FARU PROCEEDINGS – 2017

"Design that cares"

multi disciplinary approaches to creating sustainable and meaningful built environments

Volume 01

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

Selected papers from the proceedings will be invited to publish in Special Issues of Archnet-IJAR, Architectural Science Review, International Journal of Disaster Resilience in the Built Environment and Construction Economics and Buildings in 2018

About FARU
FARU is the research unit of Faculty of Architecture, University of Moratuwa, Sri Lanka. FARU which consists of four academic departments (architecture, town and country planning, building economics and integrated design) organizes international conferences for the past nine years. It attracts academics, students, and practicing professionals.

FARU 2017 is held in Colombo (Blue Waters Hotel in Wadduwa) for the tenth year and co-sponsored by University Grants Commission, Sri Lanka Insitute of Architects, True Value Products (Pvt) Ltd, J-Lanka Technologies and Sripalee Construction. The FARU Organizing Committee acknowledges the support extend by the University of Moratuwa, University Grants Commission, Srilankan Airline and all sponsors.

Director FARU: Dr. Upendra Rajapaksha
Technical & Administrative Coordinator FARU: AMS Attanayake

ISBN: 978-955- 9027- 66-9

Published by Faculty of Architecture
University of Moratuwa, Moratuwa, Sri Lanka
December 2017

Editor
Dr.Upendra Rajapaksha

Formatting & Cover Design
AMS Attanayake

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

List of Paper Reviewers for FARU 2017

1. **Professor Richard Hyde**
   Editor in Chief- Architectural Science Review Honorary Professor, Faculty of Architecture, Design and Planning, The University of Sydney, Australia

2. **Professor Juergen Reichardt**
   Munster University of Applied Sciences, Germany

3. **Prof. Horoshi Yoshino**
   Emeritus Professor, Tohoku University, Japan and Secretary Science Council Asia

4. **Professor Susan Roaf**
   Emeritus Professor Hariot Watt University, United Kingdom

5. **Professor Richard Haigh**
   Global Disaster resilience Centre, University of Huddersfield, United Kingdom

6. **Professor Robert Brown**
   Professor of Architecture, Plymouth University, United Kingdom

7. **Professor Dilanthi Amaratunga**
   Professor, University of Huddersfield, United Kingdom

8. **Professor Marc Aural Schnable**
   Professor, School of Architecture, Victoria University of Wellington, New Zealand

9. **Dr. Sepani Senaratne**
   Western Sydney University, Australia

10. **Professor Rohinton Emmanuel**
    Professorin Sustainable Design, Glasgow Caledonian University, UK

11. **Dr. Kaushalya Keraminiyage**
    University of Huddersfiled, United Kingdom

12. **Dr. Indrika Rajapaksha**
    Senior Lecturer, Department of Architecture, University of Moratuwa, Sri Lanka

13. **Dr. Angelique Chettiparambil**
    University of Reading, United Kingdom

14. **Professor Barbara Rahder**
    York University, Canada

15. **Dr. Julie Rudner**
    La Trobe University, Australia

16. **Dr. Yasangika Sandanayake**
Senior Lecturer, Dept. of Building Economics, University of Moratuwa, Sri Lanka

17. **Associate Professor Tilanka Chandrasekara**
Oklahoma State University, USA

18. **Dr. Shaleeni Cooray**
Senior Lecturer, Department of Architecture, University of Moratuwa, Sri Lanka

19. **Dr. Thanuja Ramachandra**
Dept. of Building Economics, University of Moratuwa, Sri Lanka

20. **Dr. Anishka Hettiarachchi**
Senior Lecturer, Department of Architecture, University of Moratuwa, Sri Lanka

22. **Dr. Arosh Gamage**
University of New South Walse, Australia

23. **Dr. Rangajeewa Rathnayaka**
Senior Lecturer, Department of Town and Country Planning, University of Moratuwa, Sri Lanka

24. **Dr. Wajishani Gamage**
Senior Lecturer, Department of Architecture, University of Moratuwa, Sri Lanka

25. **Ruwandika Senanayake**
Department of Intergrated design, University of Moratuwa, SriLanka

Organizing Committee: FARU 2017

Dean, Faculty of architecture
Prof. Lalith de Silva

Director Faculty of Architecture Research Unit FARU
Dr. Upendra Rajapaksha
(*Head, Department of Architecture*)

Members
Dr. Indrika Rajapaksha, Archt. Prasanna Liyanage, Archt. Kavindra Herath, Dr. H. Chandanie

Secretariat
Mr. A M S Attanayake
Mr. R A J Kithsiri

Contents

Editor's Note

Architecture (and built environment) provides refuge from the external environments but has a multitude of needs and functions to perform and care. The domain of architecture is thus diverse and includes responses to various needs underlining the essential role research has for the furtherance of and sharing knowledge for the practice and discipline. The impact of architecture as a social product, environmental, contextual and technological entity and economic discipline on quality of life leads to policy relevance, practice and further research. While to a certain extent, these concerns are independent domains of knowledge, they interact together in the design process and performance during occupancy and usage. Architecture thus involves team work and multi-disciplinary (and inter disciplinary) approach for innovation – hence the need to understand the art and science of creating meaningful built environments.

Theme of FARU 2017 recognizes design as a discipline that cares and serves a multitude of concerns and functions through its life cycle within a broader context of built environment involving architecture, town and country planning, building economics and product design. FARU 2017 invites research papers from academics, researchers, students and practitioners from all these disciplines and allied fields.

FARU 2017 highlights the significance of architecture (built environment) in caring environmental, physical, energy, socio-cultural, and economic concerns and needs, and thus the quality of life of people. Annual 10th International Conference of FARU in 2017 invites contributions on research and intellectual developments as well as on innovative case studies in the following areas:

Environment and energy
People, socio-cultural and physical context
Technology and materials
Cost, management and life cycle
Urban environments, planning, urban health and climate
Integrated design
Landscape architecture

Dr. Upendra Rajapaksha
Director, Faculty of Architecture Research Unit
Faculty of Architecture, University of Moratuwa, Sri Lanka

Rajapaksha.U, et al (eds), 2017, "Design that cares"- multi disciplinary approaches to creating sustainable and meaningful built environment: *Proceedings of the 10th International Conference of Faculty of Architecture Research Unit (FARU), University of Moratuwa, Sri Lanka,(Vol. 01)* pp. 11 - 16 ©

KEYNOTE ADDRESS 1

THERMAL LANDSCAPING OF MUD BRICK BUILDINGS: CREATING COMFORT IN ALL SEASONS

ROAF SUE
Emeritus Professor of Architectural Engineering, Heriot Watt University, Edinburgh
s.roaf@hw.ac.uk

Abstract:
Because so many architects and engineers today use complex building models they often find it difficult to understand how to actually design a comfortable low energy building. Building simulation models and energy rating tools systematically ignore much of the basic common sense methods needed to design 'comfortable' buildings. In response to such flaws the comfort community is now re-thinking the whole issue of how to provide comfort in buildings, not least because of the growing levels of fuel poverty, even in developed nations, as energy prices rise and the value of incomes fall. A novel three step process for the design of buildings is proposed that may lead to more comfortable, lower energy and thermally safer building, with a place also for sensual design 'highlights'.

Emerging approaches to Thermal Comfort

The 20th Century concepts of comfort were predicated on a dated model that involved the using of cheap fossil fuel energy to run climate conditioning systems but over the last decade new 21st century comfort approaches have begun to be explored including[1&2]

[1] Roaf, S., F. Nicol and H. Rijal (2015). Designing for Comfort at High Temperatures: Introduction, *Architectural Science Review (Eds. S.Roaf, F.Nicol, H.Rijal)*, 58.1, pp.1-4.

1) **From Active to Passive:** Only heat / cool buildings when absolutely necessary - naturally ventilate them for as much of the year as possible. The myth of 'efficiency' is pervasive implying that better machines are the solution, but why use machines at all if you don't need to?

2) **Heat / Cool People not the Building:** A strong move is back to using what the Californians call Personal Environmental Technologies (PETs) - like small heaters, fans or air-conditioners to provide local comfort for individuals within lower (or higher in warmer climates) background temperatures.

3) **From Still to Breezy air movement:** Most of the early work in comfort was done in climate chambers in northern Europe and the whole 20th century comfort approach defines air movement as 'draughts' – a very bad thing. In fact, breezes can be vital for comfort at higher temperatures[3].

4) **From Neutrality to Delight:** Stop thinking that the only way to provide comfort is to put people in a uniformly warm / cool thermal soup in a room. Re-learn how to make people *sense* 'thermal delight'. A radiantly cosy fire in winter or a convectively cooling breeze can trigger sensual pleasure.

5) **Design Climate Refuges into buildings:** As temperatures soar and plunge in the more extreme weather being experienced globally every building should have an identified warm or cool refuge.

6) **Time and Place are key to Harvesting comfort from the micro-climates in and around buildings:** Every place, site, aspect, room will have its own micro-climate that, once understood, can be used to provide more or less comfortable locations for different activities over a year.

7) **Adaptive Behaviours are a key:** Including lots of opportunities for people to adjust themselves, their locations and their buildings to achieve comfort - including shutters, curtains, shades, screens and the ability for people to move around within or between spaces in search of warmth or coolth.

But the above ideas around comfort that are circulating need to be placed within a straight forward process that enables designers to create really comfortable buildings.

---

[2] Roaf, S., L. Brotas and F. Nicol (2015). Counting the Costs of Comfort: an Introduction, *Building Research and Information (Eds. S. Roaf and F.Nicol)*, 43:3, pp. 269-273.

[3] Roaf, S., F. Nicol, and R. de Dear (2013). "The Wicked Problem of Designing for Comfort in a Rapidly Changing World." *Architectural Science Review*, 56 (1): 1–3. http://dx.doi.org/10.1080/00038628.2012.753783

The proposed three step design process is based on ideas derived from the science of creating perfumes[4] which of each is a 'chords' composed of three notes, as in music. The base note of the chord provides the long lasting, durable character of the scent. The full 'heart' note is the big signature flower scent, but fades over a shorter time and the 'top' note is the short, sharp scent that wakes you up to enjoy the full experience of the perfume. These provide the character, the personality and the style of the experience of a scent and inspired the following three step plan for the design of comfortable buildings.

Three Step Process for Designing Resilient and Comfortable Buildings

Step 1: Getting the Basic Building Form Right: *Everything you cannot change in a building*

Step 1 covers the design of the basic building Form that will endure over time and involves all those things you cannot change about the building: its plan forms and sections, orientation, envelope openings, height in sky, depth in the ground, floor to ceiling heights, structural shading and roof overhangs, materials, thermal mass, the emissivity and Absorbance of surfaces etc. These determine the basic thermal 'pulse' of a building that is reflected in the amplitude of the daily and annual temperatures within a building, depending on how coupled to, or de-coupled from, the outside weather the internal climate is. This step creates the deep thermal 'character' of a building and how **Well** or at worst **Psychotically Behaved** it is. In many modern over-glazed buildings extremely bad characters are masked by spending huge amounts on mechanical heating or cooling systems top keep the buildings habitable. A stable Base Note is key to creating a comfortable building.[5]

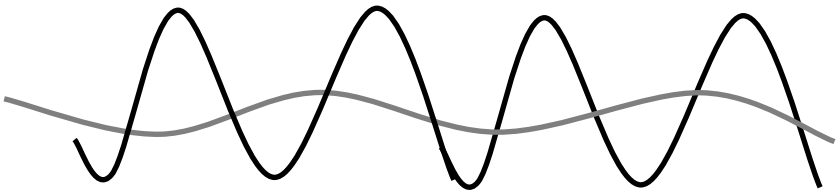


Figure 1. Level 1 design determines how 'Well-Behaved' a building is in terms of its internal thermal pulse. Reflected in the diurnal or seasonal amplitude of its indoor temperatures.

[4] https://en.wikipedia.org/wiki/History_of_perfume

[5] Humphreys. M., F. Nicol and S. Roaf (2015). *Adaptive Thermal Comfort: Foundations and Analysis*, London: Earthscan/Routledge. March 2012 ISBN ISBN: 978-0415691611.

Figure 2. These three examples show UK buildings that if they are Well Behaved with stable indoor climates, over-glazing leads to overheating and glass boxes are very bad Level 1 buildings.

Step 2: Providing Adaptive Opportunities: ***things about a building that you can change***

These may include wall U-values and levels of insulation, occupancy and Internal Loads, glazing types and window opening methods and extent, air infiltration, furnishings, clothing, local or central heating or cooling systems, shades and shutters, curtains, blinds, conservatories, porches, verandas and landscaping. The adaptive opportunities can range from the HVAC engineer's end which is purely mechanical to the passive architectural end of the spectrum, theoretically the domain of the architects, but one they are often poorly trained to exploit. Comfort often results from people taking advantage of these Adaptive Opportunities to improve their comfort.

This level really gives the building its personality that can change dramatically over time as they are re-furbished or re-built or their systems are regularly replaced. The problem today is that many building designers only know how to use energy consuming heating and cooling systems to improve comfort and have forgotten all the old ways of passively achieving comfort with behaviours. Thus you might have the same type of Level 1 So / So building but it can either be a good or a bad building depending on whether the full palette of adaptive opportunities can be used to advantage of or not as shown in Figure 3.

The trend to mechanisation of buildings was driven by Building Standards and Regulations requiring only a very narrow acceptable temperature band (eg. Say 20^0-24^0C for thermostats) that make air-conditioning a necessity.[6] However good designers now use Adaptive Thermal Comfort Standards allowing a far

[6] F. Nicol (2017). Temperature and adaptive comfort in heated, cooled and free-running dwellings, , Volume 45, 2017 - Issue 7. Pp730 to 744. Published online: 20 Feb 2017, http://dx.doi.org/10.1080/09613218.2017.1283922

range of broader temperature deemed acceptable and comfortable for locally adapted local populations to local climates[7].

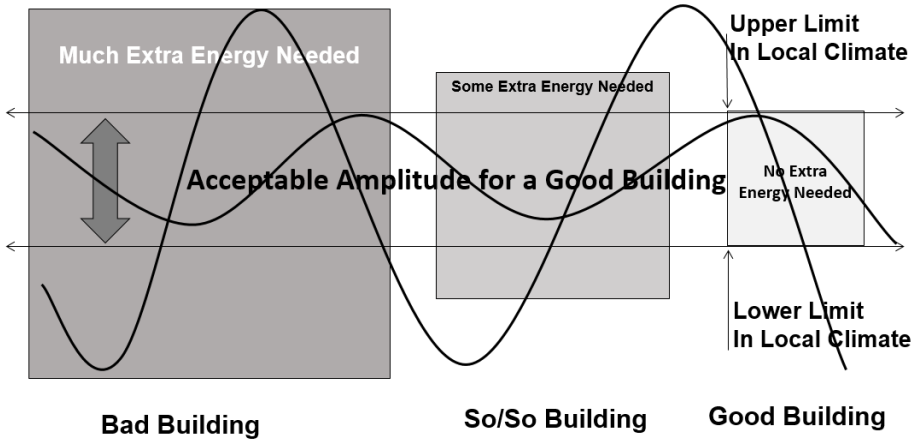


Figure 3. A building an acceptable indoor temperature amplitude can need minimal extra heating and cooling unlike a bad one that needs much energy to remain habitable.

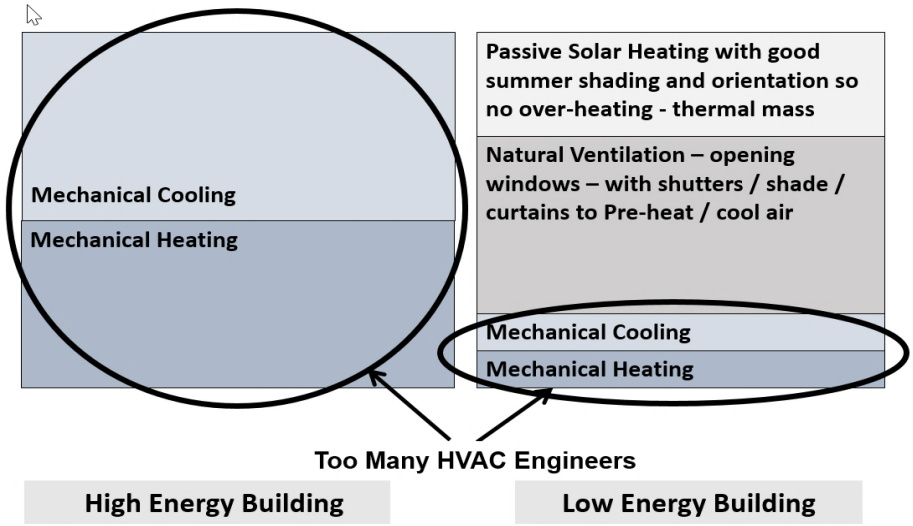


Figure 4. Too many HVAC Engineers and Architects do not use many passive opportunities to achieve comfort but rely on energy expensive mechanical systems to make buildings habitable.

[7] Nicol, F., M. Humphreys and S. Roaf (2012). Adaptive Thermal Comfort: Principals and Practice, Taylor and Francis.

Step 3: Designing the realm of Sensual Perceptions: ***This step is all about the Mind***

How we perceive, sense or feel the building is crucial. When walking into a room you instantly record (subliminally, or if extreme, consciously) a first impression of just how comfortable, safe, well or happy you might feel inside it. These feelings may be to do with: a view, art, sounds, scents, style, colour, light, temperature, composition of shapes, decoration, furnishings, people or event events associated with the building and so on. I have put together a simple scale from 'Wow to Well-being' just to indicate the huge ranges of influences on how we 'feel' in the space.

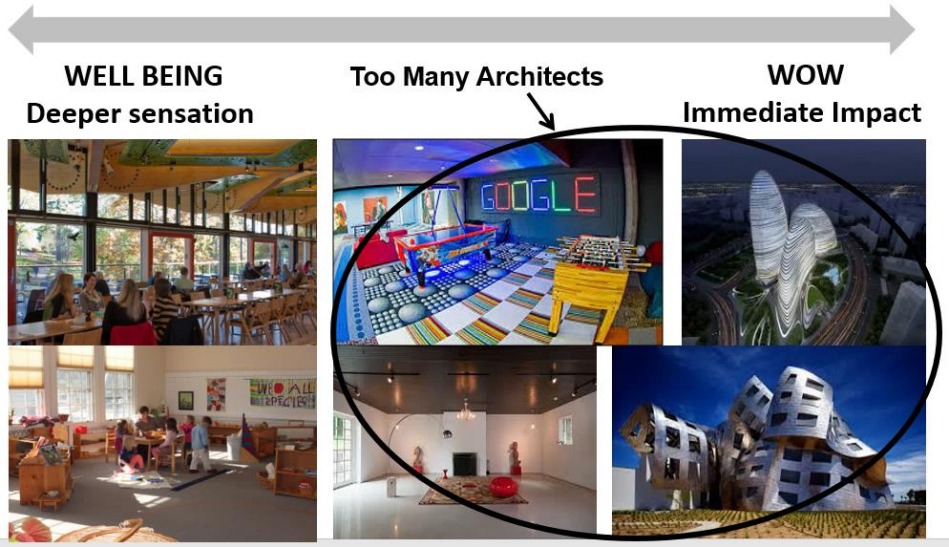


Figure 4. The impressions a building or room might give you can range from instant shock and awe to much deeper and more durable feelings of well-being and happiness.

Conclusions

Referring back to the emerging trends in comfort above[8] note that the first six are all to do with designing a *Well-Behaved* and *Climate Safe* Step 1 building. Only the 7th point deals with the Step 2 adaptive opportunities and behaviours. Perhaps it is time to re-think our building design approaches.

[8]To explore these more see: www.windsorconference.com for the conference proceedings for 2014 and 2016: http://nceub.org.uk//W2014/webpage/pdfs/proceedings/Proceedings_Windsor_Conference_2014.pdf

Rajapaksha.U, et al (eds), 2017, "Design that cares"- multi disciplinary approaches to creating sustainable and meaningful built environment: *Proceedings of the 10th International Conference of Faculty of Architecture Research Unit (FARU), University of Moratuwa, Sri Lanka,(Vol. 01)* pp. 17 - 25 ©

KEYNOTE ADDRESS 2

THE SOCIAL IMAGINARY OF DATA IN SCIENCE + ART + DESIGN + FASHION

Dr. KATHERINE MOLINE
University of New South Wales, Australia
k.moline@unsw.edu.au

Abstract

Paradigm shifts wrought by big data now connect previously discrete fields of knowledge and reveal the interconnections between climate change, social inequality and speculative economics. At the same time the depersonalisation of information disengages public interest and paralyses individuals' agency which are both required to resolve the complex issues revealed in data. Integrated design seeks to overcome this complex knot; it counters design's tendency towards specialisation and the ongoing fracturing of design sub-disciplines, which merely reinforces hierarchical structures and continues to reproduce the problems of intercoonection. Through the concept of the social imaginary, this paper discusses integrated design approaches that address the failure to imagine complex, global and rapidly shifting futures by engaging with the emerging possibilities of fashion. It explores the new social imaginaries occurring in recombinations of art and science engaged with the global challenge of understanding the embodiment of big data. Philosopher Cornelius Castoriadis and anthropologist Arjun Appadurai define the social imaginary as a practice that is beyond mere fantasy, and the primary form of agency in rapid globalisation. They propose that the social imaginary foregrounds a greater possibility for recasting a future that is responsive to rapidly changing conditions. Drawing on examples of practices that engage with the social imaginary, this paper argues that *Levi's Commuter Trucker Jacket with Jacquard by Google* (2017), which facilitates interactivity through conductive threads woven into the cuff, embraces one idea of fashion technology that allows wearers to remain connected, even when on the move.

In contrast, the *Robotic Spider Dress* (2015) by Annouk Wipprecht communicates the wearer's dynamic emotional state through biotech sensors that trigger extending and retracting armature. Such proactive protection distinguishes the Spider Dress as both garment and device, and remodels fashion as a combination of design and engineering. I argue that the integration of science and art in these garments makes new imaginaries possible and offers particular trajectories that may thwart the further splintering of cultural, economic and geopolitical flows by design specialisation. I contend that the Commuter Jacket and mechatronic Spider Dress not only communicate the wearer's external connectedness or internal emotional states, they also reveal the complexity of integrated design and the agency and imagination required as we begin to embody the data around us in the context of rapid change and convergence.

The Social Imaginary of Science and Art and Design

The reconnection of cultural, economic and geopolitical, as well as technological flows, weaves data conductivity into haute-tech and ready-to-wear apparel. Through the concept of the social imaginary, this paper outlines how integrated design approaches in fashion expand futural alternatives relevant to populations impacted by climate change, social inequality and speculative economics. To describe how two items of apparel design or fashion-tech exemplify design integration (with science) and challenge reductive stereotypes of design, I will first define what is meant by the social imaginary. I will then analyse *Levi's Commuter Trucker Jacket with Jacquard by Google* (2017) and *Intel Robotic Spider Dress* (2015) by Annouk Wipprecht through the conceptual framework of the social imaginary. My argument is that data plus science plus art and design in fashion makes new futures possible, weaving traditionally discrete flows together and potentially redirecting society towards a more habitable future.

Theories of the social imaginary proposed by philosopher Cornelius Castoriadis, anthropologist Arjun Appadurai and cultural theorist Nikos Papastergiadis provide a number of nuanced definitions. Briefly, for Castoriadis, it is the social imaginary (communicated in images, practices and institutions) rather than ideology or technology that constitutes a society. For Appadurai, the social imaginary is key to human agency in globalisation where the imagination is understood as a 'social practice' that is 'no longer mere fantasy', but in fact 'a form of work' that arbitrates individual agency and the possibilities defined by the global context.[9] Thus, Appadurai extends Castoriadis's proposal that the social imaginary establishes institutions that provide meaning to human experience, and surmises that the social

[9] Arjun Appadurai, 1996, *Modernity at Large: Cultural Dimensions of Globalization*, University of Minnesota Press, p.31.

imaginary, where imagination is seen as the cultural practice that shapes societies and the spaces between societies, is fundamental to understanding everyday experiences. Papastergiadis attends to how theories of the social imaginary acknowledge that institutional restrictions circumscribe autonomy, as well as create opportunities to engage with strangers and develop connections between cultures.[10] These factors are key for developing global responses to rapid change arising from the convergence of data.

In terms of design that cares and fashion design transformation, especially pertinent is the relevance of Castoriadis's reconfiguration of the individual and the social. As sociologist Anthony Elliot notes, Castoriadis 'rethinks the relation between self and society'.[11] In other words the social imaginary of data reveals its character as both problem and solution, and through its embodiment in fashion ameliorates the depersonalisation with which data is often associated. In simple terms embodied data interaction transforms into design that cares. The definition of the social imaginary is elaborated by Appadurai.

He describes it as 'a social practice' related to how the 'image, the imagined, the imaginary' operate in globalised culture.[12] Furthermore, he suggests:

> [T]he imagination has become an organized field of social practices, a form of work (in the sense of both labor and culturally organized practice), and a form of negotiation between sites of agency (individuals) and globally defined fields of possibility. […] The imagination is now central to all forms of agency, is itself a social fact, and is the key component of the new global order.[13]

Appadurai also concurs with Castoriadis's contention that the social imaginary establishes institutions that provide meaning to human experience.

Of the many accounts of the social imaginary, Papastergiadis's is closest to my reading and supports my aim to understand the role and application of design in fashion technology and tech apparel. He focuses on aesthetic or cosmopolitan imaginaries because of inadequacies in the 'terms of reference' in critical theory for understanding what he poetically describes as 'the work that occurred in the work of art'.[14] At the same time, Papastergiadis draws attention

[10] Nikos Papastergiadis, 2012, *Cosmopolitanism and Culture*, Polity Press, p.103.
[11] Anthony Elliott, 'The Social Imaginary: A Critical Assessment of Castoriadis's Psychoanalytic Social Theory', *American Imago*, 59:2. 2002, p.143.
[12] Appadurai, Modernity at Large, p.31.
[13] Ibid.
[14] 'Interview with Professor Nikos Papastergiadis on Cosmopolitanism and Culture', June 19, 2014, *Global Studies Association*,
https://globalstudiesassoc.wordpress.com/2014/06/19/interview-with-professor-nikos-papastergiadis-on-cosmopolitanism-and-culture/

to Castoriadis's acknowledgement that questions are blocked by closed institutional structures, described by Castoriadis as 'the cognitive closure of the institution', and engagements with strangers that facilitate the mutual exchange of understanding culturally specific commonplaces that may have universal application.[15] In the context of rapid global change this will no doubt be of utmost significance in cross-cultural collaboration. I shall now discuss a recently launched garment that my analysis demonstrates opens up aspects of the social imaginary of data.

The Social Imaginary of Data in Levi's Commuter Trucker Jacket

Levi's describe the 'Commuter™ collection' in the rhetoric of advertising as 'stylish' and 'performance-driven' and the *Commuter Trucker Jacket with Jacquard by Google* (2017) as designed for maximum movement for the 'urban cyclist'.[16] Woven in Cotton (88%), Elastane four-way stretch denim (2%) and CORDURA® Nylon (10%), Levi's draws attention to the textile as hard-wearing, with terms such as 'exceptional durability' and 'abrasion resistant'.[17] Of course, the term 'Jacquard' in the title, indicating the conductive yarn, is usually associated with the history of textiles and the invention of the Jacquard machine in 1804 that mechanized and automated the weaving of complex patterns, such as damask. Associating jacquard with wearable technology adds a traditional dimension and echoes the nostalgic sentiment evident in the jacket's form. A sense of mobility and flexibility is provided by Elastane used in the adjustable waistband and cuffs, a zip-out hood with brim that folds into the collar, and snap closures. The 'Trucker' of the title refers to the reflective 3M™ Scotchlite™ tape on the back of the jacket reminiscent of high-visibility clothing worn by road workers and classic detailing associated with the casual reliability of loose-fitting slim cut outerwear. Levi's launched the Trucker Jacket as an aniversary celebration of fifty years since the release of the original trucker jacket in 1967, a quintessential sartorial reference to Americana.[18] The re-imagined yet nostalgic jacket wirelessly connects to the wearer's smartphone and headphones and operates with technologies originally developed for the Google Smartwatch released in 2014. These technologies include vibration to flag incoming data, and a tap and stroke gesture interface to direct and control instructions and access navigational maps, listen to music and communicate with friends.

---

[15] Nikos Papastergiadis, 'Art from Asia: Aesthetic Cosmopolitanism and the World in Art', in eds. Pultz Mosland, Sten Petersen, *The Culture of Migration: Politics, Aesthetics and Histories*, I.B.Taurus, 2015, p.143; Castoriadis, The Greek Polis and the Creation of Democrary, The Castoridis Reader, p.270.

[16] Levi's advertisement, 2017, http://www.levi.com/US/en_US/mens-clothing-jackets/p/249130000

[17] Levi's advertisement, 2017, http://www.levi.com/US/en_US/mens-clothing-jackets/p/249130000

[18] Ben Evans, 'Celebrating 50 Years Of The Levi's Trucker Jacket', *Vogue Daily*, October 25, 2017, http://www.vogue.co.uk/gallery/levis-trucker-jacket

The garment was designed by mostly anonymous designers at Levi's, led by Vice President of Innovation Paul Dillinger, and technologists in Google's high security lab ATAP, led by Ivan Poupyrev. Although an earlier technology-free iteration of the garment was released two years earlier in Winter 2015, the latest version launched online and in Levi's stores on 2nd October 2017 looks like a retro denim jacket aside from a large button on the cuff. The button houses a wireless radio, a processor and a battery. Advertising images of the jacket picture an agile worker on a bike riding to work, and showcases the longer fit of the jacket that protects the lower back while leaning forward. In many ways, the jacket and its associated marketing campaign epitomises current visions of urban living; residing close to work and engaging in sustainable commuting practices that reduce the consumption of fossil fuel. Further commitment to environmental sustainability is demonstrated by the care with which the manufacture of the garment was contrived in order to fit the looms and machinery already in use in textiles production, thus rendering minimal obsolescence for the loom. The one shortcoming of the design is the disclaimer that the jacket can only bear 10 washes before the technology ceases to function. It is anticipated that the technology will become robust through further development should consumers respond positively to the recently launched beta-version.

David Pierce at Wired describes the garment as a gadget and explains that the button requires fortnightly USB recharging when the jacket is used only for riding, and twice a week if worn throughout the day.[19] Unsurprisingly, this is not the first time that the scientist Poupyrev has engaged with the social imaginary of data. Prior to his work at Google, he was the principal research scientist at Disney's Imagineering division responsible for Aireal, an air-blowing device that creates sensations of tactility when synchronised with video, creating an added dimension to immersive technologies such as virtual reality interaction in gaming.[20] The project's fashion design leader Dillinger, although sceptical of tech apparel (or wearables), has said 'We realized that even though we live in the physical world, we're becoming ever more reliant on the digital world'.[21]

As Appadurai notes in relation to the social imaginary, fashion has sometimes been criticised as ephemeral trivia, but when seen through the lens of the social

[19] David Pierce, 'I Wore the Jean Jacket of the Future', *Wired*, September 25, 2017, https://www.wired.com/story/i-wore-the-jean-jacket-of-the-future/

[20] Rajinder Sodhi, Ivan Poupyrev, Matt Glisson, Ali Israr, AIREAL: Interactive Tactile Experiences in Free Air, ACM SIGGRAPH 2013, https://www.disneyresearch.com/publication/aireal-interactive-tactile-experiences-in-free-air/

[21] David Pierce, 'Google Is Hacking Our Clothes to Work Like Touchscreens', *Wired*, May 25, 2015, https://www.wired.com/2015/05/google-wants-turn-everything-wearable/

imaginary it can be understood as the paradigm for the embodied affect of big data. In fact, Appadurai asserts that ephemerality motivates many characteristics of contemporary design and consumer practices, such as product obsolescence, the increasing pace of the fashion cycle, and the transitory nature of product images and lifestyles as seen in advertising and mass media. Novelty, according to Appadurai, is merely a 'symptom' of a new logic of consumerism where 'desire is organized around the aesthetic of ephemerality'.[22] *Levi's Commuter Trucker Jacket* embodies one application of the social imaginary of data and the aesthetic of ephemerality and features the connectivity to others that data technology now affords.

The Social Imaginary of Data in the Intel Robotic Spider Dress

A second example of fashion technology—perhaps one that is more experimental—reverses the connectivity of *Levi's Commuter Trucker Jacket* by communicating the wearer's internal affective state. Titled *Robotic Spider Dress* (2015), this garment functions as 3D printed armour that protects the wearer by sensing intimate physical responses to the environment.

The designer of the *Spider Dress*, Dutch-based Anouk Wipprecht, describes her design as concerned with proxemics—the study of personal space and distance from others. In simple terms the dress was developed in partnership with technology giant Intel Edison to communicates the wearer's mood. Wipprecht's techno-wearables typically wrap the body with a carapace that renders artificial intelligence on the human body as couture. Her playful work with fashion-tech has featured in collaborations with bands such as the Black Eyed Peas and cultural festivals such as Eurovision.[23]

In contrast to the *Commuter Jacket*, the *Robotic Spider Dress* communicates without the wearer having to 'move a finger'.[24] It is a shell constructed with selective laser sintering that houses a micro-controller and respiration sensor with which the wearer can retract the arms of the device by breathing deeply and extend them with shallow breath. The proximity sensors effectively measure personal space and the wearer's distance from others. The extension and retraction of the arms corresponds with the principles and science of proxemics that defines personal space as less than 46 centimetres, social space as between 46 centimetres and 122 centimetres, and public space as greater than 122 centimetres or arms length.[25] Defending the wearer's personal space

[22] Appadurai, *Modernity at Large*, 84.

[23] Anouk Wipprecht, http://www.anoukwipprecht.nl.

[24] Todd Harple, 'Pathfinding and Innovation Lead', Intel, https://www.youtube.com/watch?v=D40n_oZW5Ig

[25] Anouk Wipprecht, CNET, Published on Jan 6, 2015, https://www.youtube.com/watch?v=V_3LuShd6dg

in response to external stimuli, the garment measures not only distance but also speed of approach. When approached rapidly, the wearer's breath signals the defence posture of the robotic arms that rise high and semi-extended around the wearer's head, but when approached in a leisurely fashion the arms will gently greet you horizontally and at full extension, as if anticipating a hand shake.[26]

To provide some context for the *Robotic Spider Dress*, Wipprecht's previous sensing garment *The Synapse Dress* (2014) was designed to detect where the wearer focused and to record their surroundings. Comprising an electroencephalogram (EEG) head-set, sensors and a camera, the wearer was able to record a visual diary of what they liked by directing a camera positioned on the front plate of the corset. The *Synapse Dress*, like the Spider Dress, includes proximity sensors that distinguish between intimate, social and public space. If someone is too close, the dress sets off warning signals that evoke flashing lights on a police car via eight eye-shaped bulbs radiating from a central mandala. Should the wearer like to invite someone closer, the lights radiate a soft, slow glow. Another garment developed in collaboration with Intel is the *Butterfly Effect Dress* (2015) by Turkish designers Invrell and Turver. Like the *Robotic Spider Dress*, this dress is also triggered by proximity sensors. The butterfly wings flutter more rapidly when someone is at close proximity, and the wearer can press a button and release the paper and fabric butterflies to create a spectacular butterfly dance.[27] Becca McCharen's *Adrenaline Dress* (2016) is another intelligent garment that responds to breath. Her background in architecture, evident in the concertina screen on the back of the dress, informed the creation of 365 moving parts constructed of carbon fibre that expand when the garment detects a fight or flight response on the part of the wearer.[28] While the *Butterfly Dress* is gentle in its protective defense and the *Adrenaline Dress* communicates a visual warning, the *Robotic Spider Dress* expels people from the wearer's personal space and could conceivably damage an interloper's eye. Among other significant examples of independent fashion-tech research, *FOOTwerk: Improvisations in Gender, Sound and Space* (2015) by Alexandra Murray-Leslie of the design/art collaboration Chicks on Speed, is worth mentioning.[29] This device, developed at Singapore National University, generates sound according to the bodily movements of the wearer.

---

[26] Hep Svadja, 'Anouk's New Creation: Intel Edison Based Spider Dress 2.0', *Make* (zine), December 19, 2014, http://makezine.com/2014/12/19/anouks-new-creation-the-spider-dress/.

[27] Deb Miller Landau, 'Fashion Metamorphosis: Meet the Butterfly Dress', *iQ*, March 2016, https://iq.intel.com/fashion-metamorphosis-meet-the-butterfly-dress/

[28] Chloe Olewitz, 'Intel's morphing Adrenaline Dress will transform when it detects elevated stress levels', *Digital Trends*, January 2016, https://www.digitaltrends.com/cool-tech/intel-adrenaline-dress-morphs-based-on-stress/

[29] In collaboration with Kenneth Feinstein and Dr. Sam Ferguson, featuring Marla Bendini and Melissa Logan, *FOOTwerk* is an ongoing project by Murray-Leslie that explores computer-

What does the *Robotic Spider Dress* communicate about the social imaginary of data? At first glance, it conjures reflections on media reports of the reduced capacity for interpersonal affect emerging with the growth of mediated communication and dwindling face-to-face interaction. From this perspective, the dress compensates for the diminished sensitivity to personal space at which people feel comfortable. In short, greater screen time means less physical time. The social imaginary of data in this dress regulates social behaviours with gesture via robotics that are controlled by breath. When the wearer feels uncomfortable, the arms reach high and semi-extended. If the wearer is comfortable, the arms extend horizontally. The fact that both defensive and welcoming movements are forbidding gestures when made by a spidery arm and can push away other people indicates a general level of discomfort in the company of others. The dress thus reveals a potentially negative aspect of the affective dimensions of the social imaginary of data. It is not inconceivable, however, that hackers and imitators are already constructing and customising their own version of the Spider Dress with off-the-shelf technology for commercial and other applications that modify and nuance the social behaviours the dress creates.

In terms of the social imaginary of data and it's value for understanding emergent conceptions of the embodiment of data, I will conclude with a brief reflection on the differences between *Levi's Commuter Trucker Jacket* and the *Robotic Spider Dress*. The anonymous collective of agile workers envisioned in the Commuter Jacket welcomes data input as it is designed to provide continuous connection for bike riders. As above, it can be assumed that over time the technology will become more robust, as beta versions are already on the streets. Here, data is imagined as a material we ride, an endless stream of information that we receive and with which we connect with others. In contrast, the *Robotic Spider Dress* introduces a physical brake designed to impede and deflect unwanted proximity. It reverses the direction of the imperative for data consumption and connectivity embodied in the Commuter Jacket by sensing intimate human responses of the individual wearer to ward off people who stand too close or approach too rapidly.

Conclusion

In conclusion, I see in Wipprecht's *Robotic Spider Dress* the work of art and design in contributing to the social imaginary as discussed by Nikos Papastergiadis. To elaborate, the Spider Dress demonstrates the criticality and control that art and design provides to science. While the Commuter Jacket elicits connotations of riding a wave of data, the Spider Dress does the reverse

---

enhanced footwear as an apparatus for extending the creative capacities of the human body in live art.

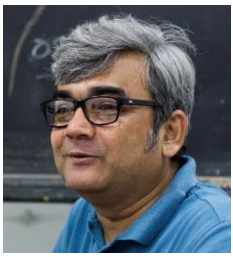
by protecting the wearer from too much information. As a product of art and design integrated with science, the Spider Dress symbolically rejects the dominant incoming direction of data as an unstoppable force. The differences between the two garments indicates the value and contribution of art and design as we collectively create and navigate the social imaginary of data. In short, the value of art and design is that they make meaning sensible. In the context of this conference on design that cares, the social imaginary of data in fashion-tech is one of the more promising trajectories on the spectrum between fashion driven technology, such as *Levi's Commuter Trucker Jacket with Jacqaurd by Google*, and technology driven fashion, such as the *Robotic Spider Dress*, when considering fashion design transformation.

Through the concept of the social imaginary, this paper has explored two integrated design approaches that address the failure to imagine complex, global and rapidly shifting futures by engaging with the emerging possibilities of fashion. The new social imaginary of data occurring in the convergence of art, design and science engaged with the global challenge of understanding the embodiment of data and the drive towards its consumption are generating futural alternatives relevant to world populations impacted by rapid change. Exploring fashion-tech as a means to reconnect and integrate disciplinary expertise in art, design and science has significant potential to lead the exploration of new approaches and deflect the dangerous consequences of unanticipated effects in the convergence of data that measures rapid change.

Rajapaksha.U, et al (eds), 2017, "Design that cares"- multi disciplinary approaches to creating sustainable and meaningful built environment: *Proceedings of the 10th International Conference of Faculty of Architecture Research Unit (FARU), University of Moratuwa, Sri Lanka,(Vol. 01)* pp. 26 - 33 ©

KEYNOTE ADDRESS 3

SPACED OUT: LESSONS FROM CINEMA

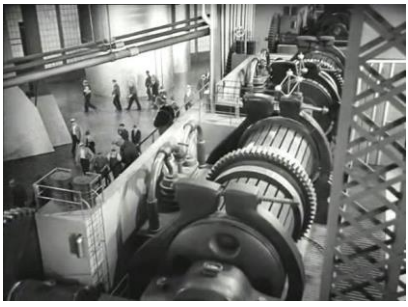


PROFESSOR ARUN GUPTA
National Institute of Design, Ahmedabad, India
guptarun@nid.edu

Human beings and their interface with the spaces they live in, or around, whether natural or designed, is the stuff of many great films. Whether at work or at home, cinematic imagination of space has given film characters the ideal vehicle for an emotional anchor (or it's opposite). Spaces have carried with them promises of deliverance and happiness or premonitions of disaster and dire straits. All too often spaces in films have stood for psychological, cultural and social & political inferences and insights.

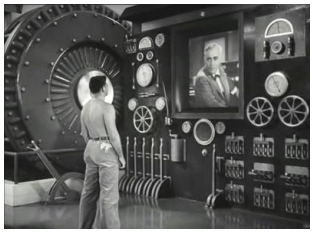
01. MODERN TIMES (USA / 1936)

Thus, Chaplin in his 1936 B&W magnum opus 'Modern Times' colours his visualization of the industrial factory space with a certain impending menace (through sheer scale and an emphasis on dehumanized and profit-friendly insistent processes in a man-made mechanized environment of unfeeling efficiency).





The unfeeling efficiency of profit-friendly production is supervised by the Big Brother factory owner, who watches his men work to death while he lazily plays a jigsaw puzzle in between snooping on his worker bees. He is aided in this process by a designer architecture, which emphasizes his lofty position while reducing the toiling masses to mere cogs in the big bad machine. Our little man, out for a toilet break, can't even snatch a relaxing smoke on the sly. As the Eye is everywhere. Way back in 1936 Chaplin was able to foretell an Orwellian army of 'security camera' eco systems that pervade our public and private life today.


