colours and textures of flooring, furniture and surface finishes also determine the satisfaction of an occupant. Further, as Levin (2003) described, open plan environments are promoting low maintenance and operational costs, but it cause stress from loss of acoustic and visual privacy, from noise, and from a loss of occupant control over the indoor environment. Proper space planning and management provide cause to spatial comfort in work place. Thus, proper space planning and management concentrate about the efficient and effective use of work space.

2.3.6 Building maintenance and cleanliness

This includes cleanliness of the overall building and cleaning service provided to the workspace and general maintenance of the building. As Minnesota Department of Health (2008) described, inadequate cleaning is a significant aspect when considering about the deficiency in indoor environment quality. Dirty, dusty and minimally cleaned environment may cause allergy and possibly other symptoms to sensitive building occupants. Therefore, factors such as general cleanliness, general maintenance of the building and personal workspace should be considered when assuring satisfaction regarding building maintenance and cleanliness (Altomonte and Schiavon, 2013).

3. Research Methodology

The research was approached using survey method and a semi structured questionnaire survey was carried out to evaluate the satisfaction level of occupants and occupants' expectations for comfortable working environment. Total of fifty numbers of occupants were randomly selected from five green certified factories for the survey, which have obtained the green certification before minimum of three years. Mean Weighted Rating system was used to analyse the questionnaire findings. Arithmetic Mean of responses was calculated for each criterion and based on the calculated mean values, satisfaction levels were evaluated.

4. Data Analysis and Discussion

4.1 OCCUPANTS' SATISFACTION LEVEL OF GREEN CERTIFIED FACTORY BUILDINGS IN SRI LANKA

The Occupants' satisfaction survey was conducted to measure the level of satisfaction of employees towards green certified factory buildings under 07 categories i.e. Thermal Comfort, Indoor Air Quality, Acoustic Comfort, Visual Comfort, Spatial Comfort, Building Maintenance and Cleanliness and Overall Satisfaction level. Further, 1-5 Liker scale, where 5, 4, 3, 2 and 1 represent Excellent, Good, Moderate, Poor and Very Poor satisfaction levels respectively was used in data collection. Mean Weighted Rating system was adopted to analyse the collected data and to determine the user satisfaction level on each criteria. *Figure 1 to Figure 7* shows the calculated mean values of the occupants' satisfaction under the above mentioned 07 criteria.

According to the *Figure 1*, "ability to adjust the room temperature" scored as the lowest mean value (2.20) which indicates a poor satisfaction level of the occupants under the thermal comfort criterion. Except that criteria, occupants have good satisfaction level on other two parameters.

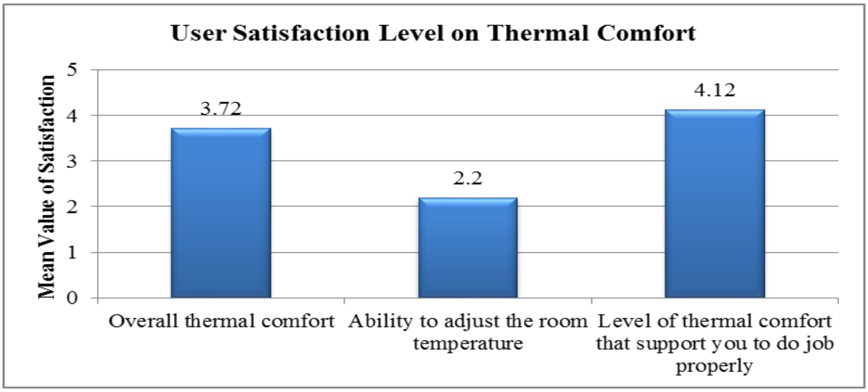

Figure 1: User satisfaction level on thermal comfort

As it is shown in *Figure 2*, Indoor Air Quality criterion is considered, "ability to adjust the room ventilation scored approximately mean value of 02 and scored as poor. The factor "moisture controlled ventilation" scored approximately mean value of 03 and rate as moderate. Further, all the other criteria (06 out of 08) scored approximately mean value of 04 showing that the occupants' satisfaction level is good.

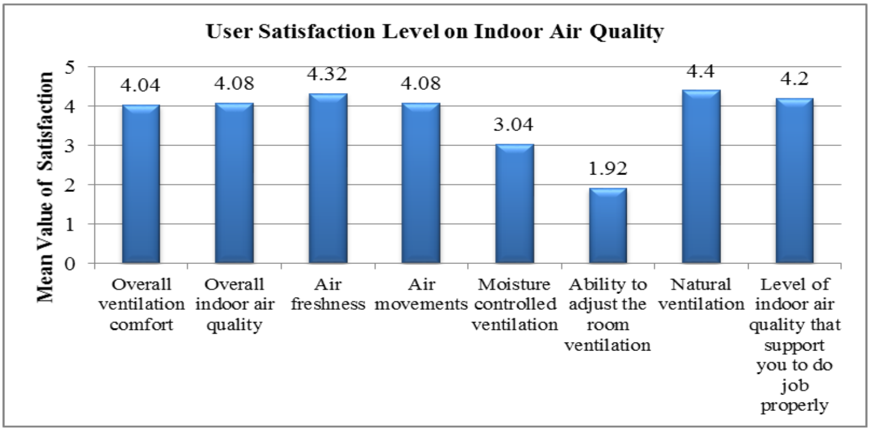

Figure 2: User satisfaction level on indoor air quality

All the factors affecting Acoustic Comfort were scored as less than 04 (Refer *Figure 3*). The analysis indicated that the "noise from ventilation system" was scored mean value of 03 approximately which means the satisfaction is in a moderate level. However, the mean value scores, the satisfaction on acoustic comfort lie between moderate to good level.

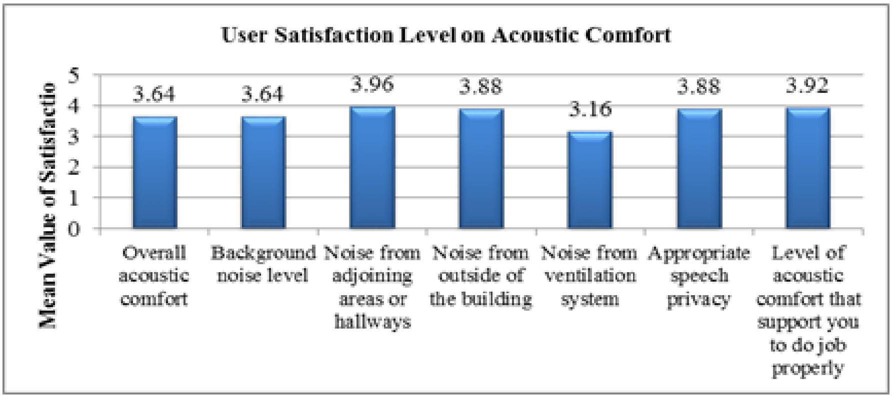

Figure 3: User satisfaction level on acoustic comfort

Further, according *Figure 04*, "noise from the lights" and "ability to adjust the light level" under Visual Comfort, indicate the highest and lowest satisfaction on the given scale respectively. Except those criteria, occupants comprise with a good satisfaction level on other criteria (09 out of 11), which scored approximately mean value of 04.

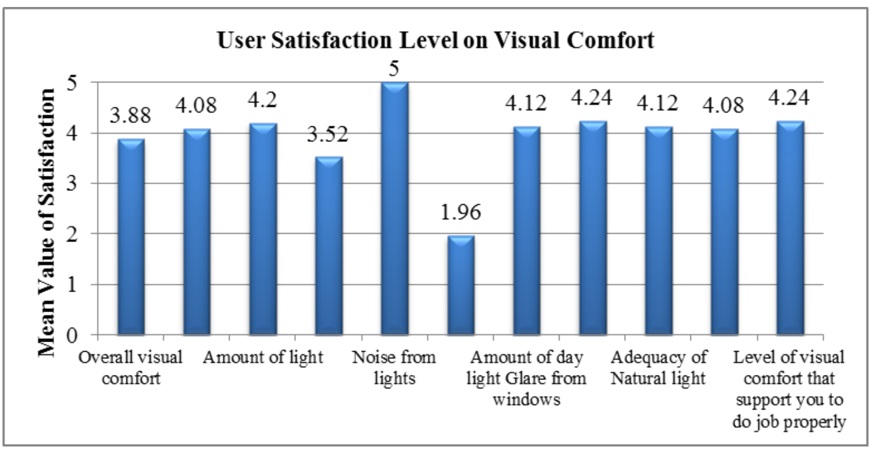

Figure 4: User satisfaction level on visual comfort

In Spatial Comfort category, most of the criteria (4 out of 5) scored as the satisfaction is in a good level while, "overall spatial comfort" varies from moderate to good level (Refer *Figure* 5).

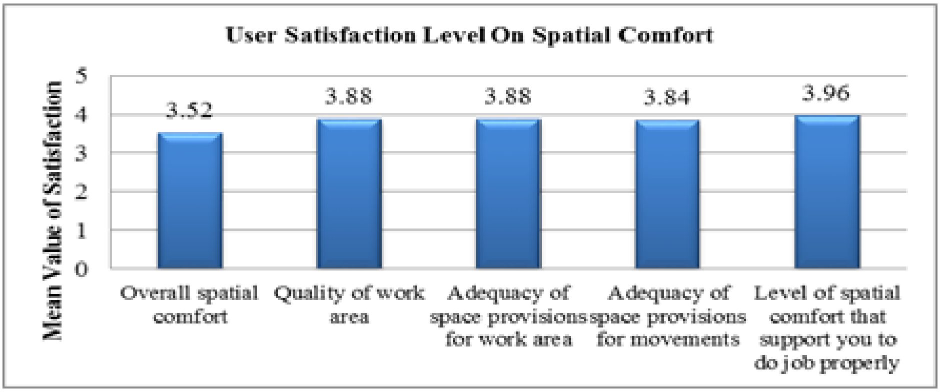

Figure 5: User satisfaction level on spatial comfort

As it is shown in *Figure 6,* the occupants are moderately satisfied about the "cleaning service provide for work space while the occupants' satisfaction on Building Maintenance is at a good level.

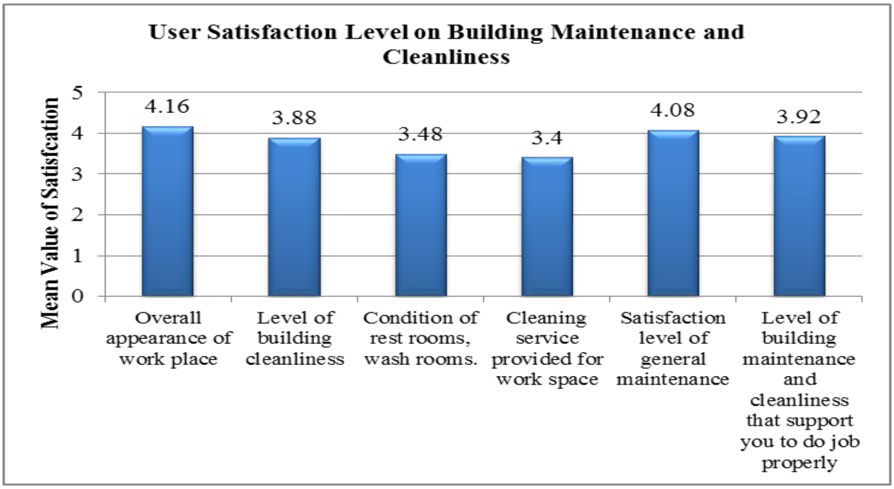

Figure 6: User satisfaction on building maintenance and cleanliness

According to *Figure 7,* overall satisfaction level indicate the general satisfaction level of occupants and that was scored approximately mean value of 4, which means the overall satisfaction of the occupants' in green factory buildings in Sri Lanka is at a good level.

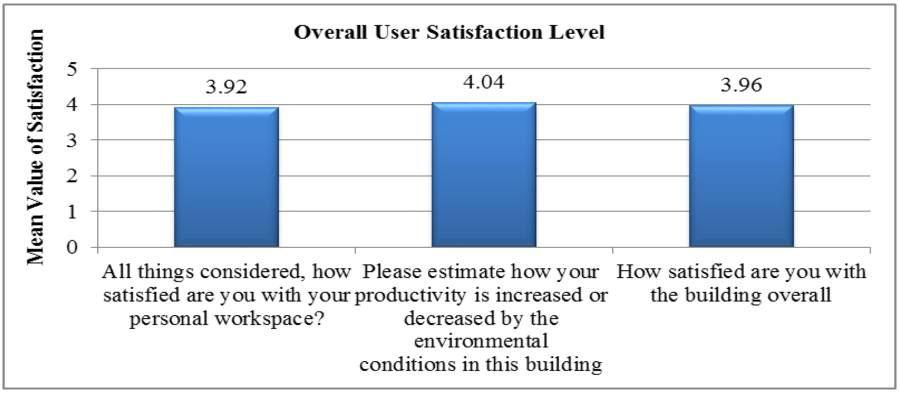

Figure 7: Overall user satisfaction level

The above analysis identified the factors which the occupants are satisfied with and dissatisfied with. The areas on which occupants' dissatisfied with are adjusting the light, room temperature, and room ventilation levels. Further, the analysis also indicated that the factors which the occupants are moderately satisfied with. They are moisture controlled ventilation, noise coming from ventilation system, condition of rest rooms and washrooms, and cleaning service provided for work space. The next section analyses the causes for occupants' dissatisfactions.

4.2 CUASES FOR DISSATISFACTION

The causes for dissatisfactions are summarised in the *Table 1*.

Table 1: Causes for Occupants' Dissatisfaction

Dissatisfaction Factor	**Cause**
Adjusting the light level	Light dimming facilities are not available for the workers
	Lighting controllers are at the engineering control rooms
	Automation of artificial lighting system
Adjusting the room temperature level	Temperature controlling facilities are not available for the workers while employees in the top management can adjust their room temperature
	Controllers of the ventilation system are at the engineering control rooms
Dissatisfaction Factor	**Cause**
Moisture controlled ventilation	Use of evaporative cooling systems
	Moisture controlling systems are not available

Adjusting the room ventilation level	Room ventilation controlling facilities are not available for the workers while employees in the top management can adjust their room ventilation
	Controllers of the ventilation system are at the engineering control rooms
Noise from ventilation system	Additional noise due to the operation of diffusers in ventilation system, other than the sound from machinery which the occupants always get use to
Condition of rest rooms and washrooms	Deficiencies on the housekeeping systems of the factories
Cleaning service provided for work space	Deficiencies on the housekeeping systems of the factories

According to the *Table 1*, the main causes for occupants' dissatisfactions on adjusting the light, room temperature, and room ventilation levels are, the unavailability of relevant controlling facilities for the light, room temperature, room ventilation and moisture level with the workers and those controllers are available at the engineering control rooms.

5. Conclusion

Conventional buildings have more impact on environment and consume more resources. With the global environmental conditions, limitation of resources and competition, organisations tend to develop green buildings. The green building concept can be identified as a new approach to develop facilities with reducing adverse impact on environment, save energy, water and material resources in construction and operation of the buildings as well as minimising the cost.

When considering about various types of buildings, a considerable impact is occurred to the environment by factory buildings as their resource consumption is high compared with other facilities. Therefore, management of factory buildings tend to follow green concept in their factory buildings. Management should implement green strategies in the factory buildings while concerning about the satisfaction of occupants on the factory environment. Because, Occupants' satisfaction is identified as very essential factor that is directly affect to occupants' productivity, efficiency as well as organizations' profitability.

A comprehensive literature identified thermal comfort, indoor air quality, acoustic comfort, visual comfort, spatial comfort and building maintenance and cleanliness as the key criteria which affect the occupants' satisfaction in building. Based on the identified criteria, a user satisfaction survey questionnaire was prepared and Mean values were calculated. In addition, the overall satisfaction level of the occupants was also measured. Based on mean values, user satisfaction level on each criterion was determined. By evaluating mean values, it was identified that there is a good satisfaction level on each criterion except the criterion adjusting the light, room temperature, and room ventilation levels, moisture controlled ventilation, noise from ventilation system, condition of rest rooms and washrooms, and cleaning service provided for work space.

Further, causes for dissatisfaction of occupants on green certified factory buildings were also identified through semi-structured questionnaires. The unavailability of relevant controlling facilities for the light, room temperature, room ventilation and moisture level with the workers, and controllers are available at the engineering control rooms are the main causes for dissatisfaction. Use of evaporative cooling systems and deficiencies of the housekeeping and maintenance systems are contributing factors to this end.

Hence, the research identified that the satisfaction level of occupants is at a good level though there are some factors that lead to occupants’ dissatisfaction. Addressing those factors and eliminating the causes of dissatisfaction will help to achieve better performances from the green certified factory buildings in Sri Lanka in the near future.

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STRATEGIES TO DEVELOP EFFECTIVE BIM MODELS TO SUIT 4D MODELLING

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Abstract:
Rapid upsurge of technology accredited 4D Building Information Modelling (BIM) as a BIM centric scientifically-derived scheduling process. It upgrades the project outcome, by reducing the substantial uncertainty exists with quality, cost and time. However, 3D BIM models are being advanced not only for 4D models but also for many other visualizing and informative purposes. Hence, necessity ascends to verify whether generally developed BIM models satiate required features of 4D modelling. Consequently, research aims to identify and verify extent of suitability and practicability of using BIM models in 4D modelling. The aim accomplished through a qualitative approach utilized with a desk study, unstructured interviews and a content analysis. It documented strategies and recommendations on how BIM models could be technologically advanced to ensemble 4D visualization. It was revealed that, prevailing BIM models are not readily acceptable for 4D modelling, which need to be refined marginally for real-world approach. Structural work packages, plant, equipment and accessories of building works can be directly used to 4D modelling as already developed whereas, integrated elements and finishing need few adaptations. Despite of few limitations, it is recommended more than 90% of elements developed in BIM models can be used for 4D modelling with certain modifications.

Keywords: *4D Building Information Modelling (4D BIM); 4D modelling; Building Information Modelling (BIM); Project Planning*

1. Background

Due to the rapid growth of advance technologies man's pattern of living, working and the way of thinking is being reformed. The Architecture, Engineering and Construction (AEC) industry is one of the leading trade among other industries (Dawood, 2010), which may have significant changes in immediate future (Arayici *et al.,* 2011). In addition, AEC industry consumes huge amount of resources which causes a great impact on Gross Domestic Product (GDP), labour market and energy consumption, and also affect each and every country in the world (Gang, 2013).

According to Cooke (2013), when compared to other industries, the process of constructing buildings is primarily a labour demanding development which is engaged in a series of sequenced activities to construct a homogeneous product in order to meet the necessities of the client. Further, Arayici et al., (2011) discovered that current practice with two dimensional drawing tools have many drawbacks such as timescales, duplications, delays, over production, and effective design coordination. Hence, new technologies are being developed in solution base to increase efficiency in processing, planning and productivity and new technology identified as Building Information Modelling (BIM) gives many solutions to AEC industry too (Boton *et al.,* 2013).

Azhar (2011) stated that BIM can be used to develop an accurate simulation of a building, which is digitally constructed in 3D model can be used for planning, design, construction, and operation of a facility. One of the key benefits of BIM is to empower understanding and communication among the participants (Manning and Messner, 2008) through visualization of how the final product may look like (Hergunsel, 2011). Emerging research attempts are currently paying attention in the provision of project planners and managers with computer-based advisory tools especially with BIM to visualize the construction plan in a 4D model (3D model+ time) (Heesom and Mahdjoubi, 2004). 4D planning possess the potential to increase the communication efficiency and interpretation ability among the project team members (Sebastian, 2010). Further, it can assist identifying the effective construction strategies to shorten the project duration, judging schedule quality, and assessing their workability (Russell *et al.,* 2009). In addition, developing principles of 4D planning gives a new opportunity for the representation of construction scheduling in an animation model which will be more advanced than the traditional grant chart project planning technique (Heesom and Mahdjoubi, 2004).

Although the technology is gradually capturing the world, according to the Staub-french and Khanzode (2007), many project teams have realized that, implementing 3D and 4D modelling on practical projects is a complex process that requires a high coordinated effort and time. This knowledge gap, is one of the reasons for the low adoption of information systems among AEC professionals (Hartmann et al., 2009). Under this context, the coordination between 3D and 4D models should be analysed in order to increase the efficiency of construction scheduling.

1.1 AIM

The research aims to identify and verify extent of suitability and practicability of using BIM models in 4D modelling.

1.2. OBJECTIVES

Hence, the set objectives of the research were;

- Identify BIM models and 4D models with their features and modelling tools.
- Investigate into elements of the construction programme which need to be visualized using the model.
- Identify BIM elements which require to be incorporated in construction planning.
- Find alternative methods available to model BIM elements
- Assess usability level of BIM elements made with alternative objectives for 4D modelling.

2. Literature Synthesis

A comprehensive literature synthesis was carried out to review the current knowhow level and effectiveness of the 4D construction planning which visualize and simulate the expected construction planning at pre contract stage.

2.1. CONSTRUCTION PLANNING

Construction planning is a critical task in the early phases of a construction project determining the success or failure of a project (Allen and Smallwood, 2008). Moreover, Eastman *et al.,* (2011) defined that construction planning involves in scheduling and sequencing activities in time and space, taking into account resources, procurement, spatial constraints and other concerns in process. However, according to Heesom and Mahdjoubi (2004) there is a lack of skills in the area of construction planning, thus the continuous deterioration of the capability in effective construction planning of construction projects and additionally it impose heavy burden on project teams members. Additionally, Huang *et al.,* (2007) stated that many project planners still rely on the traditional project planning techniques.

For the aforementioned issues as Akintoye and Macleod (1997) stated, there are different solutions within the industry, whereas most efficient solution is highly rely on the virtual planning, which combines the 3D model and scheduling.

2.2. BIM AND 4D TECHNOLOGY

BIM is one of the most promising technological achievement of the AEC industry in recent years (Lee *et al.,* 2006). Even if a BIM model features are more similar of a 3D geometrical model, it encompasses a much higher level of intelligence as it integrate information used by other building analysis applications such as cost estimating, energy simulation, day lighting, Computational Fluid Dynamics (CFD), space planning and building code checking with in the model (Kumanayake and Bandara, 2009).

4D BIM is an advanced visualization technique which integrate 3D BIM model with schedules, with respect to increase the communication efficiency and interpretation ability of the project team members (Dawood and Sikka, 2007). Many authors agree that 4D BIM integrate schedules with the 3D models to simulate the construction of a project which has potential to increase the information sharing among the project team participants which assist in the problems associated with site logistics and site layout at the construction period (Dawood and Sikka, 2007; Eastman *et al.,* 2011; Zhang *et al.,* 2000).

2.3 4D PLANNING AND VISUALISATION

As previously discussed construction planning mainly involves with scheduling and sequencing activities in time and space frame. However, traditional methods are requiring more improvements as planners has to visualize in mind what they have planned and it require more time and costs (Chau *et al.,* 2003). Further, 4D technology is increasingly advancing and will have a great impact on the processes of construction management as presently adept (Wang *et al.,* 2004).

2.3.1. Expected changes for 4D visualization from conventional planning

In order to analyse 4D visualisation, it is essential to identify the process what is expected by the new technology. Table 1 analyses requirements stated by the following authors in their articles.

Table 1: Expected changes from conventional planning

Hartmann ***et al.*** (2009)	-Showing complex interdependence of tasks and the distortion as a result of focusing undue attention on particular activities**.** -Not to rely on individual experience**.**

Li *et al.* (2009)	-An effective computer-assisted technology for resource allocation and planning. -Minimize the mismatch between what is planned and actually needed. -Ability to predict whether the project will result in a profit or a loss in advance of construction. -Take real productivity rate of different machineries and manpower's into account. -Combine the three traditional techniques of resource allocation, re-source levelling and time-cost trade-off analysis.
Allen and Smallwood (2008)	-Reduce the occurrence of delays on projects.
Dawood and Sikka (2007)	-Communication of information among different stakeholders. -Provide spatial construction features or resource and working space requirements.
Huang *et al*. (2007)	-Visualizing construction-specific components such as scaffolding and other temporary works integrated in the 3D model.
Mckinney *et al.* (1996)	-Ability to identify construction problems prior to construction. -More information for construction planning. -Minimize the inability of Clients' understanding on project documents.

2.4 3D MODEL DEVELOPMENT PROCESS FOR 4D MODELLING

Eastman *et al.* (2011) alienated 4D modelling process into three main categories with respect to the inputs to develop a 3D model. In addition he described three methods as follows;

Table 2: Three categories of 4D modelling process

Manual method using 3D or 2D tools
• Planners used to create visualization by outsourcing. • An effective marketing tool but not an effective planning tool because of the limited possibilities to modify, update, and do real time scenario planning.
Built-in 4D features in a 3D or BIM tool
• Create 4D images is through filtering the relevant objects with tool like Revit. • Incapable of simulate construction with the time. • Assists tools, such as Tekla structures, Navisworks Scheduling, Synchro, and Vico Office to create 4D models basis of 4D images by enabling multiple links between the physical objects and the activities in the model.

Export 3D/BIM to 4D tool and import schedule
• Coordination of 3D model with schedules. • Requires 3D models from recognized software supported to IFC and schedule from general applications such as MS Project and Primavera.

3. Research Methodology

Primarily, through an extensive literature synthesis, the distinct features of BIM and 4D modelling tools, elements of the construction programme which need to be visualized using the model and BIM elements which require to be incorporated in construction planning were identified. Afterwards, a programme of recently completed eight-storey building has been used as the case for the analysis to verify the work packages. Subsequently, the work executed by a work package related to modelling was identified and the available options for developing models in Revit 2014 were obtained through a desk study. To verify the accuracy of description and modelling requirements of the work items, unstructured interviews were conducted. At last, the comparison between modelling requirements and available modelling options are being evaluated and critically analysed using content analysis technique.

4. Research Findings

Findings have been summarized considering both usability and practicability in developing 4D models.

4.1 USABILITY OF BIM MODELS IN 4D MODELLING

In this section, three levels of usability, such as direct (A), modified (B) and impossible (C) usable options, for each option proposed in the analysis were discussed. Moreover, those levels of options, related usability in 4D modelling, are grouped in table 3.

Table 3: Level of Usability in 4D modelling

No	Level of Usability in 4D modelling	Total number option relevant to the level
1	The experimented model can be directly used in the 4D models without modifications	38
2	The experimented model can be used in the 4D models with some modifications	34
3	The experimented model cannot be used in the 4D models or there are no options available to develop the required model or new options are needed to model the requirement for 4D	1

It is clearly presented in figure 1 that around 52% of options can be directly usable to 4D modelling without changes. Moreover, 47% of modelling options can be used in 4D modelling with some modifications.

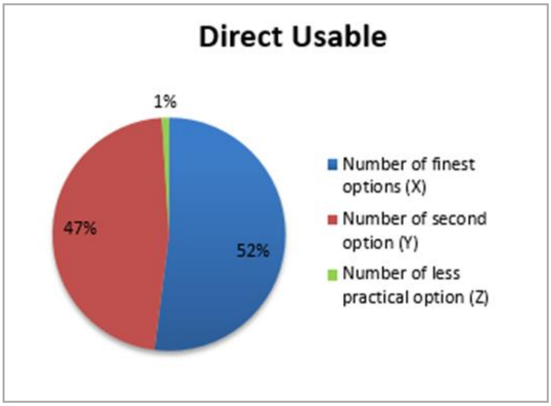

Figure 1: Graphical representation of level of usability in 4D modelling

4.2 PRACTICAL EXTENT OF USING OPTIONS TO DEVELOP MODELS

In this section, three levels of practical extent of using options to develop models, such as finest method (X), second method (Y) and less practical method (Z), for each option proposed in the analysis were discussed as grouped in table 4.

Table 4: Level of practicability of the option when modelling

No	Level of practicability of the option when modelling	Total number option relevant to the level
1	The best fitted method, for modellers, which is more likely adopt by modellers	43
2	The method which is used by modellers, if finest method of developing the model is not available	23
3	Hardly attainable method due to the complexity and practical difficulty	7

Figure 2 clearly presented that around 59% of options are likely used by the modellers. Moreover, modellers also can use 31% of modelling options if the finest option for modelling is not available. Therefore, almost 90% of options in the analysis can be used for modelling purposes.

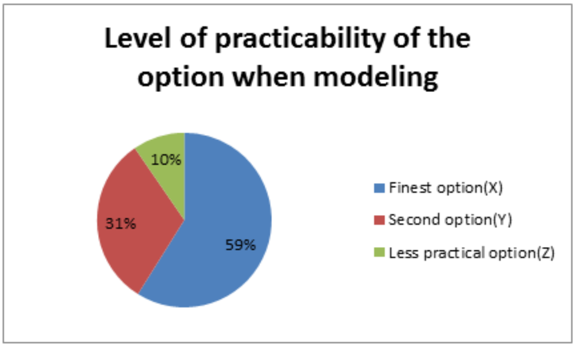

Figure 2: Graphical representation of level of practicability in 4D modelling

4.3 OVERALL COMPARISON BETWEEN USABILITY AND PRACTICABILITY OF OPTIONS

The table 5 enlighten the overall usability and practicability of the options.

Table 5: Over all comparison between usability and practicability of options

No	Level of Usability	**Number** options	(X)	(Y)	(Z)
1	Direct usable (A)	38	12	20	6
2	Partially usable (B)	34	31	3	-
3	Unusable (C)	1	-	-	1

Figure 3 explain the percentages of options as whole. Accordingly, 17% of available options can be directly usable and finest options which reveal that the 17% of the BIM models can be directly used in 4D modelling.

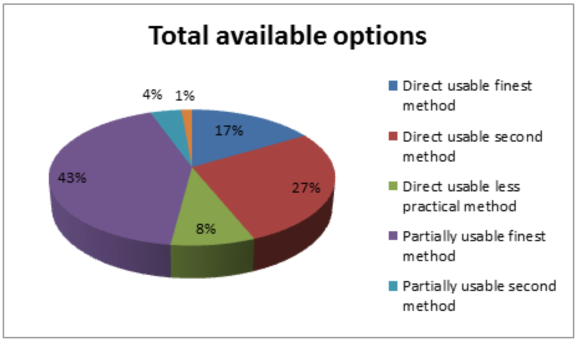

Figure 3: Graphical representation of total available options

Further, the figure 4 shows that, 91% of partially usable options are the finest method which modellers adopt in developing the general BIM models. Moreover, the balance 9% of options are second option for modellers which may be the method used by modellers if the finest method is not available. Hence, there are no less practicable options in this category.

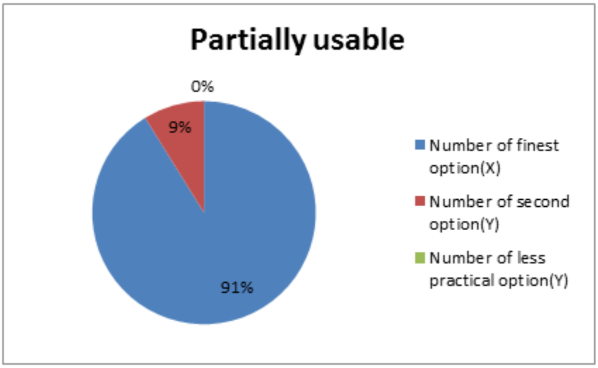

Figure 4: Graphical representation of partially usable option

Finally, there is only one option comes under the impossible options, to use in 4D models, which in the less practicable method.

5. Conclusions and Recommendations

Findings of the research revealed that BIM model of solid structural work packages, such as construction of beam, slab and column can be directly used in the 4D model without any modifications when the construction process in single step for one element. Moreover, work packages of equipment accessories also lays in the same group. However, in such situation, if the abovementioned work packages have to be visualised in several stages of construction, BIM model cannot be directly used in the construction process. Furthermore, practicality of such models is high, since the method used to model the specified work packages are widely used in actual modelling process.

Work packages related to finishing works which need to be visualise by adding layers to the existing elements, such as plastering for wall, can be directly used for 4D modelling nonetheless with some deviations to the actual BIM models. Therefore, the method and model developed to visualise such elements are not in accordance with the normal BIM models and it slightly varies. Further, work packages related doors and windows require independent visualisation to develop 4D models as frames of door and window are to be constructed in two work packages. However, the models for doors and windows are integrated in BIM models. Therefore, the separations of sub elements need to be done before use such models in 4D modelling. Likewise, most of the assembled elements used to modelling purposes such as assembled pile caps and assembled wall with the layers inside also require separation before use in 4D models. Furthermore, it is notified that near the half of BIM elements developed in the analysis comes under this group. Other than the above work packages, special works such as canopy at entrance and ceiling frame work need to be newly modelled or download families from internet. Therefore, modelling and developing models for elements rely on the new models and families.

Considering all the fact of the study, 31% of direct usable options are likely used by model developers. Accordingly, findings reveals that around 70% of options to develop BIM model appropriate to develop 4D models are not the best method used to modelling by modellers. Moreover, 16% of options which suit the 4D modelling are less practical method used by developers. That means, if this method is used other purposes of the BIM models get affected. Further, 53% of direct usable methods are second method of developing models used by developers which reveals the necessity of developing few tools which accommodate developers to use this method.

Furthermore, 91% of partially usable options, to develop BIM models, are likely used by modellers, which show that more practical methods used to develop BIM models are not suitable to develop 4D modelling purposes.

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DEFINING 'URBAN' AMONG URBANIZING RURAL: THE CASE OF SRI LANKAN URBANIZATION

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Abstract:
The level of urbanization of a country or a region is generally measured in terms of the share of its urban population. Since there is no universal definition for 'urban', countries follow different approaches such as demographic, density, administrative, economic, morphological and functional, to define 'urban' in their contexts and Sri Lanka uses a pure administrative approach. Surprising trend of urbanization was observed in Sri Lanka with a drop from 21.5% in 1981 to 14.6% in 2001 and 18.2% in 2012. This was questionable as ripple effects of urbanization can be experienced all over the country. Disputes and confusions over the definitions of 'urban' are observed at International contexts. This research investigates this issue through a comprehensive review of existing definitions of 'urban' and respective scholarly works. Initial review of literature had found that definitions of 'urban' vary greatly between countries but usually they comprise of several criteria. This paper describes these findings on conventional approach and proposes an alternative framework to redefine 'urban' in Sri Lanka, by two principle approaches 'urbanism as a way of life' and the concept of 'urban society' resulted from a complete urbanization through a human centered approach. The results indicated the geographical representation of level of urbanization in Sri Lanka and it was quantified as 34%.

Keywords: *Urbanization, alternative framework, human centered*

1. Introduction

Human settlement systems have become so much complex as there are many interactions between different types of human settlements due to recent developments in transportation and information technology. Hugo, Champion, & Lattes (2001) stated that this has resulted many people dividing lives in between urban and rural areas. Therefore the clear distinction between urban and rural areas has become less clear-cut (Beer, et al., 2014). However the simple urban/rural dichotomy has long been recognised as an over simplification of the complexity of human settlements. Urbanization on the other hand is often defined as the growth of or migration to cities and thus measured in terms of the urban population growth. It is important for any country or state to learn their stand in the urbanization process and to identify their urbanization pattern and trends in order to take policy decisions whether to facilitate or control the urban growth.

In that context, the definition of 'urban' plays an important role in determining the urban status of a particular city or a state. Definitions of 'urban' vary greatly between countries, where single and multiple criteria methods are employed to define 'urban' depending on the contexts and there are many disputes over these definitions. In Sri Lanka surprisingly the trend of urbanization level, dropped from 21.5% in 1981 to 14.6% in 2001 and increased to 18.2% in 2012. This trend is questionable as ripple effects of urbanization can be experienced all over the country.

This research attempts to study these different definitions on 'urban' with respective to the principles behind and the major critiques drawn against them. After identifying the limitations in the existing definitions and the alternative perspectives on 'urban', this study attempted to develop a framework to evaluate the level of urbanization in Sri Lanka. Second chapter of the paper briefs the methodology and the research process. The third chapter present a summary on literature done on this while fourth section illustrates a situation review on urban definitions used in Sri Lanka from 1800 to present. The final section of the paper describes the proposed framework in detail and the application at national level.