Design and the irrational greed for gain come together once again in 'Modern Times' in the famous scene of the automated feeding machine. An unsuspecting Chaplin, enjoying his frugal lunch, after a grueling and monotonous session of tightening screws on an ever-hastening conveyor belt, is caught by the factory bosses to be the fall guy in the hot seat, of the smartly engineered monstrosity which claims to significantly reduce the time taken by a worker for having his lunch. As expected, the design of the machine has not taken into account its intrinsic fallibility and the unfortunate fate of its primary victim – ordinary folk. The machine fails to deliver, although it dispenses

enough physical and psychological suffering to our easily trusting and now quite distraught protagonist.

A capitalistic society often encourages us to believe that salvation lies in consumption, and that for each one of us awaits a perfect heaven of bourgeois respectability and order. Chaplin, in ‘Modern Times’ at once celebrates and mocks at this narrative of ‘propah’ manners and mansions. Chaplin, the unemployed little man of even lesser solvency, has just escaped from the law, along with his now partner in crime, the delinquent Paulette. They catch their breath near a suburban housing development, watching an unusually happy housewife in a pinafore saying an ecstatic bye to her white-collar husband on his way to work, while standing next to their model villa. That inspires an at once amused and charmed Chaplin to dream sketch a similar existence for him and Paulette, perfect in attire and attitudes, although deliberately mocking in its absurd excesses. Later Paulette sets up a pretend villa for them, in a broken down shack by the sea. This is all they can realistically afford in the unequal economic system they reside in.



Eventually, by the end, Chaplin and Paulette turn their back to these lopsided men made exclusions and walk purposefully away, hand in hand, towards mother nature and the sunset horizon, free finally of the damaging effects of human follies, designer or otherwise. Tomorrow will be another day.

02. MON ONCLE (France / 1958)

An old, friendly, roundabout but humane way of living life versus a seemingly practical, productive but cold modernity is the binary ‘Mon Oncle’ is dealing with. And the former is, regrettably, taking a hit. Its mellow, somewhat sentimental, weapons are ineffective against the onslaught of an enemy equipped with the seductive powers of design and technology, which promise to deliver efficiency promptly and without preambles.


Monsieur Hulot, played by the Director Jacques Tati himself, is an awkward, somewhat diffident middle-aged bachelor, prone to joblessness and an indulgent eye towards human frailties, especially of his otherwise strictly brought up nephew Gerard. Unlike his sister and brother in law (head honcho in a plastic pipes firm), who live in the modern quarters of the city in an isolated gizmo prone automated mansion with regimented lines and distinct metallic sounds defining the structures within and without, Hulot lives on top of a delightfully meandering rickety house bang in the middle of the old city, surrounded by quirky yet friendly characters and incessant chatter.

Freedom is the first casualty in the landscape inhabited by Gerard's parents, the Arpels. Here the shade-less, sunless orderly roads have signs painted on them, which tell you what to do, where to go, exactly. The frantic jazz music combines well with the hurried but compliant coordinated movement of cars and their occupants.




Hulot's side of the city is on the other hand a chaotic but lively assemblage of animals, vehicles, and people, standing at cross purposes with each other in the sun, with nowhere to go in particular, but in perfect leafy harmony. A harmony Hulot is careful to restore, when a loose brick accidentally slips from the run down masonary of the dividing wall between the old and the new.



Superfluousness defines the design interventions in the Arpel household – good looking chairs that cannot be sat upon, austere overdefined spaces that hopelessly mimic what should have been seemless and natural, kitchen gadgets whose sole purpose is to delineate the science of the stupid, etc. And to top it all, an obsession with sterile cleaniness, well illustrated by Mrs Arpel's ludicurous attempts in a plastic gown (with a recurringly jarring rustling sound) to conquer all the dust that comes her way, right upto the back bumper of her husband's now-moving car.


Appearances are everything in the world of the Arpels. Thus the fish fountain must be switched on whenever a visitor is ushered in, to complete the big picture of their contemporary hi- tech designer mansion. The right visitor, of the right class, the right social standing and the accompanying fake emotions. But appearances by their very nature are deceptive, sometimes leading to opposite results. The fountain is mistakenly switched on for the bewildered fruit vendor come for a home delivery and wrongly switched off for the being-planned-as-future-Mrs-Hulot neighbour, taken for a rug saleswoman.

The affectations of the modern world make social conversations stilted and often ridiculous. An informal get-together at home discusses latest production figures of the factory, to everybody's frosty delight; a person with no interest in children tries to elicit one from an amused kid; and emptyiness (literal as well as figurative) is redefined as the cutting-edge manifestation of connectivity.

Hulot, of the old-world charm, finds himself oddly placed in the scheme of things of the new. From being flummoxed by the laser-read cabinets of the Arpels' kitchen to having inadvertent fun with wonder jugs that are unbreakable (not all of them, as he discovers to his shocked disbelief) Hulot demonstrates the sheer ineptness of the modernity project, of needless automation and fruitless innovation.


The modern seeks to artifically replace a more organic, more attractive (although messier) way of life. Gerard has great fun eating greasy savouries from a roadside cart in the company of his other frends but the machine-cooked and sanitized lonely egg of the ultra-modern Arpel kitchen draws in him no such passion.


Unlike the dull steely grey tones of the Arpel world, the world where Uncle Hulot resides is bright and colourful, with people experiencing genuine moments of conflict and camaraderie - the former effortlessly flowing into the latter, especially towards the spirits (hic!) of Café Chez Margot where all the meandering roads eventually lead.

But all that is good must come to an end. Hulot has to go. A way of living is inevitably coming to an end - a gentler, friendlier, community oriented space must give rise to the modernist grandeur of isolation and conceit. As the jackhammers noisily break down the buildings of the old town, Hulot is whisked away for elsewhere. But luckily all is not lost as yet.

Mr. Arpel, the industrialist father, accidentally discovers (like Hulot before) the mischievous power of a whistle to waylay a passerby, which brings him for the first time closer to Gerard his son. As they duck for safety, and later hold hands, a bond seems to be emerging between the father-son duo. One that would hopefully see the New not trample the Old, but instead make an amiable and mutually beneficial peace with it. Mon Oncle Hulot lives on. Amen.

Rajapaksha.U, et al (eds), 2017, "Design that cares"- multi disciplinary approaches to creating sustainable and meaningful built environment: *Proceedings of the 10th International Conference of Faculty of Architecture Research Unit (FARU), University of Moratuwa, Sri Lanka,(Vol. 01)* pp. 34-37 ©

KEYNOTE ADDRESS 4

"DESIGN THAT CARES"

PROFESSOR KENNETH SEGAL
Hadassah College, Israel
keni@publiczone-tr.com

Greetings, I would like to thank you for inviting me today to speak about "Design that Cares". Probably we should begin with the question what does design that cares mean? What do we care about – the users, the bottom line, the triple bottom line, society or the environment and what is the hierarchy within the subjects that we care about? What trumps (no pun intended…) what? Does caring for the environment rule out caring for users and their preferences? Does caring about the success of a project necessarily rule out possible choice architecture that may actually be in the users best interest? And finally what constitutes Caring Design? What are the most efficient and meaningful ways to care through design?

I would like to address this subject today and say first of all that honestly there does not seem to be any simple clear-cut answers to these questions. In fact, probably in keeping with these complex times, designing from an ethical stand point, from the position of care is multi-layered, sometimes involving some composite moral considerations. For instance, in his book "Nudge" the Nobel prize winner Thaler, speaks about the value of choice architecture or intervention – how does one point the user in the right direction to make the correct choice without limiting the users choices. Who draws the line as to limiting versus well-being? Thalers position is that their is legitimacy to altering people's behavior in a predictable way if one does not forbid or limit options or significantly change the economic incentives. According to Thaler, to count as a mere nudge, the intervention must be easy and cheap to avoid. Nudges are not mandates. For example putting fruit at eye level counts as a nudge. Banning junk food does not…

So actually, as usual with complex subjects, it is more plausible to offer various examples and allow open end possibilities to be formed through different approaches from different people.

With this in mind I will try and illustrate the what may be considered "Design that Cares" through projects of our students from the Industrial Design Department at Hadassah College, with the hope of adding to the

understanding of the potential of “Design that Cares” to bring about innovative products.

To begin with let’s turn to the prosaic and ask – What have we cared about in society in the past and how did design reflect those values? Indeed, there are various examples of a symbolic language that allow us to see a long relationship between design activity and the human need for symbols of social structure.

But let us not forget that primordially, design has been focused on developing specific functional solutions for physical needs and human survival.

Specificity or particularity was a possibility as technology was geared for a singular product produced by an one artisan. With the mass production developed in the modern era, the possibility of developing singular solutions for a relatively small scale problem was vastly diminished. But gratefully we have turned full circle and technology today allows us to develop industrially viable products for singular and small batch needs. This vastly increases our ability to develop a design that cares on small scale and large scale projects.

Noga

The first project I would like to show you deals with cognitive development of sight impaired babies. Noga, the designer had just given birth and she noticed that with her in the ward was a women who had given birth to a sight impaired baby. Being inquisitive, and caring, she began to research the development of sight impaired babies and discovered that cognitive development in most cases was slower than the norm and in many cases a permanent cognitive gap existed between seeing and sight impaired children. After reviewing the data, Noga saw that there was no real cognitive basis for this gap and that statistically, sight impaired children had the same level of intelligence as the general population. So what was holding them back? Her gut feeling was that if the intelligence levels were not the problem it had to be something with the surroundings that the children grow up in. She carried out a series of talks with development phycologists and conducted research and observations and began to see a pattern in the behavior and interaction between the mothers and their babies in the initial months of development. With this in mind she targeted studies that had to do with the effect of nurturing on the development of children and began to understand that the problem was that mothers did not develop the required deep and meaningful relationships with the babies as the sight impaired babies did not react to the mothers as seeing babies did. This lead to a more functional and less emotional interaction between the mother and baby causing what could be termed as “nurture deficit” which in turn cause a slowing down in the cognitive development process. Noga focused the

solution on getting the baby to react to the mother by using the heightened senses of hearing and smell. The product is customisable to allow the mother to create her own sound and get the baby to recognise that sound. Also the materials absorbs the smell of the mother and helps as a sensory stimulant for the baby to react to the mother as she approaches. (Short explanation with Slide) So in fact we have a relatively low tech project with long term positive implications that began just by caring.

Technology and Materials

There is a lot of talk about high tech and the use of technology to assist users. Perhaps "Design that Cares" means that innovation and technology should focus on assisting and increasing quality of life for those who are not in the main stream and have special needs . In many cases after researching the needs of the user and defining the product concept, the designer needs to discover or define new materials or technologies that support the solution so caring can also be a catalyst for innovation as we will see in the next projects.

Limor - Essential Tremor

This project deals with Essential Tremor which is a rhythmic shake caused by a neurological disorder that effects about 3% of the population. In many cases the shake is so severe that doesn't allow people to drink from a glass or eat by themselves. What Limor discovered is that this tremor can be negated by activating muscles through electronic nerve stimulation that act as an opposing force to the tremor and so stabilizing the limb, in this case the arm. This allows for stability and close to normal use of the arm to eat and drink. Besides the innovative concept the breakthrough here was achieved by developing a solution to print electronic circuits onto a stretch fabric by printing layers of polymer and then a low transmitting material that could deliver electronic pulses to specific nerves. The product is printed after scanning the individual patients' arm and producing a customized nerve map. The sleeve, designed to look like a sports accessory rather than a medical device is equipped with a small computer chip run by rechargeable batteries that reads the tremor and sends the opposing electronic pulses to negate the rhythmic shake of the arm. Limor started her project by talking about her grandmother who has this disability so her caring for a family member brought about innovation for a large number of people suffering from a debilitating disease.

Ram

The next project deals with the need for prosthetic limbs in third world countries.

The success of this project was a result of the implementation of a multi level strategy for innovation. The idea was first of all to see the prosthetic object as a fully industrial product that could be low cost, optimised and mass produced as

a modular object that evolves together with the growth of the patient. This strategy empowers the user and detaches the users from the usual dependency on NGO's and other government institutions that are usually lacking in such countries.

So, all the parts are made from reinforced injected plastic that can be changed and extended as the patient grows. The most important aspect of the project was to understand and develop the right solutions for materials. For example the material for the foot module is designed like a sport prosthetic to help youngsters run and play. This means that the material design must be very robust, easy to clean and maintain together with a large range of flexibility and elasticity.

This project won the "Red Dot Design Award" and has gained a lot of international interest and today is the basis of a start-up company that is developing the product.

Conclusion

To conclude I would like to end with a project that symbolises the idea of how "Design that Cares" can improve the quality of peoples' lives for the better not only in the area of assistive technologies but just by making everyday activities accessible. In general one could say that the approach of "Design that Cares" is based on the belief that the future of design is to focus on user needs and not market trends.

Neora Ziegler

Another aspect of "Design that Cares" is that products developed for people with special needs can sometimes be a catalyser for the development of superior products to be used by the general public. In this case, the student has created a set of cooking utensils adapted for the needs of the visually impaired and blind people who would like to cook. The utensils were designed using the sense of touch to enhance functionality and offer the visually impaired the possibility of preparing their own food. As a result of the materials and safety features the product can be used by the general public and especially third and fourth aged people interested in cooking.
Let's see the film she made:

So at the risk of repetition, "Design that Cares" actually stems from designers that care. People who see their professional fulfilment as helping other people will be the protagonists of an approach in design that will encourage all designers to care.

Rajapaksha.U, et al (eds), 2017, "Design that cares"- multi disciplinary approaches to creating sustainable and meaningful built environment: *Proceedings of the 10th International Conference of Faculty of Architecture Research Unit (FARU), University of Moratuwa, Sri Lanka (Vol. 01)*, pp. 38-46 ©

GUEST SPEECH

INTERNATIONAL COLLABORATIONS IN HIGHER EDUCATION INSTITUTIONS IN SOUTH ASIA: NEEDS, CHALLENGES AND OPPORTUNITIES

PROFESSOR DILANTHI AMARATUNGA
Professor of Disaster Risk Reduction and Management
Global Disaster Resilience Centre
University of Huddersfield, UK
d.amarsatunga@hud.ac.uk, www.dilanthiamaratunga.net

Summary

All good universities combine local and regional research and engagement with a strong international presence. The research projects, presentations and partnerships are testimony to a vibrant and ever-developing web of research and innovation that is yielding impressive results. It is also evidence for the value of a cosmopolitan community of scholars, drawn from a wide range of backgrounds, who are together bringing new insights to bear on key challenges of our age. In this context, this synopsis discusses the rationale for internationalising higher education with emphasis on international research collaborations and its potential implications, including much discussed university work rankings and publications. It discusses the status quo in Asia, in a sample of target countries regarding some of the findings of an international research collaborations entitled ASCENT. It further reflects several learning points associated with good practices in facilitating successful international research collaborations.

Internationalisation of higher education

Internationalisation of higher education is the process of integrating an international/intercultural dimension into the teaching, research and service functions of the institution. This definition understands internationalisation as a process, as a response to globalisation….and as including both international and local elements' (Knight et al, 1999). International collaboration has been an important priority for the national research strategies of all major research economies since the significant expansion of the 'endless frontier' of research after 1945 (Bush, 1945). We need to consider internationalisation as a process, drawing from and informed by our strategic positioning: articulate our values and be clear about why we are doing things; focus and build on areas of strength; aim for greater coordination; recognise internationalisation is about 'making friends' as well as the financial aspects of sustainability; and, take a

long-term view but move on several small initiatives that will consolidate our position.

The rationale for internationalisation lies in an understanding of the universal nature of the advancement of knowledge. While knowledge is often contextual, the advancement of human knowledge that is based on the common bonds of humanity is arguably a global enterprise (Yang, 2002). In the case of higher education, "Internationalisation at the national, sector, and institutional levels is defined as the process of integrating an international, intercultural, or global dimension into the purpose, functions or delivery of postsecondary education" (Knight, 1997). Internationalisation means creating an environment that is international in character in teaching, in research, in outreach. This complex definition suggests that there are many dimensions of internationalisation and that it is a dynamic process of institutional change.

To be successful we acknowledge the need to ensure that there is a comprehensive approach and that this becomes part of our philosophy, embedded in our core areas of delivery and not an entirely separate strategy or series of activities. Internationalisation needs to have parameters if it is to be assessed, and successful assessment lies only in an understanding of the contexts in which it occurs. According to "A mighty web: How research collaborations can foster growth in South Asia: Analysing the potential in Afghanistan, Bangladesh, India, Nepal, Pakistan and Sri Lanka" (British Council, 2015), Collaborative research across borders and disciplines can help drive economic development and productivity in developing countries through the discovery of scientific breakthroughs and innovations linked to health, agriculture, chemistry and engineering, as well as raise awareness of social issues such as poverty, urbanisation and environmental security. Further to this, it highlights that international research collaborations offer cost-saving benefits. For example, when countries can pool resources, labour, equipment and facilities, researchers are less reliant on funding from governments and overseas bodies. Being connected to the 'right' people within an extensive network also gives academics better access to funding for their projects.

What is driving the trend towards greater international scientific collaboration?

One in five of the world's scientific papers are co-authored internationally. As a result of the expansion of communication methods and the ease of international travel, academics and researchers are finding it easier than ever to collaborate with their foreign counterparts, making the exchange of academic ideas much simpler to organise (QS Worldwide, 2017). The ability to scrutinize, debate and share experience is essential for academic and scientific

accomplishment. Constructively challenging accepted opinions and ideas is central to their development, and international collaborations help to facilitate this.

Today collaboration has never been more important. With human society facing several wide-ranging and interlinked 'global challenges' such as climate change, food security, energy security and infectious disease, international scientific collaboration is essential if we are to have any chance of addressing the causes, or dealing with the impacts, of these problems (McLean,2011). There are innumerable other examples of the successes international collaborations can lay claim to across the globe. Such partnerships have contributed endlessly to academic and scientific progress. Researchers at the University of Huddersfield, for example on their Erasmus+ grant CABARET (Haigh et al, 2017), work on several research initiatives with teams from Lund University in Sweden, ITB in Indonesia, IH Cantabria in Spain, and Moratuwa and Peradeniya in Sri Lanka – 17 partners across 9 countries in total. In this example, they are looking at a regional problem - multi hazard early warning to foster regional cooperation for more effective multi-hazard early warning and increased disaster resilience among coastal communities.

World rankings

It is beyond doubt that rankings have become a significant part of the tertiary education landscape, both globally and locally. Undoubtedly, rankings now play such a big role in shaping the opinions of current and potential students, parents, employers, and government about the quality of tertiary education institutions (*Marmolejo, 2015)*. University leadership and policy makers excitedly await the results of yearly university rankings. Rankings are used by some governments in their higher education policy, by institutions looking for international partners and by prospective students searching for a place to study – due, often, to the lack of other widespread metrics. But how powerful are rankings in the higher education world?

QS World rankings is a popular ranking that is being widely used. *[Note: Quantum satis (abbreviation qs or QS) is a Latin term meaning the amount which is enough. It has its origins as a quantity specification in medicine and pharmacology, where a similar term quantum sufficit has been used (abbreviated Q.S.)]*. It uses a methodological framework compiled using six simple metrics in capturing university performance: Academic Reputation; Employer Reputation; Faculty/Student Ratio; Citations per faculty; International Faculty Ratio; and International Student Ratio. Citations per faculty carries 20% and institutional research quality is measured using the *Citations per Faculty* metric.

Citation analysis shows that papers with international co-authors are cited up to four times more often than those without international co-authors (Jones and Evans 2013). In this context, international research collaboration can be tracked

via the numbers of publications that are co-authored between countries. Krause (2009) argued that articles published with multi-countries or multi-institutes collaborations get cited more. Wuchty et al (2007) looked at 19.9 million papers over 50 years and demonstrated that team-authored articles typically produce more frequently cited research than individuals. A study by Cotropia and Petherbridge (2013) in law review articles which were published within two decades also demonstrated that team research is on average more frequently cited than individual research. About 90% of UK output was domestic in 1981 whereas less than half is domestic recently (Adams and Gurney, 2016). This means that almost all the growth in output of the last three decades has been produced by international partnerships. As the volume of international collaboration increased, these papers have increasingly enhanced the UK's relative international performance in comparative citation analyses.

*Nello Angerilli, the Associate Vice President International for the University of Waterloo in Canada, responded to the question: "*What is it that the most successful universities must do to appear regularly in these rankings?" as "Disseminate large volumes of research outcomes in the right journals and at the right conferences. Recruit the best possible students and maintain a research-informed teaching agenda" (Cairnes, 2013).

Quality of research

As institutions develop more experience internationally, there is a growing shift away from student-focused initiatives, that is, international student recruitment and branch campuses, towards developing research capacity in partnership with colleagues overseas (University of Oxford, 2015). Increased participation in international collaborative research and development (R&D) ventures could offer a variety of economic, technical, political, personal and institutional benefits. Although these benefits may not be realisable in every case, collaboration does offer a range of potential opportunities. These include: Enhancing Scientific Capabilities, Enhancing Stability of Science, and Addressing Global Issues. Drivers behind international cooperation also include (Boekholt, 2009): Improving national competitiveness; Supporting less developed countries by developing new capabilities; Tackling global societal challenges; and Creating good and stable diplomatic relationships (and indirectly ensuring international security)

International collaboration is increasingly indispensable to excellent research. Working internationally enables individual academics to increase their impact

and nations to pool talent and resources to address global challenges that no country can tackle alone. Adams and Gurney 2016 study on, "The Implications of International Research Collaboration for UK Universities", shows international research collaboration is also vital for individual institutions that aim to produce outstanding research, and that the increase in such collaboration has been very rapid indeed. The average UK university today is more international in its co-authorship than the most research intensive were ten years ago. By the same measure, many UK universities were already more international 20 years ago than the current average for the USA.

For universities, international links create esteem and demonstrate the wider engagement and status of an institution, helping to attract students and staff from an international catchment. At the level of individual, researchers and research groups there has also been a significant growth of collaboration, much of which will have developed outside the frameworks of formal agreements. Research advances faster and further by combining your agenda with partners (Adams and Gurney, 2016). Further, at present one can witness a growing policy attention for international collaboration. The growing attention for international co-operation policies can be explained by a number of external developments that have triggered the policy debate (Boekholt, 2009):

- The emergence of the BRIC (Brazil, Russia, India, China) countries and particularly China as a country with a large research and technological development capacity that is becoming recognised for meeting high international quality standards
- The increased political debate and urgency of global challenges such as climate change, health issues and sustainable energy resources
- The globalisation of R&D is becoming more visible particularly in industrial research and also in the world-wide mobility of researchers

Status in South Asia

The research report entitled: "A mighty web: How research collaborations can foster growth in South Asia: Analysing the potential in Afghanistan, Bangladesh, India, Nepal, Pakistan and Sri Lanka" (British Council, 2015), examines the barriers that prevent South Asian experts from linking up with research colleagues across the globe to create opportunities for collaborative research, and recommends action to address them. Based on a series of interviews conducted with global experts in 2014, the paper aims to be a guide for researchers and policy makers interested in unlocking the region's collaborative research potential. It identifies that South Asia's research capacity has been increasing but international collaborations between authors still have

much to grow. It further emphasises that South Asian countries need to take serious steps to enhance their technological readiness and innovation. Universities, institutes and local research and development (R&D) agencies in the region lag behind their counterparts in the rest of Asia in terms of R&D and technological enhancement activities, confirming the need for governments and firms to rethink their policies and strategies in this regard.

In South Asia, just 2.2% of all international collaborations involve countries within the region— like India and Sri Lanka, for instance. There are several reasons for the lack of collaborative research in South Asian nations, such as language and literacy barriers, geopolitics and other cultural issues. Funding is another major challenge. South Asia still lags behind the rest of the world in terms of R&D activity, particularly regarding collaboration on international and multidisciplinary research projects. As a result, it is recommended that a greater degree of international collaboration is fostered and members participating in research projects to drive innovations and provide a different perspective may make it easier to alleviate these issues (British Council, 2015).

Role of international collaborations in research capacity building – current status in Sri Lanka, Thailand and Bangladesh

Within this backdrop, an international research collaboration entitled ASCENT (Advancing Skill Creation to Enhance Transformation) was launched, funded by the European Union to strengthen research and innovation capacity, in this instance for the development of societal resilience to disasters. ASCENT is supporting training, skills, leadership development, international collaboration and university-industry partnerships and seeks to strengthen the ability of higher education to respond to research needs in disaster resilience (ASCENT, 2017). It is led by University of Huddersfield, United Kingdom and the partnership consists of 4 our EU partners and 8 partners from Asia representing Sri Lanka, Thailand and Bangladesh. Data was collected through the application of a combination of research methods including a detailed policy analysis, a series of semi structured interviews and a detailed survey supported by a critical evaluation of literature with a view to explore the status quo of international collaborations (among others). The analysis also focused on identifying the level of involvement in international collaboration, and the barriers that hinder international collaboration in R&I, and in this instance by taking in Disaster resilience as the chosen discipline in the chosen countries. Some of the barriers the study highlighted include (Amaratunga et al, 2017): lack of Institutional support for international collaboration (funds to attend conferences, seminars, etc.); lack of networking opportunities; finding partners with same research interests is not found to be easy; language differences; and cultural differences. Benefits that the respondents identified included

(Amaratunga et al, 2017): improving the strength of research collaborations; increasing the robustness of research outputs; contributing to global societal challenges; and improving national competitiveness. Hardly any target country's higher education institutions have a dedicated budget to support their research teams in undertaking international research collaborations, or to develop their associated internal research capabilities.

Reflection on the status in target countries

A high-level Advisory Group of leaders and experts in international science and science policy, drew on evidence, analysis and extensive consultation with scientists and policymakers from around the world and makes 5 major recommendations which are equally applicable for the sample that was investigates as reported in this synopsis (The Royal Society, 2011):

- Support for international science should be maintained and strengthened
- Internationally collaborative science should be encouraged, supported and facilitated
- National and international strategies for science are required to address global challenges
- International capacity building is crucial to ensure that the impacts of scientific research are shared globally
- Better indicators are required to properly evaluate global science

Planning is key to a successful international research collaboration. In this context, any researcher embarking on work with international collaborators is worth considering for, as identified by University of Lincoln (2010):

- Relationships are critical – early stage face-to-face meetings are suggested as a good way to foster good relations among the team.
- Aims and objectives should be specified – it is generally not advisable to assume all partners are working towards the same goal.
- Complementing capacities of collaborative – this is key to ensuring that all participants have a clear role in the project.

There is an almost universal commitment across the target countries and the surveyed higher education institutions that their higher education sector to expand the level of international research collaboration, both institution-level strategic partnerships and the more typical, researcher-level international collaboration needs serious attention. Amaratunga et al (2017) support the need to have dialogue with university researchers to enable national capacity

building in international collaborations. Such sustainable mechanisms can ensure long-term research collaborations with the countries and Higher Education Institutes (HEIs). They further conclude that the most obvious form of international collaboration - and the most easily measured - is collaboration in the writing of research findings, and participation in international research projects even though the empirical results revealed that only a third of the staff members are involved in these activities. Bureaucratic obstacles and long delays in internal administrative processes need to be removed. There is also a need for greater attention to education and invest greater amounts of funding into R&D if countries want to achieve sustainable economic growth and to play a key role and be a visible player in international platforms. There's also a role for the international community to play in facilitating conferences and forums that bring multiple stakeholders such as governments, academics and industries together to network and build the basis for potential collaborations. The potential remains very strong and South Asia continues to represent an exciting 'frontier market' for international research institutions.

References

- Adams, J. & Gurney, K.A. (2016). The Implications of International Research Collaborations for UK Universities. Digital Research Reports, Universities UK.
- Aksnes, D. W. (2003). Characteristics of highly cited papers. Research Evaluation 12 (3), 159-170. http://dx.doi.org/10.3152/147154403781776645
- Amaratunga, D., Liyanage, C. & Haigh, R. (2017). A Study into the Role of International Collaborations in Higher Education to Enhance Research Capacity for Disaster Resilience. In the proceedings of 7th International Conference on Building Resilience; Using scientific knowledge to inform policy and practice in disaster risk reduction, November 2017, Bangkok, Thailand
- ASCENT (Advancing Skill Creation to Enhance Transformation) (2017). <http://www.ascent.disaster-resilience.net>. Accessed 15 November 2017
- Boekholt, P., Edler, J., Cunningham, P., & Flanagan, K. (Ed.) (2009), Drivers of International collaboration in research. Final Report, Directorate-General for Research, International Cooperation
- Bush, V. (1945). Science the endless frontier. A Report to the President by the Director of the Office of Scientific Research and Development. (United States Government Printing Office, Washington: 1945).
- Cairns, W. (2013) University Rankings: How Important Are They? <<https://www.forbes.com/sites/evacairns/2013/10/17/university-rankings-how-important-are-they-an-interview-with-nello-angerilli-avp-university-of-waterloo-canada/4/#7205dfee6fb9 > Accessed 15 November 2017
- Cotropia, C. A., & Petherbridge, L. (2013). The Dominance of Teams in the Production of Legal Knowledge. Loyola-LA Legal Studies.
- Haigh, R., Amartunga, D. & Hemachandra, K. (2017). A Capacity Analysis Framework for multi hazard early warning in coastal communities. In the proceedings of 7th International Conference on Building Resilience; Using

scientific knowledge to inform policy and practice in disaster risk reduction, November 2017, Bangkok, Thailand

- Jones, K., & Evans, K. (2013). Good Practices for Improving Citations to your Published Work (pp. 2). University of BATH.
- *Marmolejo, F. (2015),* Why are university rankings so important? https://www.weforum.org/agenda/2015/12/why-are-university-rankings-so-important/ Accessed 10 November 2017
- QS World Rankings (2017), < https://www.topuniversities.com/qs-world-university-rankings/methodology >. Accessed 10 November 2017
- Knight, J. (1997) Internationalisation of higher education: a conceptual framework. In: Knight, J. & De Wit, H. (Eds) Internationalisation of Higher Education in Asia Pacific Countries. Amsterdam: EAIE.
- Knight, Jane, and de Wit, Hans (Eds.). (1999). Quality and Internationalisation of Higher Education. OECD, Paris.
- Krause, K. (2009). Increasing your Article's Citation Rates. Open Access Week.
- McLean A (2011), International collaboration crucial for scientific research. < https://www.oxfordmartin.ox.ac.uk/news/2011-royal-society-mclean >. Accessed 10 November 2017
- Peige, R.M. (2005), Internationalization of Higher Education: Performance Assessment and Indicators.
- Pislyakov, V., & Shukshina, E. (2012). Measuring Excellence in Russia: Highly Cited Papers, Leading Institutions, Patterns of National and International Collaboration. Paper presented at the Proceedings of STI 2012, Montréal.
- The Royal Society (2011), Knowledge, Networks and Nations: Global scientific collaboration in the 21st century , ISBN: 978-0-85403-890-9 © The Royal Society.
- University of Lincoln (2010), The Challenges and Benefits of International Collaborative Research, <https://research.blogs.lincoln.ac.uk/2010/11/08/the-challenges-and-benefits-of-international-collaborative-research/ >. Accessed 15 November 2017
- Yang, R. (2002). University internationalisation: its meanings, rationales and implications. Intercultural Education, Vol. 13, No. 1, 2002, pg 81 – 95
- University of Oxford (2015). International Trends in Higher Education 2015. International Strategy Office, University Offices
- Why Are International Collaborations So Important For Universities? (2017). < http://www.qs.com/why-are-international-collaborations-so-important-for-universities/ >. Accessed 10 November 2017

Wuchty, S., Jones, B. F., & Uzzi, B. (2007). The Increasing Dominance of Teams in Production of Knowledge. Science, 316 (5827), 1036-1039. http://dx.doi.org/10.1126/science.1136099

Rajapaksha.U, et al (eds), 2017, "Design that cares"- multi disciplinary approaches to creating sustainable and meaningful built environment: *Proceedings of the 10th International Conference of Faculty of Architecture Research Unit (FARU), University of Moratuwa, Sri Lanka (Vol. 01)*, pp. 47-60 ©

IMPACT OF LAND AREA CHANGE ON THE LIVELIHOOD OF FARMERS OF COASTAL BANGLADESH: A CASE STUDY ON BHOLA

SHIBU PRASHAD BOSU[1] & SHAMIM KOBIR[2]
[1]Assistant Professor, Architecture Discipline, Khulna University. Khulna- 9208.
shibu_arch@yahoo.com
[2]BURP, Urban and Rural Planning Discipline, Khulna University, Khulna-9208.
tahir.kobir10@gmail.com

Abstract
Bangladesh is exposed to disasters mainly due to her topographical location. Calamities such as floods, river bank erosion, cyclone, tornado, cold waves, arsenic contamination in ground water, water logging, salinity intrusion etc. are gradually intensifying by climate change and combining risks for the coastal people in Bangladesh. Such calamity took peals less in lives but more in livelihood as agricultural land and homesteads along with other livelihood options which are banished. The current study is concerned with climate change related menaces and risks that affects the occupants of coastal Bangladesh. The study outcomes revealed that the climate change has gradually affected the livelihood of coastal people in many aspects including losses and damage in crop cultivation, inadequacy of pure drinking water, extreme poverty, homestead land and natural assets etc. It has also generated a state of unemployment among the people of coastal communities. As a consequence, the affected people are losing their means of livelihoods and enforced to take numerous alternative means of livelihoods to cope with the adverse impact of climate change related catastrophes. The study detects the alternative adaptation strategies adapted by the affected coastal inhabitants in coastal Bangladesh. The present paper unveils that the coastal community people try to solve their problems through adopting and exploring alternative employments.

Keywords: *Land area, agriculture, livelihood, economic implications, coastal Bangladesh*

Introduction

The coastal population of Bangladesh is about one-fourth of the population of the country and poor livelihood groups form around three-fourth of the coastal population. Coastal livelihood of Bangladesh is highly reliant on the natural resources and ruled by the climate. It includes agriculture, agricultural related activities, fishing and some other activities such cottage industries and business etc. (Saadat et al., 2011).

The vast low-lying area along the Ganges-Brahmaputra-Meghna Delta has a high probability to be heavily inflated by climate change impacts. High population density, inadequate infrastructure, low level social development, lack of institutional capacity, and high dependence on natural resources make the situation more exposed (ADB, 2011). The frequent change in estuarine and coastal morphology lead the people to be displacedwhich is common in the coastal community in Bangladesh. It is possible to findpeople who have been evacuated up to 14 times (Islam, 2006).

The dynamic nature of Meghna estuary has direct and indirect impacts on land resources and their use. Large islands like Bhola, Hatia and Sandwip are sited at the mouth of the estuary. From the contrast between the geographical maps of 1984 and 2007 it is seen that there are substantial losses in the north of Hatia, north-east of Bhola, east of Sandwip and south-west of Ramgati island. A net land gain of 451 km^2 occurred in the Meghna Estuary within the period of 1984-2007 which represents an average annual accretion rate of 19.6 km^2 (Brammer, 2014). On the other hand at least 86,000 hectares of land was disappeared to river erosion from 1973 to 2000 (MES, 2001).

In coastal Bangladesh, the major land uses include agriculture, shrimp and fish farming, forestry, urban development and other settlement needs. There is urgent need for expansion of all current land use, while the need for new supervision is also evolving (Islam, 2006). Traditionally land use in coastal Bangladesh was predominantly for paddy cultivation with locally adapted varieties that were low-yielding. In very partial areas of the southwest, traditional shrimp culture was accomplished (Nishat, 1988).

Objectives

The main objective of this study is to create an empirical knowledge based on the effect of land erosion on the livelihood of farmers living in the coastal area of Bangladesh.

The specific objectives are:

1. To identify the impact of continuous river erosion around the Bhola, Bangladesh.
2. To understand the relationship between land erosion and livelihood of farmers of coastal area of Bangladesh.

Rational of the Study

Climate change is now the most burning and highly concerned issue for Bangladesh. It has been discussed earlier that the socio-economic consequences of climate change, sea level rise, factors of salinity intrusion and its

consequences, comparative analysis of salinity intrusion in different parts of the country are causing vulnerabilities. The current research is intended to give more details about coastal people's vulnerable livelihoods conveyed by climate change. The findings will give us a deduction about the nature of relationship between climate change and livelihood of rural poor of coastal areas. To cope with the climate change the coastal communities are taking different adaptation options. From several studies (Nasreen, 1995; 2012) it is discovered that the community based climate change risks reduction strategies and households and individual coping strategies with the existing socio-economic and geographical setting of disaster affected people have always been unnoticed. The present study, thus, have tried to find out the nature of alternative livelihood options that minimize individual's vulnerability to standard of living in context of climate change. Therefore, the study is a modest venture to explore the impact of climate change on livelihood including income, production etc. and coping and adaptation strategies of people living in selected coastal communities. Thus, the present study has given an attention to assess the impact of climate change and nature of vulnerability of coastal people's livelihood due to climate change and especially to the vulnerability of their low-income population. The developing literature on adaptation gives far more attention to agriculture and to rural livelihoods and climate change related risks of coastal communities.

Poor people living in the marginalized lands perusing nature dependent livelihoods are facing barriers and limitations earning wellbeing in the changing climate. The climate change is posing challenge to the livelihoods in different ways. Livelihoods are either disrupted by the extreme weather events like cyclone, floods, erosion, storm surges, dense fogs, sea turbulence or by slow onset disasters like salinization, dryness, ecosystem degradation etc. (OXFAM, 2009). On the other hand, attaining food security and reducing poverty in the Bangladesh has been a major challenge for both governments and development agencies due to vulnerability of agriculture to Climate change. Currently, much more people in the rural Bangladesh are considered to have food insecurity due to recurrent different climatic events like flood, storm, river bank erosion, salinity intrusion, and drought. The poor and marginal farmers are becoming more vulnerable as a result of crop loss due to climate change. (Nasreen et. al., 2008).

People of coastal belt, char and haor areas in Bangladesh are continuously struggling with impact of climate change. Climate change is pushing people to take diversified occupation to maintain their livelihood. Researchers pointed out that agriculture in Bangladesh "is already under pressure from increasing demands for food and the parallel problems of depletion of agricultural land and water resources from overuse and contamination. Climate variability and

projected global climate change makes the issue particularly urgent (Selvaraju, 2006). It is also mentionable that extreme weather events not only limits livelihood persuasion during the event but also has the potential to erode household assets, like destruction of house, trees etc. The extreme events also destroy local resource base and thus limits livelihoods and wellbeing. The household assets including human health and motivation, houses, trees, other physical assets, livelihood tools and equipments are demolished in the extreme weather events and thus reducing capitals to pursue livelihoods and accordingly reducing resilience to extreme conditions (OXFAM, 2009).

Study Area

More rice growing and frequent land use changes which affect the livelihood of coastal farmers were priority for the selection of the study area. This research is going to assess the impacts of land area change and excessive erosions towards the livelihood of farmers of the study area. The study location is near to Bhola's south-west coastal belt in Bangladesh and land area change, erosions are affecting the area with massive change of livelihood patterns most visibly. Additionally, the area is densely populated and land use changes prone area in Bangladesh that is significant consideration for choosing the study area. The total population of Bhola Island is about 1.8 million and their livelihood depends on land use as well as climate change context, as most of them are farmers. Agriculturally, the region is moderately developed, with a current net cropped area estimated at 2098 km^2. Rice occupies 72% of the net cropped area, the remaining crops being jute, wheat, potatoes, oil seeds and pulses. On the other hand, Bhola has many small islands called Char land. In case of our country, coastal islands and chars are the most vulnerable and least known geographical sites for many reasons such as usual erosions and accretions of chars and islands, problems in mapping and collecting information due to remoteness and inaccessibility of char's areas.

Villagers' dependent on the River to make their living, at the same time it is the main reason of their vulnerability. The area of the village becomes narrower every year due to the river erosion. In the existing study area, many families lost their shelter, assets due to the river erosion. The river erosion may cause the entire disappearances of the village. Embankment is broken down due to the river erosion and saline water entered into the enormous crop field through this embankment. Vast crop field was drowned at a high rate by the saline water due to previous river erosion events. Salinity is still remaining in these fields. This overall land area change and climate change as well provide a large impact on the livelihood of the farmers in the study area.

Methodology

In the primary data collection procedure both field survey and questionnaire survey were carried out. Field survey was conducted to observe the current land area change condition of the study area. Questionnaire survey was conducted on 40 households of which the numbers of participation of different status of people living there. It is to be noted that the respondents of the study areas were the forced migrants of land area changes or environmental refugees from the coastal Bangladesh. During this research, multiple answers were counted to reflect the people's observation on this issue. After the survey the results were converted into percentages to find out the ratio between the proportion of respondents and answers. The data were processed with the help of Microsoft Office Excel 2007 version.

Analysis and Discussions

MAIN SOURCE OF INCOME IN THE STUDY AREA

There are different cash-income generating activities in the study area like crop sales, fish sales, animal sales, farm labor etc. Among them majority of the respondents (47%) claimed of selling crops, rest of them were claimed to earn (27%) in fisheries, others income (18%) generated by farm labor and rest of the respondents claimed their source of income based on livestock sales (fig. 1). These outcomes may well relate with other similar research findings (see Islam and Rahman, 2012; Nasreen et al, 2008).

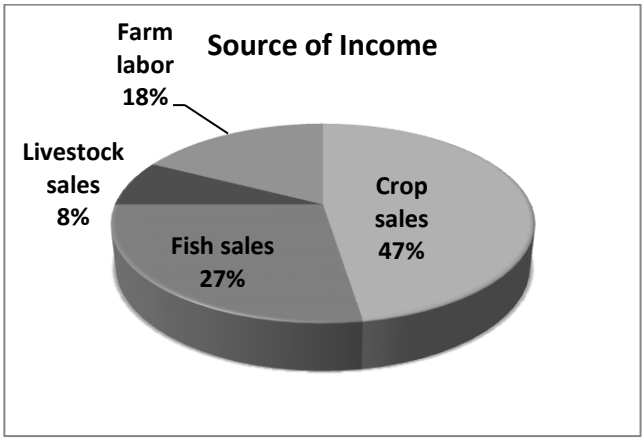


Figure 1: Source of income in the study (*Source: Author, 2016)*

IMPACT OF CLIMATE CHANGE ON EMPLOYMENT

Income is the most important factor that decides the standard of living of the households. In the coastal areas, the majority of the villagers live on 'hand to mouth'. Respondents of poor and destitute households are unable to afford to provide three meals a day for their families. Only middle and large farmer households have better income and better quality food whereas other occupational groups who are living beneath poverty line unable to afford any balanced meal. Sometime the income and occupation accomplishment is severely disrupted by frequent hazards and it incurs huge damage of standing crops and other standing resources.

It is evident that the coastal people are subject to victims of natural calamities and on average they remain unemployed few months in a year. It is also evident from the field survey that people remained unemployed for 1 month to 2 months according to 32.5 percent respondents were mostly affected by land area changes mostly river erosion. This piece of work further shows that out of 40 respondents nearly 27.5 percent people were unemployed from about 3 months to 4 months. Besides, about 17.5 percent respondents mentioned that they remained unemployed for about 5-6 months and about 10 respondents remained unemployed for about 9-10 months. On the other hand, about 5 percent respondents remained unemployed from about 11-12 months (table – 1) and it is apparent that regardless of gender variation, a substantial number of males and females are unemployed in the coastal zone (Khan, Iqbal Alam et. al., 2010).