2. Methodology

This study basically adopts mixed approach of qualitative and quantitative methodology. In the first section of the study, qualitative approach was undertaken with documentary search as the primary method of data collection. It was intended to identify the knowledge gap in this research area. The existing definitions used for urban in Sri Lanka and worldwide are reviewed with strong emphasis on the underneath principles of these definitions. In exploring the situation in Sri Lanka, the process was facilitated by the Key informant interviews conducted with eminent professionals and academic who worked and published on similar areas. Further reviewed works of Louis Wirth (1938) who proposed "urbanism as a way of life" and Henry Lefebvre (1968) who hypothetically suggested the existence of an "urban society" resulted from a complete urbanization.

The proposed framework is expressed with set of mandates, expressions and subsequently developed attributes to measure the degree of urban influence with reference to three main indications of urbanization or urban way of life which were identified from the literature review. After developing the framework, quantitative approach was used to explore the applicability of the framework at National level using the secondary data sources. In this study, rather than studying people individually, it tries to evaluate the society considering the group of people living in a GND area as the smallest unit.

3. Literature review

Hugo, Champion, & Lattes (2001) explained that the measures of urban and rural employed by most of the nations are relatively outdated. Also the criteria which define what urban is varies for different countries based on their physical, demographic, socio-economic, cultural and political conditions, but still many of them are based on similar principles. These criteria also can be referred as the conventional approaches in defining urban.

Few of the basic approaches adopted in defining urban are: Demographic approach which uses population size, Density approach which uses the density of roads, population, houses or households, Economic approach which uses the proportion of non- agricultural occupations, Administrative approach which defines urban areas on the basis of the legal or administrative status, Morphological or the 'brick and mortar approach' based on land use (the extent of the continuous built-up area and the proportion of the 'legal city' covered by the urbanized area) that considers the city as a 'physical entity' and the Functional approach reflects the multi-functional nature of urban settlements and the provision of public and private sector services to residents .

United Nations, Department of Economic & Social Affairs, Population Division (2001) had revealed that predominantly the administrative based qualitative criteria (39% of countries) is used to define urban areas. Size of population based definitions were observed in 20% of the countries, while 10% of the countries use an economic based multiple criteria approach.

Countries use both single and multiple criteria to define urban in their contexts. For an example, India uses a multiple criteria method including demographic, density, economic and administrative approaches. Several limitations are already found in the definitions used. Some are attributed to the underlying principles used while the others are influenced by the methodology adopted.

Most of the quantitative based definitions on ‘urban’ are based on statistical numbers such as number of population and population density hence do not comprehensively analyses the complexities within the society that might have strong implications when defining areas as urban or not. In other words it can be questioned whether is it fair to declare areas as urban or not simply looking at the numbers only. Wirth (1938) argued that the degree to which the contemporary world may be said to be “urban” is not fully or accurately measured by the proportion of the total population living in cities as the influences which cities exert upon the social life of the man are greater than the ratio of the urban population would indicate. He also argued that city is not only the dwelling place and workshop of modern man, but it is the initiating and controlling centre of economic, political and cultural life.

Even through the approaches such as economic, morphological and functional approaches attempt to identify urban and rural characteristics by studying the areas going beyond numbers, each approach alone does not adequately capture the characteristics which distinguishes between urban and rural. For example when trying to classify the areas based on the proportions of occupational distribution over agriculture and non-agricultural areas, areas which are predominantly agricultural might carry urban characteristics such as high proportion of built-up areas and upgraded infrastructure facilities due to development schemes introduced by the government (Weeks, 2010).

Almost all these definitions are based on the underlying assumption that two separate entities named urban and rural do exist. It is only then the areas can be classified as urban and rural. But it is questionable whether such types of two separate entities as urban and rural do exist in the present world. Wirth (1938) pointed out that since the city is a product of growth rather than of instantaneous creation, the previously dominant modes of human association always may have the influences upon the present modes of life. Pahl (1966), argued that rural/urban dichotomy needed to be replaced with a rural/urban continuum.

4. Situation review of urban definition in Sri Lanka

Sri Lanka uses a single criteria method including a pure administrative method. There are three types of local authorities in Sri Lanka naming Municipal Councils (MC), Urban Councils (UC) and Pradeshiya Sabhas (PS). According to the definition, MC and UC areas are considered ‘urban’ while PS areas are considered rural. Since Sri Lanka’s definition of urban is based on a pure administrative approach, the definition of urban has changed over time as the administrative boundaries were altered.

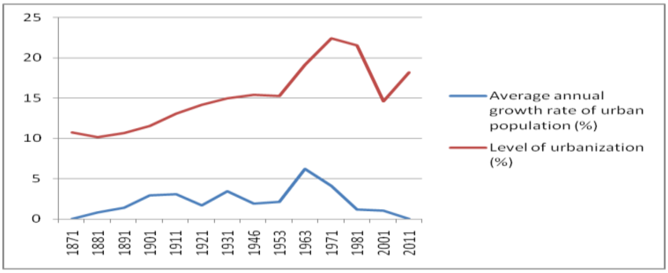

Figure 1, Urban Growth in Sri Lanka, 1871 -2011 (Source: Population Census and Demography Division, Department of Census & Statistics, Sri Lanka, 2012)

When considering the change of level of urbanization over the years, it can be identified that level of urbanization has increased gradually over time from 1871 to 1981 from 10.8% to 21.5%. And the annual growth of urbanization of this period has always been varied in between 0.8% to 3.4% so it indicates a slow growth of urban population over the years. But according to these statistical figures, it can be noted that there is a significant reduction of level of urbanization within the census years of 1981 to 2001 as the values drop from 21.5% to 14.6%. This reduction in level of urbanization is very surprising as there is no way that the urban population to reduce from 3,192,489 to 2,467,171 as there was no such massive out migration or any other cause of reduction of population. The main reason behind this drop of values is the change of policy decision which affected the definition of urban in Sri Lanka. Before 1987, Municipal Councils, Urban Councils and Town Councils areas were defined as Urban but with setting up of Provincial Councils in 1987, these Town Councils were absorbed into Pradeshiya Sabhas which fall into rural sector since then. (Population Census and Demography Division, Department of Census & Statistics, Sri Lanka, 2012) As a result, 89 urban settlements were classified as rural settlements after the 13th Amendment to the Constitution in 1987.

Table 1 – A summary of definitions used for Urban in Sri Lanka (1800 to present)

Authority / Person	**Time Period**	**Underlying Principle**	**Remarks**
Government of Sri Lanka (GOSL)	1865 – 1900	Municipal Council (MC) areas & Local Boards (LB) areas were considered as Urban Areas	Characteristics expected in defined areas (water supply & sanitation, Street lighting, market Facilities, efficient Police Service)

<table>
<tr><td colspan="4">3 Municipalities at that time – Colombo, Galle & Kandy and Local Boards - established for towns larger than ones under Sanitary Boards under the Ordinance No. 13 of 1898 and Sanitary Boards (SB) – established under the Ordinance No. 13 of 1892 for the provision of services of minor towns</td></tr>
<tr><td>GOSL</td><td>1901 - 1920</td><td>MC & LB areas as urban</td><td></td></tr>
<tr><td>GOSL</td><td>1921 - 1946</td><td>35 towns including MC, LB, SB & areas administered by BOI (Board of Improvement) as Urban areas</td><td>Areas administered by BOI being defined as urban</td></tr>
<tr><td colspan="4">‘every place which is a Municipality or Local Board, or the seat of a Government Agent, or Assistant Government Agent or of a District Court, or which has been brought under the operation of the special system of deaths registration provided by Sections 31-36 of the Ordinance No. 1 of 1895 was designated as a town.’ (Department of Census and Statistics, 1901)</td></tr>
<tr><td>GOSL</td><td>1946</td><td colspan="2">42 towns including MC, UC & LB areas as urban</td></tr>
<tr><td colspan="4">Local Government Board (1920) / Urban District Council (1928) /Urban Council (1939) and Town Councils were established in 1946 under the Town Councils Ordinance No. 3 of 1946 to replace Sanitary Boards which were not functioned as urban earlier and under Section 2 of the Town Councils Ordinance No.3 of 1946, ‘any area, which by reason of its development or its amenities is urban in character, may by Ministerial order be declared a town’.</td></tr>
<tr><td>GOSL</td><td>1948 – 1981</td><td>No change</td><td></td></tr>
<tr><td colspan="4">At 1963 Census of Population 51 areas administered by TCs were dignified to “urban” status for the first time and number of towns increased from 43 in 1953 to 99 in 1963</td></tr>
<tr><td>GOSL</td><td>After 1980</td><td>MC & UC as urban areas</td><td></td></tr>
<tr><td colspan="4">Town Councils (TC) + Village Councils (VC) = District Development Council (DDC)
DDC = Pradeshiya Sabha (1987) under the Pradeshiya Sabha Act No. 15 of 1987 and this caused a decrement in total urban population</td></tr>
<tr><td>GOSL</td><td>At Present</td><td>MC & UC areas as urban areas</td><td></td></tr>
<tr><td colspan="4">Urban population as a percentage in 1971, 1981, 2001 and 2012 is respectively as 18%, 28%, 14.6% and 18.2% which is controversial</td></tr>
</table>

As Uduporuwa (2010) highlights, downgraded Town Councils included some of the most dynamic and densely populated suburbs of Colombo such as Maharagama and some fast growing small town in Dry Zone.

Another reason for decreasing trend of level of urbanization is the absence of an island-wide census in 2001. The population census in 2001 enumerated only 18 out of 25 districts due to the war situation in the Northern and Eastern Provinces (Uduporuwa, 2010). But the urbanization level reported in 2011 census which is 18.2% is still less than the urbanization level in 1981 which is 21.5% and that shows the critical problems associated with the definition of urban in Sri Lanka. This suggests that the current definition of urban in Sri Lanka does not captures the urbanization process that the areas defined as rural are currently undergoing.

In summary the overall critiques to the existing definition of urban in Sri Lanka can be identified as; failure to revise boundaries when towns get saturated, not including sociological aspects such as urban way of life in the definition, not capturing the urban/rural interactions and urban influence over the defined rural areas, not considering the physical and social transformations of societies such as development schemes to improve infrastructure facilities, technological advancements, transportation network improvements, change of conventional livelihood and economic activities that may have strong implications on urban status and not taking into account the rapid changes in peoples’ life styles that are complex in nature.

5. Towards an alternative definition

Henry Lefebvre (1968) in his book ‘Urban Revolution’ has argued the need of theorizing ‘urban’. In doing so he refers to ‘urban’ in terms of ‘urban society’. As Lefebvre suggests, urbanization is a process that a society undergoes parallel to the historical shift from Agricultural to Industrial and then to an Urban World. He further argued that the society which has being resulted by a complete urbanization process is an ‘urban society’. This hypothesis leads to the definition of urban society meaning that it is the society resulting from a complete urbanization. Lefebvre proposes a spatial and temporal hypothetical axis from 0% urbanization to 100% urbanization. In here 0% urbanization refers to the pure nature and the 100% means the completion of the urbanization process. The importance in Lebevre’s hypothesis of complete urbanization is that it brings out the fact that it is the society which is subjected to this process of urbanization. Under this hypothesis, it can be argued that the each society could be positioned at different levels of this urbanization process thus will bear different levels of urbanization characteristics rather than being purely urban or rural.

According to Wirth (1938), urbanization is not just about people being attracted to a place called city and incorporated into its system of life but it refers to cumulative accentuation of the characteristics distinctive of the modes of life recognized as urban which are apparent among people, who have come under the spell of influences of the city. Louis Wirth in his literature ‘Urbanism as a way of life’, highlights the sociological aspects of ‘urban’. He considers three physical characteristics of cities and tries to bring out the sociological characteristics hidden behind them, which can be considered as sociological characteristics of urban way of life. The considered three characteristics of city are being relatively large, dense and bearing heterogeneous settlements. Relatively large cities lead to have large numbers of population accounting for individual variability, relative absence of intimate person acquaintanceship and segmentation of human relations which are largely anonymous, superficial and transitory. High density results in social characteristics such as diversification and specialization, coincidence of close physical contact and distant social relations, complex patterns of segregation, predominance of formal social control and accentuated friction. Heterogeneous settlements highlights the breaking down of rigid social structures & produce increased mobility, instability & insecurity, affiliation of the individuals with a variety of intersecting & tangential social groups with a high rate of membership hangover, displaced personal relations, institutions tend to cater mass rather than individual requirement and effective individuals acting through organized groups.

In summary what Wirth tries to explain is that the characteristics of city structure has caused significant urban sociological characteristics such that there is a strong diversification & specialization of people leading into segmentation of societies resulting complex patterns of segregation. Urbanism as a way of life reflects an organization of society in terms of a complex division of labour, high levels of technology, high mobility, interdependence of its members in fulfilling economic functions and impersonality in social relations. Therefore when trying to evaluate the urban status or in other words, the level of urbanization of a particular society, these sociological characteristics resulted from the urban way of life can be incorporated in to the criteria. Way of life can be expressed in terms of Lifestyle, Aspirations and Access to Facilities. (Table 2)

5. Results, Discussion & Way Forward

Since the study is based on a human centred approach, the basic idea was to decide what is urban by looking at the people's way of life. Thus it was necessary to first define the 'urban way of life'. In order to elaborate the 'way of life', three mandates were identified and these are lifestyle, aspirations and level of access to facilities. These different lifestyles, aspirations and levels of access to facilities define people's way of life.

4.1. FROM MANDATES TO EXPRESSIONS AND ATTRIBUTES

Table 2 – The explanation of each Mandate

Mandate	Explanation
Lifestyle	Practices of peoples’ day to day life. Through lifestyle the study attempts to map out people’s behavior in their regular life. The regular behavior and practices of people’s life define their overall way of life. The way people are used to fulfill their needs is very much important in deciding their ‘way of life’. Thus in here ‘lifestyle’ includes the food patterns, clothing patterns, type of shelter and means of communication.
Aspirations	Aspirations is what people dream of doing or in other words their ambitions for future. It is not only lifestyle (What people do in their day to day life) that defines overall ‘way of life’. Aspirations (what people really want for their life) also define their way of life. For example if a person currently lives in a village, leading a lifestyle of a village man but he dreams of living a lifestyle of a city dweller, in this situation even though he currently leads more of a rural lifestyle his aspirations are more urban. Aspirations of people are very subjective thus hard to map out for a particular society. But it is important to note that these aspirations are highly influential thus they may be common to a particular society at least to some extent.
Access to facilities	The facilities available in the neighborhood highly influence the people’s overall ‘way of life’. Due to the lack of common public facilities, people may have to bear a certain way of life which has nothing to do with their personal lifestyles or aspirations. For an example, a person with more of an urban life style and urban aspirations may still could not acquire an ‘urban way of life’ as the level of facilities he is accessible to do not adequately support an ‘urban way of life’. Practically we cannot ignore the fact that level of access to facilities also has an influence in determining one’s lifestyle. But at the same time there are instances where lifestyle doesn’t depend on level of access to common public facilities as they are highly depending on one’s personal choices and capabilities in fulfilling needs.

Expressions of each mandate were identified by employing Maslow’s Pyramid of basic human needs. The objective in here was to capture all necessary dimensions of a person’s way of life is composed of. Identified expressions are; food consumption patterns, clothing patterns, shelter, means of communication, way of fulfilling water needs, energy consumption, health, waste disposal and education. After identifying the expressions of each mandate, the next stage of the study was to derive attributes under each expression to evaluate the degree of urbanization.

Table 3 –Mandates, Expressions, Sub expressions and Attributes of the Framework

Mandates	Expressions	Sub-expression	Attributes
Lifestyle	Food Consuming Patterns	Types of food	Percentage area coverage of a GND covered under the 8km buffer from selected globally recognized fast food outlets.
		Daily marketing practices	Percentage area coverage of a GND under 3km buffer from selected supermarket chain outlets.
	Clothing Patterns	Types of clothes	Percentage area coverage of a GND under the 15km buffer from selected fashion stores
	Shelter	Type of tenure	Percentage of Rent / Lease household units in a GND
		No. of Storeys	Percentage of household units with two or more stories in a GND
		Type of toilet facility	Percentage of household units having toilets inside the household unit in a GND
		Type of toilet	Percentage of household units having water sealed toilets connected to septic tank or a sewer line in a GND
	Means of communication	Types of communication equipment used	Percentage of houses having Fixed line telephones
			Percentage of houses having Mobile telephones
			Percentage of houses having Desktop Computers
			Percentage of houses having Laptop Computers
		Language Proficiency	Percentage of population with English language proficiency in A GND
		Access to internet	Percentage of population having access to internet at household unit in a GND
Access to facilities	Water	Drinking Water Source	Percentage of household units having pipe borne water facility in a GND

Access to facilities	Energy Consumption	Principle type of lighting	Percentage of household units using Electricity from National Grid or Hydro-electricity projects as the principle type of lighting in a GND
		Type of cooking fuel	Percentage of household units using L.P. Gas or Electricity as the main source of coking fuel in a GND
	Health	Type of service	Percentage of area coverage of a GND under the buffer zone of 25km From selected Private Hospitals
	Solid waste disposal	Solid waste disposal method	Percentage of household units where solid waste being collected by Local Authorities in a GND
Aspirations	Education	Education attainment	Percentage of Population with a degree or above education qualifications in a GND
		Type of school	Percentage of area coverage of a GND under the buffer zone of 10km From selected International Schools

4.2. FRAMEWORK TO ASSESS THE INFLUENCE OF URBANIZATION

Lefebvre (1968) highlighted that the urbanization is not a result of capitalism or industrialism but urbanization is the deepest process that the space and society is subjected to from the very beginning, starting with the pure nature. Thus the capitalism, industrialism, globalization and modernization can be considered as the sub processes the space and society could undergo in different time periods of urbanization process. Accordingly each attribute is evaluated and weighted in terms of level of urbanization imprinted in them based on identified three factors, namely: level of globalization & modernization influence, level of dependency in fulfilling a needs and level of technological influence.

4.2.1. Level of globalization & modernization influence

Globalization can be understood as one such sub processes that societies is subjected to. The term 'globalization' is widely used to describe a variety of economic, cultural, social and political changes that have shaped the world over the past 50 old years. Hallsal & Cook (2013) argued that the increasing homogenisation of corporate power, sharp increases in wealth and poverty. Yeung (2000) describes Globalization as a multifaceted process of drawing countries, cities and people ever closer together through increasing flows of people, goods, capital, services and ideas. As Manirakiza (2012) explains, the real connection between urbanization and globalization is that globalization effects the fate of cities abound by facilitating the rise of mega-cities which are powerful enough to challenge the nation-state and enabling them to become privileged and powerful world economic dynamic leaders.

Modernization on the other hand is also can be viewed as a similar type process that societies undergo with parallel to globalization. Mondal (2015) had listed the loss of group solidarity and community life and traditional large sized joint families on one hand and growing individualism, and smaller sizes of households and development of autonomous personalities in a heterogeneous community on the other, are the commonly observed characteristics of urban as well as modern way of life.

4.2.2. Level of dependency

Wirth (1938) pointed out that due to increasing numbers of population and high densities, a large number of people get to interact and live in a limited space thus it leads to the specialization of individuals, particularly in their occupations which sustains based on an enlarged market and which in turn accentuates the division of labour. This character was accentuated with the industrial revolution and has been becoming more and more significant with the complex organizational characteristics built up in production and service sectors. In simple terms, the people in city depend upon greater number of organized groups such as tans-national, global, national and local level organizations operating in production. Deriving from the theories of Darwin, Wirth argues that in human societies, an increase in numbers when area is held constant, it tends to produce differentiation and specialization and as a result, it causes diversification of men and their activities and ultimately increasing the complexity.

4.2.3. Level of technological influence

The developments in the fields of science and information technology have made a huge influence in social life in different ways. The most important fact is that these developments in transportation and communication have contributed a lot to enormously expand the urban mode of living beyond the confines of the city itself. (Wirth, 1938) Advancements in communication and transportation technology enable people to share their lives in both urban and rural areas without being confined to one particular end. Thus it has brought enormous changes to the people’s way of behavior and can be considered as one dimension in evaluating societies stand in the process of urbanization.

4.3. APPLICATION OF THE PROPOSED FRAMEWORK AT THE NATIONAL SCALE

The above framework was applied to Sri Lanka taking GN Division as the smallest unit of calculation. The data required for each attribute was collected from secondary sources and processed using Arc GIS software to produce maps for separate attribute. The percentage value obtained for GNDs under each attribute was multiplied by the corresponding weight given to the attribute in the evaluation of attributes. Then the values obtained for each attribute were totaled to derive the composite value which represented the level of urbanization of each GND.

Table 4 – Data Collection Sources

Data Source	**Collected Data**
Department of Census & Statistics, Sri Lanka	No. of households of different tenure types
	No. of households of different No. of Storeys
	No. of households of different types of toilet facility
	No. of households of different toilet types
	No. of households with different types of communication equipment (Fixed & Mobile phones, Desktop & Laptop computers
	No. of population with English language proficiency
	No. of households with access to internet
	No. of households with different drinking water sources
	No. of households of different types of lighting sources
	No. of households using different types of cooking fuel
	No. of households practicing different solid waste disposal methods
	No. of population of different education attainment
Mapped by Author based on locational data available in internet sources	Locations of Super Markets (Cargills, Keells, Arpico & Laugfs)
	Locations of Globally recognized Fast Food Outlets (KFC, McDonalds, Pizza Hut & Dinemore & etc.)
	Locations of Fashion Outlets (Nolimit, Fashion Bug, ODEL, CIB & etc.)
	Locations of Private Hospitals
	Locations of International Schools
Survey Department, SL	MC & UC Boundary Maps (Urban Areas according to existing definition)

The results of the proposed framework indicated an average of 44% of maximum level of urbanization meaning that Sri Lanka has not yet achieved the complete urbanization with relative to the absolute urbanization assumed in this study based on the selected attributes. When tried to evaluate each GND with relation to the maximum of 44%, (By converting the range 0% – 44% into 0% – 100%) it was found that 34% of total population in Sri Lanka lives in areas with urbanization level of more than 50%. This value of 34% is in contrast to the existing urbanization level defined as 18.2%. According to the pattern identified, the highly urbanized areas are significantly agglomerated in Colombo, Kandy, Kurunegala, Anuradhapura and Ratnapura areas and the urbanization trend is that these highly urbanized areas spreading outwards from these main cities. Starting from Colombo, these urbanization effects are spreading towards the country side. A linear pattern expanding from Colombo towards Southern and Central parts and Negombo area can be identified and it can be superimposed with the transportation network in Sri Lanka and identify the linkage between the urbanization pattern and the existence of three main highways connecting Colombo with Kandy, Matara & Chilaw.

It is important to identify that there is a whole new region arising beyond City of Colombo and it is expanding towards Eastern parts of the country. Importantly it is found that, according to this framework, no area can be declared as purely urban or rural.

Even though the results directly indicate the level of urbanization of each area, it actually reflects the urbanization levels of societies living in these areas. Since this framework was developed adopting a human centered approach and by evaluating the people’s way of life, even though the final output is a map indicating levels of urbanization of each areas, the core idea is that it reflects the different urbanization levels at which each society is standing at.

4.4. WAY FORWARD

The promising results obtained at the initial stage of the study reveal the possibility of employing the framework at local scale for detailed exploration and verification.

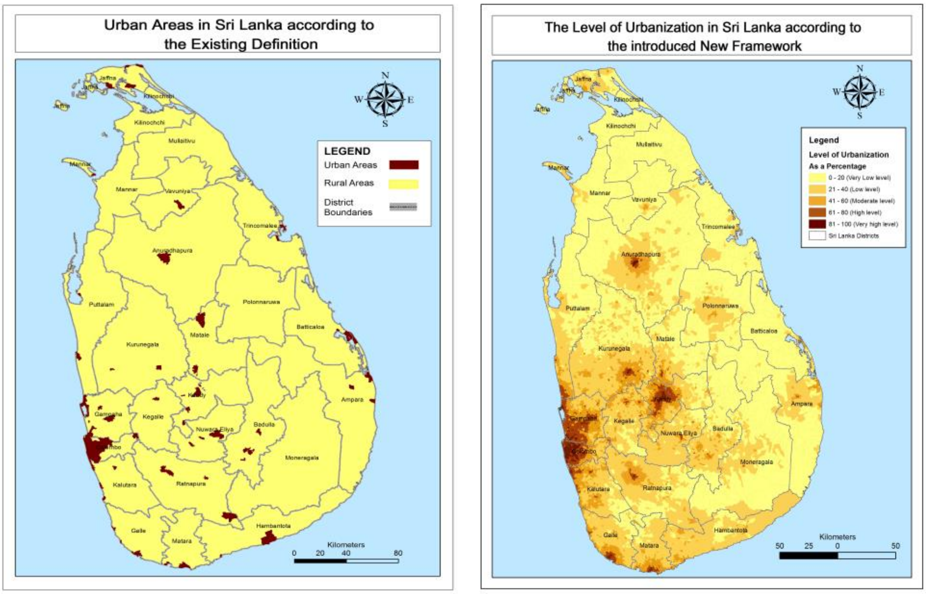

Figure 02, Comparison of urban in Sri Lanka – Existing (left) and proposed

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CRITICAL SUCCESS FACTORS FOR THE PERFORMANCE OF INTERNATIONAL CONSTRUCTION JOINT VENTURES IN THE SRI LANKAN CONSTRUCTION INDUSTRY

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Abstract:
International Construction Joint Ventures (ICJV) are formed to overcome difficulties in construction industry by the multinational parties. As Sri Lankan construction industry has significant impact towards its economy ICJV performance is considered as an important subject. Hence the aim of this research was to investigate the Critical Success Factors (CSFs) affecting the performance of ICJVs in the Sri Lankan construction industry.Initially, a comprehensive literature review was carried out to identify the concept of ICJV, its process and Success Factors (SFs) for the performance of ICJV. Expert interviews and a questionnaire survey were then used to ascertain the ICJV process as applied in Sri Lanka and the CSFs. Finally, a framework was developed for the successful adaption of ICJVs.Based on the findings, ICJV process had been divided into 4 stages, namely: preparation, formation, operation and dismantling. Out ofa total of 25 SFs 13 factors were identified as CSFs, which should prevail in all 4 of the above stages of ICJV process. Finally, the framework revealed that all CSFs in each stage were required to perform the tasks in the respective stages.

Keywords: *Critical Success Factors, International Construction Joint Ventures, Performance, Sri Lankan Construction Industry, Stages.*

Introduction
Joint Venture (JV) is “a legal entity formed between two or more parties to undertake an economic activity together” (Zhang*et al*., 2010, p.87). According to Geringer and Hebert (1989), a JV is turned to an “International Joint Venture (IJV)” when the headquarters of at least one parent firm is located outside the country of operation of the JV. Many economic advantages are offered by IJV including sharing risk and ability of acquiring managerial and technological skills (Zhang and Li, 2001). Despite the above advantages, many studies have identified IJVs as firms, which are difficult to manage due to the complexities raised by the involvement of multinational parties with different political,

cultural and legal frameworks, technical and managerial capabilities (Huang, as cited in Dagbui*et al*., 2011). IJV concept was appeared in the construction industry with the increment of magnitudes, complexities and risks associate with the construction projects (Kumaraswamy *et al*., 2000). Therefore, ICJVs (International Construction Joint Ventures) were used by the firms to improve competitive positions, enter new markets and share risks and (or) profits (Mclntoshand McCabe, 2003). Gale and Luo (2004) have stated that the JVs become successful if they perform well. Neilsen (2007) has proposed that the performance of IJVs should be discussed in relation to the development stages of an IJV life cycle. Therefore, many studies of JVs have drawn attention the CSFs for the performance of ICJVs.

During last few years, a number of ICJV projects have being carried out in the Sri Lankan construction industry. Exploring the SFs for the performance of ICJVs is critical, as there is a close relationship between the success of the ICJV and the success of the project. When considering the previous researches, any evidences cannot be found out about a research which has been carried out to identify the CSFs affecting the performance of ICJVs in accordance with the stages of the ICJV process pertaining to Sri Lankan construction industry. So this research has attempted to fill the gap to identify CSFs for the performance of ICJVs pertaining for each stage of ICJV process in the Sri Lankan construction industry.

1.1 AIM AND OBJECTIVES

The aim of this research is to investigate the CSFs for effective performance of ICJVs in Sri Lankan construction industry. The paper first reviews the concept of ICJV and its application within the Sri Lankan construction industry. The stages of ICJV process including the associated tasks at each stage as well as the Success Factors (SFs) for the performance of ICJVs were also reviewed through the available literature. It then goes on to discuss the methodology adopted in the study.The discussions on the findings commence with a review of the wider contextual factors affecting the process of implementing SFsin Public Finance Initiative projects. The key findings pertaining to the above have been presented in the form of aframework consisting of four main stages.

2.0 Literature Review

The number of construction JVs have been increased as a result of close relationships between nations, which have grown rapidly due to globalization (Andrew*et al*., 2000). An IJV is defined as, “a separate legal organizational entity representing the partial holdings of two or more parent firms, in which the headquarters of at least one is located outside the country of operation of the joint venture” (Adnan andMorledge, 2003, p.765). Zhang *et al*. (2010) have defined an ICJV as an IJV alliance applied in the construction field. JVs and ICJVs are a gradually growing phenomenon in the Sri Lankan context as well.

2.1APPLICATION OF ICJVS WITHIN THE SRI LANKAN CONSTRUCTION INDUSTRY

Wijewardana*et al.* (2013) have identified JV as an uncommon procurement method used in the Sri Lankan construction industry, under integrated system. Hence it is obvious that there is a less number of ICJVs exist in the Sri Lankan construction industry. According to Joseph and Jayasena (2008) ICJVs in the Sri Lankan construction industry had emerged during 1992-1996 period which was 3% of average use.

2.2 GENERIC STAGES OF ICJV PROCESS

Andrew *et al*. (2000) have stated the stages of ICJV process as preparation, formation, operation and dismantling. Preparation stage is the initial stage of an ICJV process and it is started with the decision to enter into an ICJV. Formation stage is commenced after the ICJV partner(s) is/are selected. Operation stage is started after the construction contract is signed between the client and the ICJV and ended at the end of the defects liability period. Dismantling stageis the final stage of the ICJV process and during this stage ICJV agreement is terminated and the dissolution of ICJV firm is occurred.

2.3 SUCCESS FACTORS FOR THE PERFORMANCE OF ICJVS

IJV performance has been defined by Yan and Grey (2001) as achieving the goals by both partners of an IJV. Ozorhon (2007) has emphasized that assessing the ICJV performance is a complex task, because of the issues occur when measuring the ICJV performance. According to Adnan*et al*. (2011) an ICJV become successful when the partners achieve the same goal by using a joint effort. Hence, SFs are necessary for the ICJV partners to achieve their goals. SFs for the ICJV performance which were highlighted by the past researchers can be tabulated as given in Table 1.

Table 1: SFs identified through the literature review

Success Factor	**1**	**2**	**3**	**4**	**5**	**6**
Mutual Understanding	√			√		
Inter partner trust	√		√	√	√	√
JV agreement	√	√				
Commitment	√	√	√	√	√	
Cooperation	√	√	√		√	√
Financial Stability	√				√	
Coordination	√					
Communication	√					

Management control	√			√	√	
Profit	√					
Partner’s experience	√					
Organizational structure	√			√		
Criteria for good partner selection	√					
Compatibility of partners’ objective	√	√				
Equity control	√	√		√		
Effective human resource management (HRM)	√					
Knowledge transfer	√					
Motivating for forming ICJV	√					
Size compatibility of partner’s firm	√					
Cultural Understanding	√			√		√
Conflict	√					
Good partner selection		√		√	√	√
Obtaining enough information about partners bef negotiation		√				
Partner’s set different source of resources					√	
Good technology capabilityand operational expertize					√	
Fulfillment of client’s expectations					√	
Good decision making				√	√	
Satisfaction			√			
Compatibility of partners’ Management culture		√				
Technology transfer				√		
Sub-contractor				√		

1; Adnan andMorledge (2003), 2; Gale and Luo (2004), 3; Wilson andBrennan (2009), 4; Adnan et al. (2011), 5; Adnan et al. (2012), 6; Liu et al. (2014)

Out of six researchers five have identified “inter partner trust”, “commitment” and “cooperation” as SFs. Inter partner trust encourages partners to transfer tacit knowledge, which is a key contributor to ICJV performance (BenerandGlaister, 2010). Commitment indicates some decisions regarding the continuous relationship, acceptance of the joint goals and the value of the partnership (Adnan andMorledge, 2003). Cooperation which changes overtime, but prevailing between two JV firms will lead to high level of trust (Wilson and Brennan, 2009). Oxford has defined both cooperation and coordination in a same manner. Hence “cooperation” has been included in this study as a SF to represent both “coordination” and “cooperation”. Four studies have identified “good partner selection” as a SF for the ICJV performance. Partners who have compatible objectives, are the suitable partners who should be selected as the ICJV partners (Adnan *et al*., 2012). Adnan *et al.* (2011) have discussed some facts such as “mutual understand”, “trust” and “commitment” regarding partner selection. So it is clear that some of the SFs mentioned here have covered the “good partner selection” and “criteria for good partner selection”. Hence those two factors have been removed from this study.Shridharan (1995) has found that “conflict” adversely affect to the JV performance. Though Adnan and

Morledge (2003) have used this factor for their study, it was ranked as the last CSF. Hence it was not investigated in this study. Size and compatibility of partner's firm and "compatibility of partners' management culture" have been identified each by different single authors. As these two factors are relative concepts, to represent both factors, compatibility of partners' management culture has been identified for this study.

3.0 Methodology

This research aims to investigate the CSFs at each stage of ICJV process which will enable the effective performance of ICJVs in Sri Lankan construction industry. Expert interviews and a questionnaire survey was used as the main data collection approach in achieving this aim.

Through a comprehensive literature surveythe stages of ICJV process, and SFs for the performance of ICJVs were identified.Expert interviews were then conducted to ascertain the application of the ICJV concept to the Sri Lankan context. Herein, four semi-structured interviews were conducted with four experts in the industry representing both local and foreign contractors who had experience in ICJV projects in Sri Lanka. Particular attention was given to identifying the tasks or activities involved in each identified stage in the ICJV process and the SFs for the success of ICJVs in the local context as per the respondents' views.

Questionnaire survey was then carried out among the professionals who have experience in involving the ICJV projects in Sri Lanka between the year 2000 and 2015, representing both local and foreign partners to investigate the CSFs affecting for the performance of ICJVs at each stage of ICJV process in the Sri Lankan construction industry. Altogether, 25 SFs were derived following the literature review and expert interviews that were used to develop the questionnaire guideline.

Selective sampling technique was used to select the sample and questionnaires were distributed among 60 ICJV partners satisfying the above criteria. Out of these, 44 responded to the questionnaire.Data collected through the expert interviews were analysed using content analysis, whereas descriptive analysis and hypothesis testing were used to analyse the questionnaire survey data. According to the responses given by the sample of the questionnaire survey, one sample t-test was carried out using SPSS software. Based on the results of the t-test, CSFs factors were identified at each stage. The following criteria were used to identify the CSFs.

1. When the significance level < 0.05, null hypothesis (factors which are deviated from the moderate level of importance) were rejected,

2. If the t-value of the rejected null hypothesis > 1.684, they were considered as CSFs

After analyzing the questionnaire survey data, two expert views were conducted to further elaborate and explain the quantitative results.

4.0 Research findings and discussion

4.1 TASKS ASSOCIATED WITH STAGE OF ICJV PROCESS

Through the content analysis of interview data, tasks to be carried out at each stage of the ICJV process were identified as given in Table 2.

Table 2: Tasks to be carried out at each stage of the ICJV Process

Stages of ICJV Process	**Tasks**
Preparation stage	Obtaining bidding document and studying the nature of the project in financial terms, scope etc...
	Establishment of the objectives of JV participation
	Defining the scope of the project
	Searching partners
	Negotiation with the partner(s)
	Selecting the ICJV partner(s)
Formation stage	Deciding the administrative structure of the ICJV
	Signing the pre-bid ICJV agreement by the parties
	Preparing bidding documents and submit to the client
	Design works of the project
	Signing the formal ICJV agreement, after accepting the bid
	Signing the construction contract between the client and the ICJV
Operation stage	Design works of the project
	Carrying out construction works
	Interim payments and sharing payments between the partners
	Maintenance works
	Disputes resolution
Dismantling stage	Adjustment of property
	Ending matter negotiations
	Liquidation
	Dispute resolution
	Termination of the ICJV agreement

Preparation is the initial stage of the ICJV process. Once the ICJV partner(s) is selected preparation stage would be ended. The main two tasks of preparation stage are deciding to enter into an ICJV and selection of partner(s). After selecting the ICJV partner, formation stage is commenced. Formation stage is ended up when the construction agreement is signed between the ICJV partners and the client. In operation stage mainly construction works are carried out and operational and maintenance works are carried out during the defects liability period. Dismantling stage is the period ICJV partners' dissolute formal ICJV contract. This stage has a short duration when comparedto other stages.