Table-1: Duration of Unemployment of the respondents due to land area change

Months	No. of people	Percentage
1-2	13	32.5
3-4	11	27.5
5-6	7	17.5
7-8	3	7.5
9-10	4	10
11-12	2	5

Source: Author, 2016

ECONOMIC IMPLICATIONS OF LAND AREA CHANGE VARIABILITY

The land area change variability has diverse physical and socio-economic impacts, both in the short and long run. Some natural hazards, like river erosion, are so intense that they destroy people's land assets, while others, such as salinity and water logging, take weeks to manifest their range of effects.

While people have to live in hostile conditions during such events, the main hardships often occur in the post-disaster period when people are left with nothing. The survey data indicate that the wage earners of nearly 95 percent household were unemployed while the female members of around 87.5 percent household are unable to get jobs related to agro based income earning activities. It is also found that climate change causes the loss of the top soil fertility of agricultural land (82.5%) and in accordance with 55 percent respondents they are incapable to cultivate vegetables due to saline water in their land. Besides these, the coastal people are not capable to cultivate seasonal crops (90%) due to land area change variability (table - 2). These findings can be judged by other research with most similar outcomes (see Islam and Rahman, 2012; Nasreen et al, 2008).

Table-2: Economic implications of land area change variability

Economic implications of land area change variability	Number of people	Percentage
Wage recipients of household remain unemployed	38	95
Female members are unable to get jobs related to agro-based income earning doings	35	87.5
Fertile agricultural land loss due to land area alteration or lost	33	82.5
Vegetables cannot be produced due to saline water	22	55
Seasonal crops cannot be cultivated due to severe climate change	36	90

Source: Author, 2016

LOSS OF SEASONAL CROPS

Land area change variability affects seasonal crop production intensely. Due to occurrence of loss of cultivable lands, crop diseases and acute weather crop cannot be grown efficiently. The Figure-3 shows nearly 57.5 percent respondents informed that, they loss 1 to 2 seasonal crops while about 27.5 per cent households cannot cultivate 3 to 4 types of seasonal crops. Besides, around 15 per cent household tried to plant seasonal crops. They are not capable to cultivate 5 to 6 types of seasonal crops due to change taking place in land area (fig. 2).

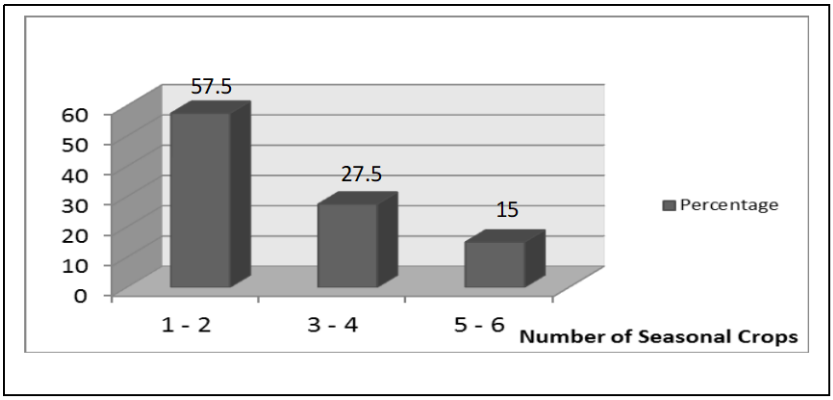
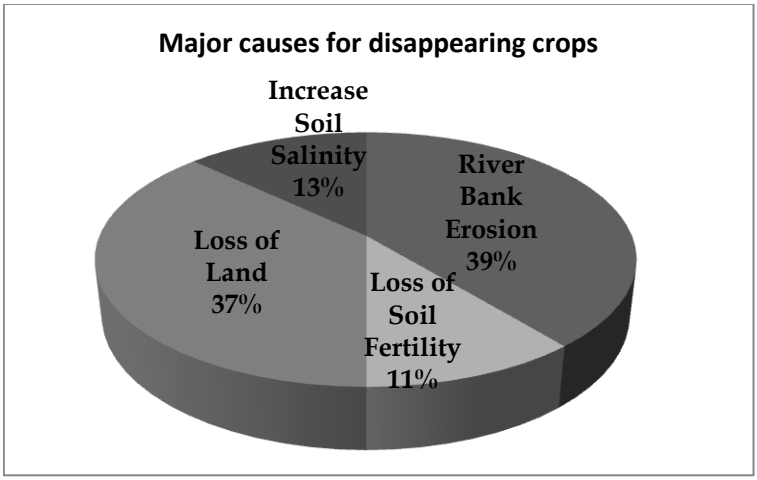


Figure 2: Percentage of seasonal crops that cannot be cultivated due to change in land area *(Source: Author, 2016)*

MAJOR CAUSES AND FACTORS FOR CHANGING OF AGRICULTURAL PRACTICES IN THE STUDY AREA

Several main causes have been recognized for these types of changing of agricultural practices in the study area. In this aspect the climate change issue has been identified as the main factors for changing of agricultural practices in the study area as well as in the whole Bangladesh. According to opinions of the respondent, the identified major causes are shown in the Fig.3. It is observed from the fig.3 that the 'loss of land' was one of the prime causes or responsible issue for changing of agricultural practices in the study area. This issue is guided by the various ways; such as land degradation, agricultural land shifted by the urban land or settlement and directly coastal land or islands are disappeared through sea level rise which is directly or indirectly associated with climate change issue for the study area as well as in the coastal Bangladesh.

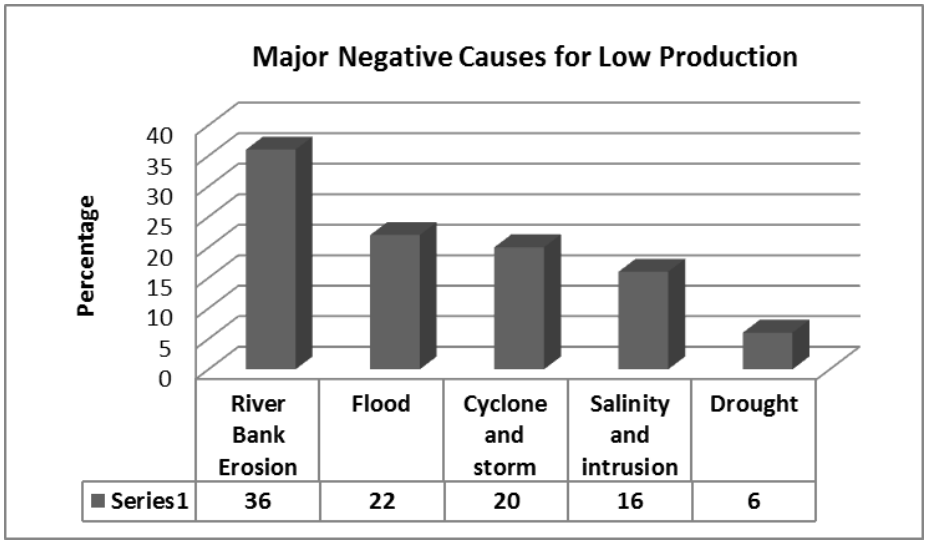
'River Bank Erosion and Increase of Soil Salinity' are also directly responsible for changing of agricultural practices in the study area. The coastal river and liner settlement with cultivable land area of river bank are regularly decreasing through the processes of weathering and erosion by the river system in the context of Bangladesh. At the same time, salinity intrusion is a severe cause for changing of agricultural practices in the study area which is also linked with flow of water and climate change issue. According to opinions of the respondent, some major negative causes were identified which are responsible for low production of crops in the context of the study area. These are shown in the fig. 3. These research findings come up with some variation with other findings in this aspect (see Islam and Rahman, 2012).



Source: Author, 2016

Figure 3: Major causes responsible for disappearing crops in the study area

The below fig. 4 also exposes that the natural phenomenon's which are related to climatic issue were seemed to be accountable for the low or negative production of crops in the study area. It was assumed from the survey that agricultural production was being negatively changed in the study area and numerous number of respondents reported that their agricultural production level and system is decreasing due the various climatic unusual behaviors such as extreme hot summer, sometimes heavy rain fall, unexpected flood and cyclone etc. It is also notable that the study area is mostly coastal based, the largest part of the areas is highly affected by flood and river bank erosion. A major portion of the respondents about 36% claimed river bank erosion as the prime cause or responsible for the negative changes of agricultural production in the study area followed by flood, cyclonic storm, salinity intrusion and drought with the relative opinions as percentage of 22%, 20%, 16% and 6% respectively (fig. 4).



Source: Author, 2016

Figure 4: Major negative causes which are responsible for low production of crops in the study area

ALTERNATIVE LIVELIHOOD STRATEGIES

The choice of alternative livelihood and other activities differ according to environment of land area change affected by climate change. The exaggerated people are taking numerous strategies like to cope with extreme climatic variability. It is seen that food crisis is a severe problem in coastal zone. Like food problem, they also endure from health, housing troubles etc. When they are unable to solve the food crises or other problems, they borrow money from others. The Table - 3 describes that to solve the food crisis or other problems about 85 percent household borrow money from neighbors or relatives while more than 57 percent of the household borrow money from *mohajan* with high interest.

During a particular time they are taking this mean but the means of borrowing money is not a last long solution. Though, they got relief from the government and NGOs, it increases the burden of loan. As a result, in disasters prone areas the coastal communities are trying to solve their problems by selling fish and other handicrafts in the local markets. Around 77 per cent families are now culturing fishes and other handicrafts to maintain certain livelihoods. Livestock rearing is also a significant source of income in all over the country. Though, the affected people cannot rear poultry and layer due to lack of dry space, but have taken livestock rearing as a major income earning source. For example,

about 90 per cent households are now rearing livestock to meet their basic needs (table – 3) and (discover similar findings in Nasreen et. al., 2012).

Table- 3: Types of alternative livelihood strategies adopted by land area change affected people

Alternative livelihood strategies adopted by land area change affected people	Number	Percent
Lent money from relatives/neighbors	34	85
Received relief	18	45
Rented money from Mohajon with high interest	23	57.5
Culture fisheries	31	77.5
Livestock rearing	36	90
Discovering community based livelihood sustenance	27	67.5

Source: Author, 2016

INDIGENOUS ADAPTATION PRACTICES IN THE STUDY AREA

In the study area, adaptation practice is habitually impulsive and instant response of the vulnerable people to different shocks. People apply their adaptation with the assets they have. The livelihood conditions of the people largely depend on the ownership of or access to capital by households which broadly determines their capacity, scope and survival strategy. Local people have improved their own adaptation strategy in last few decades. They don't know the exact meaning of adaptation, they only know that they have to live and for that reason, they have to struggle with river erosion, sea level rise and natural calamities induced problems. As a notion, adaptation for them, therefore, is the other meaning of survival.

REVIEW OF COASTAL ZONE POLICY AND STRATEGY

The government approved and adopted the Coastal Zone Policy in 2005 and the Coastal Development Strategy in 2006. The Coastal Zone Policy (CZPo) provides a policy framework for long-term ICZM (MoWR, 2005). The Coastal Development Strategy (CDS) establishes strategic priorities and activities (MoWR, 2006). The government has also approved the Priority Investment Program (PIP) to be implemented during 2006–2010. Although all these initiatives have created a high expectation among coastal communities, NGOs and government agencies working in the coastal zone, they have yet to be implemented. The CZPo establishes the goal of ICZM as "to create conditions, in which the reduction of poverty, development of sustainable livelihoods and the integration of the CZ into national processes can take place." More specifically, the following development objectives have been determined:

- Economic growth;
- Basic needs and opportunities for livelihoods;

- Reduction of vulnerabilities;
- Sustainable management of natural resources;
- Equitable distribution;
- Empowerment of communities;
- Women's development and gender equity; and
- Conservation and enhancement of critical ecosystems.

The CDS is also built on existing national sectorial strategies and plans and on the document on National Strategy for Accelerated Poverty Reduction (PRSP) (GoB, 2005). Nine strategic priorities and three routes of implementation have been adopted in the CDS document. One of the nine priorities is "Optimizing the use of coastal land." It is elaborated in the CDS document (MoWR, 2006) that the "Land use in the coast is diverse, competitive and often conflicting. Erosion of land is a common feature, especially in the Meghna estuary and on islands. Land is also degrading due to increased river erosion, salinity and water logging. Moreover, new lands are accreting and being gradually developed. Acceleration of the land accretion process and optimum use of these coastal lands would significantly contribute to the regional economy and well-being of the local people. Land zoning is one instrument that optimizes the use of coastal lands."

Comments

The economic growth encourages most of the coastal land-use pattern detrimental to the ecosystem services of the study area. The diminishing potentiality of most natural resource management options with reference to coastal zone like Bhola of Bangladesh has not been differentiated. The climate change issue has been presented in a way conflicting with the natural processes and thus not favoring the ecosystem processes that support land life. The overall economic and living conditions of the coastal Bangladesh have been ignored.

Conclusions

Normally, rice production and income from it rely on different factors like climate conditions, quality of soil, implanting systems and practices, irrigation facilities etc. Historical background of rice production can show huge changes of rice production due to land area change variables especially in Southeast Asia. Moreover, future climate risk is now a key concern for rice yield in Bangladesh especially in low-lying areas. The study area is low lying and adjacent to the Bay Bengal. Due to global warming and sea level augmentation, the area is experiencing more flooding and river erosion then before and thus may be a main reason for low yields.

The findings of the study deliver a details synopsis of the types of land area change impacts on the livelihood of coastal farmers. It is evident that, the impacts of climate change like river erosion related hazards lead to miscellaneous risks and multiple threats on the communities. Climate change induced disasters destroy livelihood options and increase peoples' vulnerabilities. There are numerous elements of vulnerabilities related to current climate variability. Due to extreme weather the climate change affected people are unable to perform their agro-based productions and face other occupational risks. Among the coastal people unemployment seems as a common phenomenon. Though the climate change affected people do not want to move from their residences, climate induced disasters force them to migrate outdoor of village in search of works.

It is evident from the study that in order to cope or adapt with the unpredicted conditions added by climate change local communities are taking several alternative livelihood strategies based on their indigenous knowledge and coping mechanisms. They are trying to adopt with the hostile impacts of climate change by adopting alternative livelihood options such as rearing poultry, planting trees, cultivating vegetables in homestead land, using pond sand filter and harvesting rain water etc. to enhance their livelihood capabilities. The government and other bodies are also providing maintenances to local people to improve a resistant society through their adaptation strategies. The government, often with support from development partners, INGOs, NGOs has introduced social safety net programmes and alternative employment opportunities for the climate change affected coastal people. The study also draws an attention to the institutional and economical factors and opportunities that facilitate people's well beings to cope with climate variability and climate induced calamities.

References

Asian Development Bank (ADB), 2011. *Adapting to climate change: strengthening the climate resilience, of the water sector infrastructure in Khulna*, Bangladesh. Philippines: Asian Development Bank.

Brammer, H., 2014. *Bangladesh's dynamic coastal regions and sea-level rise*. Climate Risk Management, v. 1, p. 21-62.

Government of Bangladesh (GoB). 2005. *Unlocking the potential: national strategy for accelerated poverty reduction.* Dhaka, General Economic Division, Planning Commission, Government of the People's Republic of Bangladesh.

Islam, R., 2006. *Pre and Post-Tsunami coastal planning and land use policies and issues in Bangladesh. Proceedings of the workshop on coastal are planning in Asian tsunami affected countries*, Bangkok, Thailand.

Islam, M.R. 2006. *Managing diverse land uses in coastal Bangladesh: institutional approaches*. In: C.T. Hoanh, T.P. Tuong, J.W. Gowing& B. Hardy, eds. Environment and livelihoods in tropical coastal zones, pp 237–248. CAB International.

Islam, M.R., Ahmad, M., Huq, H. & M.S. Osman. 2006. *State of the coast 2006. Program Development Office for Integrated Coastal Zone Management Plan Project*, Water Resources Planning Organization, Dhaka.

Ministry of Water Resources (MoWR). 2005. *Coastal Zone Policy*. Dhaka, Ministry of Water Resources, Government of the People's Republic of Bangladesh.

MoWR. 2006. *Coastal Development Strategy*. Dhaka, Ministry of Water Resources, Government of the People's Republic of Bangladesh.

Ministry of Water Resources, 2001. *Meghna Estuary Study-II. Hydro-morphological dynamics of the Meghna Estuary*, *Meghna Estuary Study*, prepared by DHV Consultants BV and associates, Bangladesh Water Development Board, Bangladesh.

Nasreen, Mahbuba (2012) *Women and Girls Vulnerable or Resilient?* Institute of Disaster Management and Vulnerability Studies, *University of Dhaka, Dhaka-1000.*

Nasreen, Mahbubaet. al. (2008) *Impact of Climate Change on Agriculture and Food Security*. Published by Action Aid International and Action Aid Bangladesh.

Nishat, A., 1988. *Review of present activities and state of art of the coastal areas of Bangladesh*. Coastal area resource development and management Part II, Coastal Area Resource Development and Management Association (CARDMA), Dhaka.pp. 23–35.

OXFAM (2009), *Disaster Risk Reduction, Climate change and livelihood of the poor and marginalized people.* A Framework for Oxfam GB Bangladesh

R. Selvaraju et al, (2006) '*Livelihood Adaptation to Climate Variability and Change in Drought Prone Areas of Bangladesh'*, ADPC, FAO.

Rajapaksha.U, et al (eds), 2017, "Design that cares"- multi disciplinary approaches to creating sustainable and meaningful built environment: *Proceedings of the 10th International Conference of Faculty of Architecture Research Unit (FARU), University of Moratuwa, Sri Lanka (Vol. 01)*, pp. 61-72 ©

INTERVENTION TO CONTROL COOLING ENERGY OF WEST FACING BUILDINGS: SIMULATIONS FROM COLOMBO, SRI LANKA

SEMASINGHE S.H.A.K.W[1] & RAJAPAKSHA U[2]
[1,2] Faculty of Architecture, University of Moratuwa, Moratuwa, Sri Lanka.
kushanisemasinghe@gmail.com , rajapaksha_upendra@yahoo.com

Abstract
Optimum building influences to decrease the energy demand and enhance the indoor thermal comfort. Buildings facing west in tropics contribute to overheating and subsequently increase the energy demand. This may create a problem of energy oversupply difficulties due to rapid growth of construction, and exhaustion of energy resources and environmental aspects. This study was designed to assess the impacts of the outdoor shadings in order to control heat gain and indoor thermal comfort of west facing front façade buildings, in accordance with the fixed north-south orientation of street and a representative building typology in Colombo. Building namely, building orientation, façade direction, window to wall ratio (WWR), floor to floor height, room depth, were modeled for shade, and cooling load and comfort hours were simulated using the Ecotect software. Buildings were mainly considered into WWR>50% , WWR=50% and WWR<50%. Results suggested that 34.3%, 19.7% and 12.0% reduction of cooling load can expect in WWR>50%, WWR=50% and WWR<50% respectively, with outdoor shading. Optimum angle was found to be 45º for tropics that has minimum cooling load. Outdoor shading with 45º shading angle has a great potential to reduce the cooling demand independent to the different WWR of west facing front façade buildings.

Keywords: *Tropics, Building Orientation, Building Envelope, Outdoor Shading, Energy efficiency*

Introduction

The issues of urbanization, high-rise, and energy efficiency are slowly affecting Sri Lanka. Research also shows that around 60 percent of the population of Sri Lanka would be living in urban areas by 2020 (Ministry of Defense, 2014), although, urban areas contributes to UHI effect, noise, pollution and ordure with the busy roads. Furthermore, availability of site context is a concern in urban areas due to rapid urbanization in Sri Lanka. Thus, respecting the street access and commercial zones, optimizing the building orientation is a major issue in urban precincts. Therefore, generation of urban compact forms with

West facing front facades are an unavoidable response in cities. Notably, highly glazed buildings have become a worldwide design trend in modern architecture for any climate (Lau et al cited in Chown et al., 2010). In developing countries including Sri Lanka, huge façade glazing has been widely used to present positive architectural images such as transparency and modernity. Besides, a huge glazed façade can also provide full external views.

With the cumulative effect, high rise buildings in warm and tropical climate are experiencing overheating due to high solar radiation. West facing large glazed facades are said to be the main cause of this problem. This is because commercial buildings in tropical climates such as those found in Sri Lanka are often installed with air conditioning and mechanical ventilation systems to sustain and improve indoor thermal comfort and productivity of the occupants. Most of the time, these systems consume higher energy among all other building services. The rapid growth of energy use is a major problem at the global perspective with concerns over supply difficulties, exhaustion of energy resources and environmental aspects (Lombard et al 2008 cited in Lau et al 2016).

Passive cooling strategies are the main contributors to minimizing the energy demands of buildings. Building Orientation plays a major role in microclimate modification and enhancing the indoor thermal comfort. Research shows the optimum orientation leads to the provision of thermal comfort, reduces the active control requirements, and provides a reduction in energy use. Literature review by Pacheco et al., 2012; identified that building orientation is the most important and frequently studied design parameter that determines building energy requirements. Al-Anzi.A et al (2010), Odunfa. K.M, et al (2015), Koranteng.C, et al (2009) and Chan.A.L.S (2012) explored the effectiveness of a proper building orientation to decrease insolation and reduce energy demands. Availability of site context is a concern in urban areas due to rapid urbanization in many countries. Thus, respecting the street access and commercial zones, optimizing the building orientation is a major issue in urban precincts. Therefore, generation of urban compact forms with West facing front facades are an unavoidable response in cities.

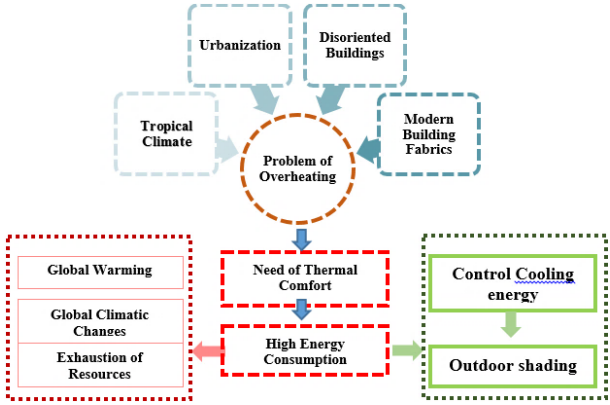


Figure1, Framework for the research background

West facing front façade buildings may be generated due to urbanization and urban planning. This study is established on the research question of 'Can orientation of a building be disregarded in passive design when outdoor shadings are optimized and what impact does it have on energy efficient cooling loads?

Main classes which can decrease insolation, increase shading and reduce energy demands are Building orientation, Window to wall ratio, Shading devices and Façade self-shading (Liu, Wittchen, & Heiselberg, 2015). Kumar, Kaushik, & Garg, 1995 evaluated the performance of solar passive cooling techniques such as solar shading, insulation of building components and air exchange rate.

The framework developed to test this hypothesis was composed of building orientation, Façade orientation, WWR, floor levels, and shadings on façade were considered as main contributors to affect the cooling loads.

Solar shading on building surfaces

Apart from the optimum orientation, solar shading can reduce the heat gain and it contributes to the energy efficiency of the building. Thus, this research focuses on optimizing the building structure within the building envelope as a heat gain control method. Therefore, it seeks to find the potential of outdoor shading in order to control energy consumption for cooling load.

(David, Donn, Garde, & Lenoir, 2011) evaluated the relations between some simplified performance indicators of energy demand, thermal comfort

and visual comfort, i.e. the solar shading coefficient, cooling energy demand, daylight autonomy and sun patch index on work plane. (Tzempelikos, Bessoudo, Athienitis, & Zmeureanu, 2010) introduced a transient thermal comfort model to investigate singularly the impact of different shades and three kinds of glazing on mean radiant and operative temperatures, thermal discomfort index, radiant asymmetry, and daily heating needs for a perimeter office with a high window area. The combined effect of different shading devices and shading control strategies for visual comfort optimization and for artificial lighting minimization have been analyzed by some authors (Koranteng & Mahdavi, 2011; Seo, Park, Ihm, & Krarti, 2012).

(Kumar, Kaushik, & Garg, 1995) analysis suggested that solar shading is quite useful for the development of passive cooling system to maintain indoor room air temperature lower than the conventional building without shade. Outdoor shading devices are the most efficient thermally because they intercept the solar energy before enter the room. Effectiveness of outdoor shading devices depends on type and placement relatively glass (Kim, Lim, Lim, Schaefer, & Kim, 2012). Jeehwan Lee et al summarized with his study that horizontal shading devices are more effective in heating and cooling energy saving than vertical shading devices (Lee, Alshayeb, & Chang, 2015). Also Poirazis, Blomsterberg, & Wall, (2008) used a comfort set point strategy for operative temperature and luminance. A minimum acceptability level for thermal comfort satisfaction was introduced.

Double skin façade

A double skin façade consists of an external glass surface, a shading system, a gap filled with air and an insulating double internal glazing system, sometimes integrated with opaque walls (Wigginton & Harris, 2004). The gap is ventilated through the air flow driven by the buoyancy effect (Natural convection) or by mechanical devices (Forced ventilation). During the summer months, in countries with warm climates, the double skin configuration could easily bring about gap overheating, with the consequent dramatic increase of cooling loads (Gratia & De Herde, 2004).

Window to wall ratio

The effectiveness of the WWR designed to decrease insulation and achieve reductions on energy demands were investigated in many researchers (Inanici & Demirbilek, 2000; Pino, Bustamante, Escobar, & Pino, 2012). External shading devices are much more effective than internal devices, providing better performance of shading and view. (Kim, Lim, Lim, Schaefer, & Kim, 2012). Jeehwan Lee et al summarized with his study that horizontal shading devices

are more effective in heating and cooling energy saving than vertical shading devices (Lee, Alshayeb, & Chang, 2015).

The focus area: case of Colombo

Specific overlapped physical appearances have demarcated the contribution to thermal comfort in urban form of Colombo.

- Location, the tropical monsoon climate
- The urban morphology
- The street profile

With the location of west coast and the fast developments, Colombo has faced the most critical climatic issue of thermal comfort. According to Emmanuel (as cited in Maharoof in 2016) at the same time Colombo is blessed with high year round incidence of solar radiation.

The preliminary selection of the urban plot was through physical observation. It was noted that the Colombo 3 and Colombo 4 areas were one of the most fast developing areas with a relatively large number of office and institutional buildings. Most of these buildings have east-west oriented front facades in response to the fixed north-south orientation of the Galle road and R.A. De Mel road. Furthermore, office building development is currently in proliferation within this continuous development of this area. Therefore, the plot defined by the two main transport lines with fixed north-south orientation in the area namely Galle road and R. A. de Mel Road was selected for the study.

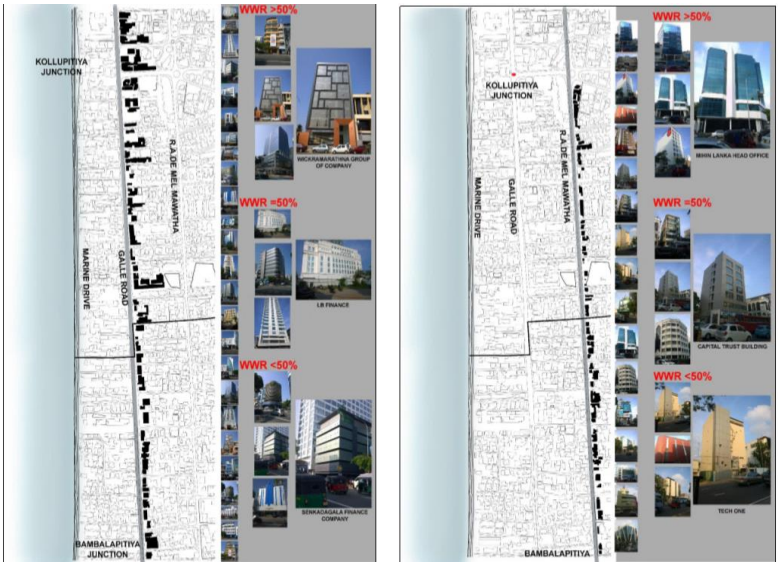


Figure 02, Identified buildings in representative plot(Photographic survey in Galle road and R.A.De Mel road)

Constructing the base cases

In the context of this exploration, there are different types of building typologies varied with the glazing area of the front façade. The initial data collection found that the base cases for simulation would be defined based on three types of WWRs.

- Glazing covers more than 50% of window to wall ratio. (WWR>50%)
- Glazing covers 50% of window to wall ratio. (WWR=50%)
- Glazing covers less than 50% of window to wall ratio. (WWR<50%)

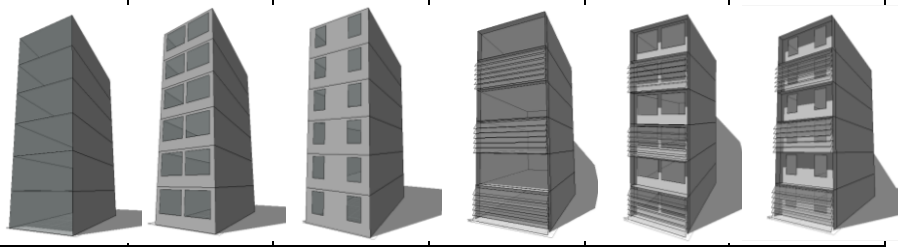
To develop the three types of base cases and identified the impact of shading on annual cooling loads following criteria were set on the base case:

- Un-shaded façade by louvers or other external shading systems
- The building plan is a square thus indicating climatic influence on all facades and disregarding the effect an elongated plan in certain orientation on cooling loads
- The building should be free standing so without shade from neighboring buildings

Types of shading device for simulations

Due to geographical location, most office buildings in Sri Lanka are facing the problem of overheating especially how direct sun light can be prevented especially from West direction. This part of the study involved simulations of three types of building facades namely WWR>50%, WWR=50%, and WWR<50%. In order to investigate the effect of shading devices on each façade type (WWR ratios) in regard to cooling energy savings, the Double Skin Facade (DSF) was applied on WWR>50%, WWR=50%,and WWR<50% separately for simulations of annual cooling energy consumption. The width of the air gap of DSF was fixed at 1000mm, vertical spacing of louver was fixed at 300mm and louver blade depth was fixed at 300mm as recommended by many studies conducted in the tropics with considerations on aesthetic and considerations on day lighting (AlTamimia et al 2011). There were a total 6 simulations carried out for this purpose. Applied shading device details are shown in Table 01.

Table 01, Base cases and proposed cases for Computer Simulation

Base Case			Proposed Case		
WWR>50%	WWR=50%	WWR<50%	WWR>50%	WWR=50%	WWR<50%
					

Types of shading device angles for simulations

As mentioned earlier, the focus of this study is on the effect of different types of shading devices on each façade types in terms of cooling energy savings (figure 03). However the focus extends to further challenge this issue with reference to different shading angles i.e. 10º,20º,30º, 45º, 50º,60º,70º,80º. In this part of simulation, the 45º angle shading was replaced by above angles with 6mm Double glazed Low e glazing with Solar heat gain coefficient (0-1) 0.7, Visible transmittance(0-1) 0.639 and U-value 2.26W/m2 k. There were 6 simulations carried out by applying to façade types of WWR>50%, WWR=50% and WWR<50% for comparisons on cooling energy savings. With this, we are able to understand the energy saving effects of various shading angles on different WWR ratios.

Method of Simulation

Developed representative building within an urban environment with typical design parameters from the initial studies carried out within the field investigation. Simulate the representative building (base case) using Eco-tect 2011 software. Simulation is for existing and proposed building with DSFs.

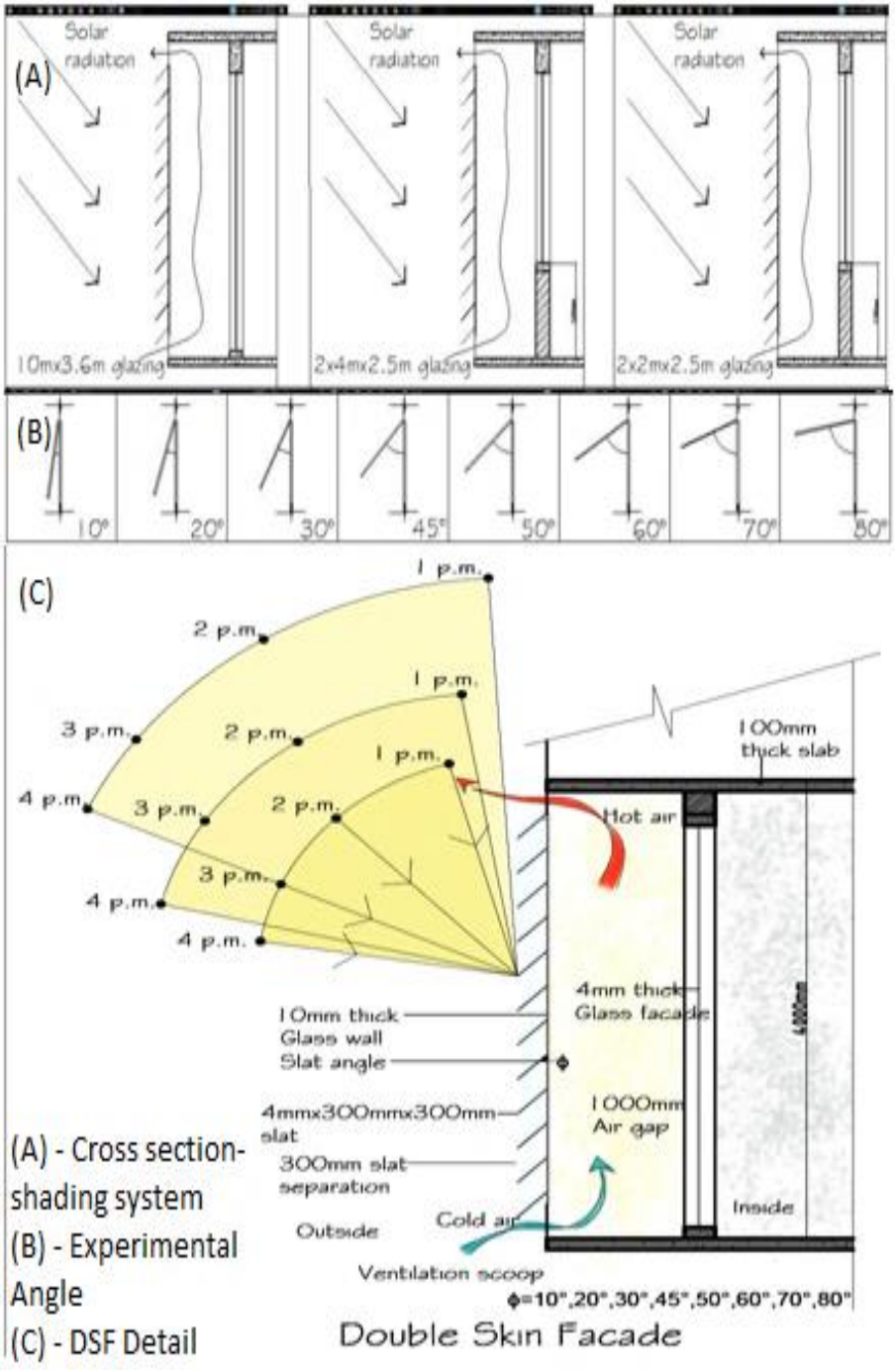


Figure 03, Existing cases and proposed cases with shading angles

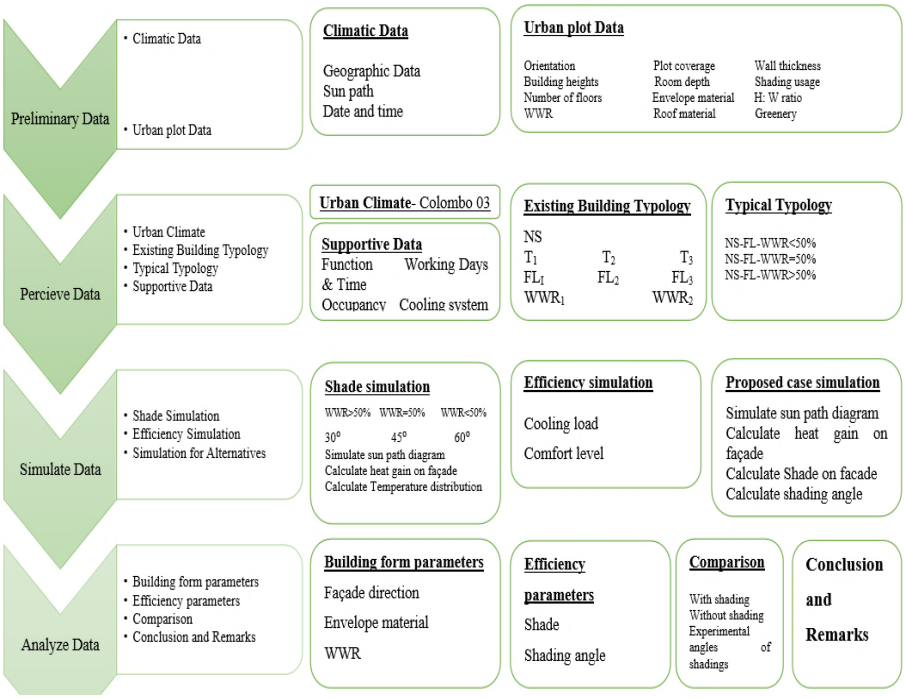


Figure 4: Framework to the Research Design: Case of Colombo urban precinct

Data Analysis

Data was analysed by STATA version 13.0. Simulated data with and without shading under each WWR category was separately analysed by one sample t-test. Null hypothesis was "cooling load is not significantly different in between shaded and non-shaded cases". Null hypothesis was failed to accept in 95% significant level as p-value < 0.05 in all cases. In addition, one way analysis of variance with Bonferroni pair wise analysis was performed to test whether any significant difference of cooling load among three WWR cases. In all pairs (WWR>50% vs WWR=50% , WWR=50 vs WWR<50% and WWR>% vs WWR<50%) cooling load was significantly different with associated p-values p=0.045<0.05 , p= 0.043 < 0.05 and p= 0.000<0.05 respectively. Minimum cooling load was observed at an angle of 45^0 of all three WWR categories and this value was significantly lower than all other cooling load values in 95% significant level, obtained at different angles, with p-values=0.000<0.05 of all cases.

Table 02, characteristics of cooling loads

WWR	With shading (Wh)	Without shading (Wh)	p-value	Shading angle=45 (Wh)	Shading angle other than 45 (Wh)	p-value
WWR> 50%	97383105	136302144	0.0000	89543096	98503106	0.0002
WWR= 50%	91677674	102301528	0.0003	82142568	93039832	0.0001
WWR< 50%	86020862	89466408	0.0083	78730552	87062335	0.0000

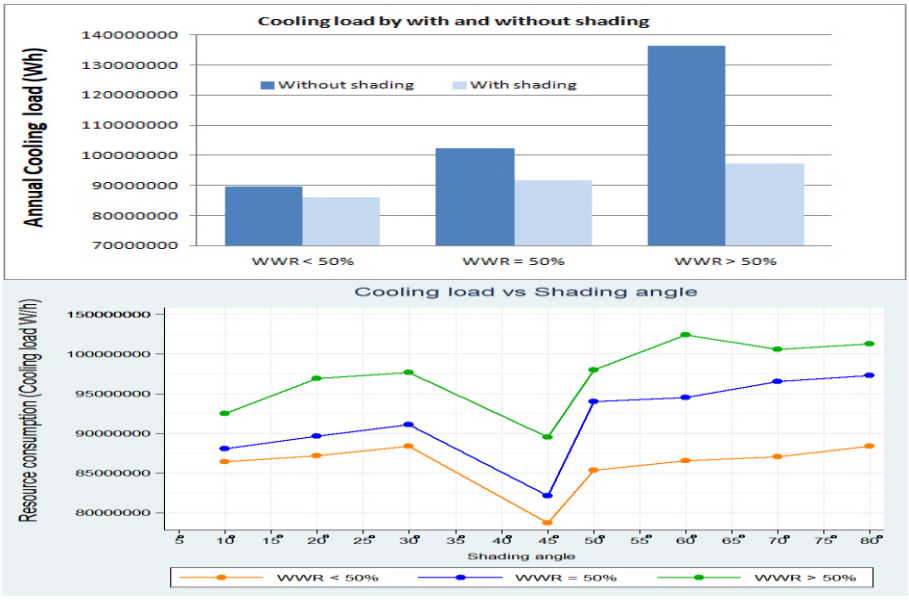


Figure 05: cooling load variation with shading and shading angle

Figure 05 demonstrate cooling load variation before and after applying shading and different shading angles. Cooling load was noticeably lower after applying shading. Lowest cooling load was observed in 45^0 degree.

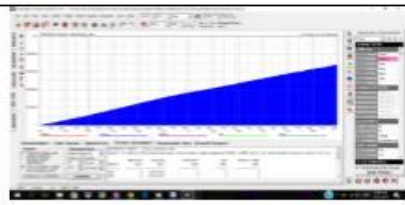
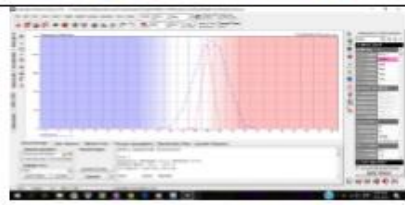
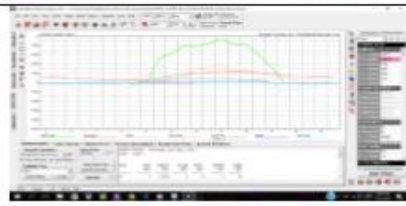
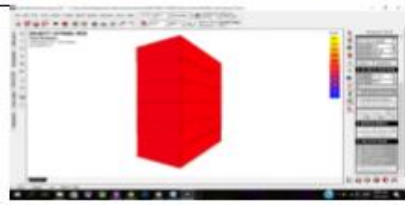
Case 1.1_ no shading			
Resource consumption (Annual cooling load/Wh)		Graph/ Monthly values	
		Cumulative values	
Thermal analysis (None Cooling system)	Temperature distribution	2D Graph	
		Percentage	
	Hourly heat gain	2D Graph	
		Watts	
	Hourly temperature profile	2D Graph	
		Celsius	
Solar access analysis		Color range for mapping	
		Watts hour per square meter	

Figure 5: Method of simulate data presenting

Limitations and Recommendations for future research

This study was carried with a series of influential factors such as geographic location, the period of the study, sky conditions, diffuse solar radiation kept at a constant. These factors can also have an influence on the selected case studies. At the same time study was conducted with free standing buildings that consisted of fixed geometric forms, material properties, and occupancy profile

which too may clearly have a significant role in the cooling load and indoor thermal comfort.

The main avenue for research could be in depth study with varied Altitude, Azimuth angles, HSA, VSA during the year. This would enable to identify patterns with shading angles and then shading devices could be further expanded with the movable shadings a cording to daily sun path and annual sun path.