4.2 IDENTIFICATION OF CSFSAT EACH STAGE OF ICJV PROCESS

CSFs are required for the performance of ICJVand to achieve goals. CSFs in each stage are shown in Table 3 with their T values.

Table 3: T test results of every stage

No	Success Factor	T Value			
		Preparation	Formation	Operation	Dismantlin g
SF01	Inter partner trust	17.32	38.96	35.61	27.05
SF02	Commitment	21.53	30.91	26.50	11.93
SF03	Cooperation	15.35	27.85	29.54	10.64
SF04	Cultural understanding	3.72	NCSF	7.50	NCSF
SF05	Equity ownershipControl	NCSF	4.55	7.55	5.75
SF06	Management control	3.02	9.73	18.90	6.37
SF07	Mutual understanding	16.35	22.20	61.53	22.31
SF08	ICJV Agreement	NCSF	13.84	25.47	14.03
SF09	Financial stability	9.81	10.72	14.63	2.64
SF10	Organizational structure	NCSF	5.63	12.75	NCSF
SF11	Compatibility of the objectives	9.10	8.26	9.90	4.93
SF12	Good decision making	12.56	18.05	42.55	17.33
SF13	Communication	21.53	19.88	38.98	13.49
SF14	Profit	9.48	13.84	18.09	10.71
SF15	Partners' previous experience in ICJVs	12.93	16.99	15.03	2.94
SF16	Effective HRM	NCSF	8.50	18.11	NCSF
SF17	Knowledge &technology Transfer	NCSF	5.18	15.20	NCSF

SF18	Compatibility of management Cultures	NCSF	4.75	6.01	NCSF
SF19	Obtaining enough information about partner(s) before negotiation	27.05	5.79	NCSF	NCSF
SF20	Good technology capability & operational expertise	15.52	10.74	18.88	NCSF
SF21	Fulfillment of client's expectations	NCSF	10.44	22.20	6.00
SF22	Satisfaction of partners	11.13	9.42	13.20	11.13
SF23	Payment separation mechanism	NCSF	2.83	22.41	13.89
SF24	Capability of tolerance	4.43	5.59	13.69	11.31
SF25	Resource sharing	NCSF	NCSF	19.88	NCSF

NCFA – Not a CSF

Among 25 SFs, only 13 factors have been identified as CSFs which should prevail at every stage, or in other words from the beginning to the end of the ICJV performance.

There are 16 CSFs which have been identified for the performance of ICJVs at the preparation stage. According to the expert views, the most important tasks associated in this stageare having successful negotiations and selecting a good partner. According to the literature, good technology capability and operational expertise, previous experience in ICJVs and financial stability are the qualities of a good ICJV partner. Experts emphasized that commitment, inter partner trust, cooperation, mutual understanding and cultural understanding cause to have long relationships with the partner. Though management control has been identified as a CSF, experts did not agree with the result, because without forming an ICJV firm, there cannot have a management control.

Among 25 SFs, 23 have identified as CSFs at the formation stage. The ICJV agreement, which is signed with ICJV partner, has been identified as an important factor which reduces disputes in later stages. The rights and obligations should be critically reviewed before signing an pre bid ICJV agreement, because sometimes a formal agreement is not signed in the Sri Lankan context. According to the experts, employer is doing interim payments to the ICJV firm, neither party is paid separately by the employer. Leading party, who gets more shares has the responsibility to divide it among the partners. But sometimes leading party delays the payment to other party. This will badly affect to the performance because of the lack of money. Hence it is advisable to agree on a payment separation mechanism before submitting the bid.

Among 25 SFs, 24 have been identified as CSFs which affect the performance at operation stage. As both parties work together mutual understanding, inter partner trust and cultural understanding are very critical in this stage. According to the experience of the experts, the parties should have capability of tolerance in some instances such as when one party fails to carry out a critical path activity then it may cause to delay to start the other party's scope. In such situation the suffered party should have the capability of tolerance. Experts have mentioned that fulfillment of clients' objectives is very essential to fulfill partners' goals in this stage. When the parties fulfill client's objectives (time, cost and quality), client will support the parties to fulfill their objectives which will enhance the performance of the ICJV.

There are 17 CSFs have been identified for the dismantling stage. This is the final stage of the ICJV process. So the ICJV partners should make good decisions in this stage to avoid disputes. Expertshave mentioned that the above identified factors facilitate the partners to fulfill their objectives in this stage to continue ICJV for another project.

4.3 DEVELOPMENT OF THE FRAMEWORK FOR SUCCESSFUL ADAPTION OF THE ICJV PROCESS

From the results discussed in section 4.2 a framework wasdevelopedto enable the successful adaption of ICJV process in the Sri Lankan construction industry(see Figure 1).The framework demonstrates the four stages in ICJV process with related tasks and CSFs for the performance of each stage successfully.

Preparation stage →	Formation stage →	Operation stage →	Dismantling stage
Tasks ❖ Obtaining bidding documents ❖ Establishment of the objective of JV participation ❖ Defining the scope of the project ❖ Searching partners ❖ Negotiation with the partner(s) ❖ Selecting the ICJV partner(s)	**Tasks** ❖ Deciding the administrative structure of the ICJV ❖ Signing the pre-bid ICJV agreement by the parties ❖ Preparing bidding documents & submit to the client ❖ Design works of the projects ❖ Signing the formal ICJV agreement, after the bid is	**Tasks** ❖ Design works of the project ❖ Carrying out construction works ❖ Interim payments and sharing payments between the partners ❖ Maintenance works ❖ Disputes resolution	**Tasks** ❖ Adjustment of property ❖ Ending matter negotiations ❖ Liquidation ❖ Dispute resolution ❖ Termination of the ICJV agreement

	accepted ❖ Signing the construction contract between the client and the ICJV firm		
CSFs • Obtaining enough information • Commitment • Communication • Inter partner trust • Mutual understanding • Good technology capability & operational expertise of the parties • Cooperation • Partners' previous experience in ICJVs • Good decision making • Satisfaction • Financial stability • Profit • Compatibility of objectives • Capability of tolerance • Cultural understanding • Management control	**CSFs** • Inter partner trust • Commitment • Cooperation • Mutual understanding • Communication • Good decision making • Partners' previous experience in ICJVs • ICJV agreement • Profit • Good technology capability & operational expertise of the parties • Financial stability • Fulfillment of clients' expectations • Management control • Satisfaction • Effective HRM • Compatibility of the objectives • Obtaining enough information about partner before negotiation • Organizational structure • Capability of tolerance	**CSFs** • Mutual understanding • Good decision making • Communication • Inter partner trust • Cooperation • Commitment • ICJV agreement • Payment separation mechanism • Fulfillment of client's expectation • Resource sharing • Management control • Good technological capability and operational expertise of the parties • Effective HRM • Profit • Knowledge and technology transfer • Partners' previous experience in ICJVs • Financial stability • Capability of tolerance • Satisfaction • Organizational structure • Compatibility of the objectives • Equity ownership control • Cultural understanding • Compatibility of partners'	**CSFs** • Mutual understanding • Good decision making • Communication • Inter partner trust • Cooperation • Commitment • ICJV agreement • Payment separation mechanism • Fulfillment of client's expectation • Resource sharing • Management control • Good technological capability &operational expertise of the parties • Effective HRM • Profit • Knowledge and technology transfer • Partners' previous experience in ICJVs • Financial stability • Capability of tolerance • Satisfaction • Organizational structure • Compatibility of the objectives • Equity ownership control • Cultural

	• Knowledge and technology transfer • Compatibility of management cultures • Equity ownership control • Payment separation mechanism	management cultures	• understanding • Compatibility of partners' management cultures

Figure 26: Framework for the successful adaption of ICJV process

This framework can be used to form the ICJV among the contractors in which at least one firm is located outside Sri Lanka and one firm is located in Sri Lanka. The purpose of this framework is to provide proper guidance to the contracting firms who engage with ICJVs for the first time and the firms that were not successful through ICJVs previously. As this framework offer directions to ICJV partners to continue the ICJV process from preparation stage to dismantling stage, partners can achieve their intended goals by following this framework.

5.0 Conclusions

JV concept in construction became popular in the construction industry with the complexities involved in the projects and the risks associated with them. With the globalization, developing countries used ICJVs a strategy to share the risks, improve competitive positions in the international construction context and to enter into new markets etc. ICJV can be defined as a separate legal entity between two or more partners which is formed to undertake a construction work together, in which at least one of the partners headquartered outside of the country where the ICJV is formed. The main difference between commonly used equity JVs and construction JVs is that a separate construction agreement is signed between the client and the ICJV firm, other than the JV agreement signed between the parties of the ICJV. ICJV process had been divided into four stages, namely: preparation stage, formation stage, operation stage and dismantling stage. Preparation stage is started with the decision to enter into an ICJV. Formation stage is commenced after the ICJV partner(s) is/are selected and is ended up when the construction agreement is signed between the ICJV firm and the client. Operation stage is started after the construction contract is signed between the client and the ICJV and ended at the end of the defects liability period. Among 25 SFs, 13 factors have been identified as CSFs which should prevail in all the four stages of ICJV process.Finally, the framework recommended that all CSFs in each stage were required to perform the relevant tasks in the respective stages.

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COMPARATIVE EFFECTIVENESS OF QUANTITY SURVEYING IN BIM IMPLEMENTATION

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Abstract
Over the past eras, dawn of innovative technologies in construction industry intensified, where Building Information Modelling (BIM) has established as a collaborative tool. Although construction industry is deemed to be conservative, the adoption of BIM redefined traditional professional boundaries. Quantity Surveyor (QS) is one prominent role which needs to compete with aforesaid challenge, where the history provides substantial evidences to its amenability. However, this conversion may influence in either way, where it can upgrade or downgrade the profession since unwieldiness may adhere to the situation, it’s being used. Hence, this paper aimed at identifying comparative effectiveness of BIM in performing QSs’ tasks. Through an extensive literature study features of BIM, QSs’ practices, and the competency of performing BIM adhered QSs’ tasks were discovered. A documentary survey utilized for the identification of potential capabilities of performing QSs’ tasks through BIM tools finally, a content analysis was conducted to analyse the data using a qualitative approach. It was revealed that when executing traditional QSs’ tasks, BIM has proven a great adeptness and contrariwise for modern tasks. Tasks directly linked with numerals experience splendid benefits through BIM. Thus, it was concluded it is advantageous to perform traditional QSs’ tasks through BIM tools.

Keywords: *Building Information Modelling (BIM); Quantity Surveyor (QS); Tasks*

1. Introduction

The dramatic evolvement of Information Technology (IT) intensively upgraded the construction industry's performance, where Building Information Modelling (BIM) has developed into one such reputable collaboration procedure. The BIM itself has a greater stimulation on everyone's profession which redefined the professional boundaries. Quantity Surveyor (QS) is appeared to be one of the significant professions in this occurrence, which needed to be amended with the adoption of BIM. The paper explores how the accustomed behavior of a QS is being influenced by BIM and comparative effectiveness of BIM tools against quantity surveying approaches.

2. Background

Over the past decades, the construction industry merged with innovative systems which upgraded the productivity, performance and established new customs of managing and organizing by the evolvement of the IT (Kim, 2003). Among those, BIM is one such newest technology in the built environment which is currently utilising data models (Gee, 2010). Succar (2008) defines, BIM as a "set of interacting policies, processes and technologies generating a methodology to manage the essential building design and project data in digital format throughout the building's life-cycle (p.29)", while Smith (2007), expresses BIM as, build a building virtually prior to building it physically, in order to work out problems and simulate and analyse potential impacts. However, it is arguable whether BIM is an anathema for current professionals in the industry, since BIM proved its capability of alleviating some of the foremost tasks of disciplines. Supplementary, Gu, Olatunji, and Sher (2009) justified that, BIM is a major challenge to the services conventionally provided by QSs and other construction disciplines. Moreover, as argued by Ashworth and Hogg (as cited in Gee, 2010) the QSs' profession, like many other professions, is an evolving discipline that needs to continue to change to meet the ever changing conditions of the building industry. Similarly, Baldwin and Jellings (2009b) highlighted that multiple computer applications have already been developed to automate certain QS responsibilities in order to alleviate some of the pressures caused by time constraints and competitiveness. Therefore, all the aforementioned findings mutually agreed that the adoption of BIM may redefine traditional professional boundaries explicitly for QSs.

However, Gee (2010) exemplified that, BIM's capabilities of automating the production of Bills of Quantities (BOQ), which is one of the QSs' fundamental tasks, which will have both positive and negative effects in the field of quantity surveying. In opposition, Ogunsemi, Olatunji, and Sher (2010) claimed that, there is a second line of thought within the construction industry which suggests that, BIM is not completely trustworthy as a QS tool as nonconformity of the output data from BIM with the standard methods of measurement. Proving the above fact, Buckley (as cited in Shangvi, 2012) contended that BIM tools are not advanced enough to be capable to substitute the experience and expertise of the QS. Thus, the question has been raised whether BIM actually provides effectiveness over QS when performing QSs' tasks.

2.1. AIM

The aim of this research is to evaluate below statement.
"Can BIM provide either an equally effective or more effective solution compared to the conventional practice of QS in performing quantity surveying tasks"?

2.2. OBJECTIVES

Hence, the set objectives of the research were;

- Identify the conventional quantity surveying tasks performed in the construction industry
- Recognize the BIM tools available to perform the quantity surveying tasks
- Evaluate the effectiveness of BIM tools in performing quantity surveying tasks
- Establish comparative effectiveness of BIM tools against conventional methods

The preliminary phase of the paper is a comprehensive literature review which identified the features of BIM and QSs' practice distinctly and discovered the competence of performing QSs' tasks that can be achieved through BIM. The subsequent sections discusses the research methodology applied, followed by explored outcomes of the study and lastly presents conclusions and recommendations.

3. Literature Synthesis

A comprehensive literature synthesis was carried out which equated traditional QSs' practices with the performance of QSs' tasks that can be achieved through BIM.

3.1. ROLE OF A QUANTITY SURVEYOR

QSs are well-known to be specialists in terms of cost and value hence, they are accountable for guide clients on the paths of cost and value, appropriate implication of design decisions and the govern construction costs (Ashworth, Higgs & Hogg, 2013). Supplementary, RICS (2012) defined the work of the QS as: "Ensuring that the resources of the construction industry are utilised to the best advantage of society by providing the financial management for projects and a cost consultancy service to the client and designer during the whole construction process (p.17)."

Additionally, Gu, Olatunji, and Sher (2009) discussed that the majority of the most imperative traditional functions carried out by QSs are based upon the measuring and pricing of construction works. Further, AIQS (2011) indicated that preparing BOQ is one of the oldest tasks performed by the QS. In fact, the QSs got their name from the BOQ. Thus, it is factual and undoubtedly reflected that there is a direct link between QS and cost parameter of a project.

3.2. WHAT IS BIM?

BIM is eminent for its ability of digital demonstration which represents the physical and functional characteristics of a facility (NBS, 2008). BIM is also acknowledged as a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle; defined as existing from earliest conception to demolition. Further, Thomsen (2010) revealed that BIM is a logical step to envision, which considers an entire building as a smart object with endless possibilities for algorithms that govern its behaviour and associated information. Alternatively, Smith (2007) defined BIM as a process of generating and managing data about the building, during its life cycle which typically uses three-dimensional, real-time, dynamic building modelling software to increase productivity in the design and construction stages. Thus, according to the above descriptions, BIM is characterized to function throughout the lifecycle of the projects. In spite of that, BIM also acts as a foreseer due to its ability of simulating physical space and expressing design intent graphically, providing a clearer image of design conflicts or constructability issues so that they are resolved before the real site operations begin (Chelson, 2010).

3.3. BIM AND QUANTITY SURVEYING PRACTICE

Technology is emerging promptly by enlightening all its subsectors across the world and making all the real life functions easier than they were. The construction industry which recognizes technology as vital has been sensitive to these technological modifications. Proving the fact, Sattineni and Bradford (2012) stated that, there is a widely acknowledgement towards the adoption of BIM, which would cause a seismic shift in the business processes within the construction industry and related fields. With relate to the QSs role, it was proved that BIM can assist the QS in various tasks rather than quantification as mentioned in the preceding paragraph. The statement was justified by Azhar, Hein, and Sketo (2010) who claimed that BIM software(s) have built-in cost estimating features. Supportively, Ashworth (2010) discovered that the speed of response and the ability to reduce manual errors have led to the wide-spread use of software applications for performing Quantity Take-Off (QTO) and estimating. Furthermore, Baldwin and Jellings (2009a) specified that the 5D model created by BIM has the potential to perform an automatic analysis of all materials and components and to derive their quantities directly from the model. Additionally, Eastmen, Liston, Sacks, and Teicholz (2008) mentioned that proponents of BIM are very useful for Value Management (VM) as the speed of response of BIM tools provides an excellent opportunity to perform VM throughout the design period. Hence, all aforementioned statements collectively agree on the opinion where BIM provide enough substitutional effort over QSs tasks.

Contra wisely, Buckley (as cited in Shangvi, 2012) recommended against this practice of preparing a cost estimate without the involvement of an estimator and he stressed that estimator's knowledge and experience are absolutely essential to adjust the estimate in accordance with the specific conditions of a project. Furthermore, he pointed out that BIM tools are not programmed to perform such adjustments by themselves. Similarly, Ogunsemi et al. (2010) have doubts over the reliability of QTO performed by BIM applications as BIM tools simply provide theoretical quantities based on the attributes of the model without any allowances for wastage, lapping etc. Moreover, Ashcraft (2008) elaborated that lack of standard contract documents delays development of BIM since consensus business model for BIM has not emerged yet.

4. Research Methodology

Through an extensive literature synthesis, the distinct features of BIM and QSs' practice together with the competence of performing QSs' tasks that can be achieved through BIM were identified. A qualitative analysis was utilized by using a documentary survey and NVIVO software, which explored the compatibility of BIM with recognized traditional and evolved tasks of a QS. The documentary survey was accompanied by research publications, online publications by personal and company blogs, online forums, online discussions at professional networks and websites.

5. Research Findings

The research findings of the documentary survey (Table 1) assisted in exploring the sustenance of BIM tools over QSs' tasks and comparative effectiveness of BIM tools against conventional quantity surveying approaches.

Table 4: Comparative effectiveness of BIM over conventional QS approaches

QS Tasks	Comparative Effectiveness against conventional QS approaches
Providing Approximate Cost Estimates	This task reflected a more effective behaviour with the amendment of BIM tools due to the absence of human errors may occur in terms of quantification and alternation of cost, as well as the reduction of time taken to the process.
Advice on Procurement	BIM techniques are more effective when advising on procurement method since, the combination of BIM and QS allows the prediction of probable uncertainties may occur during the process of selection.
Cost Planning	Due to the accelerated procedure, BIM tools are more effective when performing the task of cost planning.
Measuring Items on Site	The applicability of BIM in real site operations are still emerging. Hence, the collaboration of BIM into this task showed less effectiveness.
Preparing Bill of Quantities	BIM techniques associate much more effectively when preparing BOQ in terms of automating, removing human error, increasing efficiency and promoting collaboration.
Preparing Schedules of Works	BIM based scheduling is more effective due to early coordination, constructability analysis, and prefabrication which led to improved design and field productivity, reduced field effort, and significant reductions in the overall construction schedule, which resulted in a confident forecast of on-time delivery.
Preparing Financial Statements	BIM tools upgraded the performance of this task due to its ability of data integrity.
Controlling Costs throughout the Project	The impact of BIM tools have positive influence on the process of cost planning throughout the project by means of increases profits, lowers costs, and less scheduling time.
Assessing and Negotiating Tender	The efficacy of the process of assessing and negotiating tender is mostly relying upon the experience and the practice of a QS. Thus, the amalgamation of BIM into this task reflects a less effectiveness.
Investment Appraisal	As preceding task, the investment appraisal also requires accurate judgment of a QS which is entirely based on his practises and experiences. Therefore, it was concluded that although BIM tools support investment appraisal in a way, besides if the task take as a whole, the model is less effective.

Advice on Cost Limits And Budgets	BIM uniquely offers the concurrent and immediate availability of all of the important information about the building that results in higher quality work, greater speed and productivity, and decreased costs to advice on cost limits and budgets. Hence, BIM has proved much effectiveness over this task.
Whole Life Costing	In terms of creating, using, gathering and sharing building life cycle data, BIM provides a great efficiency in the mechanism of whole life costing.
Value Management	Acceleration of the process is the main advantage of BIM tools with regard to the value management procedure. This allows carrying out value management from the design phase throughout the entire project greatly benefit from the capability to automate. Consequently, with regard to value management, BIM tools are more effective.
Risk Analysis	If accurate and reliable information exists, BIM tools have positive influence on the results of the risk analysis, whereas incomplete, improper or unjustifiable data may cause to wrong interpretation of safety and risk analysis. Thus, it seems to be that BIM tools have equal effective influence on analysing risks of the construction procedure.
Insolvency Services	Throughout the research survey conducted, facts that suggest the efficiency of BIM tool with relevant to the task could not be found. Hence, further research should be processed to investigate the relevancy of BIM tools with the aforementioned task.
Cost Engineering Services	BIM tools have positive influence on the cost engineering services in terms of cost controlling, ensuring the right information is available at the right time, manage change and limit or even eliminate unforeseen costs, delays and claims.
Subcontract Administration	Subcontract administration reflects more effectiveness with BIM as it coordinates and accelerates the communication process between contractor and subcontractors.
Environmental Services Measurement and Costing	Neither positive nor negative facts could be found with regard to this task. Hence, further research is suggested to explore the collaboration of BIM tools with this task.
Technical Auditing	The applicability of BIM in real site operations are still emerging. Hence, the collaboration of BIM into this task showed less effectiveness.

Planning and Supervision	Numerous activities of this task should be conducted physically and it directly expressed that BIM shows less efficiency on planning and supervision. Contra wisely, the BIM's ability of planning and tracking construction activities upgraded the performance of the task. Hence, it was concluded that BIM tools are having equal effectiveness with relevant to the aforementioned task.
Valuation for Insurance Purposes	Due to the unavailability of sufficient facts, it was recommended to carry out further investigation to appraise the effectiveness of this task with the combination of BIM.
Project Management	BIM provides a significant sustenance to utilize the functions of project management in terms of identifying, managing and analysing important data as well it assist in managing concurrent activities as well. Thus, it was expressed that the impacts of BIM tools have positive influence on project management activities.
Facilities Management	Facilities management operations are strongly enlightened by the functions included in BIM tools. Hence, BIM provides a significant support to utilize the functions relate to the facilities management.
Administering Maintenance Programs	Data contained in the BIM model can be used for managing remodelling, additions, and maintenance. Therefore, BIM tools are highly reliable for the performance of this task.
Advice on Contractual Disputes	BIM greatly reduces conflict issues by integrating all the key systems into the model, hence it minimizes probability of legal disputes which ultimately assists in this particular task.
Programme Management	Programme management essentials the expertise of a QS, which could only gained through the experience and practice. Thus, it was concluded that amendment of BIM causes for less effectiveness when fulfilling this task.
Cost Modelling	Findings revealed that, BIM tools have equal effective influence on cost modelling process of the project.

Table 2, elaborates the degree of efficiency of BIM tools with regard to the quantity surveying tasks.

Table 2: Summary of key findings

Quantity Surveying Tasks	**Efficiency of BIM tools**		
	More effective	Equal effective	Less effective
1. Providing approximate cost estimates	×		
2. Advice on procurement	×		
3. Cost planning	×		
4. Measuring items on site			×
5. Preparing bills of quantity	×		
6. Preparing schedules of works	×		
7. Preparing financial statements	×		
8. Controlling costs throughout project	×		
9. Assessing and negotiating tender			×
10. Investment appraisal			×
11. Advice on cost limits and budgets	×		
12. Whole life costing	×		
13. Value management	×		
14. Risk analysis		×	
15. Cost engineering services	×		
16. Subcontract administration	×		
17. Technical auditing			×
18. Planning and supervision		×	
19. Project management	×		
20. Facilities management	×		
21. Administering maintenance programs	×		
22. Advising on contractual disputes	×		
23. Programme management			×
24. Cost modelling		×	

6. Conclusions and Recommendations

The findings demonstrated that when performing traditional QSs' tasks, BIM has proven a great efficiency besides evolved QSs' tasks interpreted a less efficiency. Particularly, tasks which have direct relationship with measuring and interpreting quantities, reached more benefits through BIM models. Furthermore, it was concluded that performing tasks which are required the skills of assessing, negotiating, supervising, auditing and planning are less effective with the assistance of BIM tools. Moreover, certain tasks seem to be having an equal impact of the effectiveness relevant to BIM. Throughout the research study, it was discovered that for several tasks namely insolvency services, planning supervisor, employer's agent and sustainability advisor not containing any information to interpret the relevancy of BIM tools and its efficiency.

This study recommends the application of BIM tools for performing the task of providing approximate cost estimation means of reducing time, cost and updating quantities without any errors. Furthermore, it suggested confidently the application of BIM tools when advising on procurement method with regard to the influence of uncertainties may occur during the process of selection. Further, considering the conflicts between positive and negative influences of BIM tools over preparing bills of quantity, the empirical evidence discussed that the key benefits of the model are strengthening the effectiveness over its negative circumstances. Hence, it can be recommended through proper improvements of BIM tools associate much more effective when preparing bills of quantity.

Further, this study praises the applicability of BIM tools over controlling cost throughout the project. It highlighted that practice of BIM tools for advice on cost limits and budgets effective as it let QS to focus on more significant and important activities. Furthermore, findings mentioned that BIM provides a great efficiency in the mechanism of whole life costing as a mean of creating, using, gathering and sharing building life cycle data and acknowledged that application of BIM tools in value management process as BIM tools allow carrying out value management from the design phase throughout the entire project.

Additionally study illustrated that application of BIM tools for administration of sub-contractors as it to increase the efficiency and rapid the speed of process. Also study recommended that application of BIM tools for administrating maintaining program and for advising on contractual disputes through the BIM tools. However, findings of this study specifically not recommended the application of BIM tools over measuring item on site, which requires further study. Moreover it cannot be suggested that practice of BIM tools for assessing and negotiation of tender as BIM tools are not capable with negotiation and evaluation process. Although BIM tools support on investment appraisal in a way, it cannot be recommended that application of BIM tools for investment appraisal when task taken as a whole. The study revealed that a necessity of a further research for ascertains the effectiveness of BIM tools over preparing financial statements, risk analysis, cost modelling and planning and supervision as those tasks have both strengthen and weakness when perform through BIM tools.

According to the findings, it would be beneficial to application of BIM tools in construction in both pre-contract and post-contract phases by meaning of reducing time, cost and improving buildability of project. Finally study disclosed that practice of BIM tools may increase the efficiency over most of traditional quantity surveying tasks performed by a QS.

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BUILDING URBAN RESILIENCE
An unplanned built-up area in Dhaka

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Abstract
The prevalence of continual increase of population, poor construction standards, lack of law enforcement and monitoring, construction on filled up canals and water bodies as well as unplanned growth in hazard prone areas in Dhaka is turning the whole city into a source of potential hazards. As a result, both the built up and growing areas possess great risks of hazardous incidents like fire, water logging, collapse of structures, and earthquake etc. This paper emphasizes the need to address the risks in unplanned built up areas and takes into account an area (part of ward No. 14 & 15) as a case with prior illustration of context of Dhaka city. It analyzes vulnerabilities of the area in terms of infrastructures exposed to risks like fire and earthquake etc and emergency response. Finally it aims to develop some notions towards building resilience and as an outcome it recommends some short, medium and long term action plans. Among the actions it prioritizes recovery of connectivity and open spaces within the area in order to ensure minimum safety. Methodology of the whole process includes literature review, analyzing secondary data, and primary data collection from site through observation and conversation with the local residents.

Keywords: *Urban resilience, unplanned built up area, infrastructures, response, and urban intervention*

1. Introduction
Bangladesh is a deltaic country located at the lower part of Ganges-Brahmaputra-Meghna basins; and well known to be highly disaster prone. The unique geographical setting, physiographic features and hydraulic system make it one of the most flood and cyclone prone areas of the world as well as exposed to violent tornadoes, Nor'westers, river erosion etc. The tectonic setup also reveals that, it lies in the seismically active zone, where several devastating earthquakes occurred in the past [Paul.et al, 2010]. All these make Bangladesh a disaster risk hotspot, ranked fifth in the top 15 countries with highest risks [World Disaster Report, 2012]. Huge population is aggravating the risks as well.

A major consequence of the recurring disasters is found in the movement of people; movement towards more inland or urban areas. It is found that rural-urban migration cause 40% of increase in urban population and in some cities this figure is as high as 70% [Parvin et al, 2013]. High population growth in the urban centres, especially in the capital city Dhaka, is in one hand generating increasing demands of infrastructures and in the other hand exacerbating hazard induced risks. Lack of law enforcement and monitoring resulting in poor construction standards, construction on filled up canals and water bodies, unplanned-uncontrolled growth in hazard prone areas, increased slum settlements- is turning the whole city into a source of potential hazards. Faster growth of cities with insensitive or non-inclusive urban land use planning, urban development and management lead to higher disaster risks [Sharma et al, 2011]. As a result incidences like fire, water logging, and collapse of structures are evident in the built up areas; and the persisting uncontrolled growth is posing threat of higher mortality due to collapse, fire and earthquake as well. Besides, the unplanned development is hindering post disaster response activities.

The paper suggests that it is high time to address the vulnerable areas and intervene accordingly to achieve resilience. Among the components of urban resilience the write up focuses on infrastructures and in a context of built up area it realizes resilience as the residents' preparedness to respond and strengthening of the area's post disaster response activities (i.e. mobility of fire fighting vehicles). As a case this particular study takes into account an unplanned residential area covering Hazaribagh and Zigatola (part of Ward 14 & 15) which had, to a great extent, developed around the Tannery industry. It has grown on lands adjacent to river Buriganga and possesses a risk of liquefaction during an earthquake. Keeping this in mind vulnerabilities regarding infrastructures are depicted here particularly with respect to fire and earthquake hazard. Discussions have been made on ways of fostering resilience by short, medium and long term action plans.

2. Methodology

The methodology of the study includes literature survey, site survey through observation and conversation with the residents, taking photographs, analyzing primary and secondary data. In addition to it the site was given as a studio project where the proposed measures were exercised to verify its likelihood. The paper contains a brief illustration of context of Dhaka from literature review followed by observations from study area and recommendations.

3. Concept of Urban Resilience

Risk of urban areas due to hazards is likely to be higher than rural because of its complex and sophisticated nature as well as greater population density.

Because all governments have an obligation to protect their citizens, resilience can be seen as a public good [Lall, et al. 2009].

Resilience refers to the ability of a system, community, or society exposed to hazards to resist, absorb, accommodate to, and recover from the effects of a hazard promptly and efficiently by preserving and restoring essential basic structures [UNISDR 2011b]. Concept of urban resilience takes into account four components like infrastructural, economic, institutional and social resilience [Jha (ed), 2013].

Urban infrastructure refers to the systems and services that are critically important for emergency response and the quick recovery of a community and its economy [Jha (ed), 2013]. Infrastructural resilience refers to a reduction in the vulnerability of built structures, such as buildings and transportation systems. It also refers to sheltering capacity, health care facilities, the vulnerability of buildings to hazards, critical infrastructure, and the availability of roads for evacuations and post-disaster supply lines [Jha (ed), 2013]. Building urban resilience often incorporate urban up gradation.

4. Context of Dhaka city- Risk and vulnerabilities

The urbanization of Bangladesh is interlinked with the intense development of Dhaka City which has developed as a politico-administrative centre [Hossain. 2008]. Due to the concentration of both domestic and foreign investment Dhaka City has experienced massive migration from the rural population in recent decades but a critical downside to this has been the dramatic rise in poverty [Hossain, 2008]. According to 2011 Census population of Dhaka city is 89, 06,039 living in an area of 316 sq km and number of household is 20, 34,146. During the last three decades, the average annual growth has been over seven percent which led to rapid expansion of Dhaka city both horizontally and vertically [Ahsan et al, 2013]. It is projected to become the fourth largest city with 22 million populations in the world by 2015 [Rashid et al, 2013]. It is developed spontaneously without observing any rigid planning guidelines or regulations and has exhibited a series of informal and organic spatial patterns [Nilufar et al, 2016]. The intervening ditches, swamps, and marshes were filled in, not in any planned manner, but as exigencies arose and private initiatives dominated the process [Huq et al. 2003]. Within this context some areas have been planned and sub divided into plots and infrastructures are constructed by authority; and in contrast a large of the city has developed organically where the land is subdivided through private or community initiatives and roads are laid to serve their needs without any approved plan [Nilufar et al, 2016].

The central part of Dhaka city is already built up and its expansion is restricted by rivers, canals and low lying flood prone areas around the city; however ignoring such barriers Dhaka is expanding towards all direction through rapid development of housing estates [Parvin et al, 2013]. More than 49% of the wetland areas decreased over the period 1960 to 2008 [Islam et al, 2012]. According to a Report of Dhaka WASA, there were 65 canals in pre-liberation Dhaka and now the number of canals is 26 [Wahra (ed), 2012]. Dhaka Metropolitan Development Plan 1995-2015 indicates eight flood–flow zones and advised to keep those as retention ponds; however many of these areas are already encroached [Parvin et al, 2013]. This way reduction in natural drainage and retentions is hampering the natural flow of water and causing severe water logging and flooding almost every year in recent decade [Parvin et al, 2013].
Extensive use of ground water but minimum recharge is directing towards high risk of drinking water scarcity. Under developed sewerage and waste disposal pose a question of sustainability of the dense communities. The fire safety issue is not highly emphasized from the city planning perspective in Bangladesh [Islam et al, 2008]. In one hand with the increase in population the fire fighting/rescue service is not being developed and in the other hand the infrastructures are not developed as well in accordance with available services. Hence the organically developed areas possess risk of unimaginable loss due to fire, earthquake and earthquake induced fire.

Dhaka lies in the second risky zone in terms of earthquake impact and it is conceivable that the Dhaka region may experience earthquakes with damage greater than intensity VIII, the level assumed based on 1897 Great Indian earthquake [Ansary et al, 2013]. As a number of development has occurred over low lying and filled up lands, incidence of liquefaction in areas are also presumed. The challenge also lies in managing the post disaster response in terms of manpower and rescuing equipments as well as debris management. The major constraint despite of the realization of the risk lies in weak implementation of national plans and policies resulting in exacerbation of the risks due to disasters.

5. Discussion on Study Area

The study area lies in the south west of Dhaka having Buriganga (embankment protected) in the west and planned Dhanmondi residential area in the east. An important feature of this ward is the Hazaribagh tannery industry. The floodplain is gradually being encroached and developed westward beyond the embankment towards the river. The particular ward is listed among the first ten with high population and building density. As the tannery is under relocation process the focus is confined within the residential areas (Zigatola and Hazaribagh) considering only its effects on it. Moreover very small amount of data of this study site have been found due to probably lack of documentation and updating, while, the site has seemed quite vulnerable during investigation and observation.

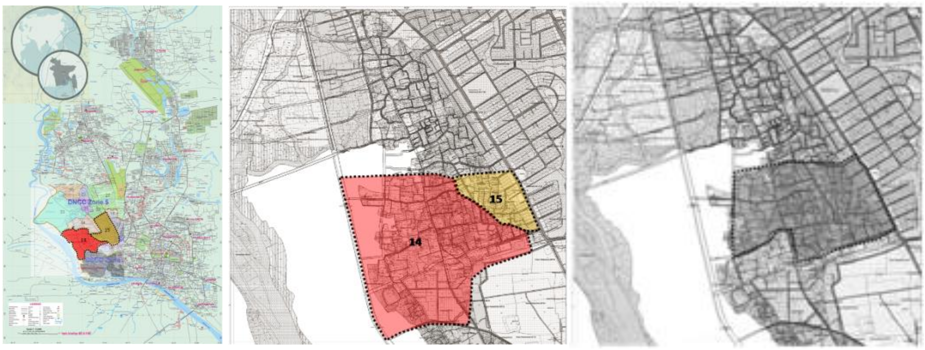

Figure 01: (from left) map showing ward location with respect to Dhaka city, study area with respect to wards and detail surveyed area

5.1. VULNERABILITIES AND PROBLEMS ADDRESSED

The paper addresses vulnerabilities of the area with respect to its location and infrastructures like road networks, utilities etc; as well as it aims to outline the risks it may encounter due to those vulnerabilities.

5.1.1 Vulnerabilities due to location – Soil condition

A major vulnerability of this area is its location being on a zone that, according to the document on Dhaka profile and Earthquake Risk Atlas, possesses a high impact index due to liquefaction; engendering great devastation during an earthquake with respect to a M 7.5 Madhupur fault earthquake scenario [World Bank, 2014]. Moreover the tannery confined area is highly contaminated and soils of part of surrounded residential zone are affected as well. These facts possess unseen threat for the residents.

5.1.2 Lacking legibility in road layout

Following the unplanned development of the area the roads are also laid in a haphazard manner impeding legibility. The wider roads suddenly fall into narrow ones and sometimes form meandering streets. The majority access roads have dead ends. This pattern is likely to engender disorder during an emergency (i.e. fire) by causing bottle neck situations or traps. Moreover it will deter any emergency evacuation with mass of people unaware of destination and not in regular practice of drills.

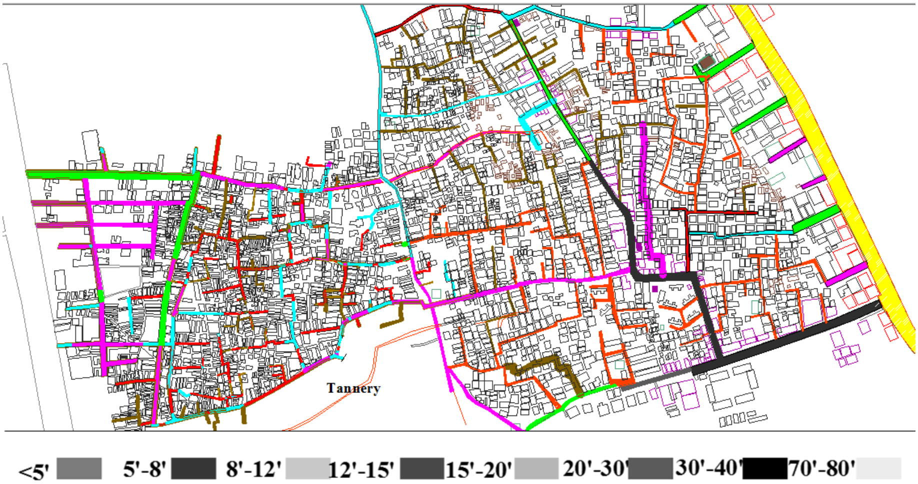

Figure 02: detail map of the surveyed area showing blocks and road networks with demarcation of width

5.1.3 Varying and insufficient road width

The access roads are mainly laid in favour of the lands and buildings that contain varying widths along a continuous road. The site plan provided above depicts the situation which reveals prevalence of roads having width below 5ft through which hardly a rickshaw or bike can move. On the other hand, the fire fighting vehicles engaged in providing emergency service consist of specific types of rescue truck/ambulance and twin vehicles having length of 16-25ft that require 20-30ft wide road for smooth operation and turning. It has limited length of water carrying pipes and container and most of the time rely on existing water source within affected site. Even if an 8 ft wide vehicle move through a 10 ft road it is likely to hinder other vehicles such as ambulance or people to move across. Only a fire bike can move through roads having width within10-5 ft that has very lower capacity. Similarly access of ambulance and its parking will face similar dilemma. Moreover narrow roads resulting in insufficient distance between buildings is likely to get blocked if building collapse during earthquake as well as spread fire rapidly in buildings. This situation is also likely to cause one safe building to suffer due to fall of a weaker structure on it because of the proximity between buildings. Delay in fire fighting is likely to intensify the damage.

5.1.4 Absence of alternative routes

As mentioned earlier the presence of dead ends within community does not provide alternative routes. This can be a major threat or trap during an emergency when people may try to evacuate or get away from any hazard. Both pedestrian and vehicle movement is likely to face this dilemma during an emergency period. This will certainly worsen any response mechanism.

5.1.5 Presence of gate locks

Few gate locks have been found in the area mainly maintained by a single housing complex or smaller communities. However, some gate locks are situated at the end of roads that restrict access of others. This will hinder movement of people and vehicle during any emergency.

5.1.6 Absence of open space

The study area is devoid of any park or playground except for the openness in colonies due to its fewer building footprints. Open spaces in communities play a vital role in residents' life. It serves as platform for people's interaction, children's playground, Physical exercises etc; in one word community space as well as landmarks to the community. The study area is not only disadvantaged with respect to community spaces but also exacerbating risks by limiting its capacity to manage a disaster. During any emergency a park or playground in proper location may prove to be very effective for sheltering people, parking of ambulance or rescue vehicles, providing medical aids, establishing incident manager's office etc. So an open space can amplify a community's capacity by triggering a planned and smooth response mechanism.

5.1.7 Improper drainage

The site doesn't fall within the perimeter or a planned drainage and sewerage system. Residential wastes fall into the drainage which most of cases are not covered. Open drainage lines are found to be containing garbage like cans, bags etc causing an unhealthy environment and logging of drainage. As heard from the residents, a heavy rainfall for hours is likely of causing logging of water on road in some areas that converged with drainage water generate unhealthy environment. Open and unplanned drainage is likely to favour breeding place of vectors as well.

5.1.8 Unplanned installation of gas supply

Supply of gas through metal pipes is found to be laid arbitrary and visible from roads; located adjacent to boundary walls can initiate hazard if hit by cars or collapsed building parts during earthquake; this may discharge gas to environment

5.1.9 Spontaneous assignment of electric posts and wires

Several electric posts are found to be irrationally placed on road decreasing the actual road width. The following pictures also depict the hazardous situation of convoluted electric wires with little or no distance from the buildings. The scenario poses a great risk of fire if not in regular period but during any small earthquake or heavy storm. This unreasonable position of posts is likely to hamper vehicular movement during a disaster aftermath.

Figure 03: (from left) electric post and wire; narrow road; drainage condition; transformer adjoining buildings; unprotected gas pipes

5.1.10 Insufficient set back between buildings

Set back between two buildings are found in major cases to be improper or in cases absent excluding few. Mainly because majority of the buildings are constructed before the establishment of building rules or those constructed later violated the rules. Inadequate distance between two buildings not only deprives the building's interior from proper light and ventilation but also provoke hazard risks like spreading of fire or damage of other structures due to collapse of adjacent one.

6. Proposals and Discussions

To achieve resilience in a dense and unplanned built up urban area the paper recommends to prioritize issues and find out critical sectors to intervene. As the area is grown unplanned and without consideration of risk preventing parameters, to develop the whole area considering all the resilience components is a time intensive approach. Therefore the paper suggests interventions in different phases and proposes a three phase action plan. Concern is to keep the interference to a minimum level while ensuring mandatory safety.

The proposals emphasize on betterment of connectivity and reclamation of open or community space which can ensure mobility of emergency vehicles and preliminary shelter spaces during emergency respectively. These, to a great extent, can save lives within a haphazardly built up area. The proposals are derived from the understandings of the context of the study area, literature review on building urban resilience as well as stance of the Dhaka city in realizing urban resilience and prevailing land development regulations

6.1. SHORT TERM ACTION PLAN

The short term action plan is confined in approaches that can be followed immediately without any physical alteration of the setting; aiming to avoid chaos and loss of lives during any emergency. It may begin with meeting or workshop of representative of residents of different neighborhood from the ward along with authority personnel and other stakeholders like representatives from fire fighting agency, urban designers, earthquake experts or experts in field of resilience etc. Focus of the workshop would be to analyze existing scenario of the whole area and come up with an effective response plan. Residents from different neighborhoods can recommend potentials within their area like wider road, open space, temporary settlements, water bodies, properly designed structures etc if any. Few successive meeting can come up with selection of volunteers, dividing of roles and responsibilities, planning of evacuation routes, delineation of roads for rescue vehicles, places for temporary shelter or preliminary medical aids, health facilities and schools to operate during any emergency. To ensure better connectivity for unhindered response operation during emergency, preparedness planning with proper drill can be done in the following ways.

- Designate roads of 10 ft and below as one way traffic
- Designate roads above 20 ft as both way traffic
- Demarcate roads favorable for emergency vehicles to operate according to its width as well as connectivity with broader city and its service; and specify separate road for people’s movement.
- Designate any refusal space within the building or in the community (open space or safe structure etc)
- Demarcate roads according to prevailing fire fighting vehicles so it can operate accordingly etc.
- Introduce (weekly, monthly, etc) programs involving community like cleaning waste on road, drain, sewer, etc to improve livable environment, prevent water logging, etc.

6.2. MEDIUM TERM ACTION PLAN

Intervening into the physical setting of the built up area to a moderate level is realized as the medium term proposals. Following the short term actions it may include widening of major roads found to be essential for mobility of emergency vehicles and establish the emergency use of a community place if any; or consolidate different open space to serve as a whole through land re-adjustment laws. To ensure better mobility and response operation widening of road may include following measures –

- Widening road(<10ft) up to 10 ft and operate it as one way traffic
- Widening road above 10 ft and operate it as both way traffic
- Ensure mandatory turning radius in the corner plots according to the vehicles of the existing fire fighting service
- Removing and relocating the electric poles that is unreasonably placed on roads
- Awarding incentives for the affected residences or structures
- Demarcate parking & operation zones in relevant intervals for rescue and fire vehicles etc ensuring relevant support like water supply
- Identify the bad condition of the sewer, drain, dustbin, etc of buildings and roads. Major intervention can be- development and construction of soak-pit, connecting the disconnected drains, opening up drain ways for proper water runoff, etc.

6.3. LONG TERM ACTION PLAN

The long term proposal is concerned with an urban renewal process where the entire area can undergo development with risk sensitive approach as priority. This approach can begin with a risk assessment of segmented areas culminating in vulnerability mapping of the entire area; which is likely to guide the zoning and find the major vulnerabilities. This will also incorporate retrofitting of critical and vulnerable structures. Nevertheless the prevailing extent of emergency service (i.e. vehicles, water source, length of pipes, ladders etc) must be considered in the development.

It also recommends that the area must go through urban consolidation process if necessary to reclaim open space; the less dense areas or areas with more informal structures (slums or tin shade) can be reclaimed as open space within a super street block providing densification in the other with proper incentives.

Restructuring the drainage, sewer and garbage collection systems with the area consolidation project should be adopted considering the reuse of waste material and water.

For this particular area concept of phytoremediation can be considered for the decontamination of soils affected from adjacent tannery.

7. Conclusion

As a considerable land within Dhaka city is developed unplanned, the paper attempts to draw awareness on it for being highly vulnerable. It assumes that for built up areas it is not wise to come up with initial ideas of developing a land with risk sensitive approaches. The write up hence recommends that the risk reduction strategies for this type area should focus on the preparedness planning and effective response mechanisms based on available urban services. The extent of intervention is distinguished here in different phases assuming that either of it can apply to an area depending on its setting (i.e. economy, residents' awareness, willingness of authority etc) as well as completion of each phase may direct to its subsequent for a complete transformation of the area into a resilient community eventually. For the unplanned developed areas it is presumed that most of the constructions either followed previous regulations which is now outdated or violated the prevailing ones. In this connection the paper comes up with the recommendations that there should be clear strategies in the regulations for built structures as well concerning the minimum safety issues; and while upgrading the laws consideration of safety issues again is a must. Despite of the realization of building resilience the major challenge lies in implementation of plans; hence strengthening of monitoring process must also be taken into account.

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CRITERIA TO BE USED IN DETERMINING PROJECT DURATION OF ROAD REHABILITATION PROJECTS IN SRI LANKA

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Abstract
Project duration is one of the critical features of a construction project which is determined by project planners during pre-tendering stages. Although there are several project forecasting techniques that are being practiced globally, in Sri Lanka it is the experience and practice that are used to determine the duration of a road rehabilitation project. Hence this research was aimed at developing criteria to determine the time of completion of road rehabilitation projects in Sri Lanka. Initially, a literature synthesis was carried out to identify project duration forecasting methods that are currently available and factors that can affect project durations. Subsequently, the extent of usage of those methods and factors, were determined through interviews. The main criteria were divided into four sub-criteria as relating to project scope, project complexity, project environment and management attributes. Based on the findings, 'Unrealistic contract durations imposed by the client' was found to be the most critical delay factor. Project scope related criteria were the most critical factors that could affect the duration of a road rehabilitation project in Sri Lanka. Thus, it is recommended to use proper methods or criteria to determine project durations of road rehabilitation projects in Sri Lanka.

Keywords: *Project duration; Road rehabilitation projects; Project duration forecasting*

1. Introduction
Today, the construction sector is a significant contributor to the rapid growth of the economies that are developing (Sawhney, Agnihotri, and Paul, 2014). Construction has three sectors in general, namely buildings; infrastructure and industrial (Ling, 2003). Roadways which belong to the infrastructure sector make a significant contribution to the growth of the economy of a country (Burningham and Stankevich, 2005). Many road construction projects in Sri Lanka, experience long delays and as a result, the economy of the country gets affected in several ways (Pathiranage, 2011).

Due to the increasing number of projects in the construction field and their complexity, it has become very essential for those involved in managing these projects to have knowledge on project management, methods and standards (Aliverdi, Naeni, and Salehipour, 2013). Professionals in the industry also have developed several models to help keep a project as planned without any cost or time over runs. These models are useful in forecasting work zone durations (Irfan et al., 2011). Majid and McCaffer (as cited in Irfan et al., 2011) have stated that a knowledge of the expected project duration can help in determining delay costs and the safety associated with a project.

According to Khosrowshahi (1997), political changes and cultural issues can make the economy of a country to lead to time overruns of its projects. Seventy six per cent (76%) of the contractors have indicated that the average time overrun of a project is between 10% and 30% of the original duration. About 56% of the consultants have also confirmed this percentage (Chan and Kumaraswamy, 1997). Perera (2006) has stated that among road construction projects in Sri Lanka; at least 80% have faced the threat of time and cost overruns which is not surprising. As observed by Pathiranage (2011), local road construction projects experience at least 56% - 88% of time overruns on the average, in relation to the originally planned project duration. In building construction, modes of modelling and the prediction of construction durations of projects have been investigated by various researchers during the last four decades (Dursun and Stoy, 2012). Hegazy and Ayed (1998) have developed a model to estimate the road construction cost by considering the physical features of the relevant project. Many studies done in the past have identified factors that can cause delays in road construction projects, but the criteria and a systemic approach for determining the duration of road rehabilitation projects are not available in Sri Lanka.

1.1. AIM

The aim of this research is to develop criteria that can be used to determine the time of completion of road rehabilitation projects in Sri Lanka.

1.2. OBJECTIVES

The objectives of this research are as follows:

- To identify the most significant reasons that causes delays in construction projects
- To identify the methods used currently to determine the time of completion of a project
- To identify the current usage of the methods used in Sri Lanka
- To identify reasons for not using scientific methods to determine the time of completion of projects
- To identify criteria that will help to determine project durations

- To rank the criteria that will help to determine the time of completion of projects

This paper commences with a review of literature on duration forecasting techniques and reasons for delays in the construction industry. The subsequent section presents the research methodology followed by a section presenting the findings of the study. The final section presents the conclusions and recommendations.

2. Literature Synthesis

A detailed literature synthesis was carried out to identify the causes of delays in road projects, project duration forecasting techniques and factors affecting project duration.

2.1. REASONS FOR DELAYS IN ROAD PROJECTS

A construction duration will consist of two parts (Kaliba et al., 2009), namely contract time and delay. In construction, a delay could be expressed as the time overrun which can be either ahead of the completion date denoted in a contract, or ahead of the date that the parties had consented for the deliverance of the project (Assaf and Al-Hejji, 2006). Due to higher overhead, material and labour costs caused by inflation, project delays nowadays have become a common subject in the international construction industry (Goodrum, Wan, and Fenouil, 2009). Barrie and Paulson (1992) have categorised the causes of delays into four groups as changed conditions and change orders; extra works; owner or his/her agent; and third party contractors. Throughout the literature review 32 reasons were identified and these reasons have been professed under the sub topic 4.1. On the other hand, a project duration accurately forecasted will help to avoid delays.

2.2. PROJECT DURATION FORECASTING TECHNIQUES

Forecasting of the construction duration of a project which can be achieved by many means will depend on the stage at which the construction is planned (Kawakye 1997). Predicting project performance is very essential in tracking and controlling a construction project (Pewdum, Rujirayanyong, and Sooksatra, 2009). According to Kim (2007), a critical component of project management is the forecasting of the project duration. Several forecasting methods have already been proposed based on earned value technique, fuzzy logic, social judgment theory and neural network (Wichan et al., 2009). The BTC model, ANN model, Earned Value Method, Fuzzy Logic and Simulation Model are some of these methods. It is also essential at this stage, to ascertain the factors that will assist in forecasting project duration.

2.3. FACTORS AFFECTING PROJECT DURATION

In order to predict project duration accurately, certain factors such as construction cost, contract procurement, site conditions, buildability of the design, quality management etc., need to be considered. These factors can be divided into four sections (Chan and Kumaraswamy, 2002) as indicated below.

- Project Scope
- Project Complexity
- Project Environment
- Management Attributes

Pathiranage (2011) has explained that many road construction projects experience long delays and that as a result, the economy of the country gets affected considerably. According to Dursun and Stoy, 2012, construction duration is a significant factor that gives rise to complex scenarios in the construction industry in numerous ways. Therefore a necessity has been aroused to identify the significant factors which affect to predict the project duration accurately in order to avoid unnecessary delays caused due to errors in calculating project duration. The factors affecting the project duration which were identified through literature have been further discussed under findings.

3. Research Methodology

An extensive literature survey was carried out to identify the methods that are used currently to determine project durations. In order to validate the findings of the literature survey, preliminary interviews were conducted with three industry experts employed in the road sector. One interviewee was from a contractor organization with 23 years of experience while the other two were from consultancy organizations with 15 and 21 years of experience respectively. The software program NVivo 10 offered by QSR (Qualitative Solutions and Research Ltd.) was used to analyse the findings of the preliminary interview. A detailed questionnaire survey was carried out among professionals working in the construction industry in Sri Lanka to identify the basis on which the time of completion of a project is currently determined. The data so collected was analysed using statistical analysis tools, RII and AHP (Analytical Hierarchical Process).

4. Research Findings

The research findings of the preliminary interviews and the detailed questionnaire survey helped to develop criteria that can be used in determining the time of completion of construction projects, causes for delays in construction projects and the reasons for not using scientific methods to determine project durations.

4.1.SIGNIFICANT CAUSES OF DELAYS IN CONSTRUCTION PROJECTS

The causes for delays in construction projects identified through the literature review were ranked through the questionnaire survey to identify their degree of significance. The data collected through the questionnaire survey was analysed using RII to achieve this purpose. The data analysis indicated that “Unrealistic contract durations imposed by the client (unrealistic time allocation)” was the most critical reason for delays in construction projects with a RII value of 0.90. Fifty eights percent (58%) of the respondents ranked this reason as “very highly critical”.

The causes for delays in construction projects thus can be ranked as follows:

1. Unrealistic contract durations imposed by the client (unrealistic time allocation)
2. Land acquisition
3. Inadequate contractor experience
4. Shortage of skilled labour
5. Delays in subcontractors’ work
6. Environmental problems
7. Low speed of decision making among project teams
8. Contractors’ deficiencies in planning and scheduling during preconstruction stage
9. Changes in the design and scope
10. Political interference
11. Poor site management and supervision
12. Inadequate managerial skills
13. Shortage of managerial and supervisory personnel
14. Project construction complexity
15. Shortage of materials
16. Imprecise contract clauses and late payments
17. Financial problems
18. Delays in making decisions and getting approval by the owner
19. Improper design
20. Poor financial management
21. Improper control over site resource allocation
22. Unforeseen ground conditions
23. Required variations of works
24. Lack of communication between the consultant and the contractor
25. Client-initiated variations
26. Lack of communication between the client and the contractor
27. Poor procurement programming of materials
28. Low labour productivity
29. Low speed of decision making within each project team

30. Poor preliminary planning
31. Difficulties in obtaining work permits
32. Coordination and communication problems

4.2. PROJECT DURATION FORECASTING TECHNIQUES

From the literature review, various project duration forecasting techniques such as BTC model, ANN model, Earned Value Method, Fuzzy Logic and Simulation Model were identified. According to the findings of the interviews, the usage of these forecasting techniques in Sri Lanka was very rare for different reasons which will be discussed later. The Sri Lankan practice for determining project duration is to use a rule of thumb or prior experience.

4.3.REASONS FOR NOT USING A SCIENTIFIC METHOD TO DETERMINE THE DURATION OF A PROJECT

According to the interview results, no scientific method is used for determining project duration in the Sri Lankan industry. From the interviews, some of the reasons for not using a scientific method could be ascertained. During the questionnaire survey, those reasons were ranked in order to identify the most significant reason among them. The most significant reason for not using a scientific method was found to be “Knowledge level of the people” having a RII value of 0.70 followed by “Attitude of the people” which had a RII value of 0.683.

Table 1: Ranking of the Reasons for not using a Scientific Method to determine the Duration of a Project

Reasons for not using a Scientific Method to determine Project Duration	**RII**	**Rank**
Knowledge level of the people	0.700	**1**
Attitude of the people	0.683	**2**
Political issues	0.633	**3**
Traditions	0.616	**4**

The respondents of the questionnaire survey, however, expressed several other reasons for not using scientific methods in Sri Lanka for determining the time of completion of projects. They are as follows:

- As Sri Lanka is a third world country, Sri Lankans are always keen to first satisfy their personal requirements to gain industrial benefits.
- There is political influence when determining the durations of road projects.
- There is a practice to adopt ad-hoc methods based on experience.
- There is only a short documentation period.

- There is lack of transparency in the process.
- There are cultural issues specific to the country.
- In the construction industry, there is an absence of scientifically developed financial procedures.
- There is no proper forecasting method available to predict weather patterns and climatic conditions.
- Clients attempt to reduce the contract period by considering the views of the people in order to mitigate the impact of a project on the society especially when the project is located in urban areas.

4.4. CRITERIA THAT WILL DETERMINE THE TIME OF COMPLETION OF PROJECTS

From the literature survey, it was discovered that there are several factors that can affect the duration of a project. With the assistance of the interviewees, these factors were categorised into four main types as project scope related criteria, project complexity related criteria, project environment related criteria and management attribute related criteria. Table 2 depicts the findings of the literature review and the additional criteria identified through the preliminary interviews.

Table 2: Criteria to decide the duration of road rehabilitation projects

	Literature findings	**Added by interviewees**
Project scope related criteria	• Construction Cost • Contract Procurement • System variation	• Volume of the work in critical activities • Magnitude of the workload for the contractors • Number of phases • Surface improvement • Widening of lain • Changing Pavement structure • Amount of work
Project complexity related criteria	• Client`s attributes • Site conditions/site access problems • Build ability of project design • Quality of design co-ordination • Quality management	• Replacement of exiting services • Public requirement • Resources availability • Acquisition of land

Project environment related criteria	• Physical • Economical • Social-political • Industrial relations	• Geographical Location • Structural elements (Culverts, drainage, bridges) • Weather condition • Soil condition • Funding agent expectation, Loan duration & conditions • Economic condition in country
Management attributes related criteria	• Client/Design team management attributes • Construction team management attributes • Communication management for decision making • Organizational structure and human resources management • Productivity	• Work involvement in each parties • Contractor`s team and Client's team understanding

The questionnaire survey was used to identify the significance of each factor under each category. The data collected through the questionnaire survey was analysed using AHP hierarchy to rank the importance of the factors under each category. From this, the criteria to be used in determining the time of completion of projects could be identified. Figure 1 illustrates the AHP Hierarchy for the ranking criteria.

The findings revealed that the "Volume of work involved in critical activities" was the most significant factor among project scope related criteria. The most significant factor among project complexity related criteria was identified as the "Replacement of exiting services" whereas "Geographical location" was identified as the most significant factor among project environment related criteria. "Client/Design team management attributes" was identified as the most significant factor among management attribute related criteria. The validity of the collected data and their level of consistency were verified through consistency calculations. Through these mechanisms, a ranking method to determine the project duration of road rehabilitation projects in Sri Lanka was developed. The overall importance score was obtained using the AHP process and multiplying the importance score of each sub criteria by its importance

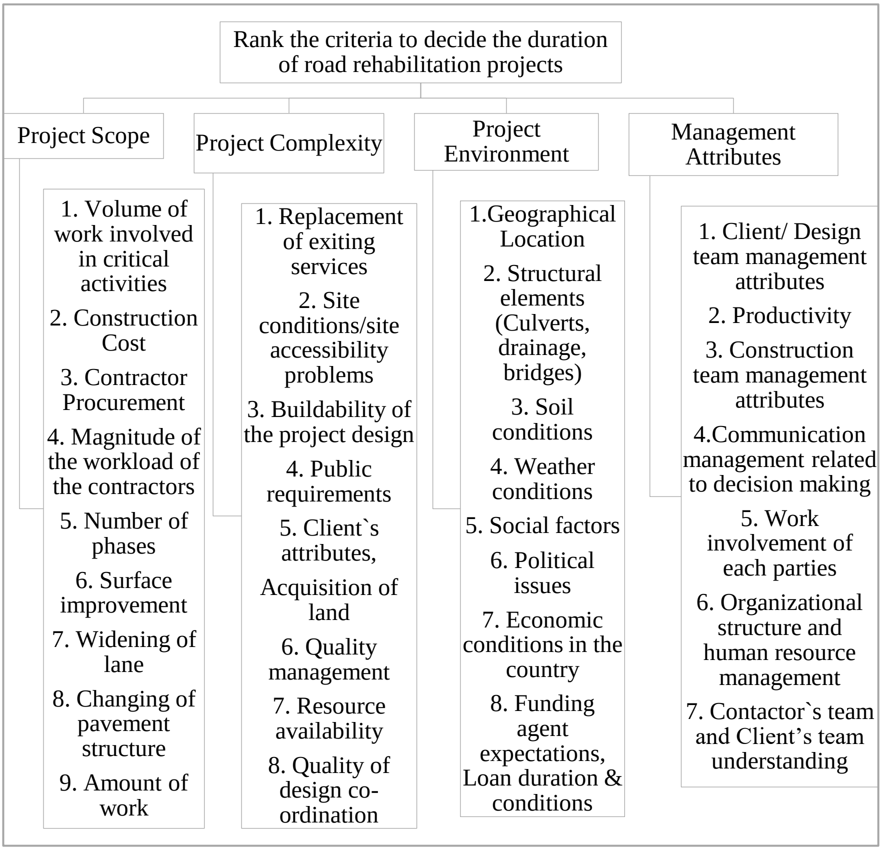

Figure 1, AHP Hierarchy for the Ranking Criteria

score. Figure 2 illustrates the criteria identified as helping to determine the time of completion of projects.

The "Number of phases" was found to be the most critical factor to be considered in determining the time of completion of construction projects in Sri Lanka followed by "Volume of work involved in critical activities" and "Contractor Procurement".

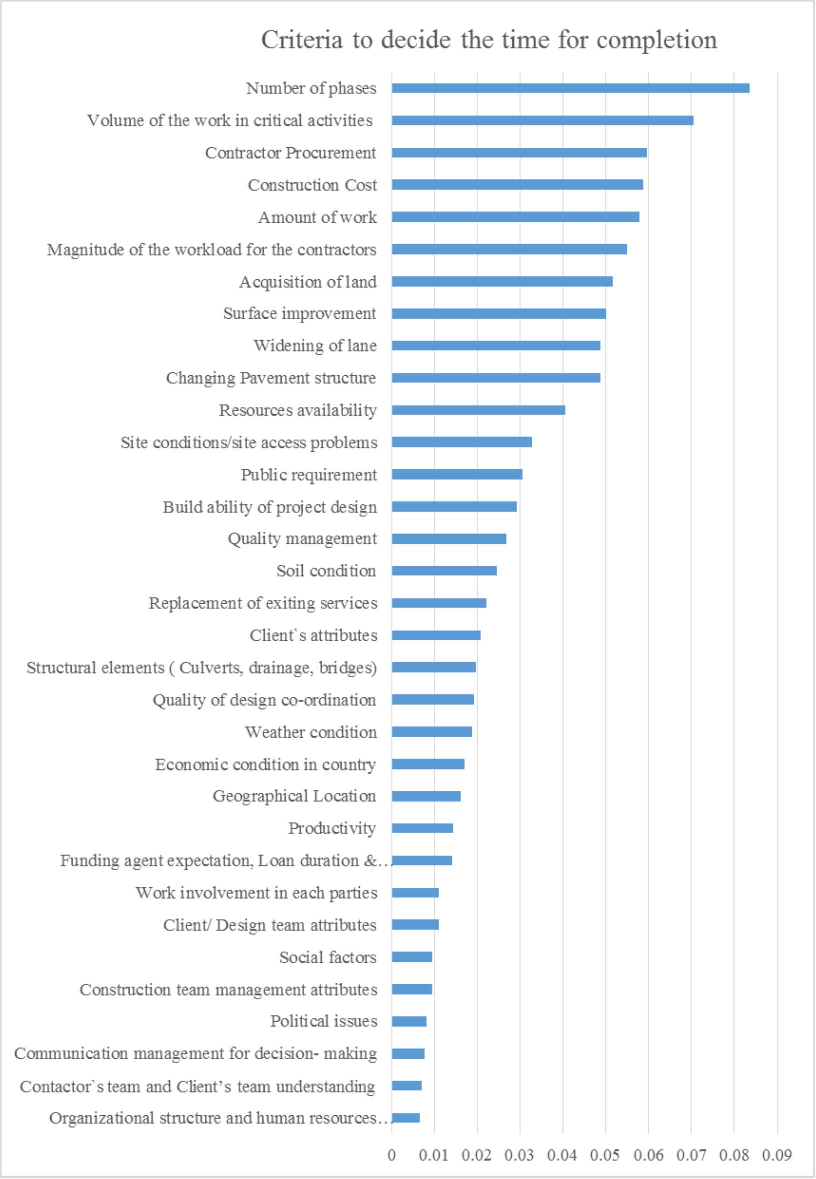

Figure 2, Graphical Illustration of the Criteria Ranking according to the Overall Importance Score

4. Conclusions and Recommendations

The findings demonstrated that “Unrealistic time duration” was the most critical factor that causes delays in construction projects. It can therefore be concluded that the determination of a realistic time duration was the most important solution for mitigating project delays. On the other hand, it is essential to use a project duration forecasting technique such as the BTC model, ANN model, Earned Value Method, Fuzzy Logic or the Simulation Model. However in road construction projects in Sri Lanka, instead of using a scientific project duration forecasting technique, a rule of thumb or prior experience is used to determine project duration.

It is necessary to consider the ranking of the criteria that affect project duration to formulate recommendations that will help to manage project durations of road rehabilitation projects in Sri Lanka. Initially, it is recommended to pay attention to the most critical factor, project scope related criteria. Thereafter, project complexity related criteria followed by project environment related criteria have to be considered. Finally, management attribute related criteria have to be considered in deciding the project duration.

It is recommended that knowledge of the relevant parties on realistic forecasting of time durations should be enhanced by responsible professionals working in the local construction industry. As the government is also involved with the road sector, it will also be its responsibility to see that political influence is mitigated and that there is an established independent decision making process for determining project durations. These steps will help to mitigate delays in projects and enable the projects to be successful as far as their costs and time are concerned.

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INTERACTIVE ARCHITECTURE AND CONTEXTUAL ADAPTABILITY: **ISSUES OF ENERGY SUSTAINABILITY IN CONTEMPORARY TALL OFFICE BUILDINGS IN COLOMBO – SRI LANKA**

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Abstract:
Interactive Architecture (IA) and contextual adaptability promotes operational energy efficiency of buildings by enabling building – climate interaction. However, Tall buildings tend to be non – interactive and climate isolated due to focus on other design considerations. Three recent office buildings in Colombo were selected for investigation to examine the level of interactive contextual adaptability, following a qualitative short – listing. After a general evaluation of energy use intensity (EUI), the designs were analyzed using a theoretical framework, and a thermal behavior investigation. The research revealed that low levels of building – climate interaction results in susceptibility to indoor overheating. Particularly, peripheral passive zones indicated elevated temperature levels attributed to increased solar exposure due to poor envelope design. Elevations in indoor temperatures, ranging from 3° to 4° Celsius were observed, which corresponded with 30% to 50% increase of space cooling energy load.

Keywords: *Tall buildings, Energy Efficiency, Indoors Overheating, Interactive Architecture, and Contextual Adaptability*

1. Introduction

Architecture is the convergence of human and environmental communication. It is a discourse between its occupants, users, the functions it serves, and its regional climate, all tied together in a harmonious aesthetic. (Fox & Kemp, 2009) Buildings of the current age facilitate unique applications that address dynamic, flexible, and constantly evolving activities of the current zest of human life.

Global socio – economic trends play a significant role in this interplay. Much of the economy has shifted from the primary and secondary sectors to the tertiary sector, becoming service oriented. This has resulted in more corporate office buildings in the nexus of the global built environment. 80% of the building stock of Colombo, Sri Lanka is office buildings. (Rajapaksha, Jayasinghe, & Rajapaksha, 2015)

Due to unsustainable development, global warming, climate change, and quantum depletion of non – renewable sources of energy are some key issues faced by the contemporary global society. (IPCC, 2014) Statistics indicate that Colombo’s office buildings are high energy intensive. 64% of the country’s total energy consumption can be accounted to its building stock, of which 26% are non – domestic buildings. (Rajapaksha et al., 2015)

Building operational energy, which is energy that powers the building’s habitability through indoor thermal moderation (space cooling and heating, lighting, water heating etc.). accounts for the significant majority of energy use in buildings over its useful life. Typically, 90% of a building’s energy is consumed in operation over its complete lifespan. (Mohammad & Saraswat, 2014)

Up to 32% of operational energy used in commercial buildings is spent on HVAC (heating, ventilation, and air – conditioning). In warm regions, increased energy is used for space cooling of building interiors to achieve required comfort levels. Mitigating space cooling energy demand through the manipulation of the architectural design by employing strategies of building climate interaction leads to energy sustainability.

2. Interactive Architecture and Contextual Adaptability

Interactive Architecture is simply architecture that is reactive and responsive to its users, climate, and context by achieving design, operational, and functional goals through the use of technological, social, and contextual developments of its age. (Achten, 2013)

Figure 27 – Interactive Architecture

The convergence of embedded computation (intelligence), and a physical counterpart (kinetics), facilitates buildings to be interactive. Kinetics could be described as an aspect of pragmatic adaptability, where the building form follows performance implications; expanding, contracting, and adapting to meet spatial, functional, humanistic and contextual demands. (Fox & Kemp, 2009)

The energy dimension of interactive architecture is based on climatic awareness and response. The definition of contextual adaptability in the kinetics of interactive architecture is synonymous with ecological design, i.e., design that respects the symbiotic relationship between all links of human made and natural systems. (Yeang, 2008)

Integrating strategies of building climate interaction at the onset of the architectural design process by propagating the concept of Architecture towards building behavior, and ways of engagement of interactive modes, leads to better energy efficiency. Conversely, non-interactive architecture leads to context isolation and increased energy use for indoor climate moderation of buildings.