Concluding remarks

A significant amount of undue expenses and energy is consumed in tropical region buildings to keep inhabitants in comfort. Furthermore, required energy proportionally rises with WWR. Applying outdoor shading considerably reduces the cooling demand independently to the WWR. In addition, external energy demand significantly associated with shading angle and lowest when angle is 45. Shading with angle 45^0 reduces 34%, 20% and 12% of energy consumption for WWR>50%, WWR=50% and WWR<50% respectively. Introducing shading with optimum shading angle will give a huge external energy reduction and this brings positive benefits to the major potential problem of oversupply difficulties due to rapid growth of construction and exhaustion of energy resources and environmental aspects.

References

Aksamija, Ajla. “Regenerative Design of Existing Buildings for Net-Zero Energy Use.” *Procedia Engineering* 118 (2015): 72–80. doi:10.1016/j.proeng.2015.08.405.

Atzeri, Anna, Francesca Cappelletti, and Andrea Gasparella. “Internal Versus External Shading Devices Performance in Office Buildings.” *Energy Procedia* 45 (2014): 463–72. doi:10.1016/j.egypro.2014.01.050.

Baldinelli, G. “Double Skin Façades for Warm Climate Regions: Analysis of a Solution with an Integrated Movable Shading System.” *Building and Environment* 44, no. 6 (June 2009): 1107–18. doi:10.1016/j.buildenv.2008.08.005.

Chan, A.L.S., T.T. Chow, K.F. Fong, and Z. Lin. “Investigation on Energy Performance of Double Skin Façade in Hong Kong.” *Energy and Buildings* 41, no. 11 (November 2009): 1135–42. doi:10.1016/j.enbuild.2009.05.012.

Eskin, Nurdil, and Hamdi Türkmen. “Analysis of Annual Heating and Cooling Energy Requirements for Office Buildings in Different Climates in Turkey.” *Energy and Buildings* 40, no. 5 (January 2008): 763–73. doi:10.1016/j.enbuild.2007.05.008.

Gratia, Elisabeth, and André De Herde. “Is Day Natural Ventilation Still Possible in Office Buildings with a Double-Skin Façade?” *Building and Environment* 39, no. 4 (April 2004): 399–409. doi:10.1016/j.buildenv.2003.10.006.

Hyde, Richard. *Bioclimatic Housing: Innovative Designs for Warm Climates*. Routledge, 2012.

Rajapaksha.U, et al (eds), 2017, "Design that cares"- multi disciplinary approaches to creating sustainable and meaningful built environment: *Proceedings of the 10th International Conference of Faculty of Architecture Research Unit (FARU), University of Moratuwa, Sri Lanka (Vol. 01)*, pp. 73-85 ©

MICROCLIMATIC IMPACTS OF HIGH-RISE CLUSTER DEVELOPMENTS IN COLOMBO, SRI LANKA

VIDANAPATHIRANA. M[1], PERERA. N.G.R[2] & EMMANUEL. R[3]
[1,2]Department of Architecture, University of Moratuwa, Sri Lanka,
[1]*malithie.v@gmail.com*, [2]*nareinperera@gmail.com*,
[3]School of Engineering and Built Environment, Glasgow Caledonian University, UK,
Rohinton.Emmanuel@gcu.ac.uk

Abstract
Colombo is rapidly expanding both horizontally and vertically. With limited land and infrastructure resources, the adoption of compact forms invariably result in high-rise developments and Colombo is not an exception. Current regulation limits its scope to individual plots rather than an urban area. We map the city and its current developments utilising the Local Climate Zone system, to identify critical zones and select case studies. With a focus on microclimatic impacts at street level, we simulate selected high-rise clusters, typical podium shape changes, within a similar Frontal Area Index (FAI), using the software ENVI-met. Results show that having a block form podium and increasing building height resulted in lower mean radiant temperature (MRT) values. Reducing the FAI or removing podiums increased wind movement, yet resulted in adverse MRT effects at pedestrian levels in the immediate vicinity of the cluster. The theoretical shadow umbrella simulation option reduced MRT by a significant degree while still maintaining comfortable wind speeds. Conclusions highlight that high-rise building clusters have a significant impact on their surrounding environment. Thus, it is essential that urban planning and policy strike a balance between development goals, quality of life of inhabitants and climatic implications.

Keywords: *High-rise cluster, Podium forms, Frontal area index, Shadow umbrella, Microclimatic implications*

1. Introduction

The creation of compact urban forms with a view to - minimise space and energy - more often than not, translates into high-rise developments, with a focus on energy management at their outer envelopes. A building focused approach, means that buildings are treated as stand-alone entities with minimal consideration of their impact on the surrounding urban landscape and vice versa. If / when each building pursues its own sustainability agenda without regard to its urban context, the result will diminish the natural energy resources

available for nearby buildings and worsen the outdoor environment generally. (Futcher et al, 2017)

The introduction of haphazard developments, especially those of the scale of over 100 meters in height results in changes to the surrounding micro-climate, both favourably and unfavourably and could be the cause for increased discomfort for users of the buildings and surrounding region. As seen in Hong Kong in 2006 with the wide spread of disease - deemed to be caused by stagnant air and reduced wind flow - as a direct result of the unregulated construction of high-rise buildings. Unchecked development in Colombo could also lead to unliveable environments and health hazards.

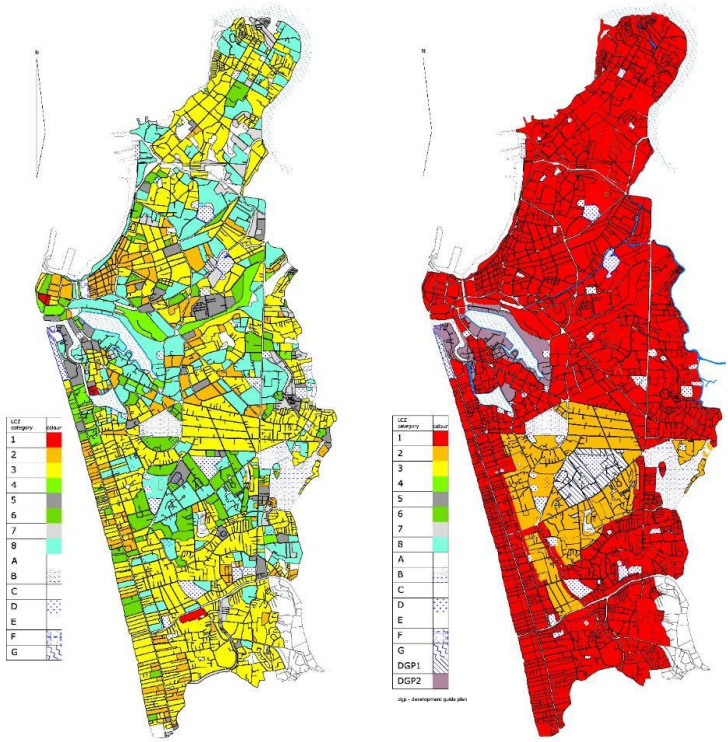


Figure 1. Existing (2010) and projected (2020) LCZ classification patterns for Colombo (Source: Perera and Emmanuel, 2016)

Perera and Emmanuel (2016) highlight this issue, by comparative mapping of the existing and projected Local Climate Zones (LCZ) in the purview of the 2008 ‘City of Colombo Development Plan (Amendment)’ by the UDA for

2020 (Law No. 41 of 1978 (Gazette of Democratic Socialist Republic of Sri Lanka Extraordinary No 1535/4 of 6th February 2008)). (Figure 1.)

With mega constructions already underway in Colombo, we explore a better understanding in a warm humid context, through the study of the microclimatic implications of these buildings and building clusters.

The primary objective - and therefore the innovation - of the research, is an attempt to bridge gaps relative to the effect of high-rise developments / clusters in the hot humid climate of Colombo, Sri Lanka with a view to problem identification and the conception of a holistic approach to urban planning, urban design and policy.

We generate the following research questions to facilitate the objective of the study;

- How has the urban morphology of Colombo changed?
- High-rise developments in Colombo and their effects? A climatic snapshot of the existing built fabric of Colombo.
- Key climatic factors effected by high-rise developments and how to mitigate street level pedestrian comfort and the UHI effect in Colombo by manipulating form, layout and other morphological factors.

Limitations of the research;

- This study is limited to a selected study area of Colombo, Sri Lanka which has a warm humid climate.
- As the study focusses on the effects of high-rise developments and mitigating UHI factor, all climatic effects were considered at height of 1.8m. (Screen Level)
- Local climate zone mapping was carried out under calm and clear sky conditions. Critical areas or hot-spots were selected from the analysis of the LCZ mapping.
- Simulations were done considering the month of April 2017 which is deemed one of the most uncomfortable months of the year in Sri Lanka, thus taking into consideration the worst possible scenario.
- Simplification of the urban morphology for both LCZ mapping and ENVI-met simulation studies.

2. Background

High-rise and sustainability

The definition of high-rise is abstract and refers to a very tall building. As defined by the UDA planning and building guidelines (UDA, 2008), a building with 13 or more floors including the ground floor is defined as a high-rise.

While high-rise developments can have a significant positive impact on social and economic elements of a city, ‘ the high-rise building typology is not usually considered environmentally sustainable, due to its intensive use of energy, material and other resources during its whole life cycle, although it has merits such as saving land resources and transportation costs’ (Goncalves, 2010). Thus, a philosophy of ‘do less harm’ than ‘do more good’ is adopted in the construction of high-rise developments and city planning.

Effect of high-rise buildings on climate elements

There are various elements in the built environment which alter its surrounding thermal environment. Few such elements mentioned in Pandya (2014) when considering high-rise clusters are; Urban geometry – Variations in building heights and distances in-between them; Local climate – relative humidity, external air temperatures and prevailing wind speeds and directions; Orientation and overshadowing – Position of tall buildings with respect to south (northern hemisphere) and its exposure to solar radiation and overshadowing over low rise buildings within the cluster; Solar access, solar radiation and albedo; Urban canyons.

In addition to reflecting direct solar radiation high-rise buildings also absorb and reflect solar radiation from other buildings. This is especially seen in instances where the urban fabric consists of buildings of differing heights **(**Arslan and Sev, 2014). Arslan et.al further stated that urban structure, city size and population, density of built-up area, ratio of building height to distance between them, width of streets, materials used in construction, types of surfaces and sky view factors of structures, are some factors which impact climate of urban heat islands. Similarly, Giridharan (2004) considered physical properties that are influential on creating a heat island effect: ‘thermal properties of material, radiative geometry, urban greenhouse effect, anthropogenic heat, reduction in evaporative surface, reduction of albedo by canyon geometry, and reduced turbulence transfer’.

Wind flow is significantly altered by the presence of high-rise buildings. The strong winds generated near a high-rise building result in loops of dust and air pollution forming near user areas while the cleaner air flows over the urban canopy layer. (Aldeberky, 2004)

Urban Heat Island (UHI) and Local Climate Zones (LCZ)

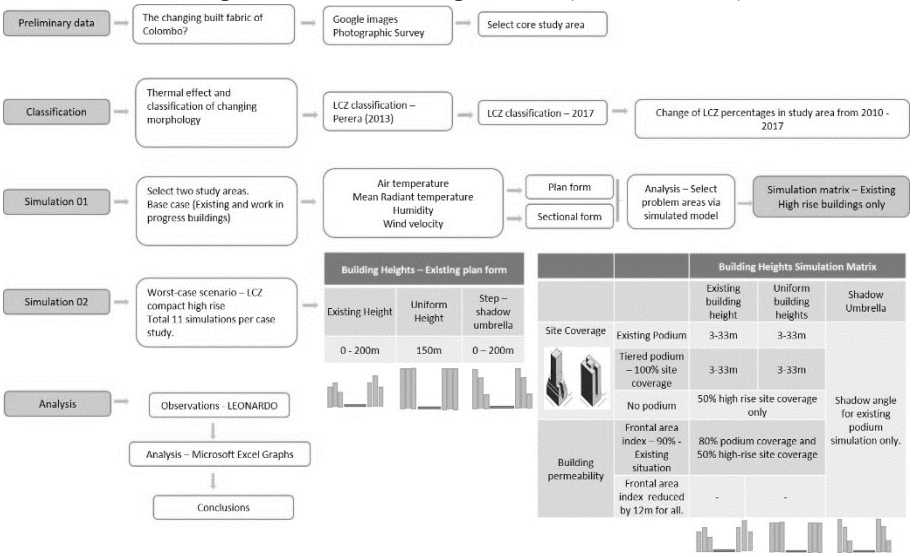
“In order to achieve this goal of a sustainable city, it is essential to understand urban climatic information and apply them in the urban planning and design process”. Mills et al. (2010). Evaluating the UHI impact on a city has been adopted as a well-accepted and easily understood means to bridge the climate-urban design links in development of urban areas. The new “local climate

zone" classification system provides a research framework for urban heat island studies and standardises the worldwide exchange of urban temperature observations (Stewart, and Oke, 2012), thus, creating the opportunity to build upon the simple 'urban' to 'rural' comparison. LCZs are formally defined as regions of uniform surface structure, material, and human activity that can span hundreds of meters to several kilometres in horizontal scale. The discussion on UHI intensity is then translated as a comparison between LCZs, thereby easily adopted in different contexts and climates. Although there are 17 different classifications, it is still a generic system and thus, cannot capture all the various peculiarities of a city. Its view of the landscape universe is highly reductionist, and, like all classifications, it's descriptive and explanatory powers are limited (Stewart and Oke, 2012).

3. Method

We adopt a method of first understanding the existing context - utilising the LCZ classification system - and thereafter, simulating the impact scenario

Figure 2. Research Design Matrix (Source: Author)



(using ENVI-met) of future developments, on its immediate environs. The step-by-step approach adopts the following research design matrix. (Figure. 2.)

Site Selection and LCZ classification

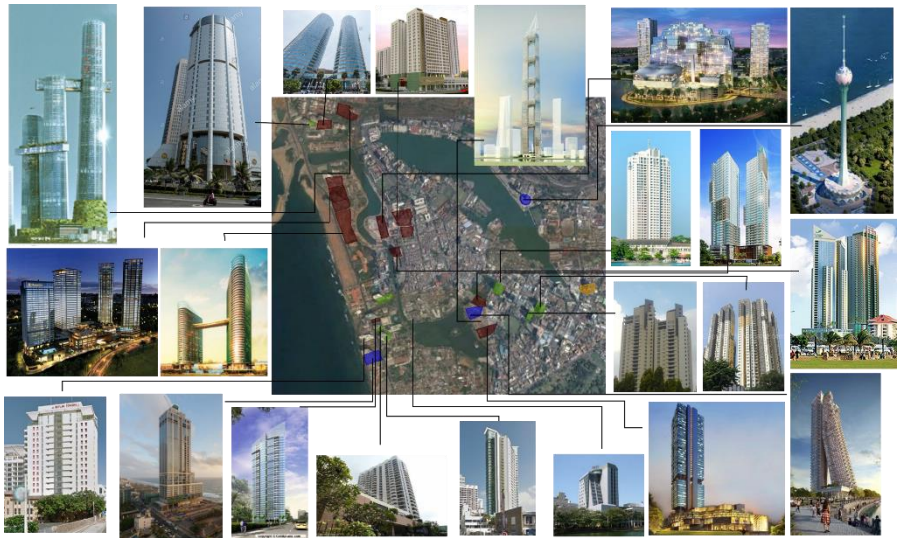


Figure 3. On-going and planned developments in Colombo (Source: Author)

The greatest impact of Colombo's rapidly changing skyline is seen predominantly in close proximity to the commercial hub and also abuts significant heat sinks in the city – the Ocean and Biera Lake. (Figure 3.)

A detailed LCZ classification that builds upon the classification by Perera (2015) based on data collected in 2010, showed significant development by 2017. (Table 1.)

Table 1. Percentage increase or decrease of LCZs from 2010-2017

Local climatic Zone	2010 condition of study area		2017 condition of Study Area		Percentage increase or decrease of 2010 values in 2017
	Sq.m	Percentage	Sq.m	Percentage	
LCZ 1 – Compact high-rise	23960	0.98	271184	11.16	1031%
LCZ 2 – Compact midrise	200430	8.25	784769	32.29	291%
LCZ 3 – Compact low-rise	487620	20.06	565710	23.28	16%
LCZ 4 – open high-rise	104717	4.31	134500	5.53	28%
LCZ 5 – open midrise	402310	16.58	56502	2.33	-85%
LCZ 6 - open low-rise	383063	15.76	246030	10.12	-35%
LCZ 7 – lightweight low-rise	41990	1.73	20000	0.82	-52%
LCZ 8 – Large low-rise	717670	29.53	351440	14.46	-51%

Based on the LCZ evaluation, we select two cluster developments, (classified as LCZ1) as case studies. Site 01 - 'Crescat Region' is along Galle Road (oriented North-South) the main vehicular artery in Colombo running parallel

to the coastal line. Site 02 - 'Altair Region' is flanked by West Beira Lake on one side and Union Place (main road) on the other. Site 01 shows a linear formation in its high-rise buildings, while Site 02 shows a more circular cluster with a playground at its centre. (Figure. 4)

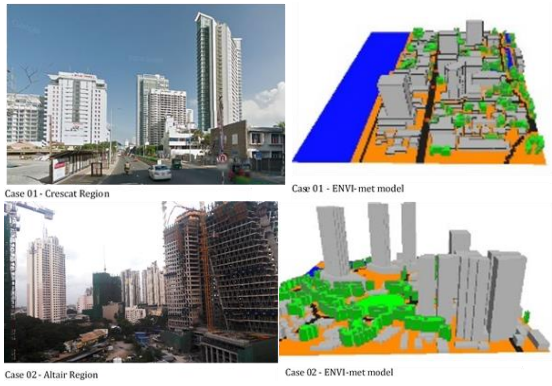


Figure 4. Selected case study sites and simulation model *(Source: Author)*

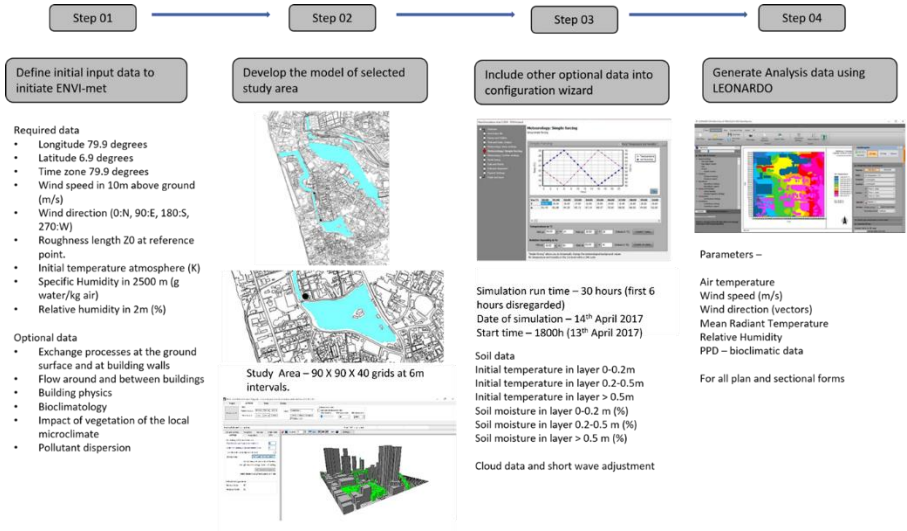


Figure 5. Simulation matrix *(Source: Author)*

Simulation Method and Matrix

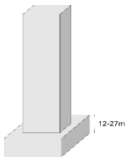
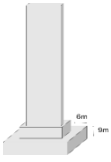
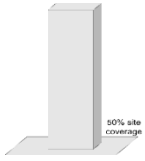
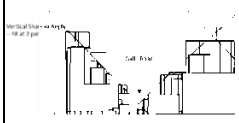
We utilise ENVI-met, a holistic microclimate modelling system to generate comparative data for different morphology scenarios. ENVI-met is a three-dimensional microclimate model designed to simulate the surface-plant-air interactions in urban environment with a typical resolution down to 0.5 m in space and 1- 5 sec in time. (envi-met.info).

Data for 22 simulation models were generated encompassing two cases, four podium forms and two building heights as per the process diagram given below.(Figure. 5). The Frontal Area index (FAI) was considered to regulate and facilitate wind movement and allow access to heat sinks in dense high rise cities. A detailed calculation of FAI for a typical Colombo scenario is seen in Vidanapathirana (2017).

Simulation Scenarios

Simulation scenarios detailed in Figure.5, represent key morphological changes at street level. The street level or screen height (taken as 1.8m) are deemed the most important in a tropical context, where outdoor living, therefore thermal comfort, is a vital concern. The following Table 2, details out the four podium forms adopted - existing, tiered, no podium and shadow umbrella. The concept of a 'shadow umbrella' discussed in detail in Emmanuel (2005), where by the use of shadow angles, buildings can be manipulated to provide shading to each other during the most crucial times of the day. This theory was used as a design consideration in order to minimize the UHI effect within this study and taken as Case 04.

Table 2. Morphology cases refered to in the simulation matrix (Figure 5)

Case 01	Case 02	Case 03	Case 04
Most existing podiums include the maximum site coverage possible (60-80%) with heights ranging from 12m to 27m of block form.	A wedding cake structure or tiered podium form covering 80% site extent was considered as the second alternative approach to urban block design. The model was designed to have an outside podium height of 9m width 6m and increasing inward by 9m in height every 6m.	The third or 'no podium' approach maintains a 50% site coverage as per UDA building regulations and attains a 'block form' at street level.	Building height was increased or decreased to form a 48° angle from the west and a 47.2° angle from the east to shadow the buildings and road before 10 am and after 2 pm which is when the road is most active.
			

Analysis protocol

Simulation output data for the parameters; Sky View Factor (SVF), Mean Radiant Temperature (MRT), Air Temperature, Relative Humidity and Wind Velocity were obtained for a single day (24 hours on 14th April 2017) using ENVI-met. The graphical analysis and presentation of climatic data generated utilised the supportive plug-in for ENVI-met – LEONARDO. Sectional wind formations were best seen the LEONARDO graphs where the wakes formed by the high-rise buildings are seen as clouds on the windward side of the building and wind shadows are formed on the leeward side.

A comparative trend pattern graphs were prepared via analysing the data extracted using Microsoft Excel. Variations for a given day were compared at different locations for each scenario. Similarly, variations within case study sites were analysed by modelling measurement points represented as receptors in the ENVI-met simulation nomenclature.

4. Results and Discussion

The analyses encompass a series of scenarios developed with the primary objective of identifying the effects on the surrounding microclimate as a result of high-rise clusters in Colombo.

Study shows that SVF is inversely related to the degree of shading, thus, as SVF reduces, shading increases. Increased podium heights offer reduced SVFs and better shading opportunities at pedestrian level. Substituting a block podium with a tiered podium increases wind flow at pedestrian level, however offers less shading as it has a higher SVF value.

Established knowledge suggests MRT is directly affected by shading and the outcome of simulation options in the study clearly supports this argument. Block form podiums thus show lower MRT values at pedestrian level when compared against no podium and tiered podium forms. Thus, as a design intervention; tiered podium forms with additional shading devices at pedestrian level such as colonnades or semi-permeable spaces such as green canopies would help shade areas, thus creating comfortable thermal conditions at pedestrian levels. The additional shading would help reduce the overall MRT increase. Figure.6 maps the effect of the different podium forms on MRT within the course of the day.

Results from simulations also show that removal of podiums from high-rise buildings result in heightened climatic effects (wind speeds, MRT, air temperature and humidity levels) at pedestrian level. (Figure. 7 and 8) It was found that removing of podiums and reducing FAI facilitate wind movements.

However, reducing FAI does little to change the wind movements within the immediate vicinity. Rather, it has a more holistic approach by allowing wind to flow into inland areas and this theory could be used in urban blocks near rivers, parks, sea front and other heat sinks to gain wind penetration and help reduce the UHI effect at night.

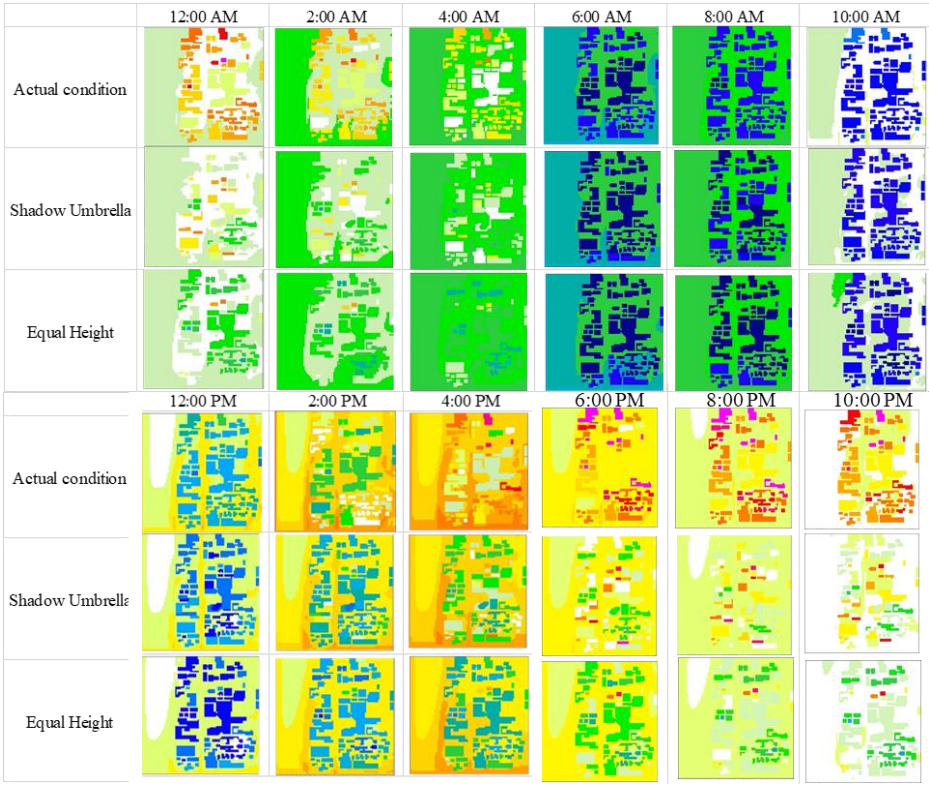


Figure.6. Effect of the different podium forms on MRT *(Source: Author)*

Colombo is fast transforming to a dense high-rise urban fabric, as seen in the projected LCZ classifications. Design interventions and regulations need to be implemented with immediate effect in order to mitigate adverse effects due to cities planned without adequate, overall consideration of climatic impacts, especially at street level. Results show the shadow umbrella intervention to be the most effective to reduce MRT and air temperatures, therefore UHI, in a compact high-rise cluster.

However, Colombo's location and orientation limits the use of shadow umbrella without compromising on wind movements. Coupling shadow umbrella cluster form with reduced FAI at heat sinks such as on the coastal belt

would improve wind flows and rate of cooling in the night while shading during the day, thereby mitigating UHI factor. Introducing permeable tiered podiums with tall, thin high-rise structures will be the most effective form of high-rise cluster to mitigate urban heat island effect in Colombo.

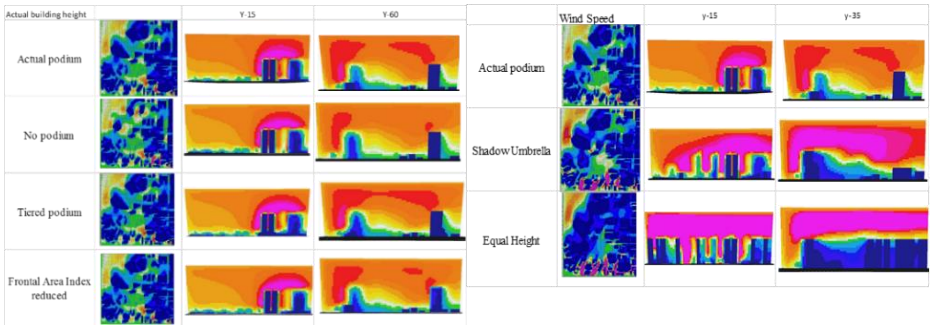


Figure 7. Effect of the different podium forms and building heights on Wind Speed *(Source: Author)*

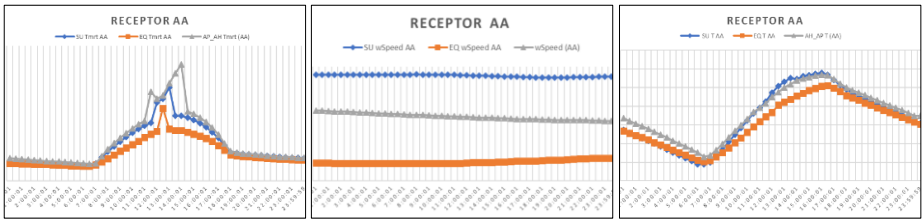


Figure 8. Effect of the different building heights on MRT, air temperature and wind at a given point through 24 hours *(Source: Author)*

5. Conclusion

The focus of the study - limited to the hot, humid climate found in Colombo, Sri Lanka - was to analyse the effect of high-rise buildings on its surrounding microclimate. The study was primarily associated with simulating changing building morphologies at the height at which a person would perceive the surrounding environment (screen height level). For a greater understanding of both the urban fabric morphology and the microclimatic aspects the LCZ classification system was applied a under calm and clear sky condition. The LCZ classification also allowed the identification of critical areas in the city, thus, selected as case studies.

A two clusters and its immediate surroundings were selected for simulations. Although, a larger area surrounding multiple clusters would have given a more

holistic understanding of the climatic effects of a high-rise cluster. The simplification of the built fabric for simulations, the simulation time (24 hours) and a single day of a year, are the limitations of the simulation software itself, yet deemed applicable in a comparative option analysis. The study took into consideration the existing cluster formation and explored changes to podium forms. Existing building formations do not adhere to a single specific typology, site coverage, orientation or height. This limits the possibility of generating general standards for future planning and policy formulation, yet establishes an important base for future studies.

The regulation on high-rise development in Colombo city defines a maximum plot coverage of 50%, but does not explicitly define or discuss the podium levels of a development. This has far reaching implications for people using the urban outdoors.

The overall effect of high-rise clusters in the city are clear in terms of their impact, especially at pedestrian level and on its immediate environs. The study highlights the need for regulation of such developments, as stated by Futcher et al. (2017) - A fabric-first approach that treats the building as an isolated entity needs to be re-evaluated to include its impacts. Otherwise, the energy efficiency of the emerging urban form may be less than the sum of its parts.

6. References

Aldeberky, A. A. (2004).*The influence of high-rise Buildings on the Environment*. Center of Planning and Architectural Studies, Egypt.

Arslan, G., Sev, A (2014). *Significant issues around high-rise residential environments*. Proceedings of 3rd International Environment and Design Congress.

Futcher. J., Mills. J., Emmanuel. R., Korolija. I. (2017), *Creating sustainable cities one building at a time: Towards an integrated urban design framework,* Cities. http://dx.doi.org/10.1016/j.cities.2017.03.009.

Giridharan R., G. S. (2004). *Daytime Urban Heat Island Effect in High-rise in High-density Residental Developments in Hong Kong*. Energy and Buildings 36, 525-534.

Goncalves, J. C. S. and E, M. Umakoshi, (2010) *The Environmental Performance of Tall Buildings*., London: Earthscan.

Mills, G., Cleugh, H., Emmanuel, R., Endlicher,W., Erell, E., McGranahan, G., Ng, E., (2010). *Climate information for improved planning and management of mega cities (needs perspective)*. Proc. Environ. Sci. 1, 228–246.

Pandya, S. V. *Tall buildings and the urban microclimate in the city of london*. (2014) University of British Columbia, 352 pp. [Available online at https://circle.ubc.ca/handle/2429/38069.]

Perera, N.G.R., (2015). *Climate-Sensitive Urban Public Space: A Sustainable Approach to Urban Heat Island Mitigation in Colombo*, Sri Lanka. PhD Thesis. University of Moratuwa, Sri Lanka.

Perera, N.G.R., Emmanuel, R., (2016). *A "Local Climate Zone" based approach to urban planning in Colombo*, Sri Lanka, Urban Climate, http://dx.doi.org/10.1016/j.uclim.2016.11.006

Stewart, I.D., Oke, T.R., (2012). *'Local climate zones' for urban temperature studies*. Bull. Am. Meteorol. Soc. 93, 1879–1900.

Urban Development Authority (UDA), 2008. *City of Colombo Development Plan (Amendment) – 2008.* Available at http://colombo.mc.gov.lk/downloads/ccdp-2008.pdf, last accesed 30.09.2017

Vidanapathirana. M. (2017). *Climatic Effects of High-Rise Developments in Colombo.* Unpublished B.Arch. Dissertation. Department of Architecture. University of Moratuwa.

Rajapaksha.U, et al (eds), 2017, "Design that cares"- multi disciplinary approaches to creating sustainable and meaningful built environment: *Proceedings of the 10th International Conference of Faculty of Architecture Research Unit (FARU), University of Moratuwa, Sri Lanka (Vol. 01)*, pp. 86-99 ©

PERFORMANCE INDICATORS FOR ENERGY EFFICIENCY RETROFITTING DECISION-MAKING IN RESIDENTIAL BUILDINGS

CHAITALI BASU[1], DR. VIRENDRA KUMAR PAUL[2] & DR. M.G. MATT SYAL[3]
[1]Assistant Professor, Department of Building Engineering and Management, School of Planning and Architecture, 6-B, IP Estate, New Delhi-110002 (India)
chaitali.basu@spa.ac.in (Corresponding Author)
[2]Professor & Head, Department of Building Engineering and Management, School of Planning and Architecture, 6-B, IP Estate, New Delhi-110002 (India);
vk.paul@spa.ac.in
[3]Professor, Construction Management Program, School of Planning, Design and Construction, Michigan State University, Human Ecology Building, 552 W. Circle Drive, Room 213, East Lansing, MI 48824;
syalm@msu.edu

Abstract
The ''energy performance of an existing building'' is the amount of energy actually consumed to meet the different needs associated with standardized use of the building' and is reflected in one or more numeric indicators known as Building Energy Performance Indicators or EnPIs that are distributed amongst 6 main factors influencing energy consumption; climate, building envelop, building services and energy systems, building operation and maintenance, occupants' activities and behaviour, and indoor environmental quality. Any improvement made to either the existing structure, physical and operational upgrade of a building's systems which enhance the energy performance is considered as an energy efficiency retrofit.

The main objective of this paper is to support the implementation of residential energy retrofits through building of expert knowledge consensus on EnPIs for energy retrofit planning. The primary outcome of the research is a Comprehensive Index of EnPIs based on quantitative information knowledge to assist architects, building engineers, and energy analysts in providing retrofitting interventions as per in urban clusters rather than implementing generic solutions that try to fit all building types. The research methodology consisted of literature review which identified 37 EnPIs for residential buildings, followed by ranking questionnaire survey by experts in built-environment to arrive at weighted-average of all indicators. A total of 280-experts were requested for survey globally, and 107 completed responses received, i.e research had 37.5% response rate.

Keywords*: Energy performance, performance indicators, residential buildings, decision-making, retrofitting planning, Comprehensive Index*

1. Introduction

Energy efficiency (EE) means reducing the amount of energy needed to perform a particular task by investing in more effective systems of delivery. Any improvement made to an existing structure that increases the overall EE of a home is considered as an energy efficiency retrofit. A retrofit is the physical and operational upgrade of a building's energy-consuming equipment. Retrofits require the replacement or upgrade of old building systems with new energy saving technology and processes (Fulton et al. 2012; Save Main Energy (SME) 2012; cited in Syal et al., (2013). A large variety of building retrofit technologies and options are available in the market nowadays. "However, the decision as to which retrofit technology (or measure) should be used for a particular project is a multi-objective optimisation problem subject to many constraints and limitations, such as specific building characteristics, total budget available, project target, building services types and efficiency, building fabric, etc." (Ma et al., 2012).

2. Performance Indicators; Existing Literature

The Institute for Sustainability, UK (2015) advocates the case for use of Building Performance Evaluation (BPE) to be conducted prior to any retrofit or refurbishment project as that helps to establish current 'performance-in-use' of the homes. Further, they justify that BPE can reduce the risk of investment in retrofitting by identifying those very specific aspects of buildings that either need retrofitting or can withstand improvements. Preiser and Vischer (2005) describe BPE as ongoing evaluation loop, wherein, feedback from evaluations leads to informed design decisions. Foerster (1985) had discussed the basic feedback loop while Preiser and Vischer (1989) conceptualized the BPE framework for 'habitability'. BPE is based on post-occupancy evaluation (POE) process model by Preiser et al (1988) in which POE is viewed as subset of BPE, and is described as the evaluation of buildings post their occupancy for a certain period (Preiser and Vischer, 2005). Further, they describe the challenge of BPE is developing precise measures of occupants experience of environmental comfort by including more performance criterion than conventionally under consideration. Vischer (1989) has developed Building-in-Use (BIU) assessment using a survey that measures occupants comfort under seven key environmental conditions, the score basically converts a qualitative measure into comparable quantitative rating. However, it is generally used for office buildings.

From 1995 to 1998, the PROBE project (Post-occupancy Review of Buildings and their Engineering) was conducted jointly funded by Building Services Journal (BSJ) and Department of Environment, Transport and the

Regions (DETR) under their Partners in Technology programme (PROBE Strategic Review, 1999), and undertook surveys of sixteen completed buildings. The project covered three major aspects of building assessments; i) how occupants perceive the building as whole including its systems, levels of comfort, productivity and well-being the building provides, ii) measurement of energy performance of systems, and their maintenance requirements, iii) effects of changes, alterations, replacements to the building and its services on its occupants. The overall purpose of this assessment was to have structured insight of actual performance of buildings against 'as-designed' to allow for appropriate design of new buildings to strike the optimal balance between energy efficiency and occupant comfort, (Cohen et. al, 1999). For the occupant survey, PROBE used Building Use Studies (BUS)30 to gauge the levels of user comfort of internal conditions, their control and management (Cohen et. al, 1999).

3. Performance Gap; Need for Study

Energy consumption patterns in buildings are linked to the operational, space utilization characteristics and behaviour of occupants in the space (Hoes et al, 2009). The IEA (2013) prescribes that the building energy performance is mainly determined by six factors: (1) climate, (2) building envelop, (3) building services and energy systems, (4) building operation and maintenance, (5) occupants' activities and behavior and (6) indoor environmental quality provided. The latter three factors, related to human behavior, can have an influence as great as or greater than the former three (Wang & Xiao, 2012). Energy in Building and Communities Programme (EBC, 2013) states that a distinction between the building and user related energy consumption patterns cannot be clearly distinguished; hence all six factors have to be studied in tandem to establish the energy consumption data for any building. These factors shall be assessed quantitatively in this research. The ''energy performance of a building'' is defined as 'the amount of energy actually consumed or estimated to meet the different needs associated with a standardized use of the building' and is reflected in one or more numeric indicators (B. Poel et al, 2007).

The hypothesis or basic premise of this research is that EnPIs can firstly provide for assessment energy performance of each of the six energy performance factor individually, and secondly, aggregate of all EnPIs for all

[30] BUS method was developed and refined during the 1990's when it was used for government funded PROBE building performance evaluation studies. Since, 1995 BUS methodology has been curated and managed by Adrian Leaman (Building Use Studies Ltd.)

factors can assess energy performance of built-environment holistically. Further, the overall aggregate performance can be established through a performance index that would have differential weightages for the different factors.

4. Objectives

The paper has covered the following objectives;

1. Identification of 37 EnPIs for existing residential buildings for each of the 6 factors; (1) climate, (2) building envelop, (3) building services and energy systems, (4) building operation and maintenance, (5) occupants' activities and behaviour, and (6) indoor environmental quality. This was achieved through desk research/literature study.
2. Developed survey questionnaire based on the EnPIs. It is a self-administered ranking questionnaire for experts, both professionals and academicians in the field of built-environment.
3. Developed a Comprehensive Index of most relevant top ranked EnPIs for the analysis of responses for selection of parameters of energy efficiency retrofitting planning.
4. Assess the correlation between the top ranked EnPIs to arrive at final set for retrofitting planning.

5. Scope and Limitations

The scope of the paper is to identify and rank the performance indicators for energy efficiency retrofitting, however, retrofitting is on macro level location specific, and further on micro level project specific. Thus, this study is limited to being an exploratory study of the performance indicators, and the study would have to be expanded in to descriptive through further localised surveys and expert opinions to develop a decision-framework for global retrofitting scenarios.

6. Methodology

In 2013-2014, Syal et. al., developed an energy retrofit decision process model which was based on data was collected from three sources: literature review, qualitative interviews of energy auditors and retrofit contractors, and job shadowing of energy retrofit professionals. These types of data collected and were then used to arrive at a common protocol for the energy retrofit decision process, and eventually an energy retrofit decision process model (ERDP), was developed. This research shall use a modified ERDP model, in order to derive weightages of Energy Performance Indicators (EnPIs) for existing residential buildings in India. The modified methodology has been elaborated in Figure 1.

7. Comprehensive Energy Performance Index

A comprehensive set of performance indicators would include all six factors choosing the most appropriate set of indicators. This is generally a two-stage process; literature review to establish the indicators across the all six factors, and then conduct a primary survey amongst the experts (for example architect, engineers, and facilities managers) in the field of sustainability of built-environment. This approach would assist in arriving at the most appropriate country-specific set of indicators.

The purpose of this research is was to arrive at the set of indicators through literature review, and develop the comprehensive index which would then be tested in further research. The ranking criterion has been developed in Table 1. This is derived from the six sections on factors affecting building performance. For residential buildings, energy consumption is majorly for operating lights, space-conditioning equipment's, appliances, water pumping, lifts, and exterior lighting. Majority of residential units and complexes in India are not centrally managed, hence, the EnPIs as applicable in IS/ISO 50001: 2011 have to be adapted to suit the needs. In Final Report Annex 53 (IEA, 2013), the factors have been clubbed under three levels depending upon the frequency of data monitoring required;

- Level A – Monthly (preferred) or annual (acceptable) energy consumption
- Level B – Daily (preferred) or monthly (acceptable) energy consumption
- Level C – Daily/hourly energy consumption

In order to achieve the objectives stated previously, first, literature review was conducted which filtered the performance indicators for assessing planning for energy efficient retrofitting. Second, structured self-administered global survey of industry experts and academic researchers was conducted to collect data for analysing the significance of the selected performance indicators. Experts were invited to indicate the significance of individual indicators by using the Ranking. Then, data analysis was conducted with both reliability and validity of the data was checked by the statistical tool Statistical Package for the Social Sciences (SPSS). Scale ranking for overall and each group was established based on the mean values of significance of indicators.

The questionnaire survey was conducted during May-July 2017. The questionnaires were distributed via e-mail to two groups of people: academicians, experienced professionals from built-environment. The main consideration for determining the target population was that they were all familiar with building energy efficiency, and thus could enhance the representativeness of perceptions received from these respondents. A total of

280-experts were requested for survey globally, and 107 completed responses received, i.e research had 37.5% response rate, which is acceptable and higher than average response rate for online survey (Survey Academy, 2010).

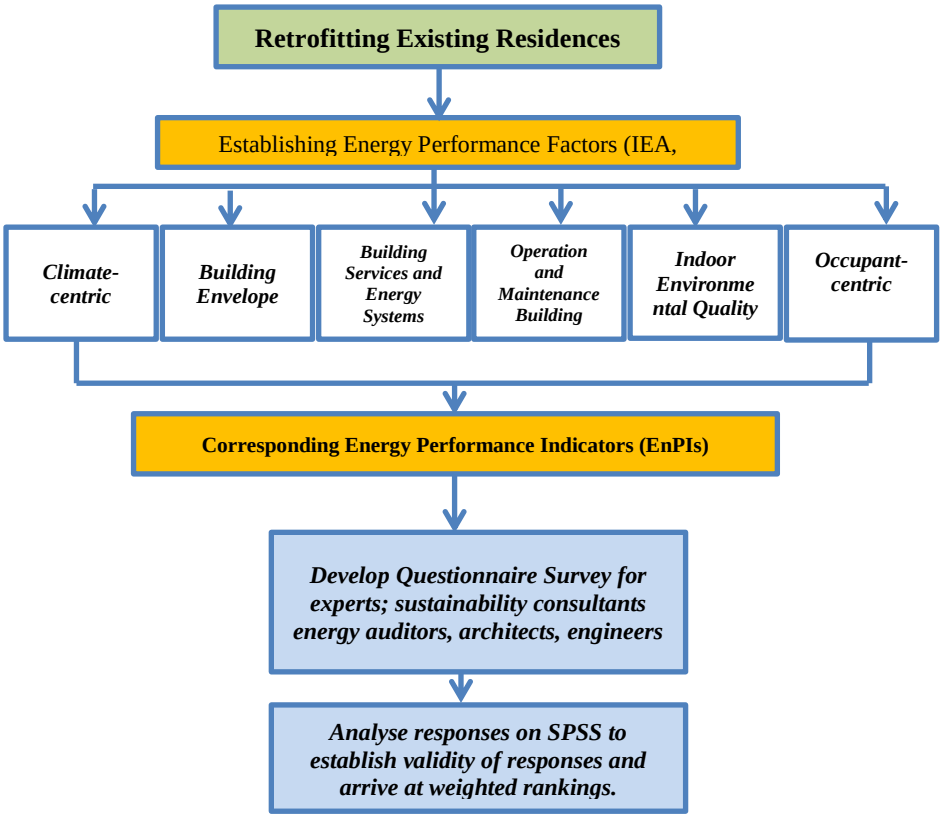


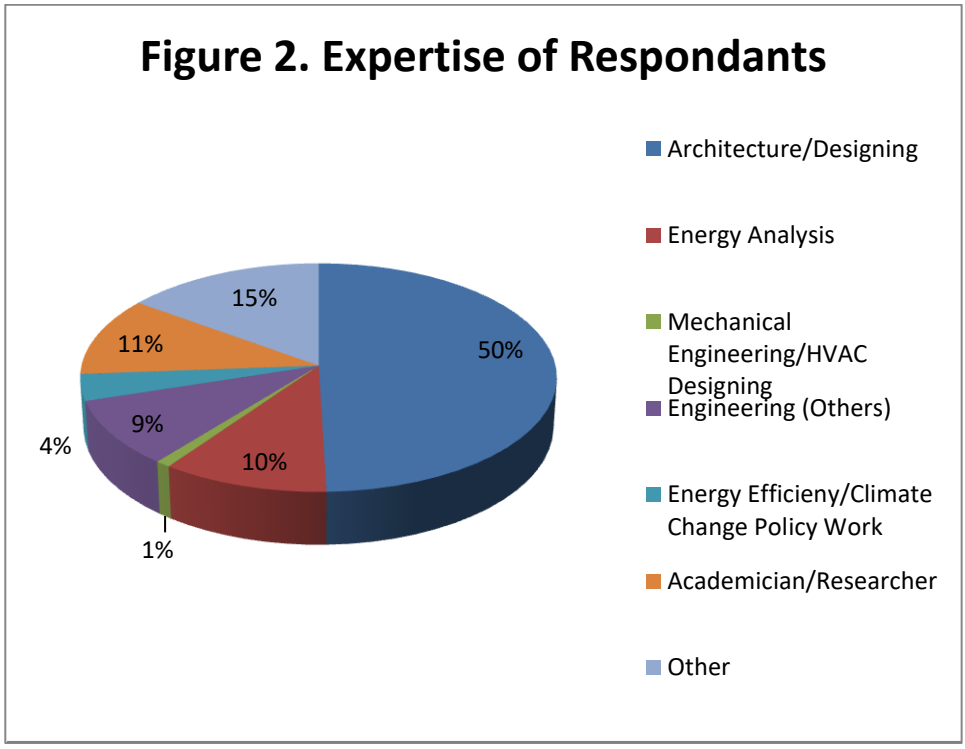
Figure 1 Methodology Workflow

8. Identification of EnPIs for Questionnaire Survey

Table 1 Criterion of EnPIs

	Level A			Level B		Level C
Factors / **EnPIs**	***Climate-centric***	***Building Envelope***	***Building Services and Energy Systems***	***Operation and Maintenance Building Performance***	***Indoor Environmental Quality***	***Occupant-centric***
1	Geographic Location	Building design	List of appliances, and usage pattern through occupancy schedules	Energy profiling	Thermal comfort; set points	Occupancy Schedule
2	Air Point & psychometric calculations	Total Thermal Transmission Surface, Total exposed vertical surface area	Space conditioning and Non-space conditioning load	Identification of user controls, and issues	Indoor air quality, air speed and Carbon dioxide concentration	Occupancy loads
3	Thermal process or semantics (gains, conduction infiltration etc.)	Airflow patterns	Annual electricity bill, Monthly electricity bill	Occupant schedule and behaviour profiling	Acoustic comfort (sound, noise, peace, silence)	Profiles of users
4	Passive features of buildings	Typology; tower, liner, liner double loaded corridor etc.	Room wise/area wise energy consumption patter in households, linked to occupancy schedules, and appliance usage schedules.	Appliance Maintenance	Lighting (Daylighting and artificial lighting)	how occupants perceive the building as whole including its systems
5	Heat Transfer	Relationship between volume of a built-form and the surface of its enclosure or compactness factor		Diagnostic plan for existence of problems, record data	Visual environment (views), nature	levels of comfort, productivity and well-being the building provides
6	Relative humidity	Total Ground Surface		Occupant Feedback & Maintenance Log	Room sizes, Room interior, style, furniture	Ways of adapting to thermal comfort
7		Window-to-floor area ratio, roof area		Main electricity-consuming common services		

9. Data Analysis



The expertise of 107 respondents can be summarised as per Figure 2. Kendall's Wis an estimate of the variance of the row sums of ranks divided by the maximum possible value the variance can take; this occurs when all variables are in total agreement. Hence $0 \leq W \leq 1$, 1 representing perfect concordance. The overall permutation test of W suggests a way of testing an argument the significance of the contributions of individual variables to the overall concordance to determine which of the individual variables are concordant with one or several other variables in the group.

Table 2 Test Statistics

N	107
Kendall's W[a]	.302
Chi-Square	1161.690
df	36
Asymp. Sig.	.000

a. Kendall's Coefficient of Concordance

Kendall's W test was carried out in SPSS for the rakings received from survey. The value of W comes out to be 0.302 which shows a low level of agreement amongst the experts. The main reason established for this is that the survey was global, and the factors which influence retrofitting decision making may vary on regional basis, especially due to

climatic variations. Thus, while for some experts factors which would have ranked higher in their locations wold not have mattered for others. The overall ranking of all factors have been considered based on % of responses received and elaborated in Table 2.

Table 3 Ranking of Factors

Factors	Id	% of Responses	Ranking
Climate-centric factor	CC	39.3%	1
Building Envelope factor	BV	21.5%	2
Building Services and Energy Systems factor	BSE	15.9%	3
Operation and Maintenance Building Performance factor	O&M	7.5%	4
Indoor Environmental Quality factor	IEQ	9.3%	5
Occupant-centric factor	OC	6.5%	6

Table 4 Ranking of Factors by Architects

The rankings of the largest group of respondents, i.e. the Architects were analysed and there were only minor modification s to the rankings as seen in Table 4.

Factors	Id	% of Responses	Ranking
Climate-centric factor	CC	47.2%	1
Building Envelope factor	BV	20.8%	2
Building Services and Energy Systems factor	BSE	11.3%	3
Operation and Maintenance Building Performance factor	O&M	3.8%	4
Indoor Environmental Quality factor	IEQ	11.3%	3
Occupant-centric factor	OC	3.8%	4

10. Findings

The mean ranks of all 37 EnPIs were derived and are presented in Table 2. 3 are from Indoor Environmental Quality factors, , 3 are from Climate-centric factors, 2 are from Operation and Maintenance Building Performance factor, and 1 each from Building Envelope factor, and Occupant-centric factor.

Table 5 Mean Rank of EnPIs

Energy Performance Indicators (EnPIs)	Mean Rank	Rank
Room sizes, Room interior, style	29.22	1
Visual environment (views), nature	29.15	2
Total Ground Surface	28.23	3
Acoustic comfort (sound, noise, peace, silence)	27.47	4
Diagnostic plan for existence of problems, record data	27.13	5
Relative humidity	26.94	6
Occupant Feedback & Maintenance Log	26.29	7
Heat Transfer	25.04	8
Air Point & psychometric values for the location	23.22	9
Consideration of ways of occupants adapting to thermal comfort	22.79	10
Airflow patterns of neighbourhood	22.61	11
Compactness factor (ratio of volume of a built-form and the surface)	22.02	12
Levels of comfort, productivity and well-being the building provides for occupants	21.57	13
Thermal process or semantics (gains, conduction infiltration etc. of built-form)	21.43	14
Main electricity-consuming common services	21.07	15
Availability of manual and automatic controls	20.87	16
Appliance use, maintenance, and control issues	20.52	17
Passive features of buildings	19.87	18
Identification of user controls, and issues	19.55	19
Lighting (Daylighting and artificial lighting)	18.16	20
Profiles of users	17.50	21
Annual electricity bill, Monthly electricity bill	15.72	22
Occupant schedule and behavior profiling	15.42	23
Indoor air quality, air speed, Carbon dioxide concentration	15.24	24
Energy profiling	15.03	25
Window-to-floor area ratio and roof area	14.92	26
Geographic location of dwelling	14.79	27
Orientation of built-form	13.70	28
Availability of manual and automatic controls	13.18	29
Occupancy Schedule, and Occupancy loads	13.10	30
Thermal comfort; set points	12.92	31

Natural ventilation	12.85	32
Total exposed vertical surface area	12.32	33
List of appliances, and usage pattern linked to occupancy	12.30	34
Room wise/area wise energy consumption pattern in households linked to occupancy	11.63	35
Space conditioning load & Non-space conditioning load	10.34	36
Building design, typology, and envelope materials	8.90	37

Table 6 Spearman's Correlation of 10 top ranked EnPIs

	Acoustic comfort (sound, noise, peace, silence)	Visual environment (views), nature	Room sizes, Room interior, style	Occupant Feedback & Maintenance Log	Diagnostic plan for existence of problems, record data	Air Point & psychometric values for the location	Relative humidity	Heat Transfer	Diagnostic plan for existence of problems, record data	Consideration of ways of occupants adapting to thermal comfort
Acoustic comfort (sound, noise, peace, silence)	1									
Visual environment (views), nature	-.158	1								
Room sizes, Room interior, style	-.202*	-.079	1							
Occupant Feedback & Maintenance Log	.086	.188	.045	1						
Diagnostic plan for existence of problems, record data	-.058	.069	.063	.216*	1					
Air Point & psychometric values for the location	-.048	-.021	.100	-.015	-.045	1				
Relative humidity	-.006	-.102	.244*	.165	.127	.145	1			
Heat Transfer	-.039	-.108	-.107	.049	**.261****	**-.350****	-.006	1		
Diagnostic plan for existence of problems, record data	.064	-.078	.020	.141	.203*	-.127	.066	.073	1	
Consideration of ways of occupants adapting to thermal comfort	-.104	-.073	.024	-.071	.244*	-.037	.051	.229*	.145	1

11. Correlation Analysis

For the top 10 ranked EnPIs, Spearman's correlation was derived. Spearman's correlation measures the strength and direction of monotonic association between two variables. All correlation analyses express the strength of linkage or co-occurrence between to variables in a single value between -1 and +1. This value is called the correlation coefficient. A positive correlation coefficient indicates a positive relationship between the two variables (the larger A, the larger B) while a negative correlation coefficients expresses a negative relationship (the larger A, the smaller B).

The strongest positive correlation was derived to be between Heat Transfer (CC) and Diagnostic plan for existence of problems, and record data (OC). This implies that the component of Heat Transfer can be determined by a Diagnostic plan. While difficult to interpret in conventional sense, this relation can be expressed qualitatively rather than quantitatively. The strongest negative correlation was derived to be between Heat Transfer and Air Point & psychometric values for the location, which would mean that Heat Transfer for a location increases as the Air Point values for a location decrease. This correlation highlights that the use of psychrometric chart is useful in determining the sizes of cooling systems by plotting the air conditions entering and leaving the coil. However, location cannot be presumed to be on macro scale as this is planning for existing buildings, thus the psychometric values have to be managed at micro level.

12. Conclusion

This study undertook a literature survey for determining the factors and their corresponding indicators that are relevant for planning for energy efficient retrofitting of residential buildings. In total 6-factors, and their 37-EnPIs were identified. Then a ranking criterion questionnaire was developed and circulated amongst experts from built-environment which received 107-valid responses out of 280-invited experts. Data analysis was carried out which identified the EnPI of Room sizes and Room interior style (factor of Indoor Environmental Quality) as ranking the highest, while Building design, typology, and envelope materials EnPI (Building Envelope factor) ranking the lowest. Furthermore, a correlation matrix was derived amongst the top 10-EnPIs to identify the final set of EnPIs which have the most significance while planning for energy efficiency retrofitting, and finally as per the study i) Heat Transfer, ii) Diagnostic plan for existence of problems, iii) Recording data and Air Point & psychometric values for the location as the indicators which require due

emphasis while considering the retrofitting design of existing residential buildings.

13. References

Cohen, R., P. Ruyssevelt, M. Standeven, W. Bordass, and A. Leaman (1999). *Building Intelligence in Use: Lessons from the Probe Project*. Usable Buildings Trust, London, UK.

Energy in Buildings and Communities Programme (2013). Available online [http://www.iea-ebc.org/]

Foerster, H., von (1985). *Epistemology and Cybernetics: Review and Preview* (Milan, Italy: Lecture at Casa della Cultura, 18 February).

Hoes, P., Hensen, J.L.M., Loomans, M.G.L.C., Vries, B. de & Bourgeois, D. (2009). *User behavior in whole building simulation*. Energy and Buildings 41(3): 295-302.

International Energy Agency Programme on Energy in Buildings and Communities (2013). *Total energy use in buildings. Analysis and evaluation methods*. Final Report Annex 53.

Poel, B, van Cruchten, G, A. Balaras, C, (2007). *Energy performance assessment of existing dwellings*. Energy and Buildings, 39, 393-403.

Preiser, W.F.E. (ed.) (1988). *Building Evaluation*, Ple num, New York, USA.

Preiser, W.F.E., and Vischer, J.C. (eds.) (2005). *Assessing Building Performance*, Elsevier, Oxford, United Kingdom.

Preiser, W.F.E., Rabinowitz, H.Z., and White, E.T. (1989). *Post-Occupancy Evaluation*, Van Nostrand Reinhold, New York, USA.

Probe Strategic Review (1999), *Report 3: Occupant Surveys*. . Building Use Studies Ltd, William Bordass Associates, ESD.

Syal, M., Duah, D., Samuel, S., Mazor, M., Mo, Y., and Cyr, T. (2014). *Information framework for intelligent decision support system for home energy retrofits*. Journal of Construction Engineering and Management. http://dx.doi.org/10.1061/(ASCE)CO.1943-7862.0000773.

Vischer, J.C. (1989). *Environmental quality in offices*. New York: Van Nostrand Reinhold.

Wang, S., Yan, C., Xiao, F. (2012). *Quantitative energy performance assessment methods for existing buildings*. Energy and Buildings, 55(2012), pp. 873-888.

Wolfgang F.E. Preiser & Jacqueline C. Vischer. (2005) '*Assessing Building Performance*'.

Z. Ma et al. (2012). *Existing building retrofits: Methodology and state-of-the-art*. Energy and Buildings, 55, pp. 889–902.

Rajapaksha.U, et al (eds), 2017, "Design that cares"- multi disciplinary approaches to creating sustainable and meaningful built environment: *Proceedings of the 10th International Conference of Faculty of Architecture Research Unit (FARU), University of Moratuwa, Sri Lanka, (Vol. 01)* pp. 100-111 ©

EVALUATING VOCATIONAL EDUCATION SERVICE QUALITY USING SERVQUAL AT COMMUNITY COLLEGE, CENTRAL UNIVERSITY OF RAJASTHAN

RASTOGI ABHIJIT[1] & GUPTA NEERAJ[2]
[1]Department of Building Engineering and Management, School of Planning and Architecture, New Delhi, India
arabhijit@spa.ac.in
[2]Department of Architecture, Central University of Rajasthan, Kishangarh- Ajmer, Rajasthan, India
ng@curaj.ac.in

Abstract
Recognizing students as key stakeholders, this research aims to assess students' satisfaction with their experiences at community college CURAJ through a Student Satisfaction Survey based on SERVQUAL model. The SERVQUAL model covers five dimensions - tangibles, reliability, responsiveness, assurance and empathy. This survey will help in strategic planning and decision-making regarding further improvement of Community College's services to students.

This paper aims to assess students' satisfaction with their experiences at Community College, CURAJ through a Student Satisfaction Survey. A questionnaire based on five point Likert scale covering various dimensions of service have developed, put to pilot test and then administered to all students of the community college. Presently there are four batches of the B.Voc. (Interior Design) Programme. Few open ended questions will also be included in the questionnaire to assess the weakness and strength of the community college at CURAJ. The reliability of the data collected will be checked by using SPSS and the student inputs will be analyzed according to the principle of weighed averages.

This survey will provide valuable information about perceived service gaps and other inputs to support strategic planning and decision-making at community college and thus help to improve quality of programmes and students' services.

Keywords: *SERVQUAL Model, Service Gaps, Likert Scale, Community College, B.Voc. (Interior Design) Programme*

1. Introduction –

With growing emphasis on skill development through vocational education and training, there is a need to measure the quality of education and the consumer.

Thus, with an overarching mission of quality improvement of vocational education programmes this research proposes to assess students' perception about quality of ongoing vocational programmes under community college scheme at the Central University of Rajasthan.

Differ from contemporary universities, the vocational training institutes/centres attention is focused to provide formal skill training and strictly concentrated on the obtaining of students' skills expected by the employers' market. Important information for graduates is the percentage of employment on appropriate positions. The results of students can be measured not only by the examination grades but also by subjective satisfaction of students (Vostrá Vydrová, Jindrová, Dömeová, 2012).

The education services performance in the form of skills and competences gained by students at such vocational training institutes results from the tangible and intangible assets. Furthermore, the learning process effectiveness can be influenced by many factors. Students' personalities and qualities can be one of them (Kostolányová, Šarmanová, Takács, 2011, Urbancová, 2012). The trend in improving the service quality in education sector is based on student-centeredness (Berrio and Henderson, 1998).

Based on the definition of quality by Grönroos (1984), the quality must be evaluated by the users or consumers of the service. In case of educational institutions, students are the prime customers and thus their perception about quality is an important variable to be studied. It is acknowledged that students' feedback is associated with definition of quality.

Grönroos (1984) states that the service quality model has three components: technical quality, functional quality, and image quality. According to Zeithaml, Parasuraman and Berry (1988), SERVQUAL is a universal method and can be applied to any service organization to assess the quality of services provided. This model covers five dimensions - tangibles, reliability, responsiveness, assurance and empathy and has been applied in education sector and also evaluation of service quality of academic libraries in developing countries. Few other models are developed specifically for education sector, each one based on their own context and requirements. Thus, for the purpose of assessment of students' experience at CURAJ, first step is to identify and list various dimensions of service relevant for the community college and vocational

education. The main objective of this paper is to undertake quick literature survey about various instruments in vogue for measuring service quality in education sector, to adapt the SERVQUAL scale for vocational education activity and to process and analyse the student's responses to identify the service gaps in community college at Central University of Rajasthan.

2. Background & Literature Review:

Vocational education in India is standardized by National Skills Qualifications Framework (NSQF). The National Skills Qualifications Framework (NSQF) organizes qualifications according to a series of knowledge, skills and aptitude. The NSQF is defined from level 1 to 10 and these are deciphered as follows: Level 1 is for unskilled worker, level 2 is for semi-unskilled worker, level 3 is for semi-skilled worker, level 4 is for skilled worker, level 5 is for supervisor, level 6 is for supervisor's supervisor, level 7 is for first level management, level 8 and 9 correspond to middle level management and so on.[31]

Each level is defined by the job roles formulated by the respective sector skill councils (SSCs) in the form of qualification packs (QPs) for the corresponding job roles. The B.Voc. (Interior Design) programme trained students for level 5, 6 and 7. First batch of the programme was admitted in January 2014 and the community college was established to run the programme on the pilot mode for the initial period of 3 years. Thus there is a vital need to evaluate the quality of the services being offered, identify the service gaps and improve the quality of services.

Various models have been proposed to measure service quality (Moore, 1987; Heywood-Farmer, 1988; Beddowes, 1988; Nash, 1988; Philip and Hazlett, 1997; Robledo, 2001). Out of all these proposed models, the most popular and widely used method of assessing service quality is SERVQUAL (Asubonteng, 1996; Waugh, 2002) developed by Parasuraman et al. (1985, 1988). SERVQUAL method is focused on identifying perceived quality, which is a customer's judgment about the excellence of a service (Zeithaml, 1987).

SERVQUAL methodology presents the differences (gaps) related to some different levels of expectation and perceptions i.e. Q = P-E, where Q is the service quality, P is students' perceptions and E is students' expectations. The service quality is based on the mean SERVQUAL score determined out of the difference between the perceived and expected service.

[31] UGC guidelines for community colleges, www.ugc.ac.in

Students' expectations and their perception level in relation to services offered were analyzed by questionnaire survey including five service quality criteria (dimensions of the students' expectations and their perceptions):

1. Tangibility: Physical infrastructure, laboratory equipment's, reading material, library and hostel facilities, staff appearance.
2. Reliability: Ability to perform the promised service dependably and accurately, sincerity, competency, punctuality and record keeping.
3. Responsiveness: Willingness to help clients/students and provide prompt service.
4. Assurance: behavior of employees and their ability to convey trust and confidence.
5. Empathy: Caring, individualized attention towards students and feedback mechanism to improve students' progress.

There was applied the scale of Likert (1 – 5) to rate the service quality level in relation to respondents' expectations and performance by asking students with using the set of questions on attributes that reflect mentioned quality dimensions (Table 1) (Parasuraman, Zeithaml, Berry, 1988).

Respondents/students of community college were asked to assess the importance degree in terms of the service quality, and then to identify which dimension has met their expectations as a result of the community college services.

3. A case study of Vocational Education:

3.1 METHODOLOGY-

The aim of the study is to compare the perceptions and expectations of students about the service quality of vocational education at community college, CURaj and to put forth suggestions to raise the education quality.

The whole basis and the value of the SERVQUAL methodology lay in the relevance of the statements asked during the survey. The questions are normally derived from the conversation with students. Quantitative and qualitative data were generated from structured closed- ended and open ended questions.

The research was conducted using a structured questionnaire covered four main sections. Section one contained questions pertaining to respondent's demographic background covered information related to gender, the training institute and field of study. Section two and three covered 25 statements of all

the five dimensions and required the respondents to indicate their opinion about their expectations and perceptions respectively of each services dimension using a five-point Likert Scale. In section four, there are three open-ended questions and one closed ended question where the respondents were ask to state their opinion regarding the training and services provided. The respondents were asking to state their opinion and comment about the training and services based on their experience. Keeping in mind the diversified educational background and the basic understanding of the students the questionnaire was prepared bilingual (i.e. in English and Hindi). The structure of the questionnaire along with the service dimensions is presented in Table 1.

Table 1. Dimensions and Structure of the Questionnaire

TANGIBILITY	1	The university campus has good physical infrastructure and provides for comfortable learning environment.
	2	The classrooms, computer and other laboratories and other academic area are comfortable, and have a good ambiance.
	3	The notes and reading material provided for various courses are good.
	4	The Library facilities are good and are able to provide adequate books and journals.
	5	The faculty and staff are appropriately dressed.
	6	Hostel facilities are good and provide comfortable living environment.
	7	The staff of hostel and dining hall is properly dressed and neat in appearance.
	8	Laboratories and workshops have most modern equipment and safety gear, which are sufficient to serve student's requirements.
RELIABILITY	9	When something is promised by certain time, it is always provided by the faculty and staff.
	10	When a student has any problem, faculty and staff do whatever they can with politeness and sincerity.
	11	The courses are taught by highly knowledgeable and competent teachers.
	12	The teachers and staff are always punctual and follow the time tables.
	13	The staff keeps accurate record of attendance, internship and exam results.
RESPONSIVENESS	14	The time of opening and closing of learning facilities like laboratories, workshops, library etc. is suitable for all students.
	15	Students are informed of schedules and changes in schedules in advance.
	16	The teachers and staff are always willing to help the students.
	17	The administrative/accounts/academic section staff of the university responds to students requests promptly.
ASSURANCE	18	The behaviour of teachers and staff is reassuring for the students.
	19	Students trust the teachers and the staff.
	20	The teachers are dependable and provide timely feedback about students' progress.
	21	Teachers and staff are friendly and polite.

EMPATHY	22	Teachers pay personal attention to each student and feedback on my work has helped me clarify things that I did not understand.
	23	The teachers and staff understand the specific needs of their students.
	24	The Principal / Head is easily available to advise students.
	25	The community college / department is sincerely interested in providing best services to the students.

The population of the study comprises of total number of students enrolled in the community college for all the four semesters. The structure of the proportional stratified sample, according to the year of study, is presented below in Table 2

Table 2. Population and sample structure according to the year of study

	No. of students enrolled	**Number of students in the sample (stratified)**	**Percentage**
Semester			
1st	23	23	100%
2nd	14	11	79%
3rd	19	19	100%
4th	15	15	100%
Total	71	68	96%
Gender			
Male	42	40	95%
Female	29	28	97%
Total	71	68	96%

Out of 71 enrolled students 68 questionnaire forms are obtained, which gives the adequate sampling size. Applying the reliability analysis on the data acquired from the survey questions, Cronbach's Alpha coefficient is found 91.12%, which shows that the scale is reliable (Sekaran, 2003).

Dimension related to tangibles includes questions 1 to 8 and analyzes physically tangible and visible assets important for providing the service (for example, infrastructure, laboratories, library, hostel facilities, teaching materials, etc.). Dimension related to reliability is represented by questions 9 to 13 and analyzes the ability to deliver the promised service accurately and dependably (for example to resolve student problems, punctuality, record keeping, sincerity and competency). Third dimension (responsiveness) includes questions 14 to 17 and analyzes the attention directed towards students in order to provide prompt service. Dimension related to assurance (questions 18 to 21) analyzes behavior and courtesy of academic and non-academic staff and their ability to convey trust and confidence. The last dimension of this model (empathy) includes questions 22 to 25 and is related to individualized attention

and care which is provided to students and their specific needs. In this research, a 5-point Likert was used. The scale was defined so that very important is coded as 5 and not important at all as 1 in the expectations dimension. Similarly strongly agree is coded as 5 and strongly disagree as 1 in perceptions dimension. The collected data was then analyzed with the SERVQUAL methodology to identify the gap between students' expectations and perceptions.

3.2 RESULTS AND DISCUSSION:

Table 3 shows the tabulated results of the SERVQUAL questionnaire of the scales of expectations and perceptions. The results of the two sections are compared to arrive at a parameter for each of the questions and also for each of the five dimensions, that is, the final score is generated by the difference between the student's perceptions and expectations.

As seen in Table 3, although not very big, certain gaps are apparent in all five dimensions between the expectations and perceptions about the service quality. The negative gaps show that the service quality perceived by the students is below their expectations and that can be viewed as an opportunity for improvement.

Questions 1 to 8 refer to the tangibility dimension, which obtained an overall average of -0.29. The expectation of students in relation to this dimension is high in questions 1, 2,3,4,6 and 8. Question 5 is the only one in this dimension that has a positive difference between perceptions and expectations (P-E); however this question refers to the presentation (appearance) of employees. This is different from all other questions except question 7 which also refers to the appearance of hostel and dining hall staff. Question 1, 2, 3 4, 6 and 8 refers to the physical infrastructure, hostels, library, course material and laboratory equipment. Its results indicate that the institution should invest in improving physical installations and/or equipment.

Table 3. Tabulation of Data

	Scale/ Ques.	Expectations							Perceptions							(P-E)
		Frequency of Responses						Average	Frequency of Responses						Average	
		5	4	3	2	1			5	4	3	2	1			
TANGIBILITY	1	43	23	2	0	0	68	4.60	34	22	12	0	0	68	4.32	-0.28
	2	25	29	8	6	0	68	4.07	10	35	17	6	0	68	3.72	-0.35
	3	29	28	11	0	0	68	4.26	21	23	18	6	0	68	3.87	-0.40
	4	40	22	2	4	0	68	4.44	30	24	8	2	4	68	4.09	-0.35
	5	26	18	16	0	8	68	3.79	36	24	4	2	2	68	4.32	0.53
	6	37	23	8	0	0	68	4.43	28	23	12	5	0	68	4.09	-0.34
	7	22	26	14	4	2	68	3.91	12	21	26	7	2	68	3.50	-0.41
	8	27	31	6	0	4	68	4.13	10	32	10	6	10	68	3.38	-0.75
	Average Tangibility															-0.29
RELIABILITY	9	25	29	10	2	2	68	4.07	23	23	14	8	0	68	3.90	-0.18
	10	53	9	4	2	0	68	4.66	29	24	14	1	0	68	4.19	-0.47
	11	50	12	6	0	0	68	4.65	33	27	8	0	0	68	4.37	-0.28
	12	37	23	4	0	4	68	4.31	25	28	13	0	2	68	4.09	-0.22
	13	51	13	4	0	0	68	4.69	41	24	3	0	0	68	4.56	-0.13
	Average Reliability															-0.26
RESPONSIVENESS	14	32	24	12	0	0	68	4.29	18	23	10	11	6	68	3.53	-0.76
	15	37	23	6	2	0	68	4.40	17	28	16	5	2	68	3.78	-0.62
	16	41	25	0	2	0	68	4.54	25	32	7	2	2	68	4.12	-0.43
	17	18	25	17	2	6	68	3.69	12	33	6	13	4	68	3.53	-0.16
	Average Responsiveness															-0.49
ASSURANCE	18	29	31	6	0	2	68	4.25	19	41	4	2	2	68	4.07	-0.18
	19	41	21	4	2	0	68	4.49	21	41	0	4	2	68	4.10	-0.38
	20	44	22	2	0	0	68	4.62	25	22	15	4	2	68	3.94	-0.68
	21	35	23	6	2	2	68	4.28	31	27	6	2	2	68	4.22	-0.06
	Average Assurance															-0.32

EMPATHY	**22**	47	19	0	0	2	68	4.60	25	25	10	6	2	68	3.96	**-0.65**
	23	35	25	6	2	0	68	4.37	23	25	12	8	0	68	3.93	**-0.44**
	24	51	14	1	0	2	68	4.65	51	11	2	0	4	68	4.54	**-0.10**
	25	39	21	6	2	0	68	4.43	29	23	8	8	0	68	4.07	**-0.35**
															Average Empathy	**-0.39**
															OVERALL AVERAGE	***-0.35***

The reliability dimension is analyzed in questions 9 to 13, which obtained an overall average of -0.25 service gap is the lowest in all. It is second most important dimension in student's expectations. Question 10, 11 and 13 (expectations version) obtained maximum average in entire table, with more than 50 of the 68 interviewed students scoring it 5, showing that the reliability dimension is important for the students. Question 10 is having maximum gap in all revealing that the students recognize this issue as essential for the quality of the service provided. Therefore, the faculty and staff must consider this issue on upmost priority and dedicate more time to resolve student's problems in a polite manner.

Questions 14 to 17 of the questionnaire refer to the responsiveness dimension and its overall average was -0.49, the worst average among the five dimensions. Question 14 reveals the maximum service gaps among all 25 questions which suggest reassessing the timings of library and laboratory facilities. The difference between perceptions and expectations (P-E) for all questions in this dimension was negative, revealing there are considerable faults in the service, which are deteriorating the quality of the service being offered.

Questions 18 to 21 refer to the assurance dimension, which obtained an overall average of -0.32. Question 20 (expectations version) obtained the highest average in this dimension also obtained the maximum gap, showing that the feedback mechanism about the students' progress needs improvement.

The final four questions, 22 to 25, refer to the empathy dimension, which obtained an overall average of -0.39. In this dimension, the greatest concern is in understanding, meeting student needs and providing best services. Therefore, a systematic approach or a quality improvement program needs to be developed by the faculty management.

The overall average for the five dimensions was -0.35. The presence of negative quality gaps in all of the five dimensions was determined. This indicates a great opportunity for improvement in the entire service providing cycle.

The deepest gaps exist within the dimension of responsiveness which is generally related to staff's sensitivity towards students, providing prompt services, responding to students' needs and the timings of laboratories library, and other facilities. Next dimension with the second largest negative gap is dimension empathy which is related to the conduct of Faculty staff towards students and their interest in students' success, attention given to students, help and support to students, being available to students when they are needed, feedback in order to improve educational and administrative processes. Both of these dimensions are generally related to staff's behavior towards students and organization's contribution and willingness to help students. It is necessary that the university invests more efforts in both academic and non-academic staff education and training. Dimension assurance is also a dimension with a big negative gap which implies that the behavior of staff towards student, the trust between them and the feedback mechanism which helps to improve students' progress. Dimensions tangibility and reliability which are related to the improvement in physical infrastructure, modernization of labs and other facilities, quality of the academic staff - their knowledge and competencies, the ability to perform reliable education service are dimensions with the lowest negative gap. This leads us to the conclusion that students perceive the quality of human resources at the faculty as the best, which is important for any university.

4. Conclusion:

Determination of the negative gaps between perceptions and expectations of the students in all five dimensions of service quality shows the quality education service does not meet their expectations. The main findings of this study are:

1. There is a shortage of faculty and staff which contributes to the service gap in responsiveness and empathy dimensions. This service gap can be minimized by recruiting academic and non-academic staff who understand the importance of services and provide prompt service and respond to student's problem with effective resolutions.

2. There is no dedicated pool of resources for the community college. The resources involved in community college are primarily

recruited for the other main core (under graduate & post graduate) programmes in the university thus reinforcing the staff capabilities through ongoing opportunities for training and development in the vocational education may improve the knowledge transfer skills of the existing faculties.

3. The students are moderately satisfied with the aspects training implementation including instructor; curriculum; and training delivery. Therefore, the implications for university authorities are concentrating their efforts to creating and maintaining a facilities and environment that can support training process and satisfied the customers. They need to improve both aspects of the quality of teaching and non-teaching services, in order to promptly respond to the customer.

The one of the most important issues mentioned in the survey, that was low-rated, is physical infrastructure and the timings of laboratories that supports realization of the teaching process and ensures students with skill and qualifications. The well-equipped laboratories can be a source of both students' and teachers' skills development and can result in the better quality output.

The results obtained from the survey provided valuable information about perceived service gaps and other inputs to support strategic planning and decision-making at community college and thus help to improve quality of programmes and students' services. We hope to make learning an enjoyable and rewarding experience for all students at CURAJ.

Accordingly, it is suggested that vocational education institutions should try to raise their service quality for imparting skill education, to be able to act independently and to be reintegrated to the society. A wider evaluation with a bigger sample and multiple institutes in different cities in future studies might reveal more detailed results.

4.1. ACKNOWLEDGEMENTS

The authors of this study would like to thank teaching assistant for their valuable support in conducting the survey and collating data. Special thanks to the management of Community College and the University authorities for their sincere contributions and supports.

4.2. REFERENCES

Asogwa, Brendan E. BEA, *"Use of ServQUAL in the Evaluation of Service Quality of Academic Libraries in Developing Countries"* (2014). Library Philosophy and Practice (e-journal). Paper 1146.

Behdioğlu, S. & Şener, H.Y. (2014), "*Improving Service Quality in Special Education Institutions: Servqual Scale",* Global Business and Management Research: An International Journal, 6(2), 169-184.

Beerio, A. A., Henderson, J., (1998), "*Assessing customer orientation in public, non-profit organizations: profile of ohia state university extension"*, Journal of Agricultural Education, 39(4), p.11-15.

Ehsan Akhlaghi , Shahnaz Amini , Hossein Akhlaghi (2012), *Evaluating educational service quality in technical and vocational colleges using SERVQUAL model*, WCES 2012, published in Procedia - Social and Behavioral Sciences 46 (2012) 5285 – 5289.

Gareth Smith, Alison Smith, Alison Clarke, (2007) *"Evaluating service quality in universities: a service department perspective"*, Quality Assurance in Education, Vol. 15 Issue: 3, pp.334-351

Grönroos, C. (1984), "*A service quality model and its marketing implications",* European Journal of Marketing, 18(4), 36-44.

Jasman Esmon & Hairul Nurasyikin Haron (2013), *Student Satisfaction Level of Quality Services Workshop Facilities in Malaysia Community College*, Volume 2 Issue 11, November 2013, International Journal of Science and Research (IJSR), ISSN (Online): 2319-7064

Kitchroen, K., (2004), "*Literature review: service quality in educational institutions"*, ABAC Journal, 24(2) pp.14-25.

Mohd Zuhdi Ibrahim, Mohd Nizam Ab Rahman, Ruhizan M. Yasin (2012), *Assessing Students Perceptions of Service Quality in Technical Educational and Vocational Training (TEVT) Institution in Malaysia*, International Conference on Teaching and Learning in Higher Education (ICTLHE 2012) in conjunction with RCEE & RHED 2012 published in Procedia - Social and Behavioral Sciences 56 (2012) 272 – 283.

Otávio José De Oliveira, Euriane Cristina Ferreira, *"Adaptation and application of the SERVQUAL scale in higher education"*, POMS 20th Annual Conference Orlando, Florida U.S.A. May 1 to May 4, 2009.

Parasuraman, A., et al, *"ServQUAL: A multiple item scale of measuring consumer perception of service quality",* Journal of Retailing 64 no. 1(1988): 12 – 37.

Rajesh Nair, Ranjith P V, Sumana Bose and Charu Shri, *"A Study of Service Quality on Banks with Servqual Model"*, SIES Journal of Management, April - August 2010, Vol.7(1): 35-45.

S. Đonlagić, S. Fazlić: *"Quality assessment in higher education using the SERVQUAL model"*, Journal of Contemporary Management Issues June 2015, Vol. 20, 2015, 1, pp. 39-57.

Shpëtim Çerri (2012), *"Assessing the quality of higher education services using a modified Servqual Scale",* Annales Universitatis Apulensis Series Oeconomica, 14(2), 2012.

Stasiak-Betlejewska R. et al.(2014), *"The services quality level assessment at the technical university using the SERVQUAL method"*, ERIES Journal vol. 7 no. 3-4.

Rajapaksha.U, et al (eds), 2017, "Design that cares"- multi disciplinary approaches to creating sustainable and meaningful built environment: *Proceedings of the 10th International Conference of Faculty of Architecture Research Unit (FARU), University of Moratuwa, Sri Lanka, (Vol. 01)* pp. 112-122 ©

DEMAND SHORTFALL IN INFRASTRUCTURE CONSTRUCTION PROJECTS: CASE OF RAIL PROJECTS IN INDIA

MITTAL YASH KUMAR[1] & PAUL VIRENDRA KUMAR[2]
[1]Department of Building Engineering and Management, School of Planning and Architecture, New Delhi, India
ar.yashmittal@gmail.com
[2]Department of Building Engineering and Management, School of Planning and Architecture, New Delhi, India
vk.paul@spa.ac.in

Abstract
This paper presents the case of shortfalls from the forecasted demand in feasibility studies of infrastructure construction projects (ICP). The demand forecast is generally required during the project formulation stage. An accurate or 'close to reality' demand forecast is significant for the success of any ICP. The paper highlights the role of the utilization of a project on the financial and economic sustainability of ICP. It also identifies the components of a project affected by the change or shortfall in demand. An evaluation of a feasibility study is done keeping the focus on demand and its consequences on expected financial and economic benefits of the project. A metro rail project is selected as a case study for the comparison of forecasted demand with the actual demand after commissioning of the project. The outcome of the exercise revealed substantial variations in demand. The case is then analysed for the extent of variation in the forecasted and actual benefit streams related to the financial and economic performance of the case example. The methodology is applied to a set of similar projects for analysing the universality of the phenomenon. The results prove that ICPs often face a demand shortfall and this has far reaching implications in terms of cost of underutilization. Finally the paper comments on the critical role of demand forecasting in meeting the objectives and success of ICP.

Keyword:. *Construction Projects, Demand Forecasting, Project Benefits, Financial Feasibility, Economic Benefits*

1. Introduction – Infrastructure Construction Projects

The dictionary definition defines Infrastructure as "the basic physical and organisational structures and facilities (e.g. buildings, roads, power supplies, etc.) needed for the operation of a society or enterprise", (Oxford, 2017). Infrastructure projects are key promoters of any economy. The overall development of any nation is dependent on the growth in infrastructure sector. Therefore, it serves as the basis for initiation of various policies and development projects by the governments. These public projects are

characterised by complex activities, large capital inputs, long duration, high risks, etc. In the fast growing world, the frequency of occurrence of these projects and the capital involved has significantly increased (Altshuler and Luberoff, 2003; Flyvbjerg, Bruzelius, Rothengatter, 2003). The availability of limited funds with developing countries makes it crucial for them to optimally utilize the capital and achieve the best possible growth rate. For the same reason, various ministries under the government follows the guidelines for project formulation, appraisal and approval and demands the preparation of feasibility report of all the prospective projects under consideration. The studies conducted for feasibility reports forms the components of detailed project report and helps in justifying the project. Specifically in case of public project, it is important to identify the beneficiaries and estimate the utilisation of the facility. The utilisation of the facility is ascertained by the demand forecast studies in the pre-feasibility and feasibility reports. The decision is undertaken based on the Financial Net Present Value (FNPV) and Economic Net Present Value (ENPV). In some sector specific projects the derived FNPV is not the suitable measure to decide the feasibility. Tsimplokoukout (2012) demonstrated the unsuitability of FNPV for a case of underground railway project at Athens. The economic feasibility serves as the deciding factor for such projects where the diverse benefits of the facility created is measured in relation to the spending. Demand forecast plays a major role in the calculation of ENPV and it is one of the most decisive contributor. These reports and studies are generally not validated before the cases are further taken up for discussion, decision and development. It results in incorporation of some of the misleading demand forecasts which vary to a great extent when compared to the actual users of a facility. Flyvbjerg (2007) describes a dire need for checks, balances, and accountability for risks in rail projects.