3. Building Climate Interaction: The Low Energy Practice

Filtering favorable weather effects from unfavorable ones, using interactive strategies through exchanges (i.e. thermal energy, wind forces etc.), between building elements and climate elements is the way forward in energy efficient design. In architectural design, interactive strategies needs to be applied at four different inter – connected levels, the micro – climate, plan form, sectional form, and building envelope to optimize energy, at the very onset of the design process. (Rajapaksha. U, 2013)

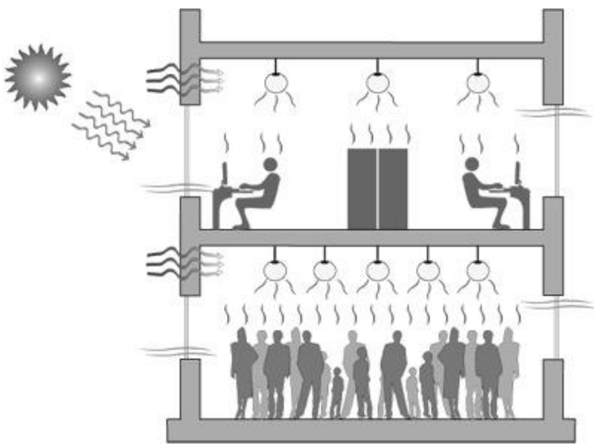


Figure 28 – External and internal heat loads acting on a building. External loads are solar irradiance; internal loads are heat emitted by occupants and equipment. (Source: Whole building design guide, National institute of building sciences, Washington DC)

Microclimate of a building is the climate conditions in its immediate context, which is affected by climate elements of the region, topography, soil structure, ground cover (vegetation), and urban forms. (M. Santamouris & D.

Asimakoloulos, 1996) Interactive strategies are applicable to the micro – climate, such as placing the built form on the site in a symbiotic manner.

Plan form of a building is majorly of two types, the deep plan form and the shallow plan form. ASHRAE 90.1 states that a floor should be divided into a 'core' and a 'perimeter' zone, the perimeter is defined as a space within 5m distances from the façade. Moreover, if the aspect ratio (length to width ratio) is less than 1, the floor plan is a deep plan form.

The shallow plan form has more capacity to interact with the climate than the deep plan form due to higher exposure to the envelope. This is beneficial in cold climates for passive solar gain to heat the interior. In tropical climates, the deep plan form promotes interior cooling through shaded areas, which is beneficial for enclosed air – conditioned buildings with limited climate interaction. (Hyde, Rajapaksha, Rajapaksha, O Riain, & Silva, 2012)
Passive and active zones need to translate 3 dimensionally from the plan form to the sectional form and building envelope. Interactive means between solar radiation and shading devices, window openings, building material properties, and roof geometry can be manipulated to achieve passive means of indoor environment modification. (Hyde et al., 2012)

Window to wall ratio (WWR) has a significant effect on building energy consumption. Lower WWR promotes higher energy saving for both cooling and heating. Optimum WWR depends on glazing type, and the climate. In the tropics, 50% or less WWR prevents excess solar exposure. (Raji, Tenpierik, & van den Dobbelsteen, 2015) Shading devices can reduce unwanted solar exposure.

According to The Council on Tall Buildings and Urban Habitat (CTBUH), a tall building is a building in which "tallness" strongly influences planning, design, construction and use, which includes height relative to context (taller than the urban norm), proportion (slender appearance), and use of technologies specific to tall building structures. Tall buildings generally operate in full air – conditioned mode.

Buildings that are not interactive and adaptive are susceptible to indoor overheating conditions, a phenomenon where indoor temperature exceeds the comfort zone. In air-conditioned buildings, the general set point temperature for thermal comfort in tropics is between 24°C to 26°. Indoor overheating may occur when air – conditioning is turned off (in weekends). The elevation of indoor temperature during non air-conditioned periods gives an indication of the air – conditioning load.

5. Research Methodology

Methodology of study included four distinctive phases, i.e., selection of cases, Energy Use Index (EUI) evaluation, Theoretical Assessment, and Thermal Investigation. Three recent office buildings in Colombo were selected following a qualitative short-listing; corporate headquarters of Citizen’s development business finance (**CDB**), People’s Leasing Co. (**PLC**), and Dialog – Axiata (**Dialog**).

5.1 Selection of Cases

All three cases are freestanding buildings, i.e., they are not structurally or otherwise attached to other buildings on any side. This was in order to assess each building individually without thermal effects from other buildings. All three cases were constructed within the past 5 years (CDB and Dialog in 2015, PLC in 2010). All three cases were fully air-conditioned buildings.

Figure 29, Left: CDB headquarters, Center: PLC headquarters, Right: Dialog headquarters.

5.2 Energy Use Index (EUI) Evaluation

Accepted level of good practice of energy use for air – conditioned buildings is within the range of **110 – 120 kWh/m^2** per year. (Hyde et al., 2012) EUI was calculated for a typical office floor of each building.

Case	**EUI** (kWh/m^2 .per annum)
• CDB	126
• PLC	118
• Dialog	106

Table 5 – Energy Use Index (EUI) of each case

CDB exceeds the upper limit of accepted energy use. PLC is within accepted levels, but above the lower limit. Hence, both buildings indicate potential for improved energy performance. Dialog's EUI is below the lower limit of the accepted practice, which indicates good energy use behavior.

	CDB	**PLC**	**Dialog**
Net office area	320 m^2	530 m^2	485 m^2
No. Of occupants	83	63	86
Occupant density	0.231	0.119	0.177
Equipment usage	98.75W/m^2	51.321W/m^2	75.052W/m^2
Lighting usage	19.688 W/m^2	8.321W/m^2	21.649W/m^2

Table 6 – Lighting, occupancy, and equipment usage data

5.3 Theoretical Assessment

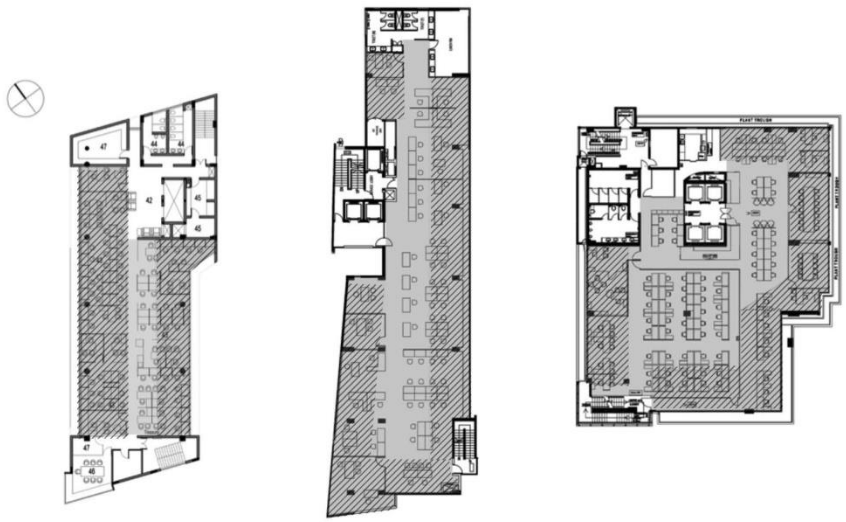


Figure 30, Plan forms of each case. From left to right, CDB, PLC, and Dialog. Lighter shaded area indicates the central zone, and the darker shaded area indicates the peripheral zone.

CDB is 8 stories in height, while PLC is 12 stories in height, and Dialog is 15 stories. Service and vertical circulation cores are located peripherally in CDB and PLC, which benefit interactive contextual adaptability by cutting off direct solar radiation and conductive heat gain. All three buildings are of northeast, and southwest orientation. CDB and PLC have shallow, linear plan forms, while Dialog has a deep plan form configuration.

Glazing used in all three buildings is 8mm thick laminated clear glass. CDB WWR is 0.4. PLC WWR is 0.4 and 0.2. Windows are in horizontal band type configuration. Dialog WWR is 0.4 and 0.6. Windows are placed lengthwise from top to bottom. WWR less than 0.5 are good practice for the tropical context. This is good practice to cut off direct solar radiation. Dialog building is landscaped vertically along a 1m wide recess. The plants reduce glare, however the recess is not sufficient to significantly cut off direct solar radiation.

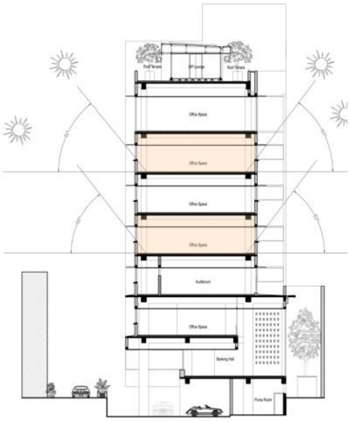


Figure 31, the sectional form of CDB. It can be seen that solar angles lower than 53° in altitude results in direct solar radiation exposure of the typical office floors. Much lower angles does not affect the building due to the tight urban context.

The glazed envelope of the Dialog building's front stairwell admits direct westerly radiation into its interior. However, heat build up is effectively removed by stack effect. This technique is a good example of interactive contextual adaptability, in specific situational use. The stack effect of the stairwell also removes heat build up in the typical office floors

5.4 Thermal investigation

Thermal investigation validates interactive design strategies and effects of qualitative elements discussed in the theoretical evaluation, and investigate the overheating potential. Thermal measurements were recorded using electronic data logging apparatus; mainly HOBO data logger thermometers and thermo couples. These were used to measure and record air as well as surface temperatures.

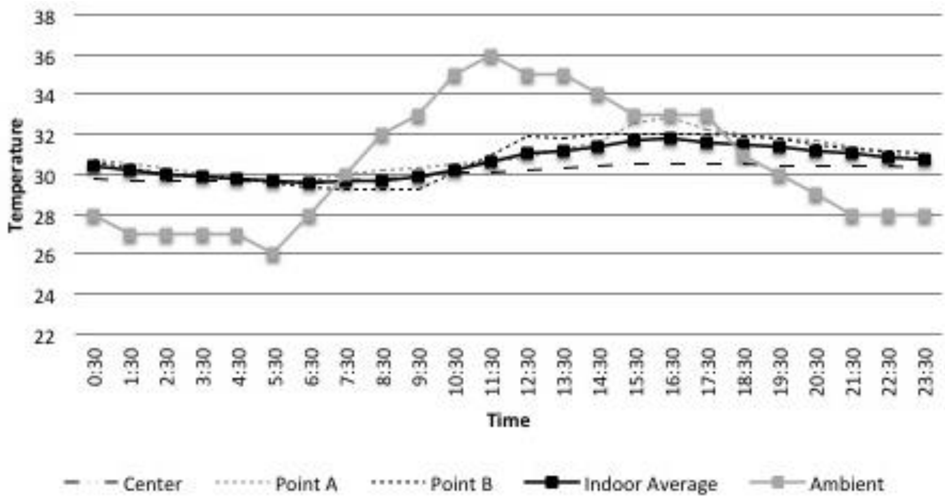
Air temperature readings were taken over non-air conditioned and air conditioned hours. Ambient weather data of Colombo city was obtained from the government Met. Department. Satellite measurements of it, was obtained from ‘world weather online’ website. Daytime hourly air temperature in Colombo Sri Lankan can reach above 33° Celsius during the period from October to April. All three cases were investigated in April 2016 during this critical period.

The climate of Colombo Sri Lanka (Latitude, 6.9271° N and Longitude, 79.8612° E) is a warm humid, tropical climate. During the period of study, a sunlit, hot and humid weather pattern was observed. Average max. Temperature was 36°C, and min. temperature was 26°C. A high level of relative humidity was experienced (nighttime 80% and daytime 60%). Cloud cover was less than 50%. Generally, the sky was clear and there was no rain.

The following comparisons were made in order to ascertain the thermal performance:

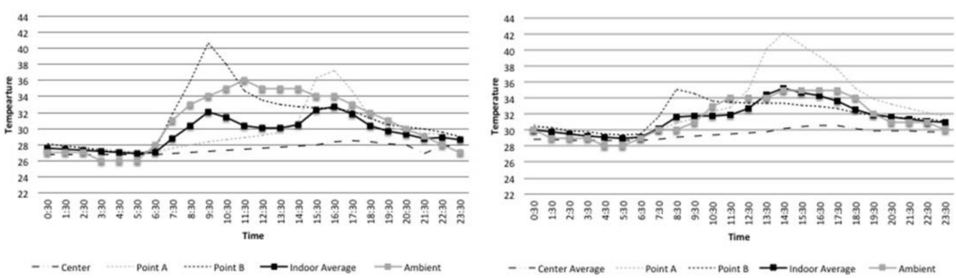
- Temperature variations in central and peripheral zones of a typical office floor. In this way, the shallow plan form and deep plan form effects on thermal behavior could be evaluated.
- Difference between Colombo’s ambient temperature and indoor temperature variations of the office floors. In this way, overheating conditions and potential could be determined.
- The daytime temperature elevation within the typical office floor. In this way, the proportionate energy demand for space cooling could be indicated.
- The patterns of temperature behavior between peripheral indoor temperature and outdoor micro – climate temperature. In this way, the thermal behavior of the typical office floors could be analyzed against effects of the urban micro context.

5.5 Results and Analysis



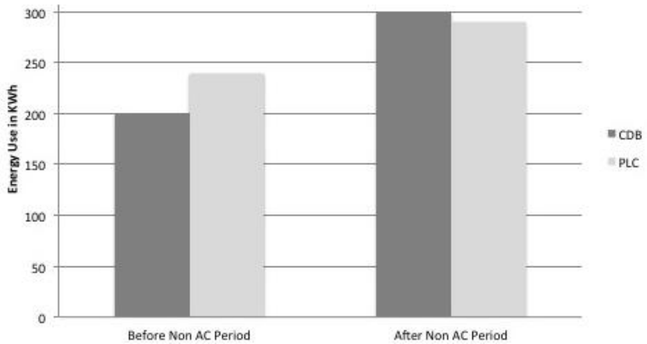
Graph 1, Indoor temperature variation of a typical office floor of CDB during the non – air conditioned period.

Graph 1 indicates that all internal temperatures of CDB were below the ambient temperature of Colombo at the time of measurement. The building was not overheated. A daytime temperature elevation of 3°C is indicated. The peripheral measurements (A and B) are 2°C to 3°C higher than the center average. Temperature elevation during the non – air conditioned period 4°C.



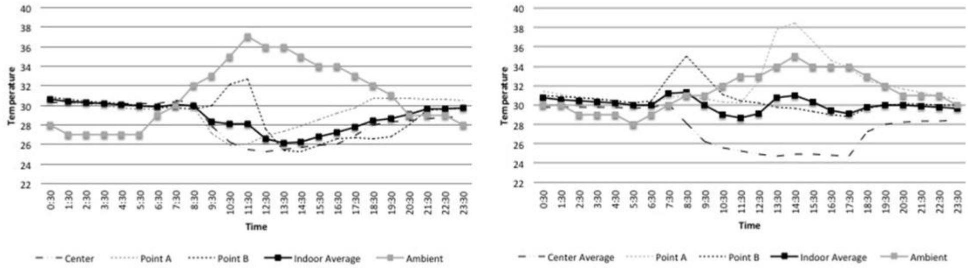
Graph 2 and Graph 3, Indoor temperature variation of a typical office floor of PLC (left) and Dialog (right), during the non – air conditioned period.

Graph 2 indicates that PLC and Dialog buildings overheat relative to the sun’s position during the day. Hence, all three cases show solar exposure to the peripheral zones. The overheated level corresponds to the WWR. In both Dialog and PLC, the side with higher WWR is more overheated. PLC indoor thermal elevation is 6°C during the non – air conditioned period. Dialog does not have a temperature elevation; the building has effectively cooled down by the end of the nighttime.



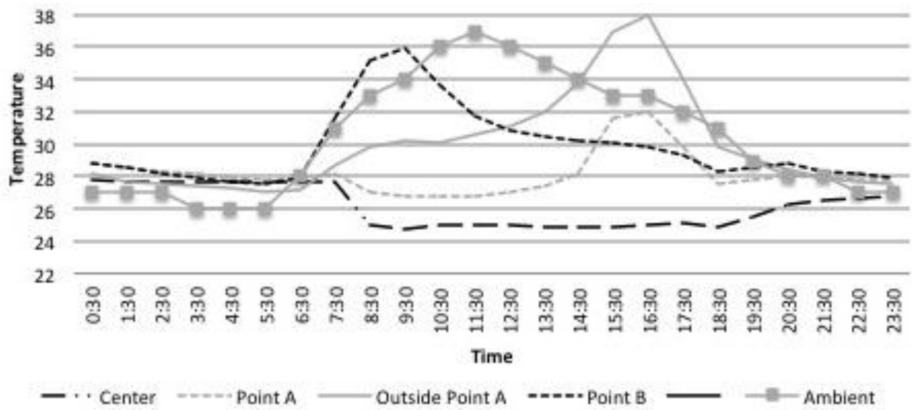
Graph 4, Energy use increase following temperature elevation after Non AC Period. Graph indicates more energy is needed after heat build up.

Graph 4 includes energy data taken from the building management systems of CDB and PLC. The graph indicates that excess energy is required for space cooling following the heat build up during the non air conditioned period.



Graph 5 and Graph 6, indoor temperature variation of a typical office floor of CDB (left) and PLC (right), during the air conditioned period.

Graphs 5 and 6 indicate that CDB and PLC are failing to maintain the indoor temperature at consistent levels during the air – conditioned period. The indoor average is above the set point temperature. Particularly the peripheral zone temperature behavior is unfavorable.



Graph 7, indoor temperature variation of a typical office floor of Dialog during the air conditioned period.

Graph 7 indicates that the Dialog building's center average temperature is consistent with the set point temperature. This is due to the benefit of the deep plan form configuration. The microclimate thermal behavior indicates that the building design has failed to design its microclimate advantageously for building – climate interaction. This was observed in all three cases during both air conditioned and non – air conditioned periods.

6. Conclusion

Interactive architecture and contextual adaptability is synonymous with ecological design. Adaptable, dynamic, and interactive buildings promote operational energy reduction through building climate interaction. Space cooling energy accounts for majority of building energy use in the tropical context. Indoor climate moderation via passive means by manipulating the building microclimate, plan form, sectional form, and building envelope can reduce space cooling energy load.

In the tropical context, the imperative is to prevent heat gain, and promote heat loss. Interactive strategies are case and context specific. The study of cases indicates that contemporary tall office buildings in Colombo are high energy intensive due to climate response failures in the architectural design. The investigation revealed that low levels of building – climate interaction results in susceptibility to indoor overheating.

The peripheral zones of all the cases were susceptible to overheating, indicating poor envelope performance and microclimate design. The deep plan form configuration showed better thermal performance at consistent levels. Indoor temperature elevation indicates the excess load on space cooling energy. The case study indicates that elevations ranging from 3° to 4° Celsius were observed, which corresponded with 30% to 50% increase of space cooling energy load.

7. Acknowledgement

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MANIPULATION OF URBAN GEOMETRY TO ACHIEVE EFFECTIVE WIND FLOW FOR PEDESTRIAN THERMAL COMFORT: WITH SPECIAL REFERENCE TO URBAN DEVELOPMENT IN COLOMBO 4, SRI LANKA

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Abstract

The urban geometries create a physical character or structure at the street with relating to neighboring local climate. The urban geometry of a specific urban area has the potential to enhance or diminish the pedestrian thermal comfort by manipulating the urban climate and manipulates the behavior of wind by controlling the velocity and wind flow patterns. In such a context the design strategies of urban geometries must be implemented with in depth understanding and considering the pedestrians' comfort. The research focus on how the existing urban geometries of selected site impact on wind flow which in reverse impact on pedestrian comfort and the impact of wind flow when these LCZ2 areas convert into LCZ1 areas. Height increase of the buildings and the density would not be an issue if the urban geometry is planned to avoid disturbance to natural wind flow and to maximize wind effects through urban canyons by manipulating H/W ratios. The research findings proved the buildings with high podiums does not help to increase pedestrian comfort in Sri Lankan climatic conditions; since the wind flow in this context is not very strong. The placement of open areas is critical as those could either increase or decrease the pedestrian thermal comfort. Hence, urban planning strategies should be 'site specific'.

Keywords: *Urban microclimate, urban geometry, pedestrian comfort, Wind behavior*

1. Introduction

"The quality of life of millions of people living in cities can be improved if the factors that affect the urban microclimate are understood and the form of the built environment responds to them in an appropriate way. Underlying this belief is the notion that climatically responsive urban design is fundamental to sustainability. When the design of spaces between buildings is informed by the opportunities and constraints of the local climate, pedestrian comfort will be enhanced encouraging city dwellers to conduct more activity outdoors, and in turn to moderate their dependence on air-conditioned buildings and private vehicles.” (Evyatar Erell, David Perlmutter, Terry Williamson , 2011). Construction of a building changes the micro climate around it. Especially near the buildings with reasonable height, high wind speed is often introduced at the level of the pedestrians who may experience as unpleasant, even dangerous. Therefore, the design of a building should not focus only on the building envelope and to provide a good indoor environment but should also include the effect of design on the external environment. The external environment of a building, in particular those related to the wind, has received relatively less attention in the community of building physics. The relationship between the effects of wind, the wind comfort and wind climate should be discussed with respect to Sri Lankan tropical standards referring climatic data and building geometry in Colombo.

Urban climate is the micro-climatic environment which represents the interactions between urban areas and the atmosphere. Pedestrian comfort heavily depends on its geometry and the wind flow pattern. Sometimes predicted thermal sensation of this local climate will represent the uncomfortable range but street geometry can raise that uncomfortable ambience in to the range of neutral or slightly comfortable. So, the street canyon geometry plays an important role regarding pedestrian comfort with the impact of urban geometry driven wind flow. Four factors of pedestrian comfort are Temperature, Humidity, Mean Radiant Temperature and Air movement. In finding about the pedestrian physical comfort due to wind flow among urban geometry; Air movement is the main factor to be considered.

These outdoor climatic parameters should be considered in the critical situation. Critical outdoor temperature occurs from the end of March to April. But the main concern in this study is about Wind Velocities. Selected site at Colombo 4, is a coastal urban site located in Western Province of Sri Lanka. So considering the South western and Southern coastal wind flow during November to April in Sri Lanka, wind velocities and ambient temperatures are recorded at selected site. This research on pedestrian physical comfort due to urban geometry driven wind flow in Colombo will continue by taking that scenario in to consideration. The study is a research based simulation study to evaluate the effects of wind flow over urban geometry to enhance pedestrian thermal comfort, in an empirical manner and to explore the possibilities of manipulating built geometry to decrease outdoor temperature levels. The study focuses on manipulation of the urban geometry as a primary design strategy to enhance the pedestrian comfort by handling wind flow effectively.

2. Wind tunnel tests and Envi-met simulations

Wind Tunnel studies are carried out to observe the wind behavior around the buildings in a geometry or to evaluate structural wind loading on a building along with the theories of building aerodynamics. Wind tunnel tests are used to measure wind velocities and to evaluate the changes of micro-climatic conditions at a selected place due to the aerodynamics of tall buildings.

"As building designers were increasingly being confronted with the poor wind environment around their creations. The wind environment in pedestrian precincts around groups of tall buildings has brought in the greatest number of inquiries to the Building Research Station (BRS) in the sixties; some 200 inquiries were received between 1964 and 1970. A number of these have been studied in detail in the BRS wind tunnel in order to provide general information. Also studies of airflow around idealized model buildings have been conducted at the BRS." (Bert Blocken, Jan Carmeliet, 2003). (Figure: 1). In this study, wind tunnel test has been carried out to judge the wind behavior of a selected existing urban area, to assume the effective architectural strategies to manipulate buildings for further simulations studies via ENVI-met V4.

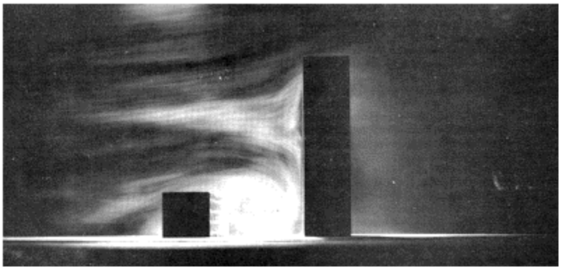


Figure 1: Smoke visualization test in a wind tunnel illustrating the flow around a slab block screened by a low building .Source: BRE, 2003

According to (S.Lenzholzer, J.Koh, 2010), it is the only software where all the factors influencing thermal comfort like wind speed and direction, and mean radiant temperature (MRT) are simulated integrally to derive thermal comfort indices. "It calculates the dynamics of microclimate during a diurnal cycle (24 to 48 hours) using the fundamental laws of fluid dynamics and thermodynamics. The model includes the simulation of flow around and between buildings, exchanges processes of heat and vapour at the ground and vertical surfaces, turbulence, exchange at vegetation and vegetation parameters, bioclimatology, particle dispersion." (The Hitchhiker's Guide to ENVI-met, 2016)

ENVI-met V4 software has three basic steps to proceed for activating the simulation. In this study ENVI-met V4 software was used to simulate the impact of wind behavior on urban canyons to modify the existing building micro climate to achieve pedestrian thermal comfort.

3. Research Problem

In the current context, Sri Lanka is at the starting point of massive vertical development projects; especially in the city of Colombo. Those major developments would mainly lie within the coastal wind flow in the near future. So, the coastal urban geometry driven wind flow is very important to consider when planning future vertical developments in ensuring pedestrian comfort in respect to tropical climatic conditions. The research questions on the most appropriate urban geometries which help to enhance pedestrian comfort by manipulating wind flows.

4. Research methodology

With the use of Colombo "Local Climatic Zone" map and the previous studies done by the researches, a specific case study area is identified and focused in to the compact mid-rise local climatic zone (LCZ2). LCZ2 category represents a dense mix of mid-rise buildings from 3 to 9 stories with few or no trees. Here brick, tile, and concrete are used as construction materials. Within these parameters, site at Colombo 4 is selected for the Calibration study; close to Majestic City and Unity Plaza buildings at Bambalapitiya, along with the Station Road connecting Galle Road and Sea Side Road. As the first step, an onsite survey was carried out to measure the Wind Velocities at the pedestrian height of 1.8m and at 3m by using Anemometers. In the same time the air temperatures at specific places were also measured by data loggers.

In parallel to the onsite investigation the climatic data of the specific dates were collected from the Department of Meteorology, to analyze the variations and to make relevant assumptions. Simultaneously a Wind Tunnel Test was conducted at a laboratory in the University of Moratuwa to study the wind behavior around the buildings in the existing environment of the selected site. With the findings of the wind tunnel test a base case simulation was carried out using ENVI-met to understand the existing climatic condition in the selected urban geometry. Validation was done by using field measurements, other collected climatic data and the results gained via ENVI-met simulations.

Five types of design strategies are tested for the same site by manipulating the Urban Geometry by considering the vertical urban developments to be taken place in the near future at coastal urban sites as such. Height to Width

Ratio and Floor Area Ratio is considered as key variables for above urban morphology manipulating options. The modifications are done in accordance with the present building regulations formulated by the Urban Development Authority (UDA). Analysis of the differences of Wind Velocities at pedestrian levels, Mean Radiant Temperature values and Leonardo contour maps which are obtained by the ENVI-met simulation process were conducted in respect to the modified urban geometries. With the results most effective architectural strategies to manipulate Urban Geometry in Coastal Urban Developments in Colombo in terms of enhancing Pedestrian Thermal Comfort are identified.

5. Simulation and Results:

Wind tunnel test was carried out on 5th April, 2016 at a laboratory in University of Moratuwa, using a scaled model of the selected site to understand and to analyse the wind behaviour over the urban canyon for the existing environment.

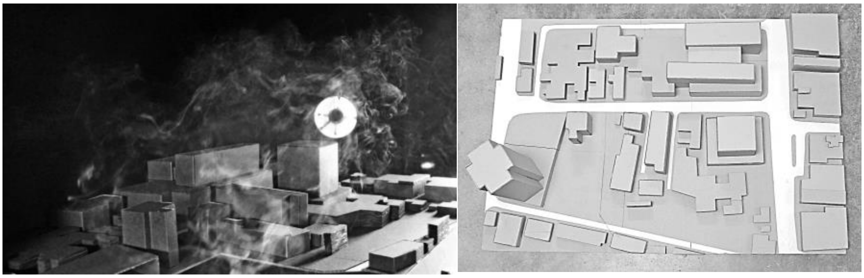
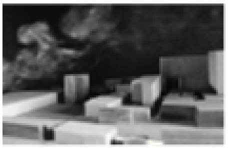
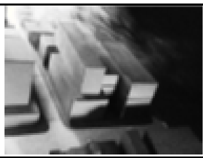


Figure 2 : Base case simulation

Through the wind tunnel tests conducted for the selected sites it made clear in selected sites majority of the wind particles flows freely over the canyon forming a combination of Wake interference flow, isolated roughness flow and Skimming flow of wind. When the building increases the wind flushes over the canopy and cause stepping effect. The existing geometry has caused downwind, wind turbulence effects, Low Bar Raw effect and Funneling effect due to varied forms of buildings whereas causes.

Wind Tunnel Test – Photographic Study

	Wind Behavior	Analysis
1		Majority of the wind particles flows freely over the canyon. It is a combination of Wake interference flow, Isolated roughness flow and Skimming flow of wind.
2		Wind flush over urban canopy causing Stepping effect with gradually increasing heights of buildings.
3		When the wind hits building surfaces, it causes downwind and wind turbulence effects.
4		Low Bar Raw effect happens at comparatively low and wide exposed windward facing building facades. Funneling effect causes along Station road.
5		When a comparatively high-rising building located in a mid-rise urban setting, if it lies along the wind direction, it helps to manipulate wind in different directions according to the shape. Multisided buildings such as this, are quite good to decrease downwash and to increase the distribution of wind over the canyon.

paration for Base Study (Simulation_1)

- Main model area, X grid = 75 / Y grid = 47 / Z grid= 30.
- Model rotation out of grid north = 342 degrees.
- Latitude 6.53 and Longitude 79.51, Reference Longitude 82.50 The cell area can be designated at any dimension from 0.5 meters to 10 meters. For selected sites, size of the grid cell is taken as (dx = 5m) x (dy = 5m) x (dz = 5m) as the minimum plot. Vegetation cover is not considered; since it is very minimal in LCZ2 conditions.

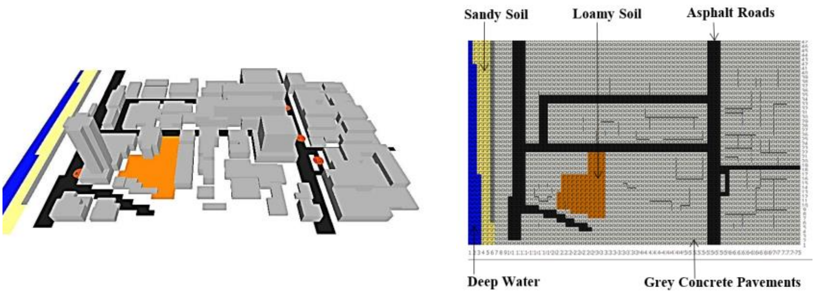


Figure 3: Building Geometry (Area Input file)of Simulation_1; Existing Condition.
Source: Author

Modified Urban Geometries for ENVI-met Simulations

Manipulated Geometry_1 (Simulation_2)

Heights of the buildings are reduced. Maximum height of the buildings within the selected area is reduced to 18m (up to six stories).

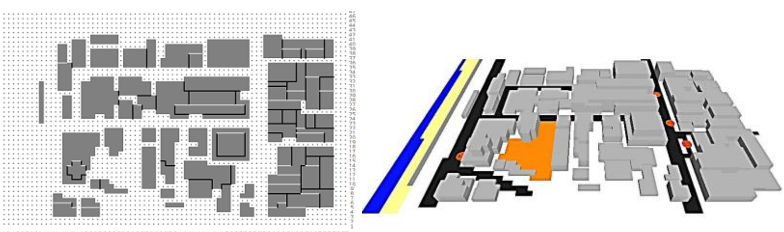


Figure 4: Building Geometry (Area Input file) of Simulation_2
Source: Author

When considering the manipulated urban geometry_1, this includes less tall buildings with fair amount of open areas. SVF for this urban canyon can be categorized as an Avenue Canyon which has H/W ratios less than 0.5. Floor area ratios and street widths are not changed. Soil and surface conditions used for the simulation is same as the Base case.

Manipulated Geometry_2 (Simulation_3)

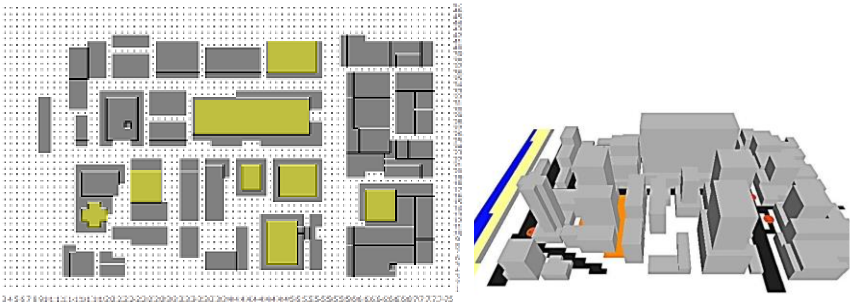


Figure 5 : Building Geometry (Area Input file) of Simulation_3
Source: Author

Heights of the buildings are increased. Majority of the buildings are around 30m in height. Number of taller buildings (45m to 70m) also increased within the selected area as highlighted in the figure 5. Street widths are not changed. Soil and surface conditions used for the simulation is same as the Base case. Majority of the buildings close to street edges are designed with a podium level as an architectural strategy. Those podiums are generally 10 - 20m in height. Some of the open areas are filled with building mass considering the urban development plan of Colombo 2020. When considering the manipulated urban geometry_2, this includes taller buildings with less amount of open areas. So the density of this area is very high. SVF for this urban canyon can be categorized as a Deep Canyon which has H/W ratios more than 2.

Manipulated Geometry_3 (Simulation_4)

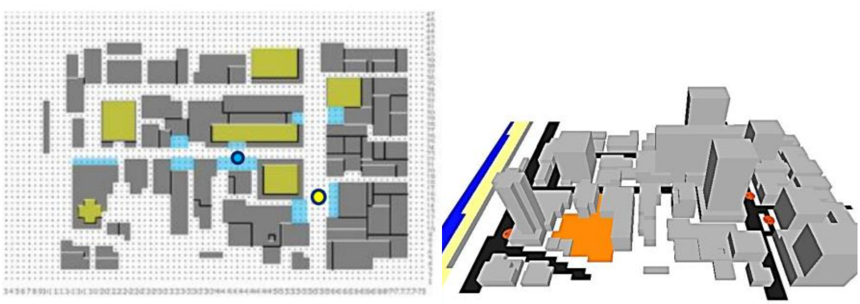
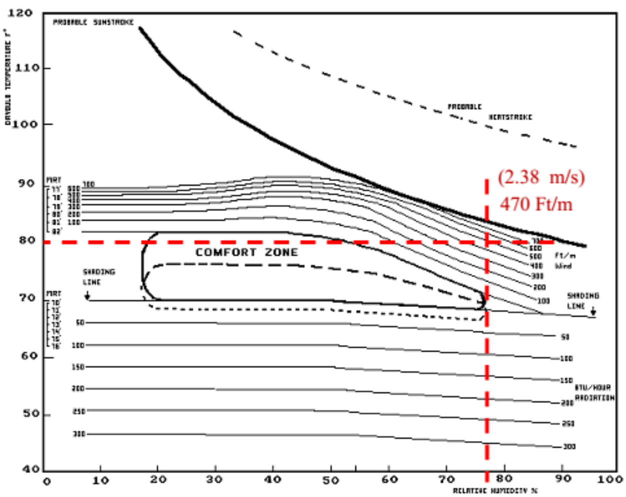


Figure 6: Introduced Open spaces + High-rise buildings & Building Geometry (Area Input file) of Simulation_4
Source: Author

Compared to Simulation_3, this has lesser number of taller buildings and more open areas. Building density is lower than in the Simulation_3, but higher than the Simulation_1 and 2. This includes 45 - 70m tall buildings which are positioned to direct wind flow into different directions, considering building design strategies as mentioned at section 2.2 in the dissertation. Those buildings are highlighted in yellow in figure: 6. Street widths has not changed. But adjoining open spaces are added along streets as shown in figure:6; highlighted in blue. Soil and surface conditions used for the simulation is same as the Base case. When considering Simulation_4, this is also having high density of buildings than in Simulations_1 and 2. SVF for this urban canyon can be categorized as either Regular canyons or Deep canyons depending on the H/W ratios at certain points of the street.