The task of conducting the feasibility studies also ends up in consuming time and cost of the project. The consulting fees paid to the consultant for preparation of DPR and feasibility reports for different projects forms a substantial part of the overall project cost. Hence, the onus of projections to meet the actual figures lies on the consultant engaged in preparation of these reports, which is generally not the case.

The objectives of this paper are:

1. To study the role of utilization of the project and the associated financial and economic sustainability;
2. To identify the components of a project affected by the change or shortfall in demand;
3. To assess the impact of the change in demand on expected financial and economic benefits of selected case study of MRTS project;
4. To check the universality of the phenomenon;

5. To assess the role of demand forecasting and examine the consequences of a shortfall in demand for the success of ICP.

2. Feasibility Studies

2.1 BASIC STRUCTURE-

The process flow of feasibility studies is listed in Fig. 1. The basic structure of a feasibility report consists of the following headings:

1. Identification of alternatives- all the possible options under consideration are identified and listed.
2. Practical alternatives are analysed on the basis of estimates of project data. Data is collected and the cost of alternatives is estimated along with identification of the socio-economic impacts of the project.
3. The desired estimates for the project utilization are done based on the project life, the time for which the project is commissioned and specifications of the project. The future benefits of the project are also forecasted and converted to the net present value after the selection and application of a relevant discount rate. Various risks, including the supply risks, demand risks, financial risks, legal risks and others, are identified and evaluated. The demand side risks include the risks related to forecasted demand and associated benefits.
4. A suitable method is selected for the evaluation of various alternatives. All the methods are listed and selection of the methods of evaluation is done based on the sector of project taken for appraisal. Cost-benefit analysis, cost- effective analysis, multi-variate analysis, etc. are the methods available to evaluate the performances of projects. More often, cost benefit analysis is used as an appraisal technique for public projects. A particular type of projects including healthcare facilities and others are evaluated using cost effectiveness analysis.
5. The selected method is utilized to evaluate the alternatives. It includes background research followed by evaluation of the proposed options based on location of the project, project outcomes, demand analysis, cash inflow, cash outflow, financial analysis, economic analysis, social impact analysis and environmental impact analysis. A discounted value of costs and revenue are considered for the above analysis.
6. The results of the analysis are compared and the alternative with maximum benefit and minimum risks is recommended.

The demand analysis serves as the basis for the analysed tangible and intangible benefits. An accurate demand analysis ensures the projected benefits

to reach the target and affected groups on time. Whereas, a deviation or shortfall from the estimated demand can result in posing questions on the success of projects.

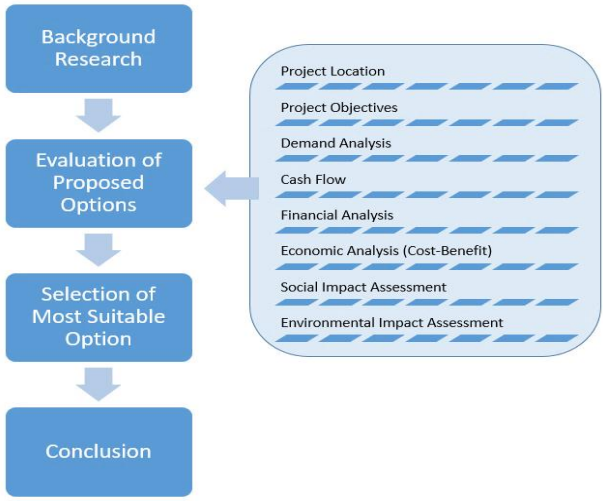


Figure1: Process Flow in Feasibility Report

3. Methodology

ICPs are spread over a wide range of sectors including transport, water supply, power, telecommunications, etc. Nature and quantum of construction activities in these sector specific projects are different from each other. Some sectors have high construction activity component like hydel power stations, transportation, urban development, etc. whereas rest are primarily based on engineering and technological inputs. The basis for selection of project for assessment of demand shortfall is the frequency of demand shortfalls in transportation projects. Flyvbjerg et al. (2007) questioned the accuracy of demand shortfall in case of public transportation projects. The findings reflect a strong trend of demand shortfall in case of rail based projects. Hence, the rail based infrastructure project is chosen as a case study and this paper focuses on demand forecast in case on 'Rail Projects' and its significance on meeting the objectives of the projects.

The data used in this study consists of demand projections in terms of ridership, year of commencement of work, scheduled date of completion of project, actual date of completion of work, value of time for different passengers, vehicle emission norms, vehicle operating costs, value of minor and major accident, etc. The source of data is Final Project DPR, Traffic and

Transportation study reports and other feasibility reports of Jaipur Metro Rail Project.

The research methodology comprises of 5 steps. Step 1 includes the study of the structure of the feasibility report. In step 2, a project is selected as a case study and the benefits of projects affected by demand forecast are identified. In step 3, the benefits of a project are then quantified based on the demand forecast as mentioned in the feasibility study. Step 4 comprises of collection and comparison of actual demand data for the selected project with the forecasted demand in terms of benefits as quantified in step 3. It is followed by checking the universality of the phenomenon of demand shortfall followed by examining its consequences on the success of a project.

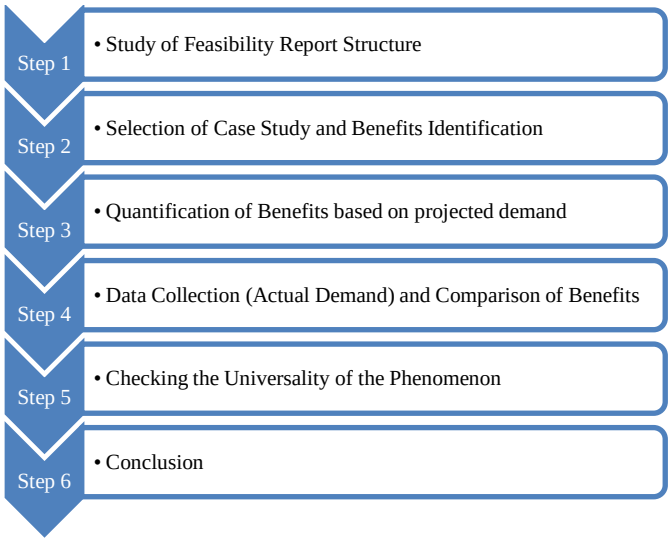


Figure 2: Methodology of the Study

4. Case Study

4.1 SECTOR AND PROJECT DESCRIPTION-

In most of the developing countries, including India, urban areas are experiencing rapid population growth. As a result, the existing infrastructure provisions in cities are exposed to increased pressure and high utilization rate. Transport infrastructure is no different where shifting from personalized modes of transport to public transport is proposed to relieve the pressure on existing infrastructure. Several strategies are under implementation under various government schemes to facilitate improved transportation system. One of the major interventions in the conventional transport systems is the introduction of

a rail based transport system or mass rapid transit system (MRTS). Ministry of Urban Development, Government of India, is promoting MRTS projects to ease pressure on road infrastructure and promote affordable public transport in tier-I and tier- II cities. In view of the above, Jaipur Metro Rail Project is selected as a case study from the transportation infrastructure sector. The benefits of the project are mentioned in the feasibility reports and DPRs during the project formulation stage. These benefits primarily comprise of the financial benefits from the fare box revenue (based on the demand or proposed utilization of the facility) and commercial utilization of the real-estate. The above benefits are weighed against the cost incurred for the O&M of project and other expenses to analyse the financial feasibility of such projects. The other stream of benefits includes the social, environmental and other indirect benefits which are included in the economic analysis for justification of the need of the project. Benefits in case of metro rail projects include the cost of reduced pollution, cost of vehicle operating costs, cost of fuel savings, cost of escalation in property values in the influence zone, cost of reduced accidents, etc. Most of these benefits are based on the level of utilization of facility. The level of utilisation in terms of demand is projected in the feasibility studies and is a key factor in deciding the success of the project.

5. Demand Forecast and Benefits

5.1 DEMAND FORECAST-

Demand forecast of such transportation projects is based on a set of feasibility studies conducted in the area of influence. Traffic volume survey, origin-destination survey and surveys related to willingness to pay serve as the basis for determining the demand forecast of an upcoming transportation facility. Table 1. presents the projected ridership of phase-IA of Jaipur Metro for the observation period of July 2015 to March 2017 (22 months). A compounded increase in monthly ridership is assumed to derive the monthly ridership using the annual proposed ridership as reference. The rate of annual increase in the ridership is 5%.

Table 1: Projected Daily Ridership in lacs

Year	Projected Average Daily Ridership (lacs)
2015	1.72
2016	1.97
2017	2.23

Source- Jaipur Metro-Detailed Project Report (2012)

5.2 ANTICIPATED BENEFITS-

The utilization of project corresponds to the benefits including both financial and economic as anticipated in the feasibility report. The benefits considered while accounting the usefulness of metro includes-

- **Saving in Cost of Fuel**- Saving is expected in the cost of fuel as the traffic diverted to metro will be dependent on a cleaner and cheaper fuel.
- **Saving in time of passengers**- Metro helps in bypassing the on-road traffic and results in time saving of the passengers. The average speed of metro is substantially greater than the on-road vehicles. It results in saving in time of the passengers.
- **Reduced congestion on road**- The diverted vehicles to metro are responsible for the reduced number of vehicles on road thus bringing the traffic volume down. The diverted traffic is a function of affected cars, two- wheelers, buses, auto-rickshaws, taxis, etc.
- **Vehicle Cost Saving**- Vehicle cost includes capital cost of vehicle and its operating cost over the period of usage. A shifted mode of travel to metro will ensure less investment in vehicle cost.
- **Reduction in emission of pollutants**- The use of metro as a public transport facility is expected to reduce emissions of the associated pollutants in air. The reduced emissions are due to the diverted traffic to metro and also due to reduced congestion on road. The combined effect of diverted traffic to metro and reduced vehicles on road is considered while assessing the overall reduced emissions of pollutants in atmosphere.
- **Safe Transport/ Reduced number of accidents**- Various traffic and transportation studies reveal that no of accidents reduce with decreased number of vehicles on road. The considered benefits include the reduced number of major and minor accidents.

The proposed benefits based on the projected average daily ridership of the Jaipur Metro Rail Project are given in Table 2.

Table 2: Quantified benefits based on projected demand in Crore Rs.

S.No.	Social/Economic Benefit Component	2015 7 months	2016 12 months	2017 3 months
1	Saving in Time by Metro Users	23.32	45.02	12.58
2	Saving in Time by Road Users	53.60	101.49	27.77
3	Saving in VOC by Metro Users	168.61	316.90	86.19
4	Saving in VOC by Road Users due to Decongestion	47.75	89.98	24.52
5	Saving in Fuel Consumption Due to Traffic Diverted To Metro	85.41	159.86	43.33

6	Saving in Fuel Consumption Due to Decongestion	18.69	34.64	9.31
7	Emission Saving : Reduction in Air Pollution	11.28	21.13	5.73
8	Savings due to fewer accidents	49.94	85.87	21.53
	Total	458.59	854.90	230.98

6. Actual Demand Utilization

6.1 ACTUAL RIDERSHIP-

Data of actual ridership for the first 22 months of operation of the case study project is shown in Figure 3. Joy-riders comprised the major share of commuters in the early phase of operation of the facility. Even though, a high footfall of passengers in the initial months of operation is observed, the actual ridership fell substantially short of the projected demand. The average daily ridership in the first month was above 50,000 which was reduced to less than 20,000 in the successive months.

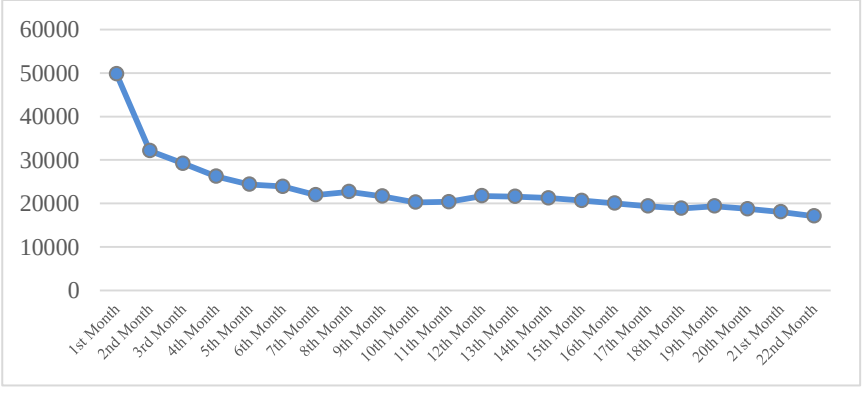


Figure 3: Daily Ridership - Jaipur Metro (First 22 months)

6.2 ACTUAL BENEFITS

The quantified benefits based on the observed ridership for the observation period i.e. 22 months, is given in table 3. The observation period is spread across three years and the actual average daily ridership for the months under consideration is used as a reference for the quantification of benefits.

Table 3: Quantified benefits based on utilization in Crore Rs. (Actual Demand)

S.No.	Social/Economic Benefit Component	2015 7 months	2016 12 months	2017 3 months
1	Saving in Time by Metro Users	2.43	5.02	0.28
2	Saving in Time by Road Users	5.60	11.32	0.62
3	Saving in VOC by Metro Users	17.61	35.33	1.92
4	Saving in VOC by Road Users due to Decongestion	4.99	10.03	0.55
5	Saving in Fuel Consumption Due to Traffic Diverted To Metro	8.92	17.82	0.97
6	Saving in Fuel Consumption Due to Decongestion	1.95	3.86	0.21
7	Emission Saving : Reduction in Air Pollution	1.18	2.36	0.13
8	Savings due to fewer accidents	5.21	9.57	0.48
	Total	47.88	95.32	5.14

6.3 BENEFITS COMPARISON

The difference in utilization benefits of the case study project is shown in table 4. A case of more than 90% of shortfall in the proposed and actual utilization of the project highlights the criticality of the shortfall in demand for large ICPs.

Table 4: Benefit comparison- Proposed and Actual

Scenario	Benefits (in Crore Rs.)
Proposed Demand	1544.46
Actual Utilization	148.35
Difference	1396.11

6.4 OTHER MRTS PROJECTS

In India, the Delhi Metro project was the first project to be commissioned in the 21st century. It started operating in December 2002. The present system serves NCR (National Capital Region) including Delhi, Faridabad, Noida and Ghaziabad. The actual ridership observed a close follow-up with the projected figures. At present the Annual ridership of Delhi Metro has crossed 1 billion mark (delhimetrorail.com, 2017). Whereas, the other cases of similar projects show a deviation in projected and actual ridership. The cases of Chennai Metro, Jaipur Metro and Bangalore Metro Projects are studied for assessment of the

phenomenon of demand shortfall at regional level. The trend in actual ridership of the case examples are presented in Figure 4.

The findings are as follows-

- Joy-riders are responsible for high footfall of commuters in the early phase of operation.
- Decline in ridership for MRTS projects with time.
- Observed demand shortfall in MRTS Projects- $1/7^{th}$ to $1/10^{th}$ of proposed demand.
- Significant cost of underutilization of facility.

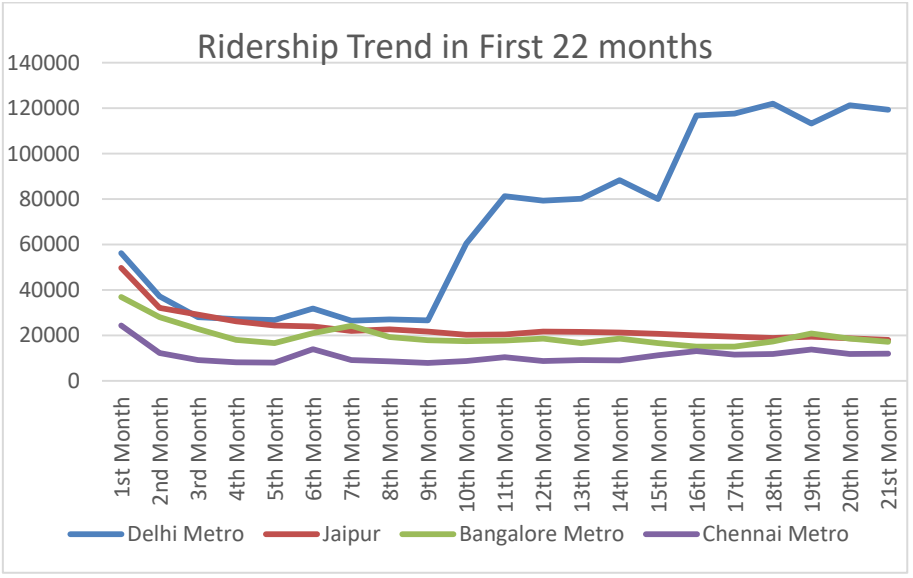


Figure 4: Ridership Trend from July 2015- March 2017 (First 22 months of operation)

7. Conclusion

The study aimed at a comparison of the projected demand of an ICP and the actual utilization of facility. The prospects of difference in demand are taken forward for inspection of the difference in benefits of the two cases i.e. proposed and actual utilization. The comparison of benefits and their difference in 6.3 proves the criticality of demand shortfall in the success of ICP based on the benefits. The universality of this phenomenon is checked by considering the case examples of three other similar projects. The study proposes a further investigation in assessment of demand shortfall and its implications over a larger set of similar ICPs. The potential approaches including 1) Scrutiny and peer review of feasibility studies; 2) Mid stage evaluation of proposed demand; 3) Phase-wise feasibility studies; 4) Standardisation of sector specific

approaches for demand forecast, etc. for bridging the gap between the projected and actual demand can be examined further.

8. References

Alan Altshuler and David Luberoff, Mega-Projects: The Changing Politics of Urban Public Investment (Washington, D.C.: Brookings Institution Press 2003), pp. 45-75.

Bent Flyvbjerg, Nils Bruzelius, and Werner Rothengatter, Megaprojects and Risk: An Anatomy of Ambition (Cambridge: Cambridge University Press, 2003), pp. 1–5.

Bent Flyvbjerg,"Cost Overruns and Demand Shortfalls in Urban Rail and Other Infrastructure," *Transportation Planning and Technology*, vol. 30, no. 1, February 2007, pp. 9-30.

Delhi Metro Rail Corporation, L., 2012. *Detailed Project Report Jaipur Metro (Phase-I) Mansarovar to Badi Chaupar*. 1st ed. New Delhi: Delhi Metro.

delhimetrorail.com. (2017). *Press Related Details*. [online] Available at: http://www.delhimetrorail.com/press_reldetails.aspx?id=ZlXC4jMrU00lld [Accessed 27 Sep. 2017].

Flyvbjerg, Bent, Mette K. Skamris Holm, and Søren L. Buhl (2005), "How (In) accurate Are Demand Forecasts in Public Works Projects? The Case of Transportation." Journal of the American Planning Association, vol. 71, no. 2, pp. 131-146.

Tsimplokoukout, K & Sfakianaki, Eleni & Metaxas, George. (2012). A feasibility study approach for underground railways - A case study: Line 4 of Athens metro. Global Journal of Engineering Education. 14. 91-98.

Rajapaksha.U, et al (eds), 2017, "Design that cares"- multi disciplinary approaches to creating sustainable and meaningful built environment: *Proceedings of the 10th International Conference of Faculty of Architecture Research Unit (FARU), University of Moratuwa, Sri Lanka, (Vol. 01)* pp. 123-134 ©

IMPACT OF CLASS ROOM COLOUR ON PRIMARY EDUCATION;
A study implemented in a boys' primary school, Colombo

HETTIARACHCHI. A. A[1] & NAYANATHARA. A. S [2]
[1] Department of Architecture, University of Moratuwa, Moratuwa, Sri Lanka
anishkah@uom.lk
[2] Department of Architecture, University of Moratuwa, Moratuwa, Sri Lanka
sewwandinayanathara@gmail.com

Abstract
Primary School is considered the starting point of the learning process of a child and should be designed with a conducive learning environment aligned with the intended learning outcomes. Colour being an important visual element of design is recognized to have a direct impact on a child's psychophysiological and behavioural aspects. This study investigates the impact of long term exposure to a monochromatic class room on primary education.

Participants were 213 grade 2 students (age-7, gender- male) of a boys' primary school in Colombo studying in identical classrooms (n=6) having a monochromatic interior (orange, yellow, green, blue, purple, pink) for two consecutive years (grade1 and grade 2). Students and class teachers were given two distinct questionnaires on student's preference, performance, learning and behavior.

Subject preference of student participants revealed that certain colours support specific skills of primary grade children. Blue and orange demonstrated most favourable impacts on their learning and behaviour. Blue was found to enhance creative artistic skills of children while orange and yellow were identified to support logical thinking associated with mathematics. Green and purple were found to have a balanced impact on improving both logical and creative thinking. Orange and green classes were with a majority of students significantly skilled in learning. A positive impact of blue colour on school attendance was identified.

Accordingly, the potential of colours in creating conducive learning spaces aligned with the learning objectives of primary education, was revealed.

Keywords: *Primary education, class room colour, skill development, preference, behaviour*

1. Introduction

Primary School initiates the learning process of a child after being guided by the parents for nearly five years since their birth. This stage is supposed to permit kids more freedom to develop thinking creatively and with reasoning (Wegerif, 2010). Accordingly, being the space where the students spend most of their time, the learning environments should be conducive in enhancing the performance of teaching and learning tasks optimally. As stated by Grangaard (1995), the enhancement of human performance requires the optimum environment and that educators must recognize the fact that surroundings are never neutral. This statement portrays the importance of integrating appropriate stimuli in the learning environment.

Children are known to be very sensitive and fond of colours. Consequently, colours can be a very effective tool in stimulating kids in their visual learning environment. Several scholars around the world have looked in to the diverse effects of colours on children and found favourable effects on their psychological and behavioural aspects which directly relate with childhood development. For instance colours are found to aid in creating a positive school ambience generating supportive feelings, emotions and psychological behaviour, reducing off task behaviour, disruptive behaviour and increasing attention and academic performance of children (Mahnke,1996).

1.1. NEED OF THE STUDY

As highlighted by Mahnke (1996), the choice of colour in schools directly correlates with its efficiency, quality, security and the cost factor. However, the impact of colour has been overlooked when designing learning spaces. Choosing the colour scheme in most cases is done by the administrators or teachers in an extremely subjective basis without considering any of the established scientific principles. Even the professionals more often do not plan colour at the onset. Often their approach is not sound knowledge of psychophysiological factors (Mahnke,1996) and emerge as an afterthought.

1.2 OBJECTIVES OF THE STUDY

The impact of colour on primary learning environments could be distinct based on its composition. Whether it is a single (Monochromatic) colour or a combination of several colours may bring about different impacts on the learner. On the other hand this impact also will be determined based on whether the colours are warm, cool or neutral and the time of exposure. This investigation claims its originality for examining the impact of long term exposure to a monochromatic classroom in enhancing skills and behaviour related to primary education. It specifically attempts to identify colours which

positively impact skills and behaviour while recognizing the distinction of the impact between the dichotomies of warm vs cool colours.

1.3 SCOPE AND LIMITATION

The investigation was carried out in a primary section of a leading boy's school with adequate learning facilities. The research is limited only to boys (n=213) in a specific age category (7years). Also the research focuses on investigating the impact of six selected colours; three warm colours (yellow, orange, pink) and three cool colours (blue, green, purple). The research is further narrowed to classrooms having a monochromatic colour scheme, thus psychophysiological impacts of class rooms with colour combinations are not considered here.

2. Literature Review

2.1 PRIMARY EDUCATION

According to the ministry of education, Sri Lankan education system is divided mainly in to four categories; primary school (age 5-10), junior secondary school (age 11-14), senior secondary school or GCE-O/L (age 15-16) and collegiate or GCE-A/L (Age 17-18) (MOHE, 2013). Each of these age categories have definite teaching and learning methods aligned with specific learning outcomes. In the teaching and learning of subjects, guided play will dominate as the main learning mode with second emphasis on active learning and minimum emphasis on desk work in key stage 1 (grade 1,2) while activity and deskwork will gradually replace play as the child proceeds to key stage 3; grade 5 (MOHE, 2013).

As per the popular culture, logical, methodical and analytical people are left-brain dominant, while the creative and artistic types are right-brain dominant. The right brain-left brain theory was originated in the work by Sperry (1981) cited in Cherry (2016). According to this theory, right side of the brain is best at expressive and creative tasks such as recognizing faces, expressing emotions, music, reading emotions while the left-side of the brain is considered to be skilful at tasks that involve logic, language and analytical thinking (Cherry, 2016). However, this notion has not been supported via scientific inquiry (Wanjek, 2013) and largely been debunked (Rogers, 2013). Contemporary research has revealed that the brain is not nearly as dichotomous as once believed. For instance, it is identified that the abilities in subjects such as maths are strongest when both halves of the brain work together. Today, neuroscientists distinguish that the two sides of the brain collaborate to perform a broad variety of tasks and that the two hemispheres communicate through the corpus callosum (Ursyn, 2016). Primary education is supposed to lay the initial

foundation in developing both logical thinking (mathematics, language and environment studies) and creative thinking (arts) equally to support successive stages of learning, leading to a well-balanced adult.

2.2 IMPORTANCE OF COLOUR IN VISUAL LEARNING ENVIRONMENT – A REVIEW OF LITERATURE

The ideal school conveys the feeling that it is a place which cares about students as individuals which paves the way towards responsible adulthood (Mahnke 1996). Providing good education is setting up a positive social climate within school, a sense of caring and guidance that must take place in a positive environmental setting (Mahnke 1996).

The design of the visual learning environment can have major consequences on attention, cognition, and learning of children. Colour plays a predominent role in a child's visual environment. The long held belief that the school environments should be coloured in white is not valid anymore due to the established sterile, neutral and non-stimulating effects of colour white on children. As established by literature, the design elements in the class room should be manipulated in such a way to stimulate children, provoking feelings of liveliness, excitement and happiness making them better thinkers and learners. Under-stimulation and lack of visual pleasure in a classroom channels the children's feelings towards irritability, fidgeting, etc (Mahnke 1996). On the other hand, environments conducive to learning should be designed carefully without over-stimulating learners.

As clarified by Mahnke (1996), under no circumstances should it be believed that by pinning drawings, cartoons or the like on the wall the children's need for change in hue, colour intensity and lightness is satisfied or that it will reduce a monotonous room experience (Mahnke, 1996). Numerous colours and details found in such material on walls may cause visual noise distracting the learners. Accordingly as a principle, the presence of colour in classroom design should neither over-stimulate nor under-stimulate a learner. Colour for the sake of colour accomplishes little that is constructive, just as bleak, less coloured environments accomplishes nothing constructive either (Mahnke 1996).

As per the theory of colour, the colour wheel makes a clear division between warm and cool colours. The theories and principles on the properties, characteristics and effects of colour too are principally explained to be dual based on the aforesaid warm / cool dichotomy. For instance warm colors are identified to be stimulating and cool colours are pacifying (Schaie and Heiss, 1964, Plack & Shick 1974, Wineman 1979, Walters et al 1982, Whitfield &Wiltshire 1990, Mahnke 1996, Stone 2001 and Ballast 2002). Hence,

integration of de-intensified warm colours (tints, shades and tones of red, oeange and yellow) in the classrooms are suggestive as a ground rule in creating a stimulating environment conducive for learning.

Many studies have established the favourable impacts of incorporating colours in learning environments. For instance, appropriate colours are important in manipulating the visibility of learning material in protecting eyesight, creating favourable surroundings to improve student's attention span, facilitating active learning and in prompting physical and psychological health aspects of children. Many cases of nervousness irritability, lack of interest, and behavioral problems can be attributed directly to incorrect environmental conditions involving poorly planned light and colour (Mahnke 1996).

By a study conducted with 10,000 children around the world, Frieling's (1957 cited in Mahnke 1996) identified best suiting colours for school environments based on age groups. His study found black, white grey and dark brown to be rejected by children between ages 5-8 while red, orange, yellow and violet were preferred. However, he pointed out the difficulty of using preferred colours identified by the tests as wall colours always and stressed the necessity to modify considering the other factors such as visual ergonomics (Frieling, 1957). Wohlfarth (1982 cited in Mahnke 1996) established the impacts of colour and light on development of elementary school children. The students who were exposed to light and colour changes were found to be least stressed, reporting reduced incidents of destructive behavior, aggressiveness and habitual disruptiveness (Wohlfarth, 1982). Introducing light and colour was also found to improve academic performance and I.Q test scores of elementary school children in a large percentage (Wohlfarth, 1982).

On the other hand Grangaard (1995) changed the classroom colour from white to blue, which is a cool colour, while removing much of the visual noise and installed full spectrum lighting with UV content. The findings of the study concluded that off task behavior declined and academic standings improved. Another study done by Ertel (1973), assessed the impact of environmental color on learning capacity. Classrooms painted light blue, yellow, yellow-green and orange were found to raise IQ levels while stimulating alertness and creativity in children. Contrastingly, white, black and brown were found to make the learners duller, causing a drop in their IQ level. Ertel (1973) further revealed the favorable impacts of orange on social behaviour, cheering the spirit and decreasing irritability.

By tracking more than 600 participants' performance on six cognitive tasks that required either detail-orientation or creativity, red was identified to boost

performance on detail-oriented tasks such as memory retrieval and proofreading while blue was found to boost creative tasks (Zue, 2009). This finding proposes the impact of red (warm colours) on left brain thinking and the influence of blue (cool colours) on the right brain.

2.3 RECOMMENDATIONS FOR PRESCHOOLS AND ELEMENTARY GRADES

As identified by Mahnke (1996), children of kindergarten through elementary school ages are mostly extraverted by nature. Accordingly a warm bright yet de-intensified colour scheme (light salmon, soft warm yellow, pale yellow-orange, coral and peach) in their visual learning environment complements this tendency, thereby reducing tension, nervousness, and anxiety. As accents, colours of the opposite temperature (cool) should also be introduced (Mahnke, 1996). Accordingly, the colours should be in a harmonious compositions of two opposite temperatures.

It is essential to reduce visual noise, visual distractions or chaos as much as possible in the learning environment which detract children's learning and performance (Grangaard, 1995). Apart from colour, using full spectrum lighting is highly recommended to support effective learning (Grangaard, 1995).

2.4 RESEARCH GAP.

The study identified a gap in available literature on the impact of long term exposure to a single/monochromatic colour on performance and behaviour of primary children.

3. Research Design

A preliminary questionnaire survey was conducted with grade 2 students of a school in Akuressa, Matara (n=86) to understand the nature of responses and vocabulary of primary school children. The final questionnaire was designed eliminating errors identified in the pilot study for the final outcome to be more accurate. Grade two class rooms in the primary section of a boy's school in Colombo were selected for the investigation based on their unique usage of colour. The students study in identical monochromatic classrooms (n=6) in the same location having walls and furniture coloured with six different colours; orange, yellow, green, blue, purple pink throughout two consecutive years (grade1and 2) with the same class teacher. Accordingly all the parameters leading to the learning environment are fixed for two years. However the

influence of the class teacher remains a significant parameter for their education, which is beyond the control of the investigator.

Figure1, Class rooms of Primary Section; Grade 1 and 2

All the grade two students of the primary section (n=213) and the respective class teachers (n=6) were selected as the participants for the final investigation. Students and class teachers were given two distinct questionnaires seeking the impacts of exposure to classroom colour (warm colours; orange, yellow and pink and cool colours; blue, green, and purple) on student's preference, performance, learning and behavior. A numbered colour palette having 6 colours was used as a guide for the convenience of children in filling the questionnaire. The teachers also provided their opinion on children's academic performance and behaviour in relation to classroom colours; statistical records related to student's attendance, sickness, punishments and outstanding/weak students. Both qualitative and quantitative survey methods were used in gathering information.

4. Data presentation and analysis

4.1 COLOUR PREFERENCE

The majority (45%) selected red as their favourite colour. The second, third and fourth significantly favoured colours were blue (21%) green (13%) and purple (9%) respectively. Accordingly, the most preferred colour of primary children is a warm colour followed by three cool colours. Conversely the majority selected black (30%) and pink (24%) colours as their least favourite colours while the third least favoured colour was found to be yellow (11%).

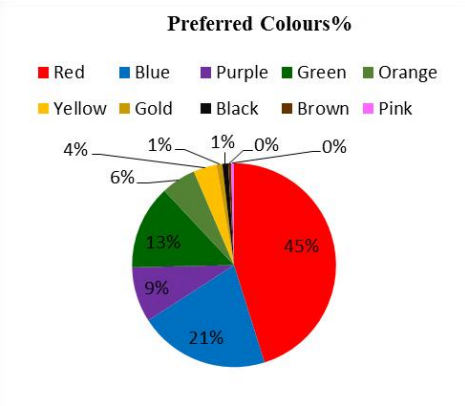


Figure 2, Preferred Colours

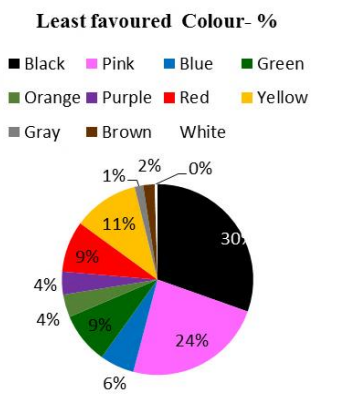


Figure 3, Least preferred colours

4.2 SUBJECT PREFERENCE VS CLASSROOM COLOUR

Specific classroom colours were found to be supportive in specific subject areas. In general terms, a majority of students in all the classes preferred arts over other subjects (Sinhala, Mathematics). However there was a significant difference in the blue class where 86% students significantly preferred arts over other subjects (Sinhala-11% and Mathematics- 3%). Accordingly, long term exposure to blue colour has impacted students to prefer a subject that involves creative thinking. A study done by Zue (2009) has similarly identified the impact of blue colour in improving creativity of participants.

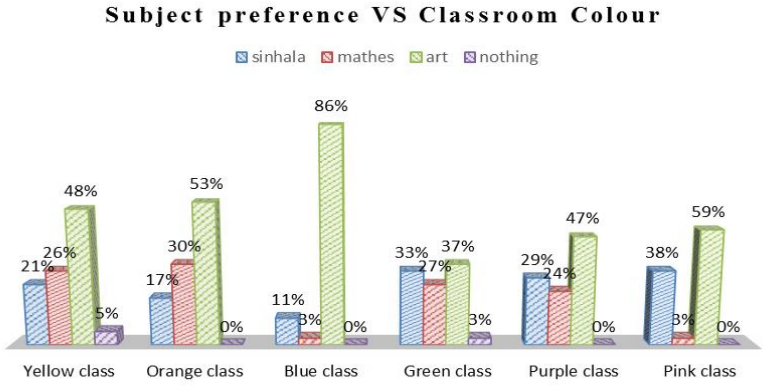


Figure 4, Subject Preference of Children

Accordingly it can be suggested adopting Sperry's (1981) conventional theory that blue supports right brain thinking in primary learning environments. On the other hand most of the students in the blue classroom had an extremely low

preference to Mathematics (3%); a subject which involves critical analytical, left brain thinking (Sperry, 1981). The same finding could be seen in the pink class as well (3%). Blue and pink are established to be pacifiers as per literature (Schauss 1979, Mahnke1996, Stone 2001).

The highest percentage of children who preferred Mathematics were found in the Orange class (30%), where the second highest is from yellow class (26%). Accordingly, aligning with Zue's (2009) findings both yellow and orange (warm colours) are found to boost left brain thinking and are suggestive to be integrated in learning environments to boost logical thinking.

However the highest number of students who preferred Sinhala subject (language) were seen in the Green class (33%), Pink class (38%) and purple class (29%) which involves logical left brain thinking (Sperry, 1981). Here green (yellow+ blue), purple (red + blue) and pink colours (red + white) have a warm colour as a parent colour. Most importantly the children of the green class were found to have a balanced preference to all the three subjects. Purple class was identified to be the second in line to have a balanced preference to all the subjects. Both green and purple are cool colours and secondary colours; a mixture of a warm primary colour and a cool primary colour in equal amounts. (Green = Blue + Yellow, Purple = Blue + Red). This might be the reason for green and purple to support both left and right brain thinking.

4.3 CLASSROOM COLOUR VS ATTENDANCE

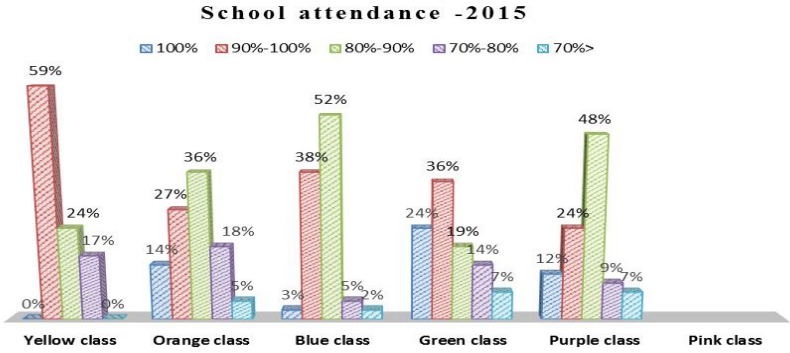


Figure 5, Attendance Vs Classroom colour - 2016

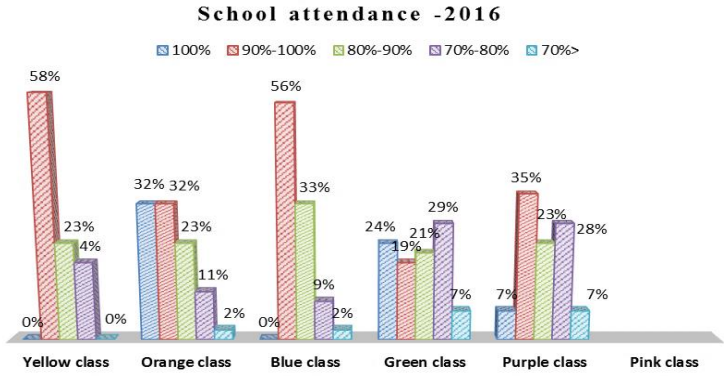


Figure 6, Attendance Vs Classroom colour - 2015

The teacher of the pink class could not provide details of attendance and below analysis was done using the data of other 5 classes. The maximum number of students who maintained 100% attendance in 2015 was reported in green class (24%). But in 2016 the highest 100% attendance was recorded in Orange class (32%). The result of the Green class was found to be the same as the previous year. However considering the student's attendance between 90% -100% the maximum number was reported in yellow class (58% and 59% respectively in 2015 and 2016). The other significant finding about yellow class is that none of the students had maintained attendance below 70% in both 2015 and 2016. On the other hand no one had maintained 100% attendance in the yellow class in both the years.

The highest number of students who had maintained attendance less than 70% in year 2015 were reported from green and purple class (7%) in both years which is another considerable finding.

The percentage of students who had maintained attendance above 80% in year 2015 was; 93% (blue class), 84% (Purple class), 83% (yellow class), 79% (Green class) and 77% (orange class). The students who have maintained attendance above 80% in year 2016 are; 89% (blue class), 87% (orange class).86% (yellow class), 65 % (Purple class), and 64% (Green class). Accordingly a positive impact of blue colour on student's attendance was revealed.

4.4 CLASSROOM COLOUR VS PERFORMANCE

Orange class (n=15) and green class (n=12) show the highest number of students who significantly demonstrate the relevant skills consistently. On the

other hand blue class was found to have the least number of significantly skilled students (n=1).

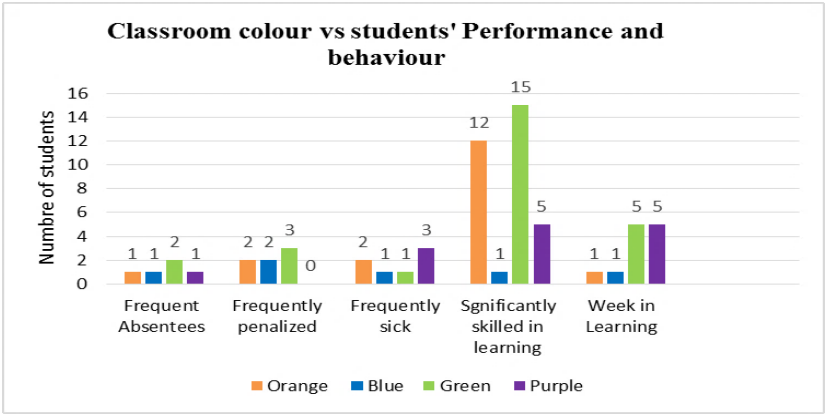


Figure 7, Performance Vs Classroom colour

5. Conclusion and recommendation

Several colours which are supportive in primary learning environments for learning and skill development were revealed by this investigation. Exposure to blue, orange and yellow colours were found as significant to have a maximum impact on primary education. Yellow and orange (warm colours) in learning environments were identified to have a positive effect on improving logical, analytical thinking ability of a child. Long term exposure to blue which is a cool colour was significantly dominating in improving creative thinking in primary learning environments. Evidence of a positive impact of blue colour on child's mentality for better school attendance is revealed. Green and purple colours being secondary cool colours were found to have a balanced impact on improving both logical and creative thinking.

Colour associated personal preferences of each student and teacher, their psychophysiological states, preconceived ideologies, copying others answers and reluctance to give genuine answers would have an impact on the accuracy of the responses. Accordingly it is recommended to conduct the investigation considering diverse samples in large sizes namely female samples and different age categories. Beyond the tested six limited monochromatic situations, the research can be broadened up in seeking the impact of other colours and their different values. Investigating on the impact of long term exposure to classroom interiors with different colour combinations is another facet worth investigating.

The observations made are highly beneficial in selecting the interior colours to create most conducive primary educational environments in future design interventions.

References

Ballast, D. K. (2002). Interior design reference manual. Professional Pub. Inc.: Belmont, CA.

Cherry, K. (2016). Understanding the Myth of Left Brain and Right Brain Dominance. Retrieved from https://www.verywell.com/left-brain-vs-right-brain-2795005.

Education First Sri Lanka, Ministry of Higher Education (2013), retrieved from http://www.moe.gov.lk/sinhala/images/publications/Education_First_SL/Education_First_SL.pdf

Ertel, H.(1973). Blue Is Beautiful, Time Magazene, Vol. 102 Issue 12, p82

Grangaard, E. M. (1995). Color and Light Effects on Learning. Association for Childhood Education International Study Conference and Exhibition, (pp. 2-10). Washington, D.C

Mahnke, F. H. (1996). Color, environment, & human response. New York.

McAuliffe,M. (2016) .Through the colour lens. Oxphord Global Press, UK.

Plack, J.J. & Shick J. (1974). The effects of color on human behavior. Journal of the Association for the Study of Perception, 9(1), 416.

Rogers, M.(2013). Researchers Debunk Myth of "Right Brain" and "Left-Brain" Personality Traits. University of Utah, Office of Public Affairs.

Schaie, K. W. and R. Heiss (1964). Colour and Personality. Berne: Switzerland, Haas Huber.