Analysis:

Analysis of Pedestrian Thermal Comfort via ENVI-met Simulations



nbo

Source: Olgay's Bio Climatic Chart

Required Minimum Average Wind Speed to reach the level of Pedestrian Thermal Comfrot is 470 Ft/m (2.38 m/s), when the Relative Humidity is 78 and Temperature of 80 °F (26.6 °C) at the selected point.

Thermal Comfort Zone for Colombo is generally 24C◦ - 26C◦. Increase of wind speeds are helping to increase the area of thermal comfort zone as shown by figure: 8. Wind maps and Sections at receptor points, generated by ENVI-met LEONARDO tool, are used to analyze the wind behavior at urban geometries.

Therefor wind behavior at 10:00 hrs, 13:00 hrs and 16:00 hrs are taken into consideration in analyzing pedestrian thermal comfort during the day.

Wind Analysis for Base Case; Simulation_1

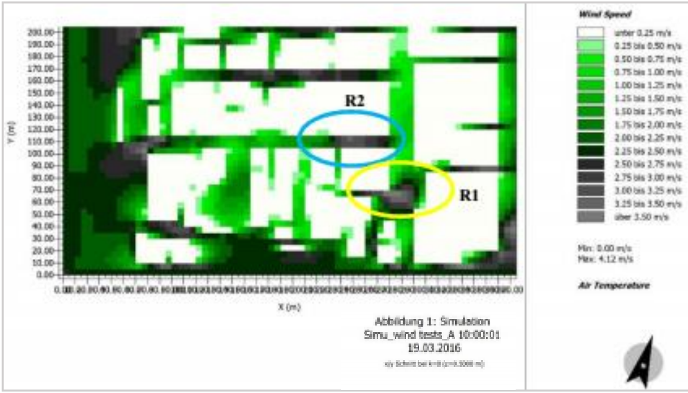


Figure 8: Receptor points - R1 & R2 , Simulation data via Leonardo tool. Source: Author

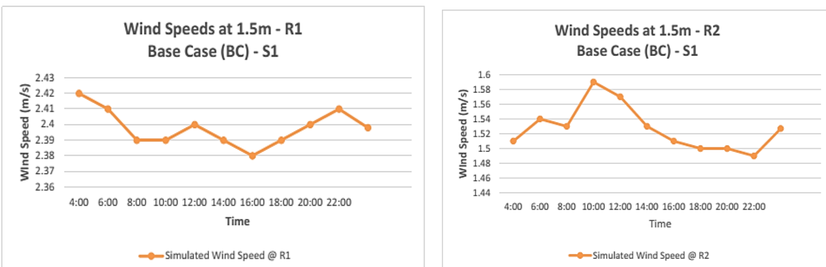


Figure 9 : Wind speed graphs at R1 & R2 for Simulation_1. Source: Author

Wind Analysis for Manipulated Geometry_1; Simulation_2

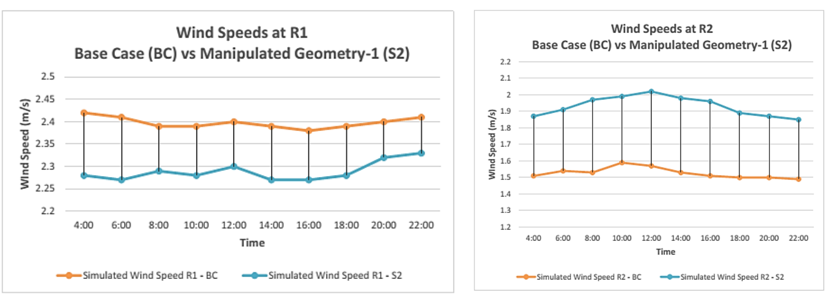
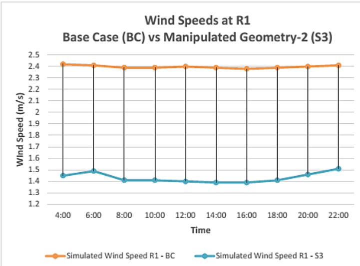


Figure 10 : Wind speed graphs at R1 & R2 for Simulation_2. Source: Author

Wind Analysis for Manipulated Geometry_2; Simulation_3



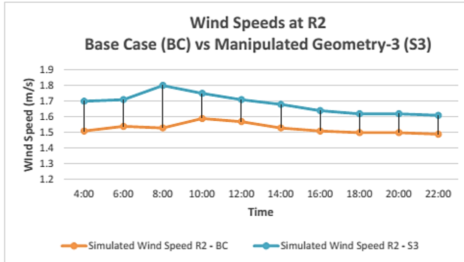
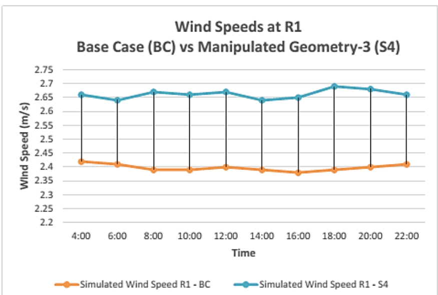


Figure 11 : Wind speed graphs at R1 & R2 for Simulation_3. Source: Author

Wind Analysis for Manipulated Geometry_3; Simulation_4



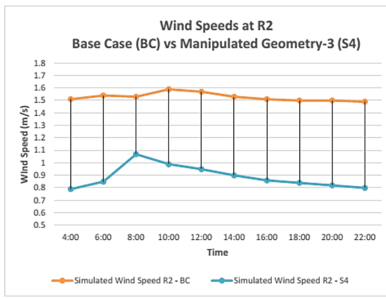


Figure 12 : Wind speed graphs at R1 & R2 for Simulation_4. Source: Author

Evaluation of Building Manipulations

Manipulated Geometry	Change of Average Wind Speed	Effect on **Pedestrian Thermal Comfort** (minimum of 470 Ft/m wind speed needs to reach comfort zones)
Simulation_2 **R1**	- 0.109 m/s - 21.5 Ft/m	R1: 2.4 m/s - 0.109 m/s = 2.291 m/s (451 Ft/m) Not Comfortable. Yet closer to thermal comfort zone.
Simulation_2 **R2**	+ 0.404 m/s + 79.5 Ft/m	R2: 1.53 m/s + 0.404 m/s = 1.934 m/s (381 Ft/m) Not Comfortable. But this helps to increase thermal comfort level at R2

Figure 13 : Evaluation of Building manipulations ***at Simulation_2***
Source: Author

Manipulated Geometry	Change of Average Wind Speed + −	Effect on **Pedestrian Thermal Comfort** (minimum of 470 Ft/m wind speed needs to reach comfort zones)
Simulation_3 **R1**	- 0.966 m/s - 190 Ft/m −	R1: 2.4 m/s - 0.966 m/s = 1.434 m/s (282 Ft/m) Not Comfortable. This creates a very uncomfortable atmosphere.
Simulation_3 **R2**	+ 0.157 m/s + 31 Ft/m +	R2: 1.53 m/s + 0.157 m/s = 1.687 m/s (332 Ft/m) Not Comfortable. Slight increase of average wind speed.

Figure 14 : Evaluation of Building manipulations ***at Simulation_3***
Source: Author

Manipulated Geometry	Change of Average Wind Speed + −	Effect on **Pedestrian Thermal Comfort** (minimum of 470 Ft/m wind speed needs to reach comfort zones)
Simulation_4 **R1**	+ 0.264 m/s + 52 Ft/m +	R1: 2.4 m/s + 0.264 m/s = 2.664 m/s (524 Ft/m) Comfortable. This atmosphere is Comfortable for Pedestrians, up to air temperature of 83°F (28.5 °C)
Simulation_4 **R2**	- 0.640 m/s - 126 Ft/m −	R2: 1.53 m/s - 0.640 m/s = 0.89 m/s (176 Ft/m) Not Comfortable. Slight increase of average wind speed.

Figure 15 : Evaluation of Building manipulations ***at Simulation_4***
Source: Author

Conclusion:

As observed through the results, manipulating buildings can be applied to achieve pedestrian thermal comfort goals in Colombo metropolitan area. When considering the urban development proposals for Colombo, LCZ2 areas would be converted in to LCZ1 areas in the near future. LCZ1 areas will consist of dense set of tall buildings with land cover of mostly paved. In such a context height increase of the buildings and the density would not be an issue if the urban geometry is planned to avoid disturbance to natural wind flow and to maximize wind effects such as funneling and channeling through urban canyons by manipulating H/W ratios.

Buildings with podiums are considered as a good pedestrian friendly design strategy for many countries due to the high wind speeds they have. According to the available literature countries in between the Tropic of Cancer and Arctic Circle, Tropic of Capricorn and Antarctic Circle are getting strong average wind speeds. Thus the downwashes due to those strong winds cause discomfort for pedestrians. Yet, since in Sri Lankan context no such strong winds are prevailing, the use of podium level buildings is not effective in increasing pedestrian thermal comfort. The research findings proved that the buildings with high podiums does not help to increase pedestrian comfort in Sri Lankan climatic conditions; since the wind flow in this context is not very strong as stated above. Further the placement of open areas proved to be critical as those could either increase or decrease the pedestrian thermal comfort due to the placement. Hence basically, urban planning strategies should be ‘site specific’ according to the observations of the research.

Based on the research findings the following design implications proposed are as follows;

- Pedestrian comfort at the selected area (LCZ2) is within the comfort zone at the current situation. But slight increase of temperature would make it uncomfortable. So, prevailing urban planning regulations should develop to consider wind manipulation strategies when converting these types of areas into LCZ1 areas in the near future.
- For the urban canyons which consist of adequate wind flow as in R1, mixture of deep canyons with regular canyons is the ideal setting as in the manipulated geometry_3 (S4). Even urban geometries are not suitable.
- H/W ratio of the canyon is critical in the manner of increasing wind funneling and channeling effects collaborated with Venturi effects; which helps to increase the average wind speeds through the canyon.

- Buildings with podiums does not helping to increase pedestrian comfort in Sri Lankan climatic conditions; because the downwashes are not so strong. Open areas should be planned at the places which consists of adequate wind flow as in R1, to activate courtyard effect for pedestrian thermal comfort.
- Direct wind disturbances to the streets should be avoided via urban planning and building aerodynamics. It can help to increase pedestrian thermal comfort at places such as R2.
- Places which are not getting adequate wind flow such as R2, should not have deep canyons. Avenue Canyons, as in the manipulated geometry_1 (S2) which are having H/W ratios less than 0.5, are more effective for those type of conditions in enhancing pedestrian thermal comfort.

Directions for Future Studies,

The present study puts forward a strong theoretical and empherical basis to the understanding of pedestrian comfort and the influence of urban geometry driven wind behavior on pedestrian comfort. Yet, due to the limited time period and available resources, scope of the research was carried within a limited framework in which one specific LCZ2 area which has the potential to be converted in to LCZ1 in the near future was considered. The Wind Tunnel Test was conducted only as a photographic study to understand the wind behavior at existing geometry whereas only 3 types of Manipulated geometries were used to simulate via ENVI-met. Also the research considered the overall geometry of urban canyons instead of focusing shadings and aerodynamics of individual buildings.

Acknowledgement:

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MANAGING OF URBAN FLOOD RISK IN COLOMBO WITH SPATIAL PLANNING

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Abstract

Land and water are inseparably linked with each other. External pressures on either water or the land result in chains of impacts on both. Uncontrolled urban growth leads intensive urban growth into natural floodplains. As a result, flood risk and vulnerabilities in many of urban areas are on the rise. The technical measures as well as other planning operations on a continuous basis, which remains unchanged urban flood risk. Presently, it has been recognized that a new approach should be designed to cope up with both flood hazard and vulnerabilities would provide long lasting solution. The importance of spatial planning for an effective flood risk management strategy highlights the multifunctional and integrated benefits of spaces. Currently, many developed countries have already adopted risk based management approach over the traditional flood protection strategies. City of Colombo located adjacent to the downstream of Kelani River is highly vulnerable to floods. It has been regularly flooded in recent decades and brings many hardships to both community and economy despite the available flood protection measures. This present research analyses literature on flood risk management and interface between flood risk management and spatial planning and it discusses the salient characteristics of risk based planning interventions.

Keywords: *spatial planning, urban flood risk, resilience, Colombo*

1. Introduction

1.1 Increasing of flood risk in colombo

City of Colombo located adjacent to the downstream of Kelani River is highly vulnerable to floods during the heavy rainy seasons. Colombo and its suburbs are located in vast low-lying flat lands where there had been many marshlands. A large part of the Colombo region is very low and during Kelani River overflows, most of these low-lying areas are inundated. World Bank Report (2013) highlighted that Colombo is highly vulnerable to flooding, and had experienced regular floods for the past 30 years, affecting over 1.2 million people annually. The flood inundation area are predicted to increase further due to climate change conditions (Niroshinie and Babel, 2011).

The flood risk management strategies in the past aimed at protecting the Colombo urban area by developing protection bunds, pumping stations, etc. Many of the strategies and the action projects emphasized the adoption of structural measures for flood risk management. However, it is quite difficult to have major structural measures due to the value and the scarcity of lands closer to the city of Colombo. Most of the flood risk management strategies are still anchored to the relief-based approach, which mainly concerns allocated funds for rehabilitation of impacted communities, emergency management, recovers the infrastructure systems, post-disaster health services, etc. Each successive government spends capital and attention to manage the flood issue in Colombo.

Nevertheless, the extraordinary flood events cause considerable damage to lives, properties and negatively affect the whole development of the Colombo urban region as well as country. In addition, the rapid urban growth in Colombo stimulated the encroachment of floodplains and wetlands particularly by poor income groups, as they cannot afford more suitable alternatives for housing. The human settlements expanded intensively over the flood prone areas despite the available land use regulations and controlling measures. Extensive reduction of wetlands has recorded during recent decades as a result of rapid urban growth especially after 80s (Hettiarachchi et al, 2014).

The new urban growth on flood prone areas could not controlled through the implementation of spatial planning measures in the past and encroachment of river and canal reservation is a common phenomenon. In 1924, the existing Kelani flood protection scheme was constructed on both the left and right banks of the Kelani River near Colombo. The 5 km south bund protects the Colombo city and suburbs from flooding and is located at a distance of between 300 and 1900 m away from the river. There are two zones designated within the flood bund as protected and unprotected area. The population has increased even in the unprotected zone significantly due to scarce land scarcity in Colombo.

Year	Unprotected area		Protected and under developed area	
	Population	Pop. Density (per ha)	Population	Pop. Density (per ha)
1981	84400	32.90	125863	34.61
2001	134779	52.55	181686	49.95
2012	159613	62.23	210969	58.01

Figure 01- Periodical changes of population and population density in designated "protected" and "unprotected "areas along the Kelani river flood bund

2. Objectives and methodology

This work critically examines the recent literature on flood risk management transformations and interface between flood risk management and spatial planning. Present review demonstrates the limitations and inadequateness of traditional flood management and helps to understand the salient features of the risk-based approach.

3. Literature analysis

3.1 Increasing pressure on urban floodplains and flood risk

Many of the floodplains in developed and developing countries are became sources of livelihood for many communities (Ludy and Kondolf, 2012). Socio economic pressure has increased on many urban floodplains and they had been occupied by rapid uncontrolled urban growth irrespective of their ecological values. Minimization of damage and the social disruption due to floods can be achieved by preventing the floodplain occupancy (Burby and French, 1981). Communities have complex reasons, such as population growth, land scarcity, land tenure, employment, history, community relationships, etc for living with flood risk (Pardoe et al., 2011). Urban growth Floodplain highlights that the habitation choices are based on the trade-offs that exists between the benefits of living in a particular location and the associated hazards (Kates, 1963; Burton et al., 1965; White, 1972 cited in Birkholz et al., 2014).

3.2 Traditional approach in flood risk management

This situation specifies that there is a lack of ability, lack of knowledge or inadequacy of traditional management policies and strategies to cope up with flood damage caused due to extreme flood events. Moreover, the recent extreme flood events and severe impacts have challenged the conventional thinking of flood risk management (Thieken et al., 2014). Researchers realized that the limitations of rationalist thinking and cost benefit assessment approaches were insufficient to capture the complexity and uncertainties associated with flood risk (Birkholz et al., 2014;Eiser et al, 2012;Klijn et al, 2014). Thus, scholars argued that the flood risk management could benefit from a more constructivist thinking which advocates more comprehensive exploration of how socio-cultural context shapes wider understanding of risks and influences, which are the outcomes of disastrous events.

The technical approach has been shifted towards a broader integrated management or' risk-based' approach and spatial planning has become a central to this new ‘approach’(Wiering and Immink, 2006; Hutter, 2007). Spatial planning is increasingly regarded as an important instrument for creation of urban flood resilience (Sayers et al., 2013; Merz et al., 2010; Klijn., 2012). However, spatial planning plays only a minor role in flood risk management despite its importance (ARMONIA, 2007). There are many hypotheses can be made; inadequateness of spatial policy and strategy making process, lack of specific policy, strategy or tools, incompatibility between ecosystems and institutional arrangement, ill consideration or involvement of water risk in spatial planning and plan making, lack of communication between ‘technical ‘domains and socio political ‘domains, lack of cooperation between different levels of spatial and water management policy makers, etc.

3.3. Flood risk management

The notion of flood risk as interaction of hazard and vulnerability and as basis for risk-informed decision-making has become widely accepted over recent years (Merz et al, 2010). Flood risk management needs to reduce the probability of flooding and minimize the potential damage. The absolute safety or complete risk reduction through the structural measures is impossible (Sayers et al, 2013). Certain amount of risk has to be retained in the system and such efforts involve the use of flood sensitive land and spatial planning, early warning, flood proofing as well as evacuation and preparation. Hence, the flood risk management strategies need to address all dimensions of flood risk and to increase the capacities to flood prevention, response and recovery. The goal of flood risk management is to minimize flood risk by implementing measures that reduce risk most efficiently and become cost effective. Then it is necessary to seek potential alternative means of flood management measures, which are most effective and within the capacity and opportunities of the particular context to be implemented. Under these situations, the traditional flood management measureswhich consist of (1) traditional engineering strategy (2) Land-use planning strategy have many limitations. The following part analyses the pros and cons of traditional flood risk management, measures.

3.3.1 Flood control infrastructure measures

Flood control infrastructure measures, such as dykes, levees, dams, and drainage channels, etc are has been repeatedly criticized (White 1945; Mount 1995, Philippi 1996; Smits et al. 2006 cited in Liao, 2014). Many of these structural measures can reduce localised flooding in the short term and their effects on hydrological and biological systems, and their role in facilitating inappropriate land use and development of risky areas render them a maladaptive solution (Wenger, 2015). Despite criticism of structural flood protection measures, many countries depend on structural flood protection measures to mitigate flood risk (Kundzewicz, 2001). However, flood control infrastructure measures, are absolutely needed to safeguard existing developments in urban areas.

Wenger (2015) has studied the existing flood protection measures particular levee issue, future flood threats, and national strategies to address them in four flood prone countries; the Netherlands, China, the USA, and Australia. Wenger (2015) has pointed out that levees are becoming increasingly unreliable because flood threats are escalating. As a result, some countries are attempting to restore floodplain storage, thereby reducing their reliance on levees, others are increasing their investment in levee construction. This analysis suggests that federal systems face particular challenges and their capacity to adopt adaptive approaches may be impaired if institutional barriers are not addressed. He further concluded that regardless of the overall approach to manage flood risk, the experiences of all case study countries offer some broadly applicable lessons for improving the use and management of levees, reducing their adverse impacts, and improving the integration of natural flood mitigation.

Flood control infrastructure systems are normally designed based on flood frequencies such as 25-, 50- or 100-year, etc and other previous experience factors. GWP (2012) report pointed that the history may no longer be a reliable guide to future events in the climate change. Liao (2014) and (Kundzewicz et al. (2014) pointed that the flood control infrastructure measures designed with a specific capacity and they do not rapidly adjust with the changes of climate and socio economic systems. Therefore, the technical measures are ill prepared for extreme floods, which are expected to increase whose exact natures are unpredictable.

Kundzewicz et al., (2014) highlights the changing patterns of climate and trends of heavy to extreme hydrological events over the past decades. It has been further alarmed that flood hazard is likely to rise in the future and that plausible climate change scenarios in future will increase both amplitude and frequency of flooding events. However, there has been no conclusive and general proof to show how climate change affects the flood behavior, based on the data observed so far (Kundzewicz, 2002).

Moreover, many researchers have interpreted the causes for increasing of urban flood risk as changes in climate, changes in terrestrial systems (hydrological systems and ecosystems, and changes in socio economic systems and they have further interpreted that relative order of importance is site-specific. The flood control infrastructure measures become increasingly unreliable under these the uncertainties of climate change and socio economic changes. Hence, these infrastructure measures bring incremental benefits with adaptation. Adaptation theorists argue that large-scale engineering solutions are highly localized and bring short-term benefits that are often maladaptive across broader scales and sectors (Adger et al, 2005; Barnett & O'Neill, 2013; Cardona et al, 2012 cited in Wenger, 2015).

Di Baldassarre et al (2015) discussed on levee effect that the non-occurrence of frequent flooding (possibly caused by flood protection structures, e.g. levees) is often associated to increasing vulnerability. Moreover, there are empirical evidences demonstrate that flood control structures tend to promote an increase in the vulnerability (including exposure) of societies. The study conducted in Sacramento-San Joaquin Delta of California had revealed that the residents were unaware of residual flooding threat on levee-protected lands (Ludy and Kondolf, 2012). They have pointed that, the lands behind levees certified as protecting against the 100 – year floods and they officially not recognized 'floodplain' and they are open to residential and commercial development because they are ''protected'' by levees. Moreover, those lands are below sea level and the 70 % of newly settled residents did not understand the risk of being flooded Despite the levels of education and income.This study concluded that climate-change-induced sea-level rise exacerbates the problems posed by increasing urbanization and aging infrastructure, increasing the threat of catastrophic flooding in the California Delta.

Many structural flood management measures are based on defense focused design perspective that seeks to resist, disrupt and dominate the natural hydrological cycle. Thus, many flood control infrastructure measures harm riverine morphological and ecological functions and increasing of long-term flood risk (Smits et al., 2006). Therefore, the structural measures destroy the natural resilience capacity of an urban system (Lennon et al., 2014).When urban areas depend on the flood control infrastructure, they are premised on the artificial environmental stability which has limited tolerationto socio – economic and environmental fluctuations.The flood-control infrastructure subjects a city to contrasting conditions which are either dry, inundated and disastrous. In addition, these structural measures such as levees and channelization transfer the local problem to somewhere else and it may cause displacement of people at another location. However, considering the increasing of flood impact and widespread degradation of riparian ecosystems, it is questionable whether the use of structural measures is truly adaptive in the long term. Liao (2014) pointed that in many cases rural communities often suffer and especially during extreme basin wide flood events, strategically flooded to avoid inundation of economically and politically more important cities. Author further pointed that this could be observed in 2011 floods of Mississippi river in USA and Chao Phraya River in Thailand.

3.3.2 Traditional spatial planning measures

Uncontrolled urban development patterns intervene urban hydrological balance in different ways. It increases the impervious surface areas, which increases the volume of surface runoff and decreases infiltration volumes. Secondly urban areas grow over the spaces naturally occupied and alters the local hydrological patterns, ecological functions while aggravating flood risk. In recent years economic losses from urban floods have greatly increased, principally driven by the expanding exposure of assets to risk. As explained by Miguez and Vero (2016), this issue is strongly linked with land use and with typical urban problems, such as housing deficit leading to illegal occupation of floodplains. The proximity economic growth centers to rivers is a major concern in the context of flood risk. A study conducted in Pordenone province in northern Italy, which has suffered several heavy floods, showed that the main driving force of increased flood risk can be attributed to new urban developments in flood-prone areas (Barredo and Engelen (2010). Third, the unsystematic urban development often disconnects the natural drainage flows and makes it difficult for authorities to effectively manage flooding in an integrated, cost-efficient way that combines the use of water bodies such as wetlands, rivers and streams, for their flood regulatory functions.

3.4 Spatial planning in the face of flood risk

Recent years many scholars emphasized limitations of traditional planning practices in the face of urban flood risk. Filatova (2014) showed that in the past, flood risk management is dominated by planned adaptation, which is primarily command-and- control in nature, e.g. spatial planning and engineered flood defenses. Hutter (2007) also pointed that the spatial planning is often narrowed down to a regulatory instrument within flood risk management. It has been showed that the conventional flood risk management measures such as structural flood defenses and zoning developments in high-risk areas set fixed homogeneous rules for all actors. These homogeneity does not consider the possible differences in positive or negative impacts they incur on various actors and they also do not pay attention to alternatives migratory measures.

Many scholars highlighted that the centralized planning together with investment in technical defense measures, and governmental disaster relief programs impede stakeholders from taking individual risk mitigation efforts. Specifically, current government responses to floods and flood risks are characterized by regulatory restrictions on floodplain land use, structural protections, and flood insurance or disaster relief - transfers to property owners. Such government interventions dramatically increase the value of coastal properties and continue to promote or maintain unwise and unsustainable coastal floodplain development (Barnhizer, 2003).

Walega (2013) described that there are three reasons for increase of urban growth along floodplains.

- There are, lack of local development plans that regulate the land development ensuring flood protection.
- Failure to comply with restrictions contained in land use planning leading to decisions on land development in areas threatened by flooding.
- Location of settlements in areas with medium flood risk in which floods are relatively rare.

This had made it necessary to understand the drivers and mechanisms, which lead to increasing of urban flood risk and vulnerability.

Sudmeier-Rieux et al (2014) carried out a study in Vietnam Spain and Nepal, in areas which are prone to natural hazards and illustrated that weak public policies, urbanization, economic liberalization are the main drivers of exposure and to some extent vulnerability. In all three cases, risk is rooted in individual and collective decisions about investments in risky development based on differing and often conflicting interests, needs, and perceptions about risk when compared with public concerns about safety. It has been pointed that the main problem with reducing risk is that it either ends up getting paid by tax payers or by marginalized populations. Therefore, one important way to reduce risks is to better analyze and reduce such transfer of risks, and then to transfer the responsibility those who identify risks.

Accordingly the authors demonstrated the challenges, which could emerge when the planning framework is not capable to convert these potentials in a coherent manner and thus forcing greater reliance on engineered infrastructure, which require additional financial investment. They have described inter linkages between land use planning and risk management and also how a coherent and stringently implemented urban land-use planning process could contribute to long-term disaster risk management. Finally, their study had concluded the need of comprehensive, coordinated planning at all scales, from national to local, aiming at an efficient and balanced territorial development, a combination of both regulatory and financial or market based incentives and public participation.

3.5 Urban Flood resilience

Smit & Wandel (2006), conceptualized that exposure and sensitivity are almost inseparable properties of a system (or community) and are dependent on the interaction between the system characteristics and attributes of the climate stimulus. The characteristics of the human settlement influence its sensitivity to such exposure. This work further pointed that human settlement characteristics such as settlement location and types, livelihoods, land uses, etc., reflect broader social, economic, cultural, political and environmental conditions, which are sometimes called ‘‘drivers’’ or ‘‘sources’’ or ‘‘determinants’’ of exposure and sensitivity. Thus, many of the determinants of occupancy or sensitivity are similar to those that influence or constrain a system’s adaptive capacity.

Secondly, drivers that directly impinge upon water stress and sustainability are the ecosystem, agriculture, infrastructure, technology, demographics and economy. The ultimate drivers which are governance, politics, ethics and society (values and equity), climate change and security exert their effect mostly through their impacts upon the proximate drivers (UN water, 2012). Therefore the primary factors that directly impinge upon urban flood risk are increasing of, socio economic development and climate change etc and the ultimate it decided by the decision making process.

Thirdly there are inherent uncertainties due to uanabilities in (stream flow, precipitation, water quality) and uncertainty in decision making due to lack of knowledge. Akter and Simonovic (2005) conducted a study in a Red River Basin, Manitoba, and Canada and showed that the Flood management decision-making problems are often associated with multiple objectives multiple stakeholders and the uncertainty in decision-making is more profound in flood risk management.

Flood management strategies could cope up with extreme events as well as uncertainties in decision-making. Review of the flood risk management system in Germany Thieken et al (2016) pointed that the risk drivers, such as climate change, land-use changes, economic developments, or demographic change together with resultant risks must be investigated at regular intervals while risk reduction strategies and processes must be reassessed as and implemented with a dialogue stakeholders.

The recent shift of urban flood risk management towards resilience concedes that it helps to reduce the impacts on flood risk prone communities can be reduced (Schelfaut et al, 2011). Urban flood resilience means the ability of a system to potentially exposed to hazard and to resist, respond, recover and reflect up to a stage, which is enough to preserve its level of functioning and structure (Scott, 2013). Vanneuville et al., (2011) emphasized that an increase of the resilience can be also referred to as ‘adaptive capacity’ or ‘coping capacity’ ‘before the event’ and actions to minimize or decrease the negative consequences after the flood event.

As highlighted by Kellagher et al (2008), the benefit of a risk-based approach distinguishes from other approaches of decision-making because it deals with outcomes. Thus in the context of flooding it enables intervention options to be compared on the basis of the impact that they are expected to have on the frequency and severity of flooding in a specified area. Therefore, a risk based approach enables informed choices to be made based on comparison of the expected outcomes and costs of alternative courses of action. Moreover, this is distinct from, for example, a standards-based approach that focuses on the severity of the load that a particular asset has been designed. Risk-based options appraisal and design involves modifying the variables describing the flooding system in order to estimate the effect that proposed flood risk management options will have on flood risk. They have pointed that the risk calculation therefore requires probability distributions for the loadings (that include spatial, temporal and inter-variable dependencies), physics-based models of fluid flows from source to receptor and a mechanism for integrating loading. As highlighted above the translation of the integration in achieving flood resilience into the practice has been pursued in two ways (1) being integrated with the technical infrastructure level and (2) the social political level (Bruijn et al., 2015).

From a political perspective a systems, approach results in very complex decision-making processes with the involvement of many actors, their interests, many uncertainties and disputable choices (system boundaries, data, methods etc). Thus, the resilient strategies highlights the integration of variety of dimensions of flood risk such as social, socio-cultural-historical, legal-institutional, political and economic differing with the flood type. Therefore, the risk-based approach depends on comprehensive and integrative concepts, encompassing many stakeholders and asking for collaboration at various levels. Schelfaut et al., (2011) reviewed the flood risk management in three case studies in Europe: Flanders (Belgium), Niedersachsen (Germany) and Calabria (Italy) and revealed that participation of all stakeholders and bottom-up involvement are considered important factors to bring flood resilience into practice.

Accordingly, they concluded that the increasing the strength of a community is also about increasing the strength and scope of the internal connections between its individuals, organizations and the physical environment that form that community. It is creating stewardship of lay people and consequently hand over responsibility from the authorities to the lay people is considered to be a challenge. Smit and Wandel (2011) also conclude that the adaptations can be considered as local or community-based adjustments to deal with changing conditions within the constraints of the broader economic–social–political arrangements. However, Su (2016) has pointed that resilience policies also need a top-down method as well as mandates and support from higher levels of government.

Many scholars have highlighted the limitations of traditional planning practices in management of flood risk. Klijn et al (2015) highlighted that the multi-layered safety approach or rather a multiple-tiered approach to flood risk management. This includes flood protection as keystone and the second layer of sustainable spatial development as supplement aiming to prevent a further rise of flood risks through demographic and economic developments in the future, and the third layer is meant to reduce the effects of any undesired flooding event. At present, many countries especially, Germany, Netherlands, UK, Australia, USA etc have already recognized the need to adopt risk based management approach over the traditional flood protection strategies (Moel et al., 2009). The spatial policies such as 'space for nature', 'space for water', 'green-blue network', 'climate-proof city', etc are the evidences.

3.6 Spatial planning and urban flood resilience

Spatial planning is a regulatory instrument, which decides the physical landscape pattern, and hence it regulates the implementation of socio economic development. Recent experiences of many of urban issues indicate the lack of feasibility of existing approach of planning to address the urban complex and uncertainty. Many of urban areas are facing increasing of flood risk and they are the evidences for the existing urban fabric in many of our towns, and cities were built without consideration of flood risk (White, 2008). Second, in the past, many of the planning measures for flood risk management were often developed in the domain of water management and from a water-management perspective. As a result, policy makers encounter strong local opposition, sometimes results in major project delays, inadequate solutions or even in the cancellation of projects aimed at providing more space for water. With the experiences in the Netherlands Neuvel (2010) argued that spatial planning should not only be regarded as an instrument for regulating the land required for flood reduction, but also as an important substantive perspective through which participation can be facilitated and through which water management objectives can be balanced with other spatial claims on the landscape. Accordingly, scholars argued the inseparably link between spatial planning and water management and the limitations of existing problem framing and approach of decision-making (Lu, 2014).

Meantime, as water sector, spatial planning domain has also experienced transformation because number of planning concepts, such as coherent, convenient, etc could not be achieved through the existing planning process or through the physical hard planning (see Hart, 1976 cited in Albrechts, 2004). Thus, spatial planning strategies are evolved from the integrated perspectives that transcend traditional sectoral policy divisions through a specific focus on the spatial impacts of sectoral policies (Albrechts et al., 2003). Second, the new approach encompasses comprehensive coordination of all scales from national level, regional level to local level aiming at an efficient balanced territorial development.

Accordingly, the spatial planning tries to coordinate different spatial sector claims and tries to balance spatial claims to achieve sustainable territorial development or serves as a bridge between different spatial levels and policy fields. With an interdisciplinary and comprehensive approach, spatial planning strives for a physical organization of space, which is coherent and desirable from both sector and multi-sector points of view. Therefore, the new approaches of spatial planning evolved with more concerning of open dialogue, accountability, collaboration, and consensus building and they have become key concepts. Then spatial planning provides benefit as a substantive focus in interactive policy and strategy-making processes. Moreover, the spatial planning has become a process of policy-making that guides spatial development or frames the activities of stakeholders to help achieve shared concerns about spatial changes (Albrechts, 2004). Therefore, the spatial strategies are not framed and operate in a rather autonomous, isolated and technocratic way as in the past. Besides, spatial planning leads towards the development and implementation of spatial measures can have a benefit in dealing with current and potential conflicts (Neuvel, 2010).

In this context, it is highly emphasized that the urban development should be carried out “with the water”, “with the river”, and not ‘against the water’. New spatial strategic capacities have developed focusing on water and water as a vehicle for attractive living and working conditions and water concerns. It has further highlighted that water concern become stronger in spatial planning, and using strategic water management as a vehicle for integrating economic and environmental interests. (Woltjer and Al, 2007). Van Leeuwen et al., (2007) highlights spatial planning can be perceived as a policy-making process through which the actors involved try to define and create desired spatial situations while defining and preventing undesired ones. Under these circumstances, is capable to direct people and properties into less hazardous areas and thereby reduce hazard risks by controlling the timing, location, type, intensity and other characteristics of development (Godschalk, Brower, and Beatley, 1989 cited in Burby, 2000). In this context, spatial planning is perhaps the most effective approach to preventing the increase in flood risk, through active controls on (re)development of land and property in these areas (Sayers et al,. 2013).

Deyle and Butler (2013) highlighted the functions of spatial strategies, which need to create flood resilience in urban areas through protesting, accommodating and avoiding/retreating. Su (2016) has divided the spatial planning strategies in the face of urban flood resilience as (1) prevention (2) accommodation (3) fortification (4) protection (5) retreat and (6) green infrastructure. Moreover, planning more space for the river, wetland planning, polder and retention areas, and permeable surface design to increase urban flood resilience do matter in reducing flood risks. Accordingly, spatial strategies emphasize allowing more space for water, highlight the natural landscape, and create more water adaptive space.

The recognition of flood risk management is growing but the practices are still not widely used or understood at strategic and local levels (Burby and May, 1997; Richards et al., 2008). Nevertheless, many of the countries are facing challenges in implementing risk sensitive planning measures in flood management. The main question is how to frame process perspective spatial strategies on flood risk management, which is owned different understandings of cause effect relationships and diverging interests. Because risk-based planning explains integrating the risk-based land use planning approach into urban governance (Jha et al. 2013).

Many scholars have been argued about this challenge. Moss, (2004) highlighted that the integration of flood risk management and spatial planning highly depends on the framings and institutional processes. Dawson et al., (2011) and Vinke-de Kruijf et al., (2015) also pointed that the effectiveness of planning strategies is sensitive to socio-economic pressures, institutional capacities and governance arrangements. Lyles et al., (2013) also pointed that the development of integrated strategies in flood risk management is determined by three generic factors; (1) planning process (2) planning context and (3) planning outputs. Hutter (2006) also explained that the strategy formulation determine mainly by three factors such as context, content and the process.

4. Discussion and conclusion

Flood control infrastructure measures and blanket land use regulations failed and it is highlighted that need of find measures to reduce the consequences of floods. The traditional flood risk assessment and management approach emphasize the need to tackle the community vulnerability. It is increasingly acknowledged that the flood control infrastructure measures need to associate with spatial planning measures in order to achieve resilience for urban floods. The past literature emphasized that the water management and spatial planning domains have developed their bodies of knowledge over a long time separately.

However, water management and spatial planning domains are sharing a similar perspective more and more. Although parallel, both domains have walked through similar paths. The best answer to flood management lies in an integrated approach and joint actions.

The shift to integrated flood risk management has been highlighted the need of perceptional changes of experts and society. Flood risk resilience requires integration of space, time and socio economic activities, it should integrate all the actors mainly, authorities, inhabitants, developers, etc. Flood risk perception has received growing attention in recent years owing to the assumption that they provide useful insights for flood risk management. Moreover, the urban flood resilience depends on the inclusion of diverse views, knowledge and perceptions. The perception of flood risk is governed mainly by the situational and cognitive factors, which are specific to the context. Therefore, there are two main approaches in flood risk assessment and management predominant in the literature (1) rationalist approach (the official authorities define the acceptable level of risk) (2) constructivist approach (individuals and social groups define their acceptable level of risk by considering their social context).

The technical flood protection measures always play a substantial role in reducing the impacts of flooding in Colombo. The repeated urban flood events and the increasing of flood impact over the last years challenging the existing flood management approach in Colombo, integration between the spatial planning and water management as well as the governance systems. At last the paper question the appropriateness of 'rationalist approach' and the 'constructivist approach' for flood risk management in the context of Sri Lanka.

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FORMING THE NEGATIVE: ARCHITECTING THE SPACE IN BETWEEN
From the Interior to the Exterior of the Dressed Figure

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Abstract
The fleshy human body is defined and given meaning through the dress. Western ideals and cultural practices identify the dress as a *fit-on* to the body. Whereas, Asian cultures recognizes the dress with multiple layers of clothing creating spaces between dress and the human body. Inspired by this practice and concept of the dress, the research aims to identify possibilities and notions of creating the dress from the interior to the exterior; designing from spaces in between to result in an exterior. In the process of developing a new approach for designing the dress, the need arises to re-identify its function as well. Therefore, the research relates to the contemporary functions of a dress and redefines them within the possibilities of the previously identified creation of the dress dependent upon the space in between. The research used an inductive methodology following the grounded theory to identify a concluding theoretical framework for designing the dress from the interior to the exterior. The research was primarily funded by qualitative data from archival sources. The research was funded by the Senate Research Committee of the University of Moratuwa under the grant no SRC/ST/2016/18.

Keywords. *Space Between, Negative Spaces, Fashion Approaches, Inductive approach, Grounded theory*

1. Introduction

When considering the transgressional history of the dress it is hard to identify whether the invention of the dress was merely to shelter the body, for it can be seen that using adornment for gender clarification dates back to pre-history. Regardless of the need of the dress, the dress through time while acting as a second skin has been creating and providing meaning to our cultures and societies and about our cultures and societies to us. This back and forth meaning provision related to the dress varies primarily in the contexts of the West and the East. The silhouette of the West begins with the light weight and free flowing garments of the Greco-Roman period and converts into a stiff dress. Where the dressed silhouette was not defined by the lines and contours of the body but by pre-made structures that was made to result in a pre-defined visual figure.

The story of the dress in the east through time had a liberated definition of the silhouette resulting in styles of dressing where the second skin was donned with spaces between allowing a freedom of movement and also a more dynamic range of meaning. The research focuses on the chronological variations of the dress in the Indian sub-continent and the West to derive a sense of meaning up-to-date through dress. This comparative study is necessary due to the extent of globalized practices in the present day.

The first drastic measures of liberating the female figure from tight predefined silhouettes arose with the degree of functionality that was required in the times of WWI. While the products of the East have been flowing into the European region for centuries through the Silk Route, it is only as late as the 20th century did the concepts of dressing of the East officially took-on the runways of Europe with Issey Miyake's participation in the Paris collection in 1973. With his introduction to dressing the human figure allowing free space between the dress and the figure bought in a new era of liberated dressing in the Western fashion culture. Similar ideologies were followed by two other prominent Japanese fashion designers Rei Kawakubo and Yohji Yamamoto.

The concluding theoretical framework of the research is a result of the identification of a theoretical gap in using the concept of space in between body and dress as an approach to design the dress. The framework will fund future pragmatic development of the dress based on an interior to exterior approach.

2. Methods and Methodology

The research paper aims to realize a theoretical framework based on a divergent collection of existing practices. Therefore, an inductive approach was followed. As depicted by Thomas (2006), Strauss & Corbin (1998) claims the emergence of a theory from studying data is the primary purpose of the inductive approach. He further continues explain underlying purposes of the genral inductive approches as following.

- to condense extensive and varied raw text dadat into a brief, summary format
- to establish clear links between the research objectives and the sumamry findings derived from the raw data and to ensure that these links are both transparent (able ti be deminstrated to others) and defensible (justifiable given the objectives of the research)

- to develop a model or theory about the underlying structure of experiences processes that are evident in the text data.

Therefore, the research was conducted through the general inductive approach primarily due to its appropriatedness for realizing models or theories based on the “underlying experineces” that can be identified in data.

The general inductive approach was followed by the grounded theory to analyse gathered data. “…grounded theory seeks not only to uncover relevant conditions but also to detemine how thw actors under investigation actovely respond to those conditions, and to to the consequences of their actions” (Corbin & Strauss, 1990).

3. Spaces and Silhouettes of the Dressed Figure: the Western Ideal

The territory that is considered as Europe in the present day recognizes itself as a civilization from the beginning of the Hellenistic era of the Grecian Empire. Therefore, for the scope of the research, the study of the silhouettes for the West will begin with this period. The Hellenistic period begins with a rich exposure to wide range of cultures with the conquests of the Alexander the Great in 323 B.C. and ends with the conquering of Greek states by the Romans beginning from 1st cent. A.D. This section will explore the chronological variations of the silhouette, where a notion of liberation arose and where and how the physical female figure was liberated. The research will later identify a revival of the Greek celebration of feminine contours in the modern era. Section 3 will showcase two types of spaces, a static space and a dynamic space within the Western ideal. It will further showcase the how the dress was created from the exterior to the interior allowing the gap for the research scope.

03.1. CHRONOLOGICAL VARIATIONS

The world’s oldest human figurine is a 4inch tall clay statue discovered in Austria known as the Venus of Willendorf. The figure has some of its features completely ignored and the others greatly exaggerated. (How Art Made the World; More Human Than Human, 2005) The exaggerated features allow the depiction of a very fertile woman. This was 30, 000 years ago and our obsession with a figure to idealize our need to become more human than human has already begun. While the obsession of the perfect human figure follows up-to-date, in which perfection is understood as the ideal showcasing of socially constructed gender role, a peak point in the perfection of the figure can be seen in the Greek Classical Ages; the Hellenistic period with its advances in art, mathematics, philosophy and politics. The mostly worn lightweight garments; *chiton* draped over the curves of female figure enhancing the form of the body while providing great freedom of movement (Department of Greek and Roman Art, THE MET, 2003). This ideology is evident in their sculptures for the perfect figure in Classical Greece was the athletic figure. Therefore, the undressed figure was created showing a figure partially relaxed and partially in movement. The layers of drapery enhanced this athletic ideology, folding and creasing following the curves of the body.

Figure 1, Free flowing garments creating space between while enhancing the athletic Greek figure (Source: http://www.metmuseum.org/toah/works-of-art/03.12.17/)

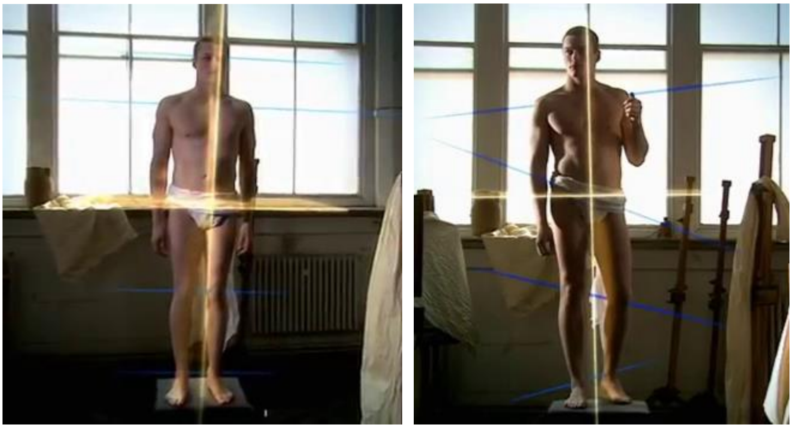

Figure 2, The Grecian athletic figure seen in all period statues (Source*: (How Art Made the World; More Human Than Human, 2005)*

The Roman era had a similar sense of dressing, where both men and women both wore garments flowing over the body resting in the shoulders. This pattern continues till the end of the Roman Empire and the in-flux of the *barbarians*; people of the present day Scandinavian region as referred to by the Romans, and the concept of the ‘pant’ came into the civilized Western world. This was worn under the free flowing garments. The variations of this styling continued and a significant change in the dressing of men and women can be seen in the Renaissance, where the dress upon the body was used to show a preconceived idea of the figure than the previously recognized celebration of the body by the use of free flowing garments. The exaggerated figure first was created by adding multiple layers of fabric under the final outerwear (Entswitle, 2000). The function of many layers of fabric was created with crinolines and corsets resulting in very narrow waistlines and wide hips. A static space was created under the outerwear between the crinoline and the body. Due to the tightening of the upper torso to create a narrow hip movements were restricted although there was obtained static space in the lower torso (Stets & Burke, 2000).

The WWI changed the manner of dressing completely going back to free flowing garments of ancient times but additionally freed the ankle as well. The figure of the 1920’s was radically different that it ultimately resulted in a rectangular figure where the dropping dress from the shoulder swallowed the hips into the dress as well (Sonelik, 2014).

03.2. LIBERATION OF THE BODY

The 1900’s began with the knowledge of health hazards of the crinoline. This resulted in a gradual decrease of the wideness of the corset and the concept of “monobosom”, where the female bust was less highlighted so that the characteristic “S-curve” of the period would be highly visible (Glasscock, 2000). While recovering from WWI, 1920’s had a sense of *liberation* and *modern times* deeply rooted even in the daily practices. Pioneered by designers who have set-up studios and design houses in Paris, 1920’s liberated the female body to such an extent that it had lost all sense of curvaceous bodies of the female. Leading designers like Coco Chanel found inspiration for her clothing mostly from detailing and silhouettes of men’s suits. While comfort of stylist garments has reached great degree by this time it has lost the sense of femininity in the silhouette.

It can be noticed how the waist has completely disappeared with the uneven placing of the feather trim. The idea of black in women’s clothing and rich in details of manly garment construct reached its height and stays important up-to-date with Coco Chanel’s *Little Black Dress*. The relation to the male garment construct to liberate the female body can be seen later on in the 1980’s which continues to the present day with creations of Rei Kawakubo, in her brand *Comme des Garcon* (Like a Boy) and in creations of Yohji Yomamoto who rejected ideas of beauty in the norm by creating garments which acknowledged the idea of space in between for liberation and freedom of movement.

Figure 3, early versions of the Little Black Dress, By Chanel, 1927 (Source: http://www.metmuseum.org/toah/works-of-art/1984.28a-c/)

The 1930's looked for the curves of the female figure again without losing the comfort, the mobility and the freedom of the dress of the1920's. The westerns who looked into the Orient through centuries to bring out a sense of exotic in the West shows intriguing examples of Asia in the western dress in the 1930's (Koda & Martin, 2004).

The lost feminine figure has reappeared in these dresses by relating to Asia and its traditional roots. While the Madme Gres' rendition of the cocktail saree dress is a direct reflection of the saree with a reduced length Balenciaga's evening wrap has considered being voluminous, creating a space between finding inspiration in the kimono (Koda & Martin, 2004).

03.3. RECOGNITION OF SPACE IN BETWEEN

The 1968 May revolution in Paris bought a novel era of design and construct to all creative fields. 1970's began with attempting to break away from all the previous styles of fashion and therefore dressing. Amid, this revival Issey Miyake, entered the Paris fashion arena with the idea of *A Piece of Cloth; A-POC.* A-POC provided freedom of movement of the body as never seen in the Western fashion arena. The later developments of A-POC provided a very extensive freedom to the wearer that the design was in a tube of cloth which could be manipulated and worn as preferred by the wearer. Even in his later collections such as *Pleats Please* more and more kinetic space was created within the space between body and dress as a result of the construction of the dress.

As it was mentioned before in the 1980's the simultaneous introduction of the Japanese contemporary duo, Rei Kawakubo and Yohji Yomamoto brought out the ideas of space in between the dress and the to break away from celebrated feminine silhouettes (Manning, 2015). These spaces were filled and layered to convert and deform the shape and form the figure.

Figure 4, A-POC by Issey Miyake,
(Source: Fashion Memoir: Issey Miyake by L Benaim)

The research identifies the acknowledgement and recognition of the space in between by Issey Miyake, Rei Kawakubo and Yohji Yomamato, but does not identify an approach of designing the dress based on the space in between. It was understood that the designs created for the exterior resulted in dresses with spaces between and not styles of dressing which was resulted dependant on the interior. For the fluid space is subjected to change with the change of the exterior and does not showcase a change in the exterior as a result of the change of the interior; the space in between.

04. Spaces in Between; the South Asian Figure

The South Asian feminine figure is dominated by the pleats, folds and drapes of the saree. Section 4 identifies various expressions of the saree with examples from India throughout the wide variations resultant of the various states and the styles of dressing Sri Lanka. Then, the chronological variations of the saree are taken into consideration. Finally, the relationship of the saree to constructing a dressing style from the interior to the exterior is explored.

04.1. EXPRESSIONS OF THE SAREE

It is said that one can never go wrong with a saree. While this statement resembles the deep acceptance of the saree in our societies it also expresses the wide range of suitable expressions that can be realized through the wearing of the saree. Traditional styles of saree draping communicate the area of the wearer as well. The freedom and allowance of movement of particular drapes defines the plausible activities that can be conducted by the wearer.

04.1.1. The emotional and sensitive saree

The emotions that can be expressed enhanced and expressed through the saree is of a great magnitude. The fall of the saree; *pallu* allows facial expressions to be highlighted. The covering and the uncovering of the body with movements takes the wearer from modest to seductive in an instant (Banrjee & Miller, 2004).

Figure 5, Facial expressions enhanced with the use of Pallu
(Source: (Banrjee & Miller, 2004)

Figure 6, Dramatic expressions of the exposed skin by covering other areas using the saree (Source: Banrjee & Miller, 2004)

In these examples it can be noticed how the saree has been used to bring out a variety of meanings, by and about the wearer integrating with facial expressions and bodily movements. Due to the construction of the dress from interior to exterior the use of the body is exaggerated in the exterior.

The wearing of the saree to suit the activities that is conducted wearing it, additionally to providing ease of work, it also showcases the social standing of the wearer. The saree above the ankle is worn by the working class woman with many a chore to complete. The worker in the paddy field wears the hem of the saree at a midi length, at a glance communicating to the viewer of their daily practices. In such cases the attributions of femininity to the wearer is received not due to the enhancing of the female figure by the saree, but because of the social placing of the saree (Lynton, 1995).

04.3. FROM THE INTERIOR TO THE EXTERIOR

The saree is dressed from the underneath to the final outer wrap and the underneath layers can be seen from the outside with the movement of the body. The manner of dressing in the saree creates a resultant final outer wrap dependant on the underneath layers as opposed to being two isolated entities.

When the final outer wrap of the saree is considered as the dress; the exterior, the pleats and folds underneath can be considered as a dressing of the space in between; the dressing of the interior. The research identifies this as a potential area of inspiration to develop a framework. The below shown variety of draping styles while primarily depicts the geographical area of the wearer to the viewer who is unaware of this location resemblance finds further meaning in the manner of dressing.

Figure 7, Overlapped pleats, drapes and folds of the Saree forming the interior to the exterior (Source: Banrjee & Miller, 2004 edited)

5. Architecting the Space in Between

Section 5 formulates the theoretical framework on which pragmatic explorations of dressing the spaces in between can be conducted upon. The need of architecting the space arises due to the fact that within the concept of architecting, the dress can systematically move from obtaining voluminous spaces to the minimum space through specific verifications in the method of structuring the space. Therefore, section 5, first elaborates on the need of architecting the spaces in between and its benefit to create the final outcome and then creates a theoretical framework for forming the spaces between dress and body.

05.1. THE RATIONALE OF ARCHITECTING

The identification of parallels between architecture and fashion has historical roots which perhaps pre-dates Vitruvius (1st cent. BC) (Quinn, 2003). The parallel is such that, the dress is considered as a second skin to the body whereas buildings are seen as an extended version of shelter of the second skin. The difference in magnitude stands as the primary classification factor (Miles, 2008).

When drawing parallels and identifying similarities between fashion and architecture, two main patterns were recognized. One was to see similarities in the visual language and to identify a nature of rigid construction of the dress. The second was to find similarities in the approach itself which resulted in visually differentiated outcomes yet in a process of deconstructing the dress and the building it would showcase similarities in the build-up. The research identified the potential of the latter method to construct a theoretical framework for dressing the space in between. In that, the recreation of the city of Rome by Giambattista Nolli (1701 – 1759) focusing on the spaces in between building of the city provides inspiration for the architecting of the dress. The Nolli map immediately takes the viewers focus to the between spaces. Therefore, especially with a scale of the city it allows the understanding of the flow of the city.

Figure 8, Nolli Map (centre of Rome)
(Source:http://www.lib.berkeley.edu/EART/maps/nolli_06.jpg)

The deconstruction of the Nolli map can be identified in several aspects.

- Addition of structural elements – the creation of the dynamic city of Rome can be done through the systematic addition of its elements dependant on a pre-defined hierarchy
- Layers of structural elements - the city can be thought of as overlapping layers. This could follow a visual hierarchy or hierarchy of usage. Furthermore, the layers can be identified as separate layers or constructed with intertwined layers.
-

- Structuring using separated elements – the visual expression of the Nolli map shows us that the city can be constructed using a variety of separated forms to finally result in an intertwined whole.
- Filling - another manner to see the construction of the Nolli map is to see it being filled with objects and spaces to result in the final city with its dynamic expressions.

These particular allowances of architecture make it the ideal methodology to follow when creating the dress taking the approach of constructing from the interior to the exterior.

05.2. FORMING THE SPACE IN BETWEEN

The understood practices of dressing through chronological variations of the East and the West and the final identification of the possibility of architectural methodologies to fund the construction of space in between, the following theoretical framework can be produced.

01. Body + Addition of elements – material can be added on to the body to enhance forms, to deform the figure creating resultant meanings.

02. Body + Filling – A defined boundary that is dependent on the movements of the body can be filled.

For these two methodologies the following assumption can be made due to the given cases

- The extent of the space varies between an unknown maximum and a bare minimum upon the body.

The minimum as explored by Issey Miyake;

> "*In 1970, Issey Miyake appeared on the fashion scene with his idea of "Peeling Away to the Limit." ... At the beginning, his clothing consisted of pieces of irregularly shaped fabric. ... Breaking all of the rules, his pieces of material were merely clinging to the body. Moreover, each piece was stripped away one after another until the body itself was in full view. The result, in a way sadistic, was to take the body and the clothing away from each other, reducing their relationship to the minimum*." (Koike, 1978).

Expansive undefined maximums as evident in these 19th century crinolines.

03. Body + Layers – layers of material can be constructed from the interior to the exterior. In this process the earlier concepts through data showcases two distinctive categories.

Multiple layers originating from multiple base forms

Multiple layers originating from a singular base form

*Figure 9, Various expansions of the crinolines of the 19th century (*Source: https://agnautacouture.files.wordpress.com/*)*

Figure 10, Ensemble by Rei Kawakubo and Junya Watnabe - multiple layers of fabric filling up the space from the body to the exterior dress (*Source: http://www.metmuseum.org/toah/works-of-art/2001.742a,b/*)

04. Body + Structuring – focus can be drawn to specific areas of the body by using means to visually enlarge it -as in the pre-historic Venus of Willendorf- or by framing in various manners to create dramatic exposure -as the saree covers specific parts of the body to highlight other areas-.

6. Conclusion

The research aimed at identifying a framework, a set of fundamentals to begin pragmatic construction of the space in between body and dress through archival sources. Following an inductive method through the means of grounded theory the research continuously questioned the existence of the theoretical gap the research explored. With the understanding of historical practices of both east and the west it came into light that the recognized gap of a specific approach of constructing the dress relating to the space in between does exist. Finally, a set of fundamentals were developed allowing the inception of pragmatic explorations of the space in between. The research concluded that the space in between can expand from the minimum limit of the skin of the human to unknown vast expansions. This space can be dressed with multiple layers of separated material or a singular material folded and pleated into multiple layers to result in different meanings. When conducting pragmatic construction, it is mandatory to keep in mind that the resultant should be the exterior and not the interior similarly to contemporary practices.

Figure 11, Use of cylindrical structural elements (Source: Student design project, Dept. Of Integrated Design, University of Moratuwa)

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THE VISUAL PERCEPTION OF OCCUPANTS' ON DAYLIGHT; *Emphasis on the diversity of luminance ambience due to architecture & effect of glare in office environments.*

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Abstract
The research investigates the occupant perception of daylight in office buildings in Sri Lanka. Specific focus is drawn to the potential diversity of a luminous ambiance environments, created by daylight and problems associated with glare effect to the visual comfort. The methodology involves an investigationto find the level of occupants' perception through a questionnaire survey and analysing the data using the SPSS analytical computer software. In addition, pointed Lux levels in selected areas were measured to find out the activeness of day lighting level using Daylight factor. Simultaneously a photographic survey is used to identify the brighter and darker zones and design intervention of the building designs. According to the data analysis, 97% of responses are found to be less sensitive to day lighting. The results suggest the occupants in investigated office buildings consider daylight as an insignificant component in office environments. Further, it was found that glare; due to extensive difference of lighting level between inside and outside, was an issue to be addressed.

Keywords: *luminous environment, visual comfort, luminance ambiance, occupants' perception, daylight, Lux level*

1. Introduction
In tropical countries like Sri Lanka, day light is available throughout the year but most people who live in tropics have less sensitivity towards achieving maximum use of it in their day-to-day activities. Especially in office buildings which mostly function during daytime have anti -daylight integrating windows and methods such as blackout curtains trying to build artificial working environment using artificial lighting systems consuming energy. Evenif the occupants are interested in integrating day light in to their working spaces the building design itself is not flexible enough to satisfy the need. The problem could be, either with the designers of these buildings or the general lack of knowledge and advantages in daylight integration in to buildings of people who lives in tropics. This may be identified as a third world syndrome.

In offices, workers spend longer hours in front of computers, making them particularly sensitive to veiling reflection and glare, in which day light is often found to be the source of discomfort. As a result free source of light has slowly lost interest from architects and clients throughout of the years and mostly until the 1970's in majority of buildings. However, the rising conscience that artificially lit environments significantly increase the energy consumption of buildings (Baker,1998) and often generate unsatisfying or discomfort environments from the occupants' point of view (lam, 1972), have forced architects and scientists to reconsider daylight a serious option in providing comfortable spaces for offices. (Dubois, Demers, &Potvin,2007)

Thus, this research aims to find the reasons for the above scenario in terms of the occupants' perception through analysing the daylight level in the office environment. The research is based on visual perception and that level of perception depends with human sensors and activity pattern. This further investigates the importance of the day light diversity in office buildings, and level of impact to the employees' and their self-satisfaction.

2. Data/variables and their definition in office environment

- Level of daylight

There is a maximum day light level in office buildings 350 lux the challenge is how to control that average 350 lux level and used daylight factor help to use the standard percentage of the day lighting level in the office spaces. However indoor and outdoor lux level variation help to produce more glare. (Szokolay,1975)

- Activity type

In every office building, the level of daylight integration depends on their activity. Sometimes Daylight is a must for that specific activity. Without daylight that activity cannot be function properly.

- Occupancy pattern

In office buildings its occupancy pattern varies with the interior arrangement as an example, open plan office concept is used to get more daylight in to the working areas.

- Occupancy perceptions

3. Field study program

The research was carried out during the month of February as it is considerably consisted with the most days of warm temperatures and low rainfalls throughout the year.

A pilot studyinclusive of a questionnaire survey was carried out to identify best potential two cases where 20 office buildings were studied.There Tripoli market building and SLLRDC building were selected which were identified to be designed for maximum daylight consumption.Both the buildings selected as case study, are located in Colombo area, therefore climatic conditions were constant to the both buildings

- Case Study 1 - Tripoli market building: One participant from each working table was selected to participate in the questionnaire survey. 30 responses were taken.

- Case study 2 - SLLRDC building: Responses from the selected 32 occupants in design division and 20 occupants in wetland divisions were taken.

30 mints were offered for each participant to fill the questionnaire according to their own preferences.

4. Data presentation tools

SPSS (Statistical Package for the Social Sciences) is a statistical analysis and data management software package. SPSS can take data from almost any type of file and use them to generate tabulated data. This package programs is available for both personal and mainframe computers as well as to calculate daylight factor and understand the relationship between the occupants' perceptions and the day lighting level in a selected area. Diagrams which indicate the measured point lux levels,column charts and pie charts using Microsoft Excel and plots of distributions and trends are used as descriptive statistics to conduct complex statistical analyses.

5. Methodology and tools to measuring daylight

Working office hours were divided in to four segments as 8.00am to 10.00am, 10.00am to 12, 12 to 2.00pm and 2.00pm to 4.00pm to take the average lighting levels using lux meter as a light measuring instrument. The measurements were taken at selected points in a (5'x5') grid pattern to get more accurate average values. Each grid point gives variable values and each point measurements were taken at 30 minutes intervals within each segment of two hours. Simultaneously the day light factor is found tounderstand the standard lux level in the selected office buildings.

Measurement heights

• Common areas (lobbies, corridors, courtyards)

Measurements are taken @ zero level and lux meter is moved on the ground level using cord or cable.

• Working areas

Measurements taken @ 2’6” level and lux meter is moved on the working plane. (Figure 01)

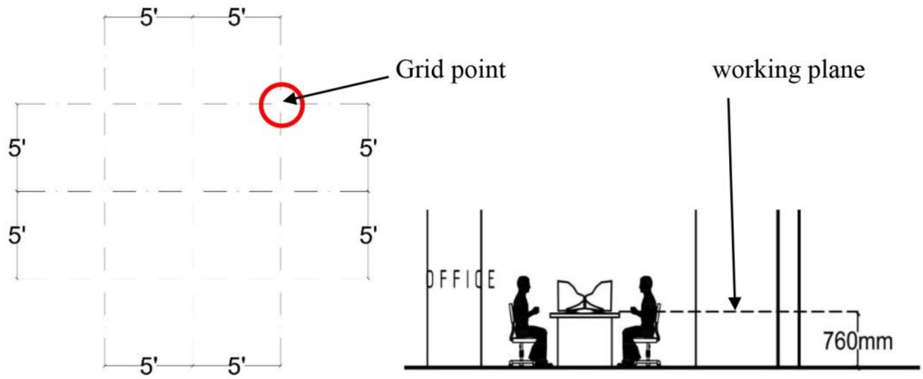


Figure 132; 5’x5’grid point and 760 high working plan
(Source; author)

6. Method of analysis

The data gained through SPSS analysis and questionnaire survey is analysed and compared with the lighting level condition which then is used to construct a relationship between the lighting level and occupants’ perception.

6.1 Expected Research outcome

The diversity of the daylight environment has been explored by various researches and ,according to those researches, the diversity of the daylight environments indeed addresses the inherent subjectivity to each individual, leaving him/her the choice of selecting various lighting levels according to the specific activities and locations . However, day light directly affect to the professional rendering outcome. This hypothesis is investigated along with the reasons to prefer enclosed office environments.

6.2 The daylight distribution in two buildings

As shown in the figure 02, in Tripoli market shade blinds are used to avoid glare. As a result, inside daylight factor become less than 2% and dim daylight conditions prevail in daytime.

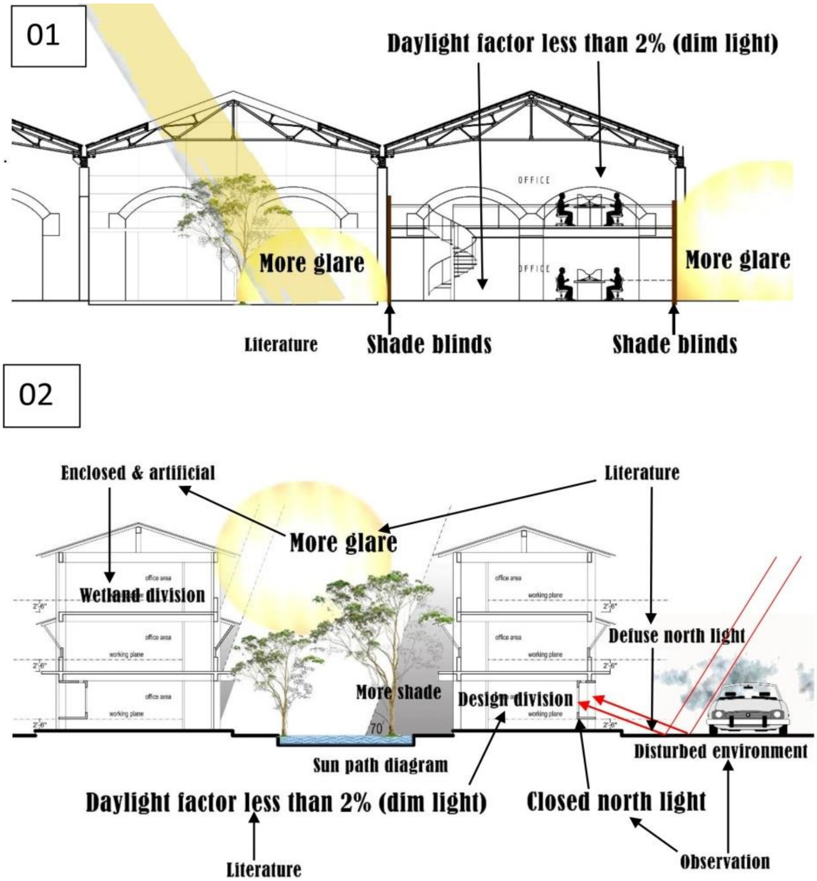


Figure 2; daylight distribution analysis in 1) Tripoli market and 2) SLLRDC

In SLLRDC, in design division; the north light is disabled to avoid unfavorable outside environment due to dust and vehicle fumes and noise.this has resulted inside daylight factor to be less 2% and has caused dim daylight in daytime.
In wetland division a considerable contrast between inside and outside (figure 02) could be visible which cause higher amount of glare. Thus the occupants are tend to operate in that division using artificial lighting and ventilation.

6.3 Data analysis

T test statistic methodology

The t-statistic was introduced in 1908 by William Sealy Gosset, a chemist working for the Guinness brewery in Dublin, Ireland. (Richard, 2004)
A t-test helps you compare whether two groups have different average values (for example, whether men and women have different average heights).

What is a t-value?

The t-value is a test statistic for t-tests that measures the difference between an observed sample statistic and its hypothesized population parameter in units of standard error. A t-test compares the observed t-value to a critical value on the t-distribution with (n-1) degrees of freedom to determine whether the difference between the estimated and hypothesized values of the population parameter is statistically significant.

Main Questionnaire Analysis

The questionnaire was developed with one to five scales according to the statistic methodologies and each answer given by occupants.Five optional questions are analyzed using two tail t-test in statistics.

A; 95% valid Data **P**; 5% negligence data

Observer values close to the ‘0’ become significant, where asobserver values close to the two tail‘t’ values, become insignificant. Critical‘t’ Value is selected according to the test sample for the barrier analysis. The following table shows results captured from two tail‘t’ value table.

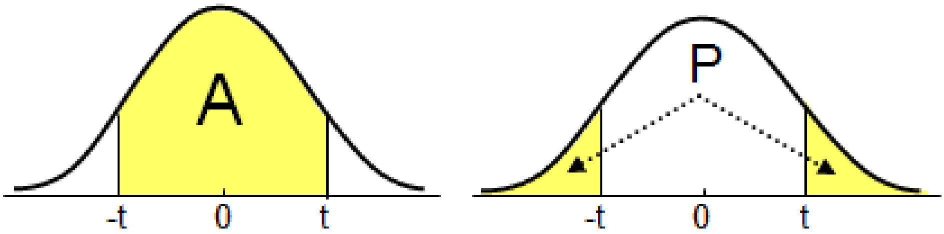


Table 01; two tail t-test in statistics

Critical ‘T’ value modular table

According to the ‘T’ test statistic methodologies, Critical T value modular table is a constant and can download from any statistical websites and refer from statistical books. The important thing is, number of occupants’ or responses who answer the questionnaire survey.

(N-1)=X

N; number of responses
X; value must include to the 'T' value table of Critical 't' value selection

In Tripoli market building Critical't' value selection for analysis

Area of right	0.2 60%	0.1 80%	0.05 90%	0.0025 95%	0.01 98%	0.005 99%	0.001 99.90%
Confidence level = 29	0.854	1.311	1.699	2.045	2.462	2.756	3.396

Table 2; Table of critical 't' value selection
Source; www.ruf.rice.edu/~bioslabs/tools/stats/ttable

Data analysis were based on hypothecs testing and testing statement given as follows,

1) Ho: |- μ| ≥ μ0 vs H1: μ ≤ μ0
2) Ho: |- μ| ≥ μ0 vs H1: |- μ| ≤ μ0

μ= observers' 't' value
μ0= critical 't' value

Observer 't' value |2.045 ≥ +/-2| critical 't' value (significant factor)
Observer 't' value |2.045 ≈+/-2| critical 't' value (insignificant factor)
Observer 't' value |2.045≤ +/-2| critical 't' value (significant factor)

Observer 't' value; 't' value taken from T test table't' value taken from T test table (given by SPSS after enter the excel data sheet)
Critical 't' value; 't' value taken from critical T value section (that is the constant)

Table 03 clearly shows the responses have high't' values and it become insignificant according to the hypothesis, Observer't' value [2.045> +/-2] critical 't' value. However significant values indicates higher value such as (2.045+2 =4.045) and observer 't' value higher than the 4.045.

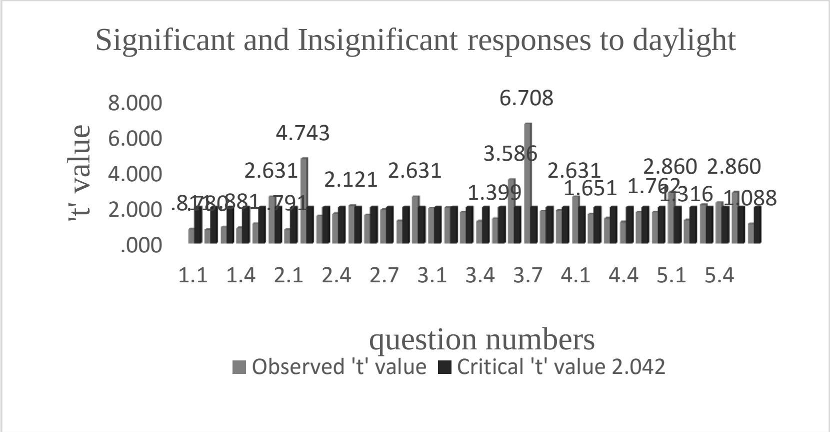


Table 3; Significant and insignificant response to Daylight in Tripoli Market (Source; Excel column draft use with SPSS data)

6.3.1 'T' value analysis in Tripoli office building

According to the't' test in the Tripoli market 93% of observer't' value lies within the **[2.045 +/-2]**range and resulting majority of responses to be insignificant. This suggests Tripoli market occupants' are less considerate or less sensitive to the day light.