Schauss, A.G .(1979): Tranquilizing effect of color reduces aggressive behavior and potential violence. Journal of Orthomolecular Psychiatry, 8, 218-220.

Stone, N. (2001). Designing effective study environments. Journal of Environmental Psychology, 21(2), 179-190.

Ursyn, A. (2016). Knowledge Visualization and Visual Literacy in Science Education, IGI Global, USA. ISBN-13: 978-152250480.

Walters, J., Apter, M. J. & Svebak, S. (1982).Color preference, arousal, and the theory of psychological reversals. Motivation and Emotion, 6, 193-215.

Wanjek, C. (2013).Left Brain vs. Right: It's a Myth, Research Finds, Retrieved from https://www.livescience.com/39373-left-brain-right-brain-myth.html

Wegerif,R.(2010).Mind Expanding: Teaching for thinking and creativity in primary education, Mc Graw Hill Open University Press: USA.

Whitfield, T. W. A. & Wiltshire, T. J. (1990). Color psychology: A critical review. Genetic, Social, and General Psychology Monographs, 116, 387-411.

Wineman, J.D. (1979). Colour in environmental design: Its impact on human behavior. Environmental Design Research Association, 10, p.436-439.

Zhu.J. (2009). Effect of Colors: Blue Boosts Creativity, While Red Enhances Attention to Detail." Science Daily. Science Daily, 6 February 2009. www.sciencedaily.com/releases/2009/02/090205142143.htm

Rajapaksha.U, et al (eds), 2017, "Design that cares"- multi disciplinary approaches to creating sustainable and meaningful built environment: *Proceedings of the 10th International Conference of Faculty of Architecture Research Unit (FARU), University of Moratuwa, Sri Lanka, (Vol. 01)* pp. 135-147 ©

ESTABLISHING A FRAMEWORK FOR THE EARNED VALUE MANAGEMENT APPROACH IN LARGE SCALE BUILDING PROJECTS

WICKRAMASOORIYA. K.J.[1], PERERA. B.A.K.S.[2] & RODRIGO. M.N.N.[3]
Department of Building Economics, University of Moratuwa, Sri Lanka
[1]kavinduonline@yahoo.com, [2]pererabaks@gmail.com, [3]navomail@gmail.com

Abstract
Earned Value Management (EVM) was introduced as a powerful project control mechanism to make projects move towards their success. As sophisticated large scale building construction work is now being undertaken in Sri Lanka, the development of an EVM framework can be made a key to project success. Hence, this research was aimed at developing a framework for adopting the EVM approach in large scale building projects. EVM principles that are applicable throughout the project management cycle were identified from a literature review. Eight expert interviews were thereafter conducted to identify the current practices of EVM in Sri Lanka, barriers that impede the implementation of EVM and solutions that will mitigate those barriers. A questionnaire survey was also carried out to identify the significance of the barriers that impede the implementation of EVM in Sri Lanka and the degree of importance of the various solutions that can mitigate those barriers. Findings revealed that though the basic principles of EVM are known by almost all users, most of them do not want to rely on EVM. The lack of awareness about EVM was identified as the most significant barrier that impedes the implementation of EVM. The most important solution that could be adopted to mitigate this barrier is to conduct training sessions on the EVM approach for those from the top to the bottom of the organization concerned. A framework for the EVM approach in large scale building projects was developed ultimately.

Keywords: *Project Management, Project Life Cycle, Performance Measurement, Earned Value Management, Large Scale Building Development*

1. Introduction

Construction projects that are large and complex need many efforts if they are to survive within a competitive environment (Ashworth, 1999). Construction industry professionals have used various project management tools to manage project outcomes (Knutson et al., 2011). Traditional project management tools such as the Critical Path Method (CPM), Program Evaluation and Review Technique (PERT) and S curves are commonly used by project management teams to measure project performance (Cooke and Williams, 2009). However,

those traditional project management tools are not up to the expected level (Soloman, 2002). As a result of the multidisciplinary efforts made by researchers, Earned Value Management (EVM) has emerged as an effective project management tool (Bhosekar and Vyas, 2012).

EVM gives insight into the evaluation and tracking of physical accomplishments of a project by integrating its technical performance, schedule and cost parameters into a contract (Project Management Institute [PMI], 2008). By adopting EVM principles in construction projects, cost performance index and schedule performance index get quantified thus establishing a sound basis for financial and time consequences (Meredith and Mantel, 2000). Proper utilization of EVM enables early warnings on the schedule and cost performance and compels a manager to make correct decisions (Salikumar and Johny, 2016).

Recently, it has been discovered that EVM applications give best results mostly to extremely large projects that have long durations (Lipke et al., 2009). Hence given the dynamic nature of construction, the EVM approach can be exploited to provide solutions to complex multi-objective issues in real life construction site management practices (Alfaj et al., 2016).

According to statistical data published by the Central Bank, several large scale development projects have already been initiated in Sri Lanka with local and foreign investments. Several researchers have discussed the introduction of scientific and systematic frameworks for the EVM approach in the construction industry without being specific to any particular area. Hence, there is a gap in the literature about the use of the EVM approach in large scale building projects which needs to be discussed along with its characteristics. Therefore, this research was conducted to develop a framework for adopting the EVM approach in large scale building projects in Sri Lanka.

2. Literature Findings

2.1. CONSTRUCTION PROJECTS

Construction industry can be considered as a main player of socio-economic development (Behm, 2008; Hussin et al., 2013) of a country. It plays a silent role in improving the well-being of the people and can also be termed as the backbone of national development (Pekuri et al., 2011). Each construction project has works, products, stakeholders and locations that are different from one another (Gunathilaka et al., 2013). Construction projects are considered risky and complex in nature (Ajayi et al., 2011). Variables associated with construction projects can cause a diverse range of hazards throughout their

project life cycles and can ultimately produce adverse outcomes (Doloi et al., 2011). Many researchers are of the opinion that construction projects have to be constantly managed with a degree of excellence if project success is to be achieved (Atkin et al., 2003).

2.2. PROJECT PERFORMANCE MEASUREMENT

The principles and processes of project management emerged with the growing demand to ensure the success of projects given their complex and sophisticated environments (Nwachukwu and Emoh, 2011). Costa et al. (2006) stated that there should be a systematic way of measuring and comparing an organization's performance against what was planned, to ensure a satisfactory level of success. Considering the importance of performance measurement, several researchers have conducted studies to identify an effective mechanism for performance measurement (Antony and Thirumalai, 2014).

As a result of the multi-disciplinary efforts made by these researchers, EVM has become an effective method of performance measurement and a feedback tool for managing projects (Vyas and Birajdar, 2016). Nowadays, it is known as "management with the lights on" as it spots the path on which a project is treading while comparing it with the original pathway planned for it (PMI, 2005). EVM gives an insight into the evaluation and tracking of a project's physical accomplishment by integrating its technical performance, schedule and cost parameters into a contract (PMI, 2008). The key parameters of EVM first identify the differences among the plan, cost and progress of a project. The results lead to earned value performance measurement parameters. These parameters indicate the current position of the project in relation to its time and cost parameters. These earned value forecasting indicators finally provide the project duration and the project cost expected at the time of completion of the project. By making use of EVM results, a project team can gain several key benefits to help hem attain success in their projects. According to practitioners, EVM is also beneficial in project management as a project overviewing tool, risk identification tool, coordination tool etc. (Marco and Narbaev, 2013).

As Sri Lanka is still a developing country, its construction industry has not got experience in mega construction work which involves a large number of contracts. Nevertheless, the construction industry in Sri Lanka nowadays is competitively involved in projects exceeding Rs 1000 Million in contract value and faces numerous complexities in managing its projects. Therefore, the EVM approach can be used to solve complex performance issues that arise in large scale building construction (Takim et al., 2003). Considering the construction background of Sri Lanka, the standard set by the PMI can be considered as the

most suitable standard for the country. The steps stated by PMI for EVM implementation in projects are described below.

2.3. EVM PRINCIPLES ADOPTED DURING PROJECT LIFE CYCLES

The EVM implementation guidelines provided by the Project Management Institute have been divided into two broad categories - establishment of a Performance Measurement Baseline (PMB) and measurement and analysis of the performance against the baseline. Each category has been further divided into five sub activities to ensure their successful implementation.

Establishment of a PMB-Decompose the work scope to a manageable level, assign unambiguous management responsibilities, develop a time-phased budget for each work task, select EV measurement techniques for all tasks and maintain the integrity of the PMB throughout the project life cycle

Measurement and analysis of the performance against the baseline- Record resource usage during project execution, objectively measure the physical work progress, credit earned value according to EV techniques, analyse and forecast cost/schedule performance and report performance problems and/or take action

This incorporation of EVM steps into project life cycles will provide project managers with a better understanding of the possible successful completion of a project using EVM principles. Several researchers have also discussed EVM as an effective tool for performance measurement. Thus, this method can be implemented in Sri Lanka too.

3. Research Methodology

This research has used a mixed approach since it was focussed on reducing the weaknesses and the problems linked to mono methods, improving the validity and reliability of the results and enriching the comprehension of the studied phenomenon and the emergence of new dimensions (Jick, 1989; Sechrest and Sidani, 1995; Teddlie and Tashakkori, 2003; Johnson and Onwuegbuzie, 2004). Greene et al (1989) highlighted five purposes for using the mixed method as i) triangulation, ii) complementarity, iii) initiation, iv) expansion and v) development.

An extensive literature survey was initially carried out followed by semi-structured expert interviews carried out with eight professionals who had experience working in the construction industry. The details of the interviewees are given in Table 1. The main objective of the expert interviews was to validate the literature findings to verify their applicability in Sri Lanka. According to the literature, EVM applications are very much used all over the world as a tool for the performance measurement of a project. Hence, expert

interviews were used to ascertain the current level of practice of EVM in Sri Lanka. Data gathered from the expert interviews were analysed using NVivo 11 content analysis software.

Table 1, Details of interviewees

Code	Interviewee	Type of organization	Profession	Experience
IA	Interviewee A	Contractor	Construction Manager	21 Years
IB	Interviewee B	Contractor	Construction Manager	16 Years
IC	Interviewee C	Contractor	Site Manager	17 Years
ID	Interviewee D	Contractor	Construction Manager	20 Years
IE	Interviewee E	Consultancy	Quantity Surveyor	25 Years
IF	Interviewee F	Consultancy	Project Manager	15 Years
IG	Interviewee G	Consultancy	Project Manager	22 Years
IH	Interviewee H	Consultancy	Quantity Surveyor	25 Years

The questionnaire survey was carried out with several professionals working in the construction industry in Sri Lanka. Although 100 questionnaires were distributed, the number of responses was only 66 indicating a response rate of 66%. Among the respondents, 30% were planning engineers, 20% head office quantity surveyors, 20% contract administrators, 16% project managers and 14% site quantity surveyors. The main objectives of the questionnaire survey were to identify the importance of EVM as a problem solving mechanism in project management, to analyse the severity of barriers that impede the implementation of EVM in Sri Lanka and the importance of the solutions that can mitigate those barriers. The data collected were analysed using Relative Importance Index (RII) to rank the barriers and solutions. As the final step of the research, by making use of the research findings, an EVM framework for large scale building construction was developed.

4. Research Findings

4.1. CURRENT PRACTICES OF EVM IN THE CONTEXT OF SRI LANKA

Experts expressed their viewpoints on the current level of practice of EVM in Sri Lanka. According to the findings, there is no specific method that has been identified for performance measurement in the construction industry in Sri Lanka. Performance evaluation in the construction industry is thus done using the results of diverse applications. The experts were familiar to some extent with S curves, Gantt charts, cash flow statements and EVM. According to

them, if a project needs to be completed within its planned budget and time schedule, close management control of the field operations would be a necessity. EVM can be regarded as dealing with a single system (instead of multiple systems) that can track a project in terms of work, time and money.

The next step was to identify the EVM parameters adopted in Sri Lanka. It was revealed that practitioners are mostly familiarised with basic key parameters and performance indicators but not with forecasting indicators. It is because they had only little faith in these forecasting indicators, the results of which could vary due to managerial decisions and external factors.

The suitability of the EVM approach was thereafter discussed with the practitioners in the industry. A majority of interviewees expressed that EVM can be practiced regardless of its type except in projects which have low budgets and durations in which it is not worth practising EVM. They furthermore declared that projects having several complexities rather than small projects can benefit by EVM applications. A majority of them, however, were not aware of the improved applications of EVM such as earned schedule analysis and EVM standards that are being practiced in other countries.

During the expert interviews, the interviewees mentioned about the actions they have taken on EVM applications during project life cycles. Though none of the above mentioned steps relating to EVM applications are being followed, the interviewees opined that there is a possibility to merge these steps with EVM applications during the project management process. According to the literature findings, action on the EVM approach begins in the planning phase of a project and terminates at the end of the project management life cycle. There are numerous inputs that come during each stage which are required to deliver best results with the EVM approach. In addition, when the system does not give desired results, the project team will be required to decide at certain decision making points whether the whole approach needs to be revised. They also opined that the performance measurement process would be easier if there is a framework to follow.

4.2. BENEFITS OF EVM APPLICATIONS THAT ADDRESS PROJECT MANAGEMENT PROBLEMS ENCOUNTERED IN LARGE SCALE BUILDING CONSTRUCTION

According to the literature findings and opinions expressed by expert interviewees, several benefits that stimulate the project management process could be identified. The detailed questionnaire survey was used to identify the features that are recognised as being most advantageous to them by the

practitioners in the construction industry in Sri Lanka. The findings that relate to the significant features of EVM approach are illustrated in Table 2.

Table 2, Benefits of the EVM approach

Benefits	RII	Rank
Cost performance index as the cost performance indicator	0.9068	1
Project overviewing tool	0.8761	2
Improved decision making tool	0.8684	3
Project coordination tool	0.8569	4
Technical and schedule performance integrating tool	0.8492	5

According to Table 2, EVM is recognised as a cost performance indicator. Since it can provide a detailed monetary indication on the planned and actual values, it will show how efficiently a project team is engaged with the cost and time of the project. Once the Cost Performance Index (CPI) and the Schedule Performance Index (SPI) are calculated, a better picture could be obtained as to whether or not the project is on schedule or within the budget, or both. The other advantage of EVM is that it is a project overviewing tool which can continue throughout the life cycle of the project by establishing a performance measurement baseline. The results of the EVM analysis can then illustrate the trend and the pattern of cost and time variations. The third advantage of EVM is that it can be used as an improved decision making tool. Since EVM integrates work, schedule and cost, it can improve the quality of decision-making at all levels in the organization. EVM can also be identified as a project coordination tool as the results of EVM metrics can be illustrated using graphs and charts to enable stakeholders to be aware of as to where the project stands with respect to the initial baseline. EVM can also be identified as a technical and schedule performance integrating tool. EVM systems ingrate cost and time components into the Work Breakdown Structure (WBS) in its initial stages. This helps to ensure that work, schedule, and cost are properly integrated at a given point of time as the project proceeds. These are the advantages of EVM that were identified by practitioners in Sri Lanka as the significant benefits of the EVM approach.

4.3. BARRIERS IN IMPLEMENTING EVM IN SRI LANKA AND THE SOLUTIONS THAT WILL OVERCOME THEM

From the responses received from the industry experts, several barriers that impede the implementation of EVM in Sri Lanka and the solutions that can mitigate those barriers were identified. The three best solutions that will

mitigate each of the identified barriers were ranked according to their RII values as illustrated in Table 3.

Table 3, Barriers that impede the implementation of EVM and the possible solutions that can overcome them

Barriers	RII	Solutions for overcoming barriers	RII
Lack of awareness about EVM	0.9183	Training of all employees from the top to bottom of the organization on the EVM approach	0.9614
		Training on EVM software applications	0.8532
		Implementing a guideline for building projects in Sri Lanka	0.7268
Taking a long time to train project teams	0.9107	Training of all employees from the top to bottom of the organization on the EVM approach	0.8562
		Obtaining top management support	0.8013
		Allocating sufficient resources	0.7997
Lack of guidance on the implementation of EVM	0.9107	Implementing a guideline for building projects in Sri Lanka	0.9562
		Training of all employees from the top to bottom of the organization on the EVM approach	0.8451
		Training on EVM software applications	0.7896
Requirement for more paper work	0.8607	Training on EVM software applications	0.8265
		Developing communication channels	0.8023
		Allocating sufficient resources	0.7965
Time required to collect relevant data	0.8415	Implementing a guideline for the building projects in Sri Lanka	0.9452
		Training of all employees from the top to bottom of the organization on the EVM approach	0.9253
		Developing communication channels	0.8265
Difficulties encountered in understanding equations	0.8223	Training of all employees from the top to bottom of the organization on the EVM approach	0.8223
		Training on EVM software applications	0.8156
		Obtaining top management support	0.8145
Belief that EVM does not give accurate information	0.7493	Obtaining top management support	0.8206
		Training on EVM software applications	0.8199
		Developing communication channels	0.8187
Lack of adequate details to make decisions	0.5572	Training of all employees from the top to bottom of the organization on the EVM approach	0.8932
		Changing the culture of the organization	0.8853
		Allocating sufficient resources	0.8523

According to the respondents, “Lack of awareness of EVM” is the most significant barrier for implementing the EVM approach in Sri Lanka. As discussed under expert interviews, the construction industry in Sri Lanka still uses traditional project management and rule of thumb methods. Therefore, respondents identified it as the most significant barrier for implementing the EVM approach. The second most significant barrier is identified as “Taking a long time to train project teams”. Interviewee IA opined that EVM is not known in Sri Lanka and that it thus takes a longer time to train a project team on this novel approach. The next most significant barrier that was identified was the “Lack of guidance on the implementation of EVM”. It was also the view of Interviewee IE that guidance is required to implement EVM principles in project management.

Table 3 illustrates the best three possible solutions that were identified from the responses received from the professionals as those that could overcome each barrier faced in implementing EVM in Sri Lanka. When considering the overall solutions available to overcome each barrier, it can be identified that providing training on EVM approach to all employees from the top to bottom of the organization, providing training on EVM software applications and the implementation of a guideline would help to mitigate most of the problems associated with the implementation of the EVM approach.

4.4. EVM FRAMEWORK FOR PERFORMANCE EVALUATION OF LARGE SCALE BUILDING PROJECTS IN SRI LANKA

This conceptual framework was established based on the main findings of this research. The framework outlines the project management process, EVM guidance and standards given by the PMI as presented in Figure 1.

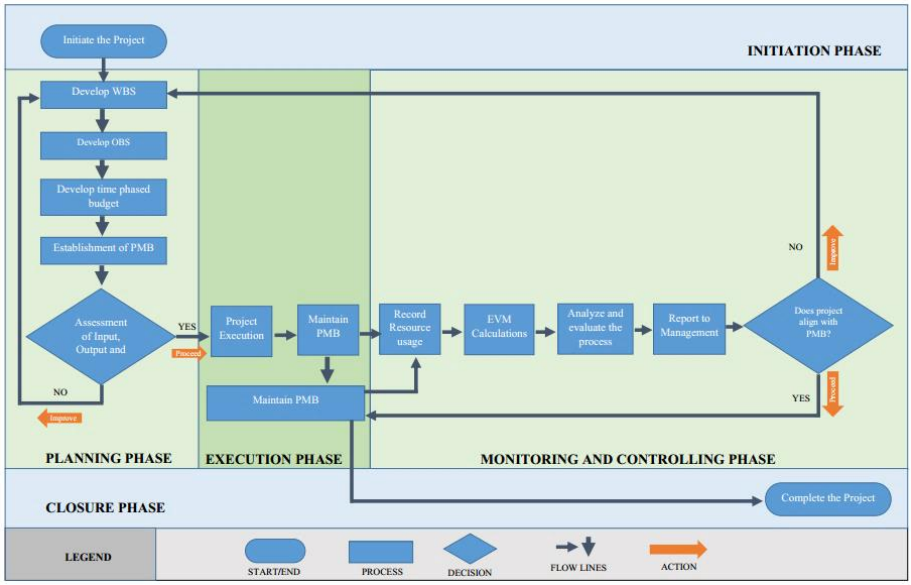


Figure 1, EVM framework for performance evaluation of large scale building projects in Sri Lanka

As illustrated in Figure 1, a sequential process is in place from the initial phase to the last phase. Since EVM is considered as a performance evaluation technique, there are more activities taking place during the monitoring and controlling phase. One of the decision making points is in the planning stage where the project team will assess the inputs and outputs to create the PMB. If they are not at a satisfactory level, the project team will design the process starting from the stage "Develop WBS". If it is satisfactory and if the information produced is relevant, the execution phase will commence. The next decision making stage will involve the analysis and evaluation of the project. During this stage, the project team will check whether the project is aligned with the PMB or not. If it is aligned with the PMB, the project team will proceed to the activities that follow while managing the changes. If the project is not aligned with the PMB, the project team will revise the element in this structure. If there is a large deviation, the project team will have to make suitable changes to the PMB and execute the activities that follow.

This framework can be used as a guideline for establishing the EVM process to mitigate confusion and discrepancies in project management.

5. Conclusions and Recommendations

The aim of this research was to develop a framework for adopting the EVM concept for performance evaluation in large scale building projects. In order to accomplish the aim of this research, several objectives were formulated. The findings of this study precisely elaborate how EVM could become an effective tool for attaining project success. The research outcomes also provide solutions that will mitigate the barriers that impede the effective implementation of EVM applications in the construction industry in Sri Lanka. After considering the different findings obtained from various sources, a framework was developed for performance evaluation of large scale building projects in Sri Lanka. The aim of this research was achieved ultimately along with its objectives which were sensibly and precisely described above.

This study entirely focused on adopting EVM applications in large scale building projects in Sri Lanka. The findings from the literature review, expert interviews and the questionnaire survey confirm the need to implement a proper framework to make a project a success. The findings reveal that when EVM is used in a conscious manner, it can track the current status of a project functioning as a tool to overview the project and let the management make improved decisions to prevent failures. Furthermore, it is found that certain areas required more attention for implementing EVM as a standardised project management tool.

According to the data collected during this research, the construction industry as it is today has to be equipped with novel project management tools like the EVM approach. Therefore, it is required to change the current state of the industry to some extent if the real value of this technique is to be obtained. On the other hand, certain steps need to be taken to implement EVM as a proper mechanism. A guideline relating to the EVM approach for projects in Sri Lanka can be developed. These guidelines have to be followed from the top level to the bottom level management of an organization as the contribution from all of them would be required for a proper EVM application during an entire project life cycle.

6. References

Ajayi, O.M. Ogunsanmi, O.E. and Salako, O.A. 2011 *Risk classification model for design and build projects*. Journal of Engineering, Project, and Production Management, 46-60.

Alfaj, N.S., Khatri, A.P. and Dhavale, T.B. 2016 *Application of Variance Analysis in Construction Cost Monitoring and Controlling*. International Journal of Engineering Research & Technology, 256-259.

Antony, P.M. and Thirumalai, R. 2014 *Project Performance Evaluation by Earned Value Method.* International Journal of Innovative Research in Science, Engineering & Technology, 73-81.

Ashworth, A. 1999 *Cost studies of building* (3rd ed.) England: Longman Group Ltd.

Atkin,B., Borgbrant, J. and Josephson, P. 2003 *Construction Process Improvement*, United Kingdom: Blackwell Publishing.

Behm, M. 2008 *Construction Sector.* Journal of Safety Research, 175–178.

Bhosekar, S.K. and Vyas, G. 2012 *Cost Controlling Using Earned Value Analysis in construction Industries*. International Journal of Engineering and Innovative Technology, 324-332.

Cooke, B. and Williams, P. 2009 *Constructing Planning, Programming and Control* (2nd ed.) Hoboken: Blackwell Publishing.

Costa, D.B., Formoso, C.T., Kagioglou, M., Alarcon, L.F. and Caldas, C. 2006 *Benchmarking initiatives in the construction industry: Lessons learned and improvement opportunities*. Journal of Management in Engineering, 158–167.

Doloi, H., Iyer, K.C. and Sawhney, A. 2011 *Structural equation model for assessing impacts of contractor's performance on project success*. International Journal of Project Management, 687–695.

Greene, J. C., Caracelli, V.J. and Graham, W.F. 1989 *Toward a Conceptual Framework for Mixed-Method Evaluation Designs,* Educational Evaluation and Policy Analysis, 255-274.

Gunathilaka, S., Tuuli, M.M. and Dainty, A.R.J 2013 *Critical analysis of research on project success in construction management journals*. In Smith, S.D., and Dagbui, A.D.D (ed), 29th Annual ARCOM Conference, Association of Researchers in Construction Management, United Kingdom

Hussin, J.M., Rahman, I.A. and Memon, A.H. 2013 *The Way Forward in Sustainable Construction: Issues and Challenges*. International Journal of Advances in Applied Sciences, 15-24.

Jick, T.D. 1989 *Mixing Qualitative and Quantitative Methods: Triangulation in Action,* Administrative Science Quarterly, 602-611.

Johnson, R.B. and Onwuegbuzie, A.J. 2004 *Mixed Methods Research: A Research Paradigm Whose Time Has Come*, Educational Researcher, 14-26.

Knutson, K., Schexnaydre, C.J., Flori, C. and Mayo, R.E. 2011 *Construction Management fundamentals* (2nd ed.) New Delhi: Tata McGraw-Hill

Lipke, W., Zwikael, O., Henderson, K. and Anbari, F. 2009 *Prediction of project outcome the application of statistical methods to earned value management and earned schedule performance indexes*. International Journal of Project Management, 400-407.

Marco, D.A. and Narbaev, T. 2013 *Earned value-based performance monitoring of facility construction projects*. Journal of Facilities Management, 69-80.

Meredith, J.R. and Mantel, J.S.J. 2000 *Project management: A managerial approach* (4th ed.) New York: John Wiley & Sons.

Nwachukwu, D.C. and Emoh, F.I. 2011 *Building construction project management success as a critical issue in real estate development and investment*. American Journal of Social and Management Sciences, 56-75.

Pekuri, A., Haapasalo, H. and Herrala, M. 2011 *Productivity and Performance Management – Managerial Practices in the Construction Industry*. International Journal of Performance Measurement, 39-58.

Project Management Institute. 2005 *Practice Standard for Earned Value Management*. Pennsylvania, USA: Project Management Institute.

Project Management Institute. 2008 *A Guide to the Project Management Body of Knowledge* (4th ed.). Pennsylvania, USA: Project Management Institute.

Salikumar, S. and Johny, M.A. 2016 *Application of Earned Value Analysis in Analysing Project Performance*. International Journal of Engineering Research & Technology, 459-464.

Sechrest, L. and Sidani, S. 1995 *Quantitative and Qualitative Methods: Is there an Alternative?*, Evaluation and Program Planning, 77-87.

Soloman, P. 2002 *Using CMMI to improve Earn Value Management*. United Sates: Carnegie Mellon University.

Takim, R., Akintoye, A. and Kelly, J. 2003 *Performance measurement systems in construction*. In: Greenwood, D. (ed), 19th Annual ARCOM Conference

Teddlie, C. and Tashakkori, A. 2003 *Major Issues and Controversies in the Use of Mixed Methods in the Social and Behavioral Sciences.* In A. Tashakkori & Teddlie (Eds.), Handbook of Mixed Methods in Social and Behavioral Research, TO, Sage.

Vyas, A.B. and Birajdar, B.V. 2016 *Tracking of Construction Projects by Earned Value Management*. International Journal of Engineering Research & Technology, 829-831.

Rajapaksha.U, et al (eds), 2017, "Design that cares"- multi disciplinary approaches to creating sustainable and meaningful built environment: *Proceedings of the 10th International Conference of Faculty of Architecture Research Unit (FARU), University of Moratuwa, Sri Lanka, (Vol. 01)* pp. 148-159 ©

THE GROUNDS FOR CARING ARCHITECTURAL PRACTICE:
How Aspiring Life's Purpose as Wellbeing is Architectural Value

KARASSOWITSCH, M
Ansal University Sushant School of Art and Architecture, Gurgaon, India
michael@karassowitsch.ca

Abstract
A comprehensive orientation to science and technology, as thought 'answers' for problems and design is not essentially caring nor humane and has inherent destructiveness to the planet's life. This paper proposes that architecture is original to dwelling and it is 'caring' as questioning life's purpose. Its role is to provide care as environments that support wellbeing. The built environment that provides wellbeing is caring. Wellbeing is defined as cascading out of life's purpose. Life's purpose is finding out what that is. Spiritual practice engages this. Spirituality in the form of rajayoga and its antecedents brings a 'more original' 'alternate cognitive knowledge' that inform discriminating architectural value from the profession's hegemony of technological problems and design. The *Verknüpfung* or 'mutual claiming of one another' of architecture and spirituality is described in outline according to my dissertation to show how architectural value may be generated in a space of discriminating means (technology) from ends in dwelling (architecture). The conclusion is that the technicist value proxy is replaced by re-allocating the discriminative capacity of consciousness to provide practice of architectural value. Caring architectural practice that serves wellbeing is based in Mind rather than body. This is illustrated with five vectors of research questioning how matters of dwelling presence aspiration at loci to provide caring architecture for realizing such practice.

Keywords: *Architectural practice; spiritual practice; technology; rajayoga; wellbeing.*

1. Introduction – architectural practice is caring.

What is the caring of architectural practice? Is design as caring possible? In order for the built environment to be caring it must provide wellbeing. Wellbeing is defined as cascading out of life's purpose. Life's purpose is about finding out what that is. Technology as 'answers' to material problems and as design and construction solutions is not in essence caring nor is it humane and it is proving to have inherent destructive qualities to the planet's life. Technological answers conceal conscious awareness if proposed as exclusive of anything exterior to its measure, denying humanity in essence. Design is technic of freedom-of-choice to organize and unify solutions to problems,

while architecture is original need that takes conscious awareness into account. Can architectural practice be caring if its technological means of design and construction are valued as its ends?

2. Proposal – architecture as wellbeing is caring.

This paper proposes that architecture's essence is 'questioning' and that it is 'more original' as in Said (1997) and Heidegger (1971; 1977), while technology as 'answers' is not original. The answers of technology, which includes design, are means and cannot question architecture. Architecture transcends its current professional basis in building and the body, e.g. the 'primitive hut' and all that implies. This paper expresses re–locating conscious awareness as taking–in–hand practice of architecture to replace the concealing technicst value proxy with architectural value. It is based on my dissertation that demonstrates the 'mutual claiming of one another' or *Verknüpfung* of practices of architecture and spirituality. [Karassowitsch 2016]

This is an innovative approach to a paradigmatic change that the architectural profession faces as our conscious awareness naturally develops self-understanding and questions meaning in dwelling that must alter the environment. Spiritual practice has been asserted as high value care since before history, originally. It is caring 'within'. Architecture is this caring in the change we must make in the environment, 'without'. This paper proposes that practice of architecture *verknüpft* with spiritual practice is Nature — which includes Mind — as care. Caring architectural practice of preparing environments may utilize technology, including design, to provide environments that are prepared to presence the aspiration of conscious aware questioning. Every individual is an architect in the sense that each individual presences this questioning aspiration as care for themselves. Architectural value may be generated in a space of practice that is opened and held open by aspiration of conscious awareness presencing as architecture.

3. Method – Toward architectural practice as a space of differentiation

Spiritual practice in the form of rajayoga and its antecedents is developed by researchers who take Mind in hand, such as Patañjali, Buddha, Vivekananda (1978), Sri Ram Chandra (1997; 2009), Krishnamurti (1985), Patel (2017), Larson and Battaracharya (2008), and many others. As practice, spirituality has inherent 'philosophy' that is 'alternate' to the common empirical scientific material and technological basis. This knowledge is not dependent on material measure and includes 'all', even if it is not (yet) known. Architecture and spirituality claim one another and are inherently mutually responsive so that the 'alternate cognitive knowledge' of spirituality serves in practice to discriminate

architectural value from technological means to differentiate value in the full field of dwelling that aspires the immeasurable and the infinite extents of life that technology can not touch.

3.1. SPIRITUALITY IN CONTEXT OF ARCHITECTURAL PRACTICE.

Rajayogic practice and architectural practice both challenge technology's meaningfulness. Its 'alternate cognitive knowledge' is concealed in the work of many architects (eg. CoopHimmelblau, Frank Gehry; MVRDV and Venturi–Brown), or in more revealed form (e.g. Louis I. Kahn and Rudolph Steiner). Rem Koolhaas in Bigness (1994) points to architecture's future, theorizing the XL project as "after–architecture". The 'Enframing essence' of technology, as defined by Heidegger (1971) and as the Machine Ages by Banham (1980), coheres with Husserl's (1981) initiation of modern phenomenology as it does with architecture now. Husserl's formulation of phenomenology is similar to elements of spiritual practice to reflect its utility.

Spirituality has a goal at infinity and takes–in–hand consciousness as practices as a path that comes to be known. Aspiration is simultaneously this goal and its revealing path. Aspiration is entirely the experience of each individual within themselves realizing wellbeing in self-application to the raison d'etre of humanity's immeasurable capacity of consciousness. Architectural practice is a singular superordinate program of preparing loci that support wellbeing as aspiration presencing as architecture. This works toward a paradigmatic transition of the architectural profession from a technicist basis of the body to its origin in Mind. This may at first seem inconclusive to readers looking for discrete terms. Architecture extends beyond the purview of Machine Ages empirical measure, but it includes it. Architecture is 'concealed' in its technological means if valued as 'answers' exclusive of value beyond measure as the ends of architecture. The practicing architect's role may transition beyond technological results to preparing environments that 'care' for the destining original to consciousness dwelling. The discriminating architect crafting consciousness at prepared loci to influence wellbeing also forms paradigm change of the discipline.

3.2. CARING ARCHITECTURE AS PREPARED LOCI OF ASPIRATION

We are free to choose. There is in fact no escape from choices and making change. Finding best purpose becomes important to us as we realize consciously responsibility of inherently changing the world. 'Questioning' in terms of our freedom-of-choice is inherent in this. Our capacity is taken as a social right and a positive attribute of advanced, technological, democratic and wealthy societies in materialistic modern globalizing cultures. Within that

valuation we face our desires and wish to achieve personal control of life in contexts that are de–coupled from tradition's more prescribed limits. Our capacity frees us to transform ourselves and the world. Design is tools to face such choice with which we make programs of desire, yet is an amoral limiting mutability that conceals. Freedom-of-choice allows us to transform our lives, but to transform freedom-of-choice to freedom-of-duty to devotion, love and merger with the ultimate condition available to us is elusive. This destined condition is more original than freedom–of–choice.

Architecture of wellbeing is finding out purpose in this ocean of change borne in freedom–of–choice. It is inexorable destiny, which gets its value through dwelling. Change has meaning beyond the material aspects at the nexus of conscious life. No matter what is measured, its extents will always escape materiality toward infinity. Changes in an environment are part of this. Assessing the value o life is the same as assessing the value of architecture. The choice we must take responsibility for due to our conscious capacity and immeasurable attributes determine identity and community and architecture originally. The purpose of dwelling — whatever that may be — is borne in the choices we make, including awareness of its questioning, even if concealed in building technological means. Architectural practice serves as the singular programme superordinate to its multiple programmes of shelter, building or technology, desire and conflict, and making lovely, radical and clever desirable shapes. Architecture aspires revealing the real importance of our influence on environments. Architecture gives measure to dwelling in a play of dwelling's purpose like quantum changes that apparently defy rationality, technological process and material forces.

3.3 'ALTERNATE COGNITIVE KNOWLEDGE' AND ARCHITECTURAL PRACTICE.

Architectural value in dwelling is accessible through 'alternate cognitive knowledge' of Mind. Neither the body or the soul can be evolved in a lifetime, but the Mind can. The Mind is component of a whole that includes the body and the soul, has karma to be transcended and the many 'sheaths' and veils to be cleared off. The dwelling Mind has four aspects in rajayoga. See Figure 1 as adapted from Patel (2017):

Chit — consciousness. This develops toward its highest form.

Manas — the contemplative function. Develops from thinking or thought to feeling to being to non–being.

Buddhi — intellect. From intellect comes intuition and wisdom. And,

Ahankara — ego or the aspects that instil drive. Ego transforms to humility and on to love.

A simple prayer may help to understand these is:

May we all develop correct thinking,
right understanding,
and an honest approach to life.

Everyone is attaining rightness in action and perfection in character.

The first, second and third lines represent *manas*, *buddhi* and *ahankara* respectively. *Chit* is reflected in the last line. It benefits from the others as their canvas.

The natural interaction of these in dwelling bids an approach to facilitating practice based in Mind, consciously. To utilize conscious awareness is

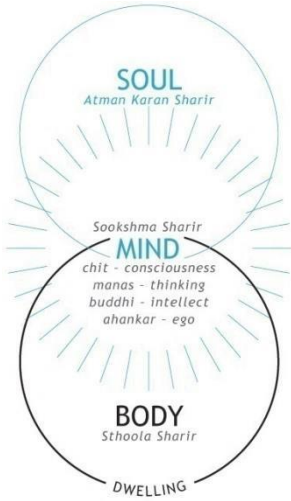


Figure 1, three bodies

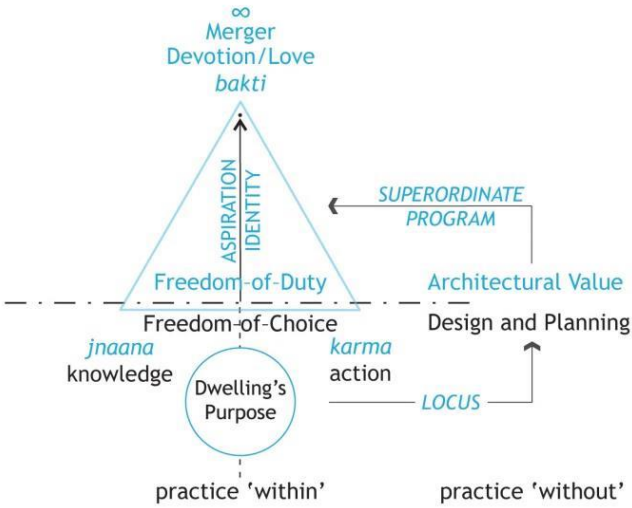


Figure 2. Freedom-of-choice in architectural value.

the superordinate choice that defines spirituality as it must architectural value. Architecture based in Mind, rather than as shelter and functions, must aspire dwelling's purpose accordingly as an original faculty of preparing loci for dwelling. This is freedom-of–choice taken–in–hand. Technology can never know spirituality and if architecture pretends it is technology, then dwelling's granted capacity falls into what Heidegger calls 'oblivion' (1977:xxxiv–v). Design is tools of freedom-of-choice to serve the superordinate program that reveals architectural value in vectors of practical research based in Mind. See Figure 2. The 'alternate cognitive knowledge' of spiritual practice is a channel

of influence for architectural practice to access aspiration that presences as architecture. This will facilitate the development of caring architectural practice based in dwellings' purpose.

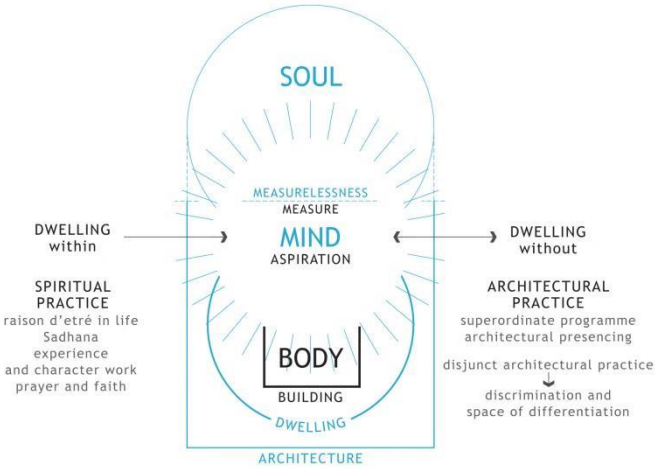


Figure 3. The role of aspiration and identity. The body dwells. Mind does and does not dwell. Building is akin the body, while dwelling extends beyond building and environment. Architecture comprehends body and Mind. Soul comprehends architecture and its aspiration.

The purpose of dwelling accords with freedom–of–choice to link 'dwelling within' and 'dwelling without'. Mind that discriminates, questioning 'what is 'I' and what is all else?' discriminating the means that serve aspiration in architectural practice aspiring the soul's 'reality' is essential to architectural practice. Architecture is thus inclusive of what we cannot measure, allowing that to influence by giving measure, whereby science finds measure and technology functions accordingly. Architectural practice responsible to the essential questioning registers the *raison d'etre* of dwelling through attainment's aspiration 'within' (spirituality) via intentional environments 'without' (architecture). See Figure 3.

'Realization' below illustrates this as Matters that are vectors of research for aspiring practice of architectural value.

4. Conclusion – Caring architectural practice is preparing loci to presence aspiration.

The principle of caring architectural practice is preparing environments that presence aspiration. Design is a tool. This practice is based in Mind questioning

destining of conscious awareness. Caring is to know means (technology) from ends (aspiration) in practice of a superordinate programme of realizing life's goal as consciousness dwelling (Mind) in community. Spirituality is experience that needs no further document than the experiencer, yet its practical forms bear knowledge that is *verknüpft* with architecture. The application of the superordinate program of questioning 'original' purpose forms practice as a space of differentiation. 'Caring' is architecture practiced this way. Architectural value today is experience of aspiring a paradigmatic 'turning' within the essence of technology from the body as shelter and technical and procedural programs to its original architectural value beyond measuring and building means.

4.1 REALIZATION — PRACTICE

Caring architectural practice providing wellbeing begins with the proposition of 'after-technological architecture. This is not non-technological architecture. After–technology architecture was already alluded by Rem Koolhaas (1994) in his text theorizing Bigness. Bigness theorizes technological capacity and power that allows results that technological tools and methods cannot predict, plan nor comprehend. Bigness theorizes this 'unexpected' folded into practice again as technicist means valuing architecture as its concealment. Bigness verifies that built environments and programmes get their importance as architecture by unmeasurable but unmistakable ends, which Karassowitsch (2016) defines in 'aspiration'. This is what Rem Koolhaas names "after-architecture" from within his adherance to the architectural profession's technicist value proxy. It is after–technology architecture; after the technicist proxy, that he is pointing to. He verifies this in the exhibit *Fundamentals* at the 2014 Biennale where he chose to exhibit technology of architecture. It is as if he came to a conclusion whereby he needed to ask, 'What did I miss in all this?" During the tour he gave to Wainwright (2014) he states,

> Architecture has become a total fiction.

while pointing to the 2 cm of drywall hiding a large volume of technology. Architecture as "a total fiction" is architecture reduced to value of measure and technology, locking out the granted capacity of human conscious awareness and its destining. Practice of more direct architectural value that questions according to Mind *with* the means of the world is research in practice to dissolve this fiction that conceals. Spirituality is the level of consciousness to which we choose to aspire. "After–technology architecture" is 'caring' practice of preparing dwelling environments as aspiration. Such practice can be pinpointed by some of its qualities of which three are outlined below:

4.1.1 Superordinate programme.

The superordinate programme of dwelling exists because conscious awareness discriminates superordinate to matter, beyond ‘interval’ and measure. It reflects a state of awareness that touches infinity. 'Alternate cognitive knowledge' defines dwelling as a field of duty, devotion and love (*bhakti*). That special moment when the recognition of a ‘design solution’ appears comes through the means of programs and purposes to touch the condition of content–less awareness, or the "unmodified Mind" as in Vivekananda’s translation of the *Yogasutra* (1978). Architectural practice is the execution of this superordinate program.