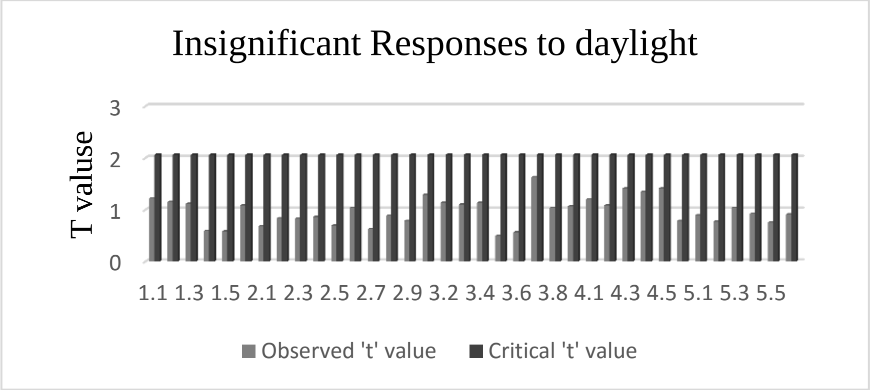


Table 4; insignificant responses to Daylight in Design Division Source; Excel column draft use with SPSS data

The column draft of the insignificant responses in design division in SLLRDC occupants clearly shows the insignificant responses to the all questions and all Observer't' value in [2.064 +/-2] range. However insignificant values are indicated between 2.064-0 range. (Refer Table 04)

6.3.2 'T' value analysis of Design division in SLLRDC

As per the analysis of 't' test in the design division 100% of observer't' value lies within the **[2.064 +/-2]** range resulting majority of responses to be insignificant. The result signifies occupants working in the design division of SLLRDC, are less considerate or less sensitive to the day light.

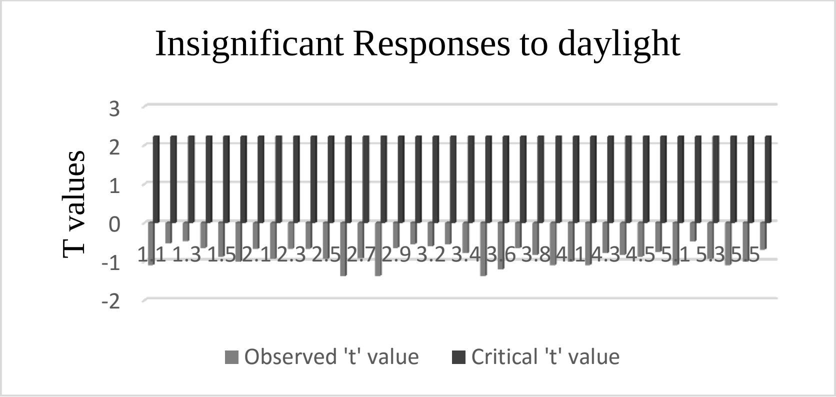


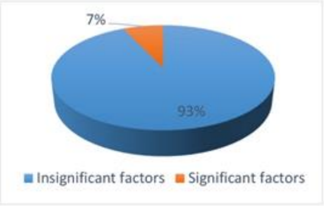
Table 05; insignificant responses to daylight in Wetland Division

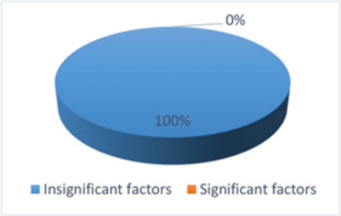
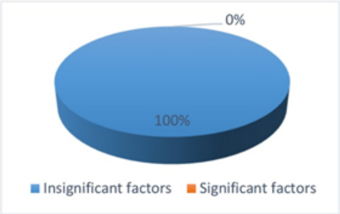
The column draft of the insignificant responses in wetland division in SLLRDC occupants clearly shows insignificant responses to all the questions and Observer 't' value lies within [2.228 +/-2] range. However insignificant values are indicated with miner value (refer table 05).

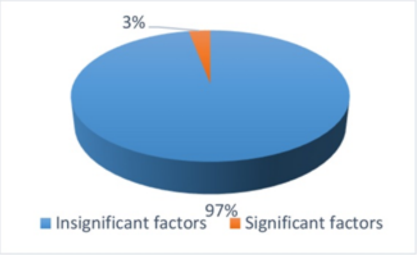
6.3.3 'T' value analysis of Wetland division in SLLRDC

According to the 't' test in the wetland division 100% of observer't' value lies within the **[2.228 +/-2]** range and majority of responses are insignificant. The result points out that the occupants working in the wet land division of SLLRDC, are less considerate or less sensitive to the day light.

Summary of data analysis

<table>
<tr><th colspan="2">Tripoli market office building</th><th>Pie chart diagram</th></tr>
<tr><td>Significant responses %</td><td>insignificant responses%</td><td rowspan="3">
</td></tr>
<tr><td>(2/30)x100=7%</td><td>(28/30)x100=93%</td></tr>
<tr><td>2= significant responses
30= number of occupants</td><td>28= insignificance responses
30= number of occupants</td></tr>
</table>

<table>
<tr><th colspan="2">Design division (SLLRDC)</th><th>Pie chart diagram</th></tr>
<tr><td>Significant responses %</td><td>insignificant responses%</td><td rowspan="3">
</td></tr>
<tr><td>(0/25)x100=0%</td><td>(25/25)x100=100%</td></tr>
<tr><td>0= significant responses
25= number of occupants</td><td>25= significant responses
25= number of occupants</td></tr>
<tr><th colspan="2">Wetland division (SLLRDC)</th><th>Pie chart diagram</th></tr>
<tr><td>Significant responses %</td><td>insignificant responses%</td><td rowspan="3">
</td></tr>
<tr><td>(0/11)x100=0%</td><td>(0/11)x100=0%</td></tr>
<tr><td>0= significant responses
11= number of occupants</td><td>11= insignificant responses
11= number of occupants</td></tr>
</table>

Average responses in selected two buildings		Pie chart diagram
Significant responses %	insignificant responses%	
(2/66)x100=3%	(64/66)x100=97%	
2= significant responses of two selected buildings 66= number of total occupants	64= insignificant responses of two selected buildings 66= number of total occupants	

According to the scientific analysis, 97% of responses are found to be insignificant in respect to performance to daylight by occupants and 3% responses are found to be significant. In addition, daylight factor and the glare has effected to emphasis the analytical result and discuss with the comparison between the occupants perception level and the day lighting level with its diversity.

According to the results of the data analysis, 97% of responses are found to be less sensitive to day lighting by occupants. The evidence suggests that the occupants in investigated office buildings in Sri Lanka consider daylight as an insignificant component in their office environments. Further, it was found that glare; due to extensive difference of lighting level between inside and outside, was an issue to be addressed. The results suggest that glare be a reason of this poor perception to daylight and how it needs to be investigated and applied innovatively and appropriately in future designs.

Conclusion

The research findings assume that in tropical countries like Sri Lanka glare is a major problem and architects must careful when designing daylight integrated buildings, especially in tropical countries. As the result of that simulations it was identified that there is a huge lux level differences between the inside and outside in Sri Lankan context. This lux level difference creates more glare and it causes uncomfortable office environment, which is a critical issue in an office environment. The occupants have been used some design strategies for reduce glare and which is the reason for the enclosed spaces using curtains and partitions. The architects must try to integrate day light with the building design considering all the benefits such as energy saving, aesthetic purposes and more importantly user perception of the building.

Acknowledgement

Dept. of Architecture, Dept. of Mechanical Engineering University of Moratuwa, National Research Council Grant 13-109 and Himalshi Rupasinghe.

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Baker,N. &Steemers, K.(2002).Daylight design of buildings. London: James & James (Science publishers) Ltd.

Hyde,R.(2008).Bio climatic housing innovative design for warm cli-mates.UK: Cromwell press.

Lam,W.(1972). Perception and lighting as formgivers for Architecture. New-york: Van nostrandreinhold.

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A CRITICAL REVIEW ON HIGH RISE BUILDINGS IN THE CONTEXT OF BIO CLIMATIC DESIGN
A case of vertical diversity in Tropical Colombo

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Abstract
Building envelop plays a vital role in creating comfortable indoor environments by cutting off unfavorable outdoor climatic conditions. The outdoor microclimate around a building varies creating diversified vertical climatic conditions. Yet less attention is given to the vertical climatic diversity in designing facades of tall buildings. The study critically discusses the facade design of tall buildings considering its vertical response and co-relationship to outside climatic diversity. Through a typical empirical study on randomly selected HRB in the existing context of Colombo, the Mahaweli Authority building was selected to investigate the co relationship of building design and the vertical character of its external climate. The final conclusion points out, that the designing process of HRB should pay more attention to bio climatic approach and design interventions with a better understanding on the external climatic character and its vertical diversity, rather than following typical two dimensional planning methods. This will result better and practical design outcome which will increase users satisfaction and improvements in energy saving.

Keywords: *High-rise buildings, Bioclimatic approach, Vertical Diversity, Tropical climate*

1. Introduction

According to the environmental records, the building sector contributes up to 30% of global annual greenhouse gas emissions and consumes up to 40% of all energy (IPCC -2014, the fifth Assessment Report of the Intergovernmental panel on Climate Change). With the current situation of the building industry, the main objective of this study focus to identify the position of high rise buildings in urban context and its impacts on environment. According to the building form, tall buildings have more opportunity to reinvent themselves as the typology for a sustainable urban future that focused for better potential with innovative approaches forms and technologies which reduce the environmental impact and support in challenges of the future climate change and energy consumption.

Most of the tall buildings are designed as stand-alone icons placed monotonously, rather than integrated into the urban fabric and respond to their immediate climate in respect to horizontal and vertical behavior of climate. Regardless of the often significant vertical height of these buildings, very few of them connect to the city fabric or each other at any level other than ground. But when considering about the urban fabric and the high rise buildings, there is a clear vertical zoning level according to the heights of the urban context.

Developing countries in tropical region such as Sri Lanka expand their development goals by introducing series of high rise buildings (HRB) that suddenly introduced to the urban fabric without considering climate sensitivity and environment impacts. This trend is growing continuously, creating more unfavorable conditions for humans as well as the environment. In such a context, building projects that claim benefit of such a bio climatic design approach are examined in the light of the results and practices of previously conducted researches and design projects done by Architect Ken Yeang.

The research aims at understanding the verticality in urban fabric and realizing a better environmental sensitive approach with the involvement of architecture. Bio climatic architecture is an innovative theory that integrates the man-made environment and natural environment with better mutual understand (Yeang, 1999). The main discussion of the study is based on the climate behavior and bio climatic approach of high rise buildings in urban context of Sri Lanka to create a better urban future.

The study focus on how the urban micro climate effects on the high rise buildings, horizontally as well as vertically in Tropical climate of Sri Lanka and how it is integrated with the bio climatic design approach and the vertical diversity of the built mass. Further it is aimed to identify the reasons for the lack of interest on the integration of bio climatic design applications on high rise building designs despite all developed knowledge in building technology and with practical knowledge by most of Architects or other consultant.

2. Bio climatic sky scrapers by Ken Yeang

Ken Yeang seeks to revision the skyscraper in terms of responsiveness to its climate and environment. There solar situation during different times of day, month and year is analyzed .this approach which aims at gaining maximum profit from alternative natural energy resources is identified as "Bioclimatic" approach, in which it is aimed to design low-energy, passive buildings with a focus on better occupant comfort and environmental sensitiveness. (Yeang, 1999). Bioclimatology, in architectural terms, is the relation between the form of a structure, and its environmental performance in relation to its external climate.

2.1 Four-partial model By Victor Olgyay

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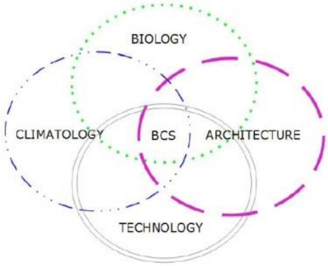
Source: (Olgyay,



1963)

Figure 1: Victor Olgyay's Vitruvius: What is BCS

Before the Ken Yeang's bioclimatic approach, Victor Olgyay created four-partial model introducing fundamental relationship between: climatology – biology– technology – architecture in 1963(Figure 02).

3. Buildings in the context of tropics

In tropics, the physiological thermal requirements and the building characteristics are equal for the entire year, because the seasonal climatic variations are slight. Avoidance of excessive solar radiation and provision for moisture evaporation by breezes are the two main issues occur in constructing in hot-humid zones.

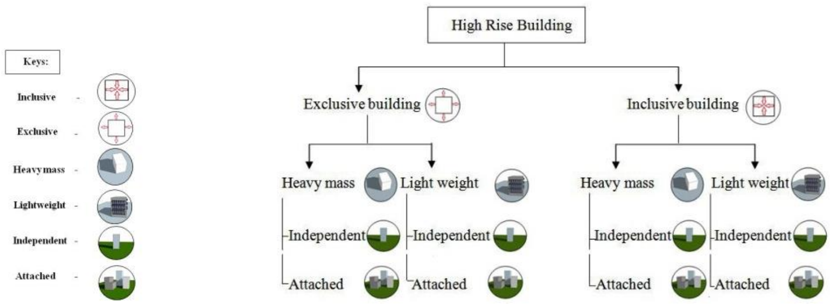
Thus the buildings in tropical context should be design to prevent heat gain, maximize heat loss and to remove any excess heat by mechanical cooling. The first two objectives can be achieved by means of 'microclimatic control' through site-layout and inner space-planning, controlling and planning air-movements, external wall and space orientation and the use of structural and constructional passive means of control.

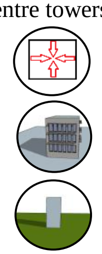
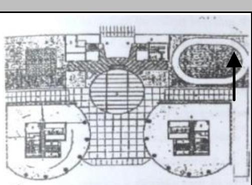
4. Urban Climate modification by building mass - Horizontal Vs Vertical

The placement of a building on the urban fabric influence radiative thermal, moisture and aerodynamic modification of the surrounding environment. The most important radiative effects are the decreasing in the solar radiation receipt by areas in shadow, reflection from sunlit walls, and the reduction of net long-wave cooling from surfaces near the building due both to a reduction in L↑ and to an increase in L↓ from the usually warm building. (Oke.T.R, 1998, p. 264)

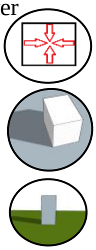
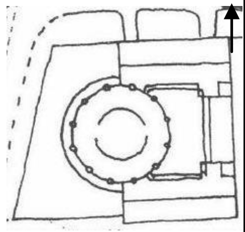
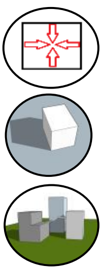
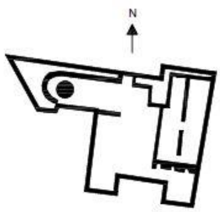
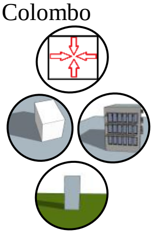
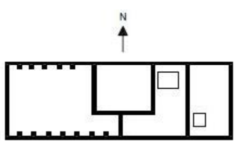
4.1 Empirical understanding of high rise building

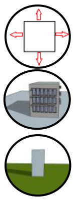
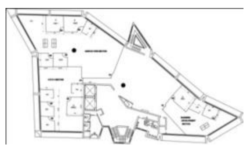
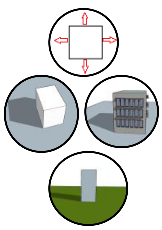
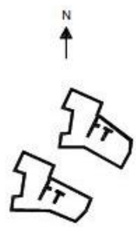
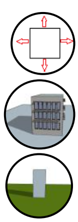
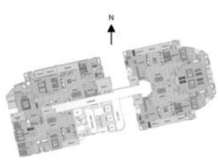
According to the building design and its respond for the outside climate of its context, buildings can be categorized. The randomly selected 12 high rise buildings, according to its primary use were examined through this process using a chart which divides the character of the building using main six keys.

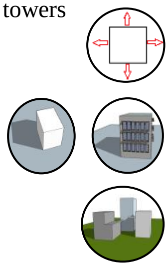
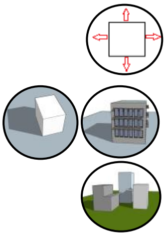
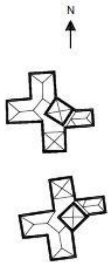
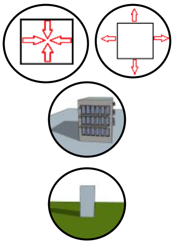
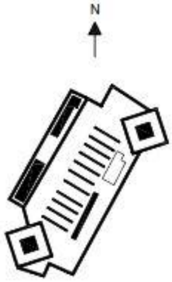


Name/ contextual respond of building	Identification	Orientation and Plan	Special references on context of bio climatic approach
Commercial Towers			
1.World trade Centre towers 		 39 floors	-situated in Colombo, close to set of HRB -Entirely artificially ventilated and lit. -Reflecting glass cladding outter envelop. -Resistance to direct gain in east and west façade design.

A REVIEW ON HIGH RISE BUILDINGS IN THE CONTEXT OF BIO CLIMATIC DESIGN

2.BOC headquarters tower 		 32 floors	-Situated in Colombo, close to set of HRB, -Entirely artificially ventilated and lit. - Aluminium cladding and glass windows in outter envelop. -Resistance to direct gain ineast and west façade design. - Improper building orientation.
3.HNB tower 		 23 floors	-Situated in Colombo, close to set of HRB, -Entirely artificially ventilated and lit. - Aluminum, tinted glass, clear glass cladding and cement rendered walls in outter envelop. -Resistance to direct gain ineast and west façade design. - Improper building orientation.
4.Galadhari hotel, Colombo 		 32 floors	-Situated in Colombo. -Light weight building, natural light and ventilation, mix use of artificial conditions. -Proper building orientation

5.Mahaweli Authority building 		 12 floors	-A bio climatic HRB located in an urban layout. -Naturally lit and ventilated originally. -Special climatically responsive features.
Residential towers			
1.Empire tower 		 37 floors	-Situated in Colombo, -Exposed to natural light and ventilation. - RCC structure mixed with lightweight character. -Resistance to direct gain ineast and west façade design. - Improper building orientation.
2.Iceland residencies 		 31 floors	-Situated in Colombo -Mix mode operation -Exposed balconies -RCC Structure with a character of light weight character. -Proper building orientation

3.Havloc city towers 		 22 floors	-Situated in Colombo, close to set of HRB, -Partly naturally ventilated and lit. -Exposed balconies and transitional spaces -RCC Structure with a character of light weight character. -Partly proper building orientation
4. Royal Park tower 		 25 floors	-Situated in Colombo, close to set of HRB, -Partly naturally ventilated and lit. -Exposed balconies and transitional spaces -RCC Structure with a character of light weight character. -Improper building orientation.
5.monarch residencies 		 30 floors	-Situated in Colombo, close to set of HRB, -Partly naturally ventilated and lit. -Exposed balconies and transitional spaces -RCC Structure with a character of light weight character. -Improper building orientation.

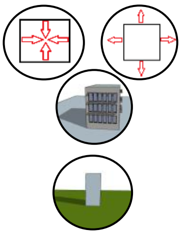
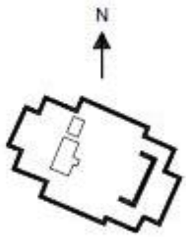
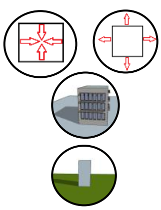
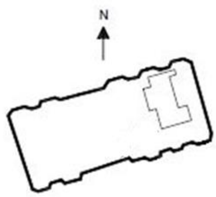
Mixed use towers			
1.Hilton residencies 		 34 floors	-Situated in Colombo,as a mix use develpment -Partly naturally ventilated and lit. -Exposed balconies and transitional spaces -RCC Structure with a light weight character. -Improper building orientation.
2.Crescat residencies 		 25 floors	-Situated in Colombo,as a mix use develpment -Partly naturally ventilated and lit. -Exposed balconies and transitional spaces -RCC Structure with a light weight character. -Improper building orientation.

Table 01: Classification of building design according to its co-relationship for the outside climate (Detail empirical analysis of High rise buildings In Sri LankaSource: Author

Analysis

The analysis highlights the less consideration of microclimate and the effect of climatic conditions to the building interiors and the impact of building construction to its surrounding environment. Further no concern has been given to the vertical diversity of microclimate to address the needs of each level to create more occupant friendly interiors. Rather the building facades are repeated in almost all the buildings. All the cases showcased the negligence of thermal landscape of building interiors and the microclimatic features. Majority of the buildings designs have followed typical floor plans considering only the function.

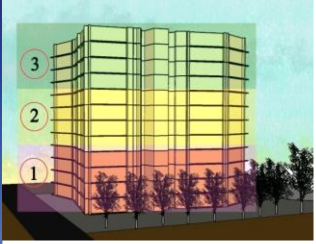
From the investigated 12 cases Mahaweli Authority building displayed better concern about the climate responsiveness in terms of bio climatic high rise design.

5. Selections of case studies

The nonresidential HRB Mahaweli Authority Building is selected as the case study for the field investigation. The building designed by Architect Geoffrey Bawa is globally commented in respect to bio climatic architecture in the context of high rise building.

5.1 Field study program

The onsite investigation comprised of two stages. Initially the selected case was studied to collect empirical data to pursue building design and main climatic approach of it. Next an in-depth investigation was conducted to study the micro climatic behavior and internal thermal environments. Through the field study air temperature, Relative humidity, and Natural lighting levels and wind velocity data of the each floor of the building was monitored in 30 minutes intervals vertically and horizontally which were then compared and analyzed. The building was classified into three levels vertically as ground, middle, upper levels and the data were obtained at three levels at the same time inclusive of all four façade of each level.



Zone – 1: First four
(1, 2, 3, 4) floors
Zone –2: Second four
(5, 6,7, 8) floors
Zone –3: Last four
(9, 10, 11 and 12) floors

Figure 2: Mahaweli Authority Building
Source: (Robson D. , 2002)

5.2 Built form

The building is 12 stories tall and the site was an awkward and irregular shaped and it was blocked between the Beira Lake and Hyde Park. Bawa exploited this however, in order to create a plan form which would respond aerodynamically to the prevailing winds while reducing solar gain, and which would give a maximum footprint, thus reducing the number of floors (Robson D. , 2007).

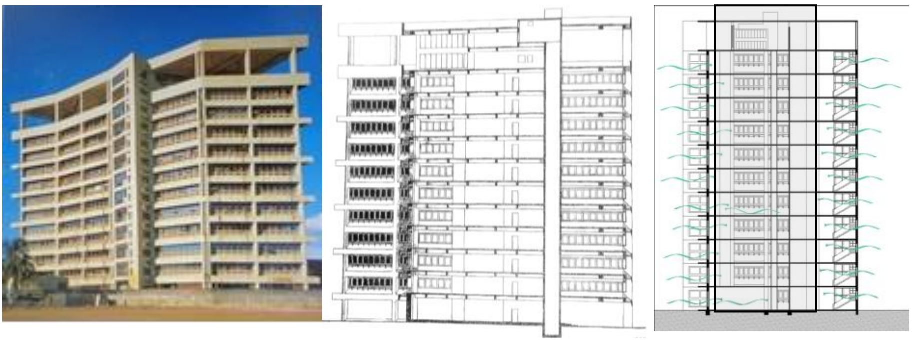
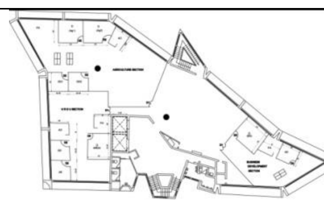
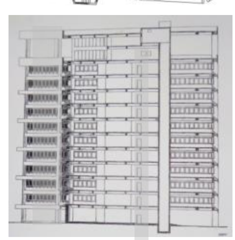
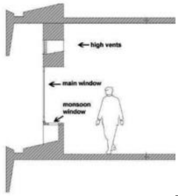
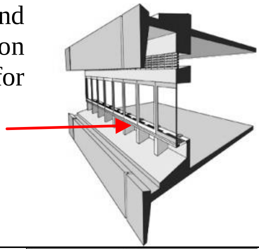
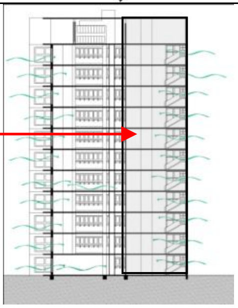


Figure 3: Sectional elevation through the building and Cross section through the north south plain to show the natural cross ventilationSource: (Robson D. , 2002) and Author

5.3 Bio climatic approach of building design – Mahaweli Authority Building

Bio climatic feature		**Mahaweli Authority Building**
1.Service core position	Double	Double core services are built on the north and south sides of the building to get maximum use of natural light and ventilation.  
2.Service core orientation	North/ south	Two service cores at north and south with better orientation allow maximum use of natural light and ventilation.

3. Natural ventilation and Sun light for service core	The core uses natural ventilation and lighting. The main lobby entrance was shaded as well as ventilated without mechanical effort. 
4. Building Orientation	North south orientation to minimize solar gain. The building's overall form, structural methodology, module cores, is oriented for maximum environmental efficiency by shading against direct heat while allowing for natural daylight and ventilation.
5. Window opening placement	Recessed and shaded windows on external façade named as 'Monsoon window' allowing natural ventilation in rainy season. 
6. Character of the West wall	Material Thickness: The West brick wall thickness is 12" in width Openings/ shading: Recessed and shaded windows are on the west side as a response to the tropical sun path. 
7.Recessed windows/Sky courts/ Balconies	-Recessed windows at entire façade -Precast ventilation grilles on the external walls shaded by overhanging floor slab with a down-hung fascia parapet. -Vertical pivot windows and horizontal precast concrete ventilation slots at sill height allows for ventilation at the body level. 
8.Natural ventilation strategies: Atria / Air- spaces and Wind- scoops (venture effect)	-The walls between office space and lift lobby have high level precast ventilation holes which allows cross ventilation. -lift lobby and all stair cores well lit and ventilated - Basic cross ventilation air flow allowing for natural ventilation to interact with the internal cooling system. 

10. Open ground floor	Only the front part which near to the main road was planned as open plain.	
11.Road and building relationship	The building is sited in a busy commercial district, facing to the main road.	
12. Vertical Landscaping	No vertical landscaping was introduced to the building.	
13. Floor layout	Similar design foot print of floors	
14. Relationship to Urban context	The building stands alone in the site. But environmentally building act as a feature which direct the natural wind towards the road side.	
15. External materials and thermal insulation	Roof (Reflective)	-Terrace open on all sides at top floor. -A white cement renderd floor finish to maximize the heat reflectance. 
	wall	Masonry work, polished cement rendered floor finish, timber window frames and concrete ventilation grills.
16.Colour of the building envelop	Light blue for the east façade and elephant gray colour for the west and south facades.	
17.Structure of the building	The two topmost floors of the building were shielded by a floating canopy. The office spaces were designed as open plan with a minimum number of interior columns. The terrace roof and the stilt structure of the ground floor act as buffer spaces.	
18.Transitional spaces	The stairway core act as a wind scoop which provide natural ventilation for the core of the building as well as a transitional space. No balconies and terraces at the building.	

Table 2: Bio climatic features apply in the Mahaweli Building

5.4 Identify the horizontal climatic diversity

The data was collected at twelve points were grouped in to three main groups considering the Zoning levels (Ground, Middle and Upper zone) using Anemometer, Hobo meter and light meter were compared and analyzed to identify the vertical diversity of microclimate. Data gained from four facades were also compared to identify the horizontal diversity of the climate in each floor level which was then compared vertically.

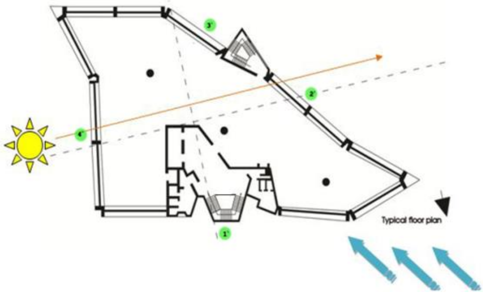
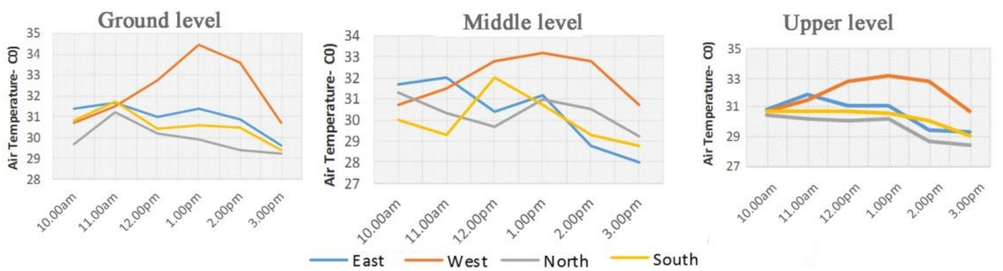


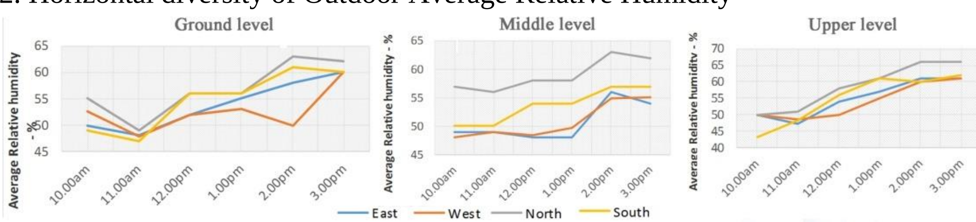
Figure 4: Locations of measurement taken points at each level
Source: By Author

5.5 Analysis of Data

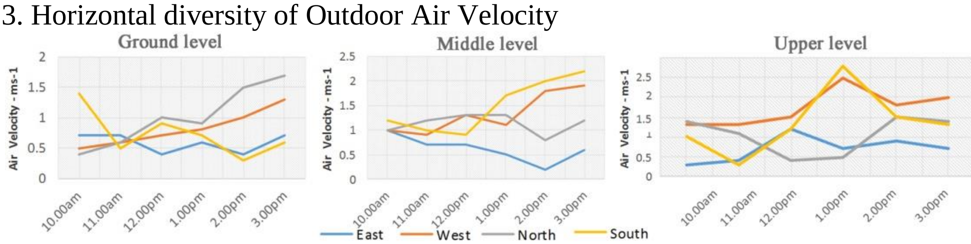
1. Horizontal diversity of Outdoor Air temperature



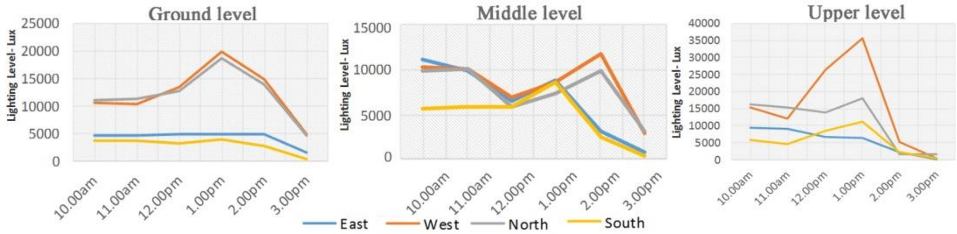
2. Horizontal diversity of Outdoor Average Relative Humidity



3. Horizontal diversity of Outdoor Air Velocity



4. Horizontal diversity of Outdoor lighting level



The collected data which were analyzed points out the horizontal variation in microclimate at each level in four facades. This suggests that the façade design of a building even at a single level has to be different to address the horizontal variation of the microclimatic conditions.

5. 6 Assessment of vertical climatic character

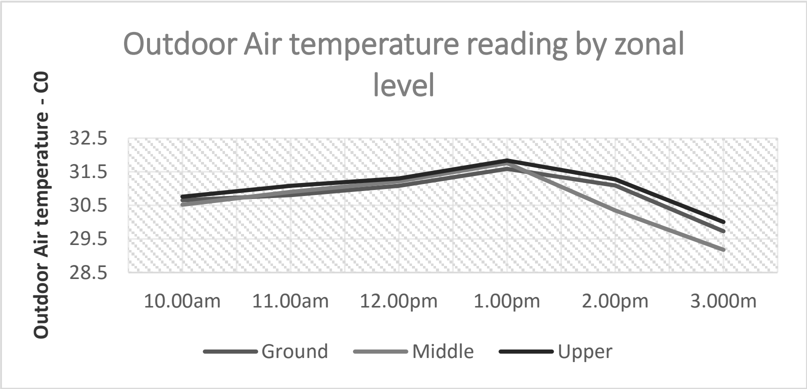


Table 3: Vertical character of outdoor Air temperature
Source: By Author

By analyzing the graph it is clear that the outdoor air temperature was slightly vary with the height of the building but the fraction of impact is negligible because of the minor lags between measurements. When compare each levels,

Ground to middle level air temperature varies by $1C^0$
Middle to Upper level air temperature varies by $0.5C^0$

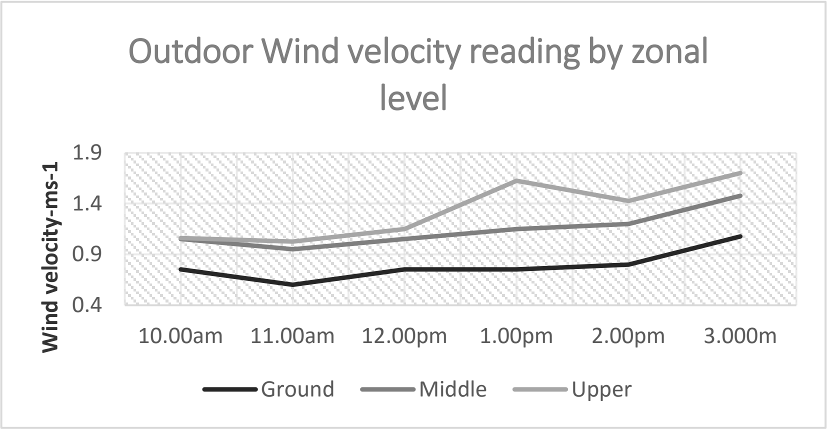


Table 4: Vertical character of Wind velocity Source: By Author

According to the graph, the ground levels experience the less air movement and the amount of wind floor was increasing with the height. Ground to middle level wind velocity varies (increase) by $0.3ms^{-1}$

Middle to Upper level wind velocity varies (increase) by $0.1ms^{-1}$

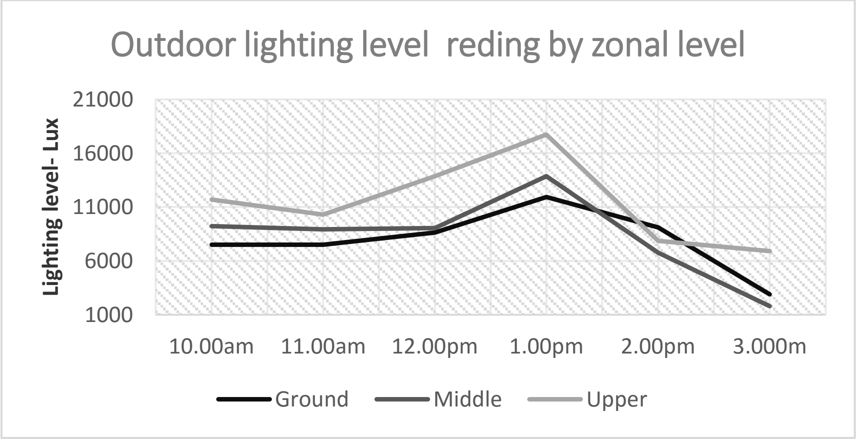


Table 5: Vertical character of lighting level
Source: By Author

According to the graph, the ground levels experience the less amount of light condition with compare to the middle and upper floors. When compare to each levels,

Ground to middle level lighting level varies (increase) by 1500 lux
Middle to Upper level lighting level varies (increase) by 2500lux

(With the height of the building there is a considerable variation in lighting level in each level).

Conclusion

The field investigation data analysis clearly points out that in different vertical levels the outdoor climatic conditions and their effect on each level vary. Thus the design of high rise buildings has to address this vertical diversity in climatic conditions in order to design tall buildings that are thermally comfortable for the occupants in each level. The façade design, openings, shading and etc. of each level should address the vertical climate rather than being monotonous.

Acknowledgement

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