4.1.2 Space of differentiation.

The ‘space of differentiation’ is an essential project of applying the superordinate program of dwelling in practice. The space of differentiation is opened and held open by the power to discriminate between dwelling's outcomes (i.e. architecture) and means (i.e. technology). The space of differentiation is akin to spirituality as practical questioning of the the purpose of dwelling turned toward personal transformative evolution. ‘What is ‘I’ (*purusha*) and what is all else (*prakrti*)?’ is the original question of practice. It is space of ‘turning’ beyond the technological mundane to practice of presencing aspiration.

4.1.3 Architectural presencing.

Architecture as aspiration ‘presencing’ as (anyone’s) awareness at a prepared environment means that architecture’s value is not matter, system or space. A brick, an arch, or any assembly, are never automatically architecture. If they are deemed to be architecture there is no way to define empirically exactly how that is so. Literature, history and criticism, as well as technicist tropes of mediation, merely reside well within a collective of massively iterated human experience: such summary evidence does not itself measure architecture and is subordinate. Yet, can anything be more trustworthy than the wildly mutable human experience when it consistently experiences the same through many individuals over millennia? This is unity as everyone constellating identity within the public sphere in aspiration. Architectural presencing is aspiration ‘physically’ borne in Nature, destined to reveal its granted role.

4.2 REALIZATION — FIVE MATTERS OF RESEARCH IN PRACTICE

The following five Matters express what 'caring' architectural practice is as research in architectural practice of service to provide wellbeing as loci prepared to presence aspiration. The conclusion of this paper is supported as

'questioning' — consciousness of research in practice — to give loci properties that allow aspiration to presence.

4.2.1 Material and environmental justice.

This is the Matter of how justice may presence aspiration in loci of dwelling. We move and house our activities in an infinite field of opportunity as change in our context in the world. High capacity for consciousness gives us awareness and choices in this change to increase that efficiency and capacity by orders of magnitude, if Nature's capacity is harmonized with humanity's role. This Matter is to find out architects' role in environmental justice in presencing architecture.

From a creature's place in the ecosystem to every particle of the universe, the evidence is growing that each has an exact place and essential role, while quantum science shows that the gaze of Mind is definitive to the object of attention. Yet, architects do not ask Nature's participation in developing and maintaining the loci of its making. We use Nature's offering as thieves, not as it is given. Our small technological part is to embalm what is taken, opposing Nature's life. Nature's law is other to systems of science and technology, but Mind creates technology and Mind is part of Nature. Nature 'comprehends' conscious awareness and the Mind that is borne within it. Human values are within Nature's terms, but humanity craves conflict and contradiction as its means for fulfilment. Mind is essential in this sense since Mind is brought by Nature as consciousness in dwelling. It is therefore powerful for the architect to *ask* when involving any atom, molecule, plant or animal, leave alone every person and community. Discovery of our role is paramount to such justice as architectural value.

A simple material example.is stone cut from the earth. It is found exactly there where it has lived centuries of megayears. How to cut it and not perforate Nature's values? How does architectural value presence Nature's value? This Matter of research is to find out how change presences aspiration in natural stone at prepared loci. Pre and post–tensioned stone structural assemblies such as columns, beams and arches have been explored by Peter Rice with Renzo Piano in the Padre Pio Church, see Milan (2001), and The Queen's Building, see Werran (1999). But the potential of structural natural stone assemblies remains unexploited in its new fullness. This Matter is to see how architecture presences environmental justice in structural stone as means.

4.2.2 Vibration

This Matter questions how architecture presences in vibration where our aural space and the EM space that travels freely through the atmosphere coincide with space that fits our body. See Figure 4.

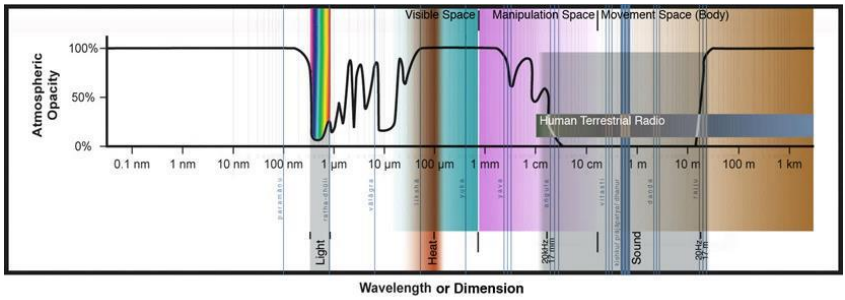


Figure 4, The grey area is the coincident dimension (log10) of audible sound waves, EM spectrum that passes through the atmosphere and the space of the body's movement, from wiggling a finger to 'room'. The 'cubit' is here Vaastu's '*kishku*', is the centre of the coincident space.

.

This is space having dimensions from ±1 cm to 20–30 meters. The cubit marks its midpoint on the log[10] scale. *De Architectura libri decem*, the *Manasara* (2001) and contemporary teaching describe harmonious proportions that mimic the energies of Nature. Yet, vibration is already the energetic harmony that forms dwelling and the world. Ancient modes appear to mimic material phenomena that have become ironic or meaningless because technicist tropes cannot currently accept what is not measured. Technics of measurement along with human sensitivity developing over millennia make possible more direct interweaving of the subtle qualities of space to deepen and transvalue proportion. Loci may be developed according to research in vibration that forms care as aspiration that presences as architecture. It is tuned vibration that reaches that of love in terms of what already allows matter, form and live's expression of consciousness.

4.2.3 Balance

Balance is a vital concept of construction. This Matter is of how architectture presences in repose and modes of stability extending to capacity and force within structural members. This questions colossal stress and strain that make the matter of construction violent as concealed explosiveness. This is also explosiveness in a void of the environment destroyed for fabrication. Images of repose are in conflict with such intensity if they are not tuned. In harnessing the forces of gravity properly, contextual vibratory spaces can support wellbeing. How does proportionate force as a state of questioning presence architecture?

4.2.4 Living loci

This Matter is research of how Mind harmonized with the infinite generosity of Nature presences architecture. Contemporary building with construction and assemblies embalmed to keep material from changing is in conflict with life. This expresses that what we build is not intended to be alive. Living things last long in a way that embalmed dead things cannot. Life heals, grows and replaces itself. Life channels energy according to need. The technicist value proxy of architecture conflicts with architecture, in conflict with it in this same way. Research toward 'after–technology' is toward direct harmony with Nature, and so also with humanity's natural aspiration, to end practices of thievery and death. The work of Small-Wright (1997) and Armstrong (2011) define two dimensions of the field. Small-Wright receives Nature's guidance for dwelling loci as 'gardens'. Armstrong engages the 'secrets' of physics and chemistry that life utilizes. Rajayoga attends to balance within through knowledge of Mind, which is expressed as aspiration; hence it leads to caring practice for wellbeing.

4.2.5 Self–understanding

This Matter 'questions' how evolutionary force in identity and unity presences architecture. How does the engagement of 'matters' in architectural practice addressed as self-understanding serve this transformation of practice? Self–understanding is part of the intention that maintains the public sphere as simultaneous identity and unity, whereby public and private space are measure that architects give to the public sphere. The architect is personally integrated with this project of finding out the role of Mind as a natural element of evolution inherent within the world in serving the superordinate questioning programme of architecture. Mind's purpose can be revealed in evolution already long underway, which rajayoga evinces, among others. Architectural practice is revealed as serving the need of human destining evolution. Identity is then the locus of all outcomes and self–understanding is the key to developing caring architecture and reassessing architectural education and the architectural profession as presencing aspiration.

References

Unknown. 2001, *Manasara Series.* P. K. Acharya. (trans.)(ed.) Delhi, Low Price Publications.

Armstrong, R. 2011, *Protocell Architecture*, Architectural Design. Spiller N., Armstrong, R. (eds.) New York, Wiley.com. March/April 2011. Vol 81, No 2.

Banham, R. 1980 *Theory and Design in the First Machine Age*. Second Edition. Cambridge, Massachusetts:, The MIT Press,.

Chandra, R. (Fathegharh) 1996, *Truth Eternal* Madras, Shri Ram Chandra Mission.

Chandra, R. (Shajahanpur) 2009 *Complete Works of Ram Chandra Volume One and Two* Complete Works of Ram Chandra Kolkata, Spiritual Hierarchy Publication Trust

Heidegger, M. 1971, *Building Dwelling Thinking*, Poetry, Language, Thought. Hofstadter, A. (trans.) New York, Harper Colophon Books.

Heidegger, M. 1977, *The Question Concerning Technology, and Other Essays* Lovitt, W. (trans.) New York: Harper Torch Books

Husserl, E. 1981, *Pure Phenomenology, Its Method and Its Field of Investigation* Husserl: Shorter Works. Jordan, R. W. (trans.), McCormick, P. and Elliston, F. A. (eds.) Notre Dame, Indiana University of Notre Dame Press.

Karassowitsch, M. 2016, *The Goal in Architecture: The Mutual Claiming of One Another of Spirituality and Architecture.* Academy of Fine Arts Vienna.

Koolhaas, R. Mau, B. 1994, *S, M, L, Xl.* Sigler, J. (ed.) (1st ed.), New York, Montacelli Press.

Krishnamurti, J., Bohm, D. 1985, *The Ending of Time.* New York, HarperCollins.

Larson, G. J., Bhattacharya, R. S. 2008, *Yoga: India's Philosophy of Meditation* Encyclopedia of Indian Philosophies Vol. 12. Bhattacharya, R. S. Gerald J. L. (eds.) Delhi: Motilal Banarsidass Publishers Private Limited.

Milan, M. Simonelli, F. *Padre* 2001, *Pio Church, Foggia, Italy* Structural Engineering International, Zurich, International Association for Bridge and Structural Engineering. Volume 11, Number 3, 1 August 2001, pp. 170-172(3)

Patel, K. D. 2016, *The Three Bodies and The Subtle Body* Heartfulness. Chennai: Sunil Kumar representing Spiritual Hierarchy Publication Trust on behalf of Sahaj Marg Spirituality Foundation. Volume 2 (14) pp. 28-39

Said, E. 1997, *Beginnings: Intention and Method*. 2nd ed. London: Granata Books.

Small–Wright M. 1997 *Behaving as it the God in All Life Mattered.* Cardiff, CA: Perelandra.

Vivekananda 1978, *Raja-Yoga or Conquering the Internal Nature (1896)*. Swami Vivekananda (Trans.) Dt. Champawat, Uttarakhand, India: Advaita Ashrama.

Wainwright, O., Levene, D. 2014, *Rem Koolhaas: 'Architecture has become a total fiction'* The Guardian London: The Guardian. www.theguardian.com/artanddesign/video/2014/ jun/06/rem-koolhaas-fundamentals-venice-architecture-biennale-video.

Werran, G. R., Dickson M. G. T. 1999, *Prestressed Ketton Stone Perimeter Frame: The Queens Building, Emmanuel College, Cambridge* The Structural Engineer London, The Institute of Structural Engineers. Volume 77 1999 Issue 20.

Rajapaksha.U, et al (eds), 2017, "Design that cares"- multi disciplinary approaches to creating sustainable and meaningful built environment: *Proceedings of the 10th International Conference of Faculty of Architecture Research Unit (FARU), University of Moratuwa, Sri Lanka, (Vol. 01)* pp. 160-175 ©

SENSING THE CITY: ARCHITECTURE & MUTISENSORY ENVIRONMENT

A case study on Chaktai khal-Khatungonj zone; some possibilities & proposals

NUSRAT SULTANA
Chittagong University Of engineering & Technology.Chittagong, Bangladesh
nusrat1emu@gmail.com

Abstract
Architecture is the art of reconciliation between ourselves and the world, and this mediation takes place through the senses. Chittagong, the second largest city in Bangladesh, reserved with a major canal, named Chaktai Khal having some specialty and historical background. describes the city's glorious senses with its historical background and activities'essence. That is why it can be an attractive place for recreation and social interaction through developing the condition & to increasing the natural beauties of the canal as well as the surrounding areas to develop the city senses. The unplanned situation of the Chaktai Khal –Katungonj area, the previous main trade route of city, has been reducing the beauty and the glory of the canal. The research approach includes the present scenario recounting problems and a systemic methology to designate the demand, management policy and potentiality of this location. To summarize, this study suggests for some recommendation and some design proposal to embellish the Chaktai khal zone so that the people of the Chittagong city can explore sustainability and investigate yet more layer of the city and city lives.

Keywords*: Sensing the city, Multisensory Architecture, Chittagong, Recreation, Social interaction, Sustainability*

1. Introduction

The problem of waterlogging in Chittagong has reached such an extent that the first monsoon rain is enough to shut down the city. The most vulnerable places are Bakalia, Chawkbazar, Agrabad, Halishahar, Kapasgola, Chandgaon, Shulakbahar, Bahaddarhat and the Probartak intersection, which went under water due to heavy rains, causing immense sufferings to the people living in these areas. Chittagong is located in the tropical zone, where high temperature and heavy rainfall with high humidity is a general characteristic of the summer season. Annual rainfall in the city fluctuates between 2100mm and 3800mm, of which 2400mm occurs only during the monsoon. However, such climate has been there for centuries, while water logging is a comparatively recent phenomenon. In the last decade or so, this problem has been increasing due to population growth, economic agglomeration with unplanned urbanisation, illegal refilling of natural water channels, and encroachment of drains. Most of the drainages are obstructed by building structures, that have overtaken the natural gravitational drainage systems of the city, which were organised

enough to cope with the natural rainfall. The causes behind waterlogging are well known and the media have been vocal on these issues. Despite that, why is there little policy intervention to improve the situation? First of all, the governance of drainage systems does not belong to any particular authority. Besides, the distribution of management of the drainage system follows the drainage hierarchy, namely the primary, secondary and tertiary drainage. The Chittagong City Corporation (CCC), for example, mainly deals with the drainages besides houses, roads and small scale, unstructured rainwater runoffs. While the Chittagong Development Authority (CDA) deals with primary and larger canals, Chittagong WASA (CWASA) is responsible for sanitation and storm water management. Hence, drainage system management is either over-mandated or under-mandated to these institutions. Some critics allege that coordination meetings among stakeholders are held only during the monsoon when the water logging issue surfaces. Recently, the CCC and CDA were given the responsibility to reclaim the Chaktai khal (canals) at a coordination meeting. However, past experiences show that the decisions made in such meetings are barely implemented. After developing the CMMP 1995 guideline, the drainage system was supposed to be implemented within one and a half years, but the plan has not been put into effect in the last 13 years. Lack of coordination also hindered the construction work of the canal (Mirza- Chaktai), which could have protected a huge area under Panchlaish and Chandgaon Police Station from waterlogging (The Daily Star, 2008).Major focus of the study is the multisensory environmental availability of the Chaktai khal following the social and economical activities of the daily users.This study search for the existing scenario of the Chaktai khal.It will also address the issues of land use,occupancy type,water way renovation, management and maintenance.This study can be a guidline for policy makers to Chittagong City to make the environment of the Chaktai khal more suitable to reinforce the need for the human experience.

2. BACKGROUND OF THE STUDY

Chaktai is the major seat of trade and commerce in Chittagong. It’s a wholesale market dealing with food items like rice, pulse, onion, ginger, powder milk, sugar, edible oil, dry fish, etc., and building materials like C. I. Sheet, paint etc. Roads and lanes in Chaktai often remain congested because of trucks loading and unloading commodities to the roadside warehouses and yards. Retailers from greater Chittagong area frequently visit Chaktai for collecting their merchandise. Though Chaktai has lost its past glory as a national business centre controlling food business in the whole country, still it has retained its Importance as a regional business hub and is continuing to contribute significantly to our national economy. Business houses are moving out of Chaktai. Unlike in the past, Chaktai is losing its importance. It is failing to

attract new businesses to the area because of certain problems. Drainage and water logging can be identified as one of the inter-related problems hindering development of Chaktai area. In fact, it is not a problem for Chaktai area alone, rather is the problem of the whole city of Chittagong. The drainage and water logging is a major problem that discourages development of Chittagong. In this area, the scope of space about social activities zone; suppressed by the culture; can be renovate again.

3. STUDY AREA

The study has tried to identify an area where the main khals draining the city terminate. Additionally in socio-economic consideration, have also tried to identify a densely populated commercially important area for the study. Chaktai commercial area fits into the above criteria. Both Chaktai and Rajakhali Khals, two main drainage channels of Chittagong, terminate in the river Karnaphuli traversing through this area. Part of the area is densely populated. Remaining part of the area is expected to be developed in the immediate future as the area falls within Bakalia, earmarked as a thrust area for development in the Structure Plan for Chittagong, 1995. For the sake of convenience, we have named the study area as Chaktai though the west bank of Chaktai khal, northern and eastern parts of the study area do not exactly fall within Chaktai.In this area,there is no recreational facilities,water sources are filled up with garbage,bad smells from the garbage,weak pedestrian facilities,local roads with land encroachment leads towards the disturbance of the environment sensitivity with emotion, sensation and reaction of the users of the Chaktai khal.It is high time we explode our natural treasure and utilize it.

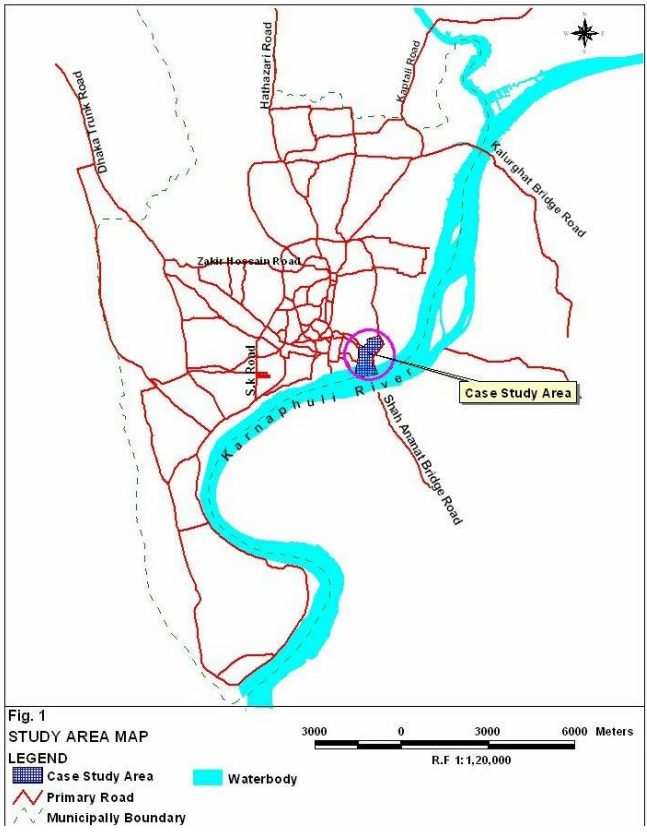


Fig. 1: Location of Chaktai commercial area (Study Area) in Chittagong(Source:Author)

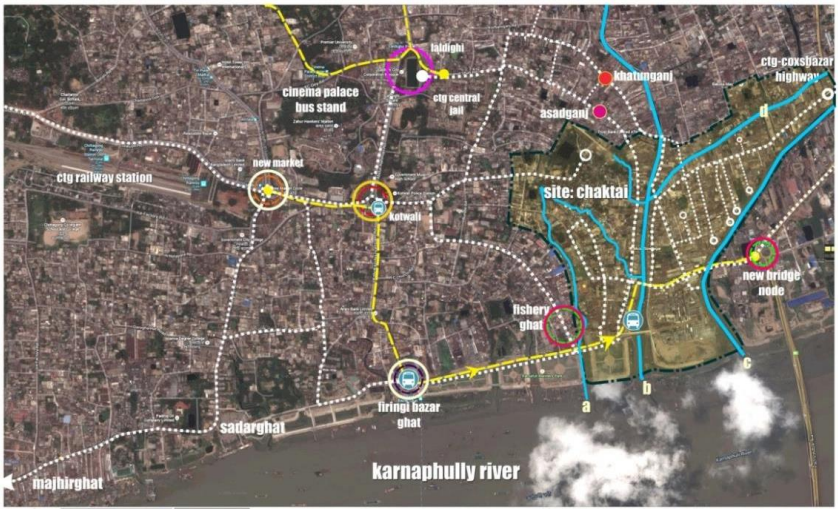
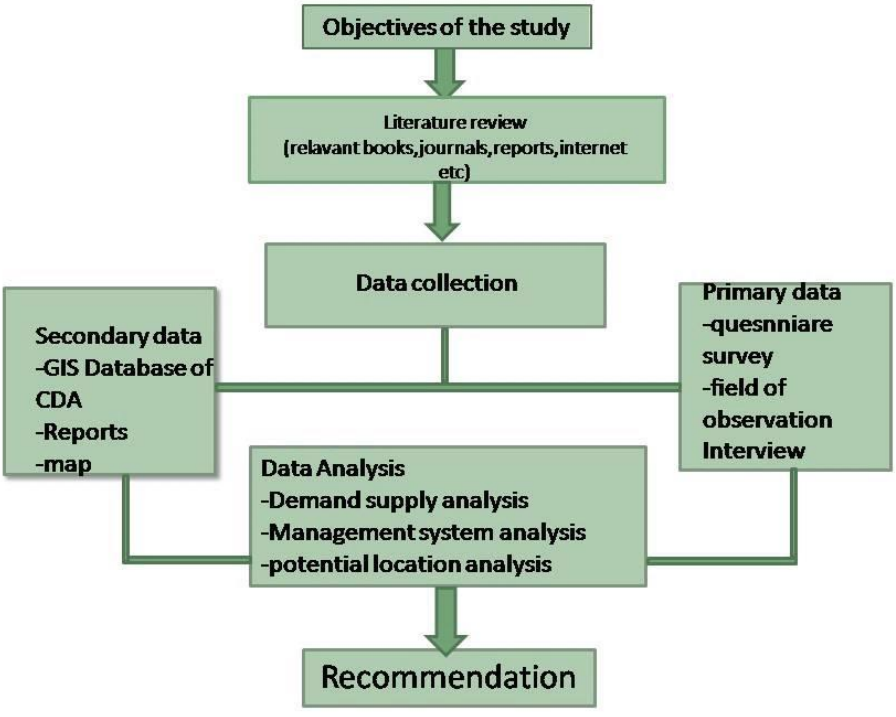


Fig. 2: Location of Study Area(Source:Google Earth)

4. METHODOLOGY OF THE STUDY

The methodology of the study follows the standard steps which included setting up of objectives, literature review, data collction, data analysis and recommendations. General methods were used to gather data such as; literature survey, questionnaire survey, field survey, field observation and interviews.A simple flow diagram shows the major steps of the study. Details of these steps are discussed below.



FLOW DIAGRAMS OF DIFFERENT STEPS OF STUDY

The following methods were mainly utilized in completing the case study.

4.1. REVIEW OF RELEVANT LITERATURE

Relevant literature which includes books, published and unpublishes thesis articles, journals, reports etc were inspected and analyzed.'the internet'is also a major part of the literature review.

4.2. DATA COLLECTION

All necessary data for this research were collected from both primary and secondary sources.

4.2.1 Primary Data Collection:

Primary data was collected to gather the first hand experiences regarding existing physical condition, social and economical condition, management, maintenance sytem at Chaktai khal zone.The management and maintenance related problems, users' perspective, view of the decision makers and professional opinionswere collected.The following methods were used to collect data.

Questionnaire Survey:

A questionnaire survey was conducted amongst the users of the area as well as the residents of the adjoining communities and users for economical activities of wholeshale market facilities to evaluate the existing problems, their demand,level of satisfaction and opinion about their facility.Total sample size was 200,which were evenly distributed between on site users (100 samples),andadjacent households(100 samples).Table 1.1 shows the distribution of the samples.As the area is about 14.49 hectares and occupies 24.69% of the study area. Built-up area is about 56.57% of the study area, and Khals and water bodies occupy the remaining 18.74% of the study area.

Field Oservation:

Field situation was observed to gather experience on the existing_condition with problems andissues. An observation checklist was prepared to collect data. potential location were verified through this process.

Interview:

Local government official and local experts were interviewed to share their experience, future plan,suggestions for opportunities and proposals.In this process officials of CDA,CCC and PWD were interviewed.

4.2.2. Secondary Data Collection:

Secondary data was collected to identify to find the existing demand supply gap.

Following data has been used to collect informations:

-Primarily GIS Data (collected from CDA)
-Coverage File of Chittagong City Corporation boundaries
-Transport network
-water bodies, land use, structure of the area
-Different Paper Maps

4.2.2. Data Analysis:

- Management System Analysis:
  Problems and issues regarding management were identified from informations collected from the questionnaire survey, field observation, interview and review of related literatures.

- Demand supply analysis:
  Data analysis like per capita distribution, land use coverage, economic dependency etc were done to understand the issues and to prepare a proposal.Demand was derived using different local,national and international standards for waterways and social interaction space along side the waterways.

- Potential area ananlysis:
  secondary data, field visit and observation mrethods were chosen.In this regard,factors like land use pattern,ownership,availiability of spaces for gathering spaces have been considered.

5. EXISTING CONDITION OF THE LAND USE

Most of the land depends on commercial activities. Moreover, there are some mixed use traditional building which one is used for store in the ground floor and residence on the upper floor.

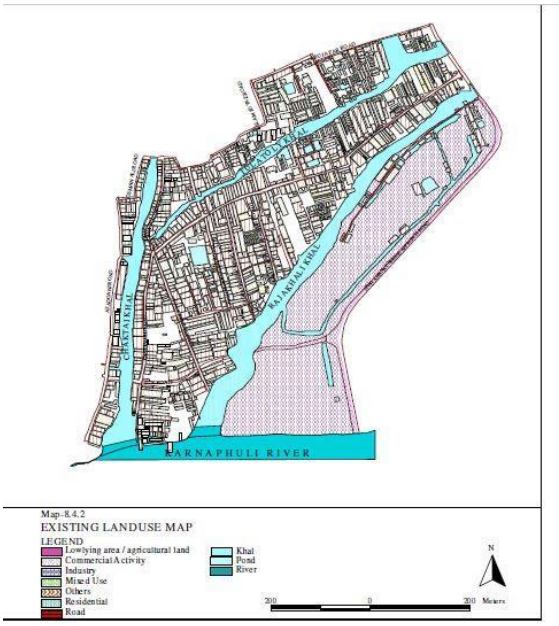


Fig 3:Existing Land Use Of Chaktai Khal
(Source :DAP)

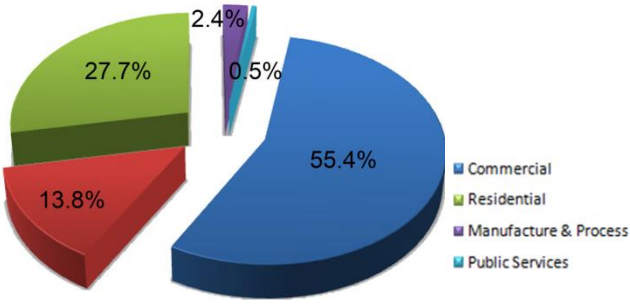


Figure 4:Diagram of Existing Land Use
(Source:Author)

5.1. Areas Vulnerable To Flooding In CHAKTAI Commercial Area.

Annual rainfall in the city fluctuates between 2100mm and 3800mm, of which 2400mm occurs only during the monsoon. However,such climate has been there for centuries, while water logging is a comparatively recent phenomenon.Chaktai khal played an important role for drainage system for the city which is hamoered by encroachment of drains,roads,illegal refilling of the drainage system.

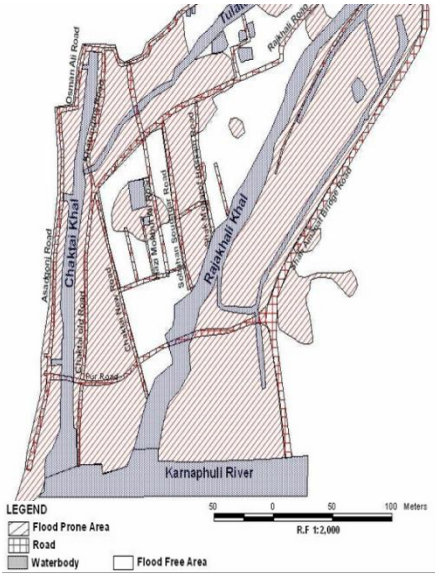


Figure 5:Flood Vulnerability Map(Source:CMP)

5.2. LAND USE IN GROUND FLOOR

Most of the building's ground floor use as a commercial purpose. there was a mixed used developement continued for a long time. Figure 7 shows the mixed use work activity of the users which suppresse by theire sence of culture and traditional activities.

Figure 6:mixed use pattern development
(Source:Author)

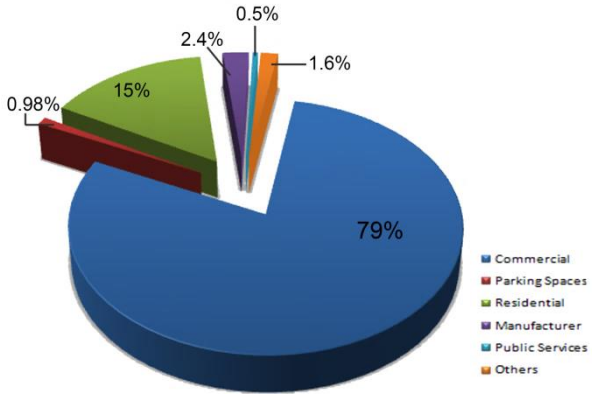


Figure 7: Diagram Of Ground Floor Land Use
(Source: Author)

5.3. OCCUPANCY TYPE:

Most of the people of this study area depens upon the commercial activities of store good (About50% of whole area). The area is a one kind of major commercial zone of the city. Retail shops do their business as wholesale which carry the traditional characteristics of their trade of local people.

Figure 8: Ground floor use for store purposes (Source:Author)

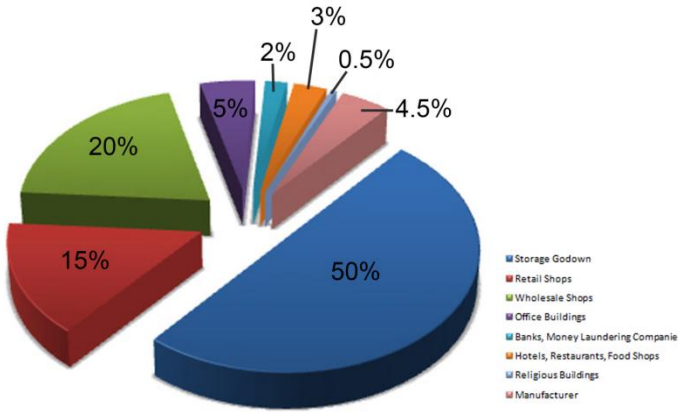


Figure 9: Occupancy type(Source:Author)

5.5: OWNERSHIP PATTERN:

Most of the building are under government control. Local peoples sell their land to government control for conservation,fro road broading purpose though they were not followed by appropriate rule.As a result these government building are encroached by political power which hinders the development of the area.

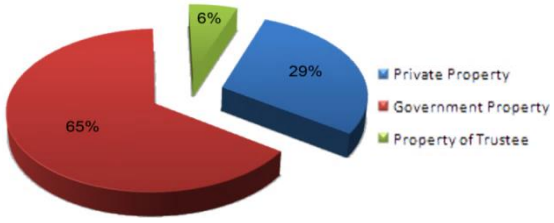


Figure 10: Ownership Pattern (Source: Author)

5.6: ROAD NETWORK:

Most of the road are secondary road with a maze. Drainage system is open to the pedestrian. No development of the road facilities.

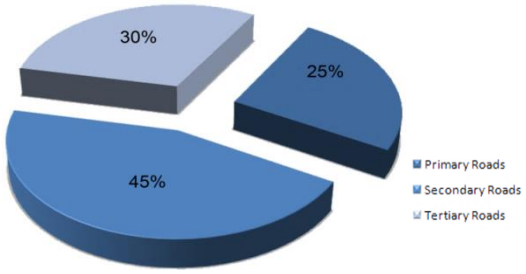


Figure 11: Road Type (Source:Author)

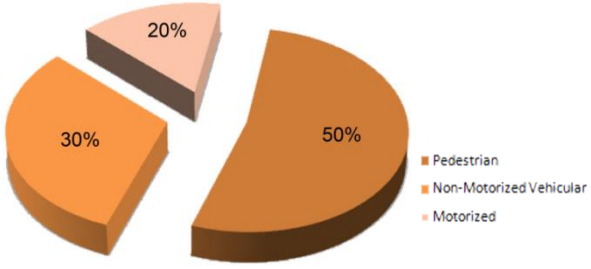


Figure 12: Vehicular Road Type(Source:Author)

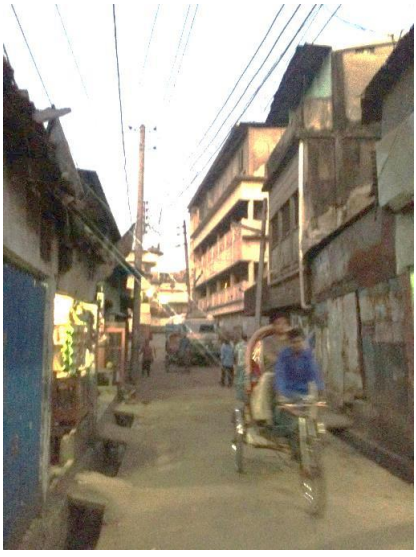


Figure 13: Existing Road Conditions (Source:Author)

Figure 14:Illegal vehicle parking on the bank of the canal road

5.7: EXISTING CONDITION OF THE WATER ROUTES

-Chaktai khal is connected to about 13 number of sub khal; Mirja khal, Chasma Khal ,Nasir khal,Kattoli,Shitol jharna,hijra khal ,Rajkhali khal & so on.It is filled under about 13 bridges .Khal has been filled by activities of people about 75% & other 25% has been filled by sand and piling

Figure 15: Existing Canal Conditions (Source: Author)

Figure 16: Existing loading condition (Source:Author)

Figure 17: No Proper Management (Source: Author)

Figure 18: Poor Drainage System (Source:Author)

6. FINDINGS:

Chaktai khal performs as major seat of trade and commerce in Chittagong.It is observed though chaktai has losts its past glory as a national business center,controlling food business in the whole country through the in proper management system,illegal encroachment of land.The discussion proves that the sense of the locality of the study area has been lost for lack of public and government concern.As a result,the glorious city essence with its multisensory characterististics such as mixed use characteristics of locality,traditional business scenario has been diminished.From the above discussuin,it is clear that Chaktai khal has possess almost all the resource that are necessary to regain the glory of her as a main regional business hub and to contribute significantly to the national economy.

7.OPPORTUNITIES:

The Chaktai khal, long khal could be act like a strong and sound environmental element. Sufficient open space including field, garden and water body; if properly used these can become asset for the place. Available space for recreational facilities. It will be helpful for managing the sensory experience for personal and collective purposes. It would be a place for representing the sensing city model of Chittagong city.

8. PROPOSALS AND RECOMMENDATIONS:

- Construction of abutment walls, lining of side slopes
- A 21m wide tidal regulator with the provision of a navigation gate at the mouth of Chaktai Khal was proposed.
- Rehabilitation of secondary khals flowing into the west of Chaktai Khal was proposed.
- For improving local drainage, tertiary drainage network for all underdeveloped areas

Figure 23: By installing landing berth water ways can be used for mass transit.
(Source: Internet)

- Provisions for drainage by the side of all primary and secondary roads are to be made mandatory. If the width of the drainage channel is correlated with the width of the road by a set rule, a lot of confusions can be avoided.
- A minimum width equivalent to 1/4th of the road width is to be kept as drainage reserve on both the side of the road for providing primary and secondary drains.
- If necessary, covered drains can be used with the dual function of a drain and a footpath. There should be provisions for storm water access to these drains from the adjacent roads.
- As mentioned earlier in observations and findings, open channels / khals are used as open sewer. We should aim at separating the domestic sewer from the storm sewers.
- Massive awareness campaign is to be launched against dumping of waste in the drains.

Traditionally, Chittagong City Corporation (CCC) is maintaining all the drains and khals in Chittagong. Under the Chittagong Municipal Services Sub-Project, CCC has constructed Box culvert under most of SK. Mujib Road resulting in the elimination of flooding of Sk. Mujib Road in Agrabad area. During the preparation of Drainage Master Plan for Chittagong in the years 1993 to 1995, both CCC and CWASA provided valuable inputs. Hence either CCC or CWASA can take up the drainage master plan project for implementation. Currently, Chittagong Development Authority (CDA) is responsible for planning and development of Chittagong. We understand that CDA has submitted schemes to the government for implementation of the Drainage Master Plan,1995. The policy proposals and recommendations made here, if accepted, can be incorporated in the Detail Area Plan(DAP) for Chittagong.

9. CONCLUSION

Drainage Master Plan was approved officially by gazette notification in March 1999. Since then,18 years have elapsed and none of the phase-I projects of the Drainage Master Plan has been implemented. A strong political will and support is necessary for successful planning and implementation of any such plan. It is hoped that this paper will provide some useful ideas to the future researchers and policy makers on drainage design and planning at city scale. It will help us to improve the city senses.If we can improve this chunk we can solve water logging,a secondary water route can be revived so that we can avoid the pressure on only vehicular road.it can create a healthy sensing city model.

ACKNOWLEDGEMENTS

[1] First, I am grateful to the almighty Allah
[2] I am thankful to my supervisor MD. Mustafiz Al Mamun, Assistant Professor, Department of Architecture, ChittagongUniversity of Engineering andTechnology (CUET) for his outstanding support and quality supervision.
[3] Thank ful to Seminar teacher Sajal Chowdhury(AssistantProfessor), Tazia Rahman(Assistant Professor)
[4] I thank all the respondents who participate in my survey.

REFERENCE

M Gubair Bin Arafat, Research Associate and Lecturer, BRAC Institute of Governance and Development, BRAC University. *The daily Star*

Kuheli, chowdhury & hossan murad '*REANIMATING OF SMALL STAGNANT WATERBODIES OF CHITTAGONG''*

Ashraf M.A. 2003. "Water *logged City of Chittagong: problems, causes behind the problems & their remedy"*, newspaper article in Bengali in Daily Azadi dated 26 & 27th July 2003.

Rajapaksha.U, et al (eds), 2017, "Design that cares"- multi disciplinary approaches to creating sustainable and meaningful built environment: *Proceedings of the 10th International Conference of Faculty of Architecture Research Unit (FARU), University of Moratuwa, Sri Lanka, (Vol. 01)*pp. 176-186 ©

WORK LIFE BALANCE OF QUANTITY SURVEYING PROFESSIONALS IN THE CONSTRUCTION INDUSTRY

PANOJAN. K.J.[1], PERERA. B.A.K.S.[2] & ABEYDEERA. L.H.U.W.[3]
Department of Building Economics, University of Moratuwa, Sri Lanka
[1]*pkpanoj@gmail.com*, [2]*pererabaks@gmail.com*, [3]*udarawabeydeera@gmail.com*

Abstract
There are different categories of professionals working in the construction industry which has made it a complex and a high-risk industry. The key professionals working in the construction industry are the architects, engineers, project managers and quantity surveyors. Because of the many risks and uncertainties involved, the construction industry causes a high level of stress in the professionals working therein. Their heavy workloads make them suffer from exhaustion, stress and burnouts creating a work life imbalance. This study investigated the work life balance of quantity surveyors working in the construction industry. The data for the study were collected from several publications in order to first identify the factors that affect work life balance of quantity surveyors. Ten interviews were conducted thereafter among quantity surveyors working in the industry to validate the literature findings. Heavy workloads, poor working environments, insufficient opportunities available to acquire new skills and lack of senior management support are some of the key factors that were identified as contributing to poor work life balance in quantity surveyors which causes exhaustion, dissatisfaction with one's own life, poor sleep and fatigue. Supportive training programs, proper organization of work, recreation activities and stress management programs were identified from the literature as steps that can be taken to overcome these health issues arising from poor work life balance.

Keywords: *Maximum work life balance, quantity surveyors, construction industry*

1. INTRODUCTION

Work-life balance means working 'smart' by not only managing one's life but even by working less in a flexible and stress free working environment (Huston, 2005). Grzwace and Carlson (2007) stated that work-life balance which promotes the well-being of an individual because of his ability to balance his personal obligations with career work leads to a healthy society although it has become a major challenge faced by the society today. In the modern world, competition among professionals who often have to face risks, leads to increased workloads and a need to work hard, all of which can affect their personal lives.

Many psychologists state that organizational values can support work life balance of employees and decrease their job related stresses and turnover by making them to get more involved with their work (Ronald, Burgess and Obberlaid, 2004). Satisfied employers are likely to pay more attention to work and serve the organization better (Mohyin, Dainty and Carrillo, 2012).Males and females react differently to workloads and work-life balance. McDonald, Brown and Bradley (2005) identified five dimensions that affect organizational life: lack of sufficient managerial support for work-life balance, organizational time limits/expectations/deadlines, negative professional consequences, limited time available to personal and family responsibilities and gender discriminations (this mostly affect the female professionals).

Construction industry is the major contributor to the economic development of a country, and its stake holders often having to deal with risks and uncertainties (Wiese, 2015), work-life balance will be important to them. Construction employees experience work life imbalance when they work long hours carrying heavy workloads to ensure project achievements related to time, quality, cost and safety (Lingard and Francis, 2006). Quantity surveyors have to work with engineers, architects, project owners, banks , insurance companies and also the government (Ochieng, 2015) and as a key professional of the construction industry, have to deal mostly with time management as a consequence of which they have to face many work-life conflicts (Hee and Ling, 2011). Nkado and Meyer (2001) were of the view that the working environment of quantity surveyors in the construction industry is complicated because there are so many other professionals working along with them. Thus, it becomes important to identify issues related to work-life imbalances of quantity surveyors and identify steps that can be taken to overcome those issues.

2. LITERATURE REVIEW

2.1 CONSTRUCTION INDUSTRY

In many developing countries like Sri Lanka, several organizations are engaged in construction industry projects which are funded considerably by their respective governments (Iresha and Seneviratne, 2014). Asquin, Garel and Picq (2010) indicated that most professionals working in construction projects have to simultaneously handle several different and interdependent tasks and that only a few construction professionals can afford to enjoy a luxury life by handling only one task at a time. According to Asquin, Garel and Picq (2010), there are features common to different categories of professionals working in construction projects, i.e., architects (Sang, Dainty and Ison, 2007), engineers, construction project managers (Edum and McCaffer, 2000) and quantity surveyors. A balance between personal and professional domains will enhance the employees' performance, productivity, job satisfaction, and commitment

contributing to a well-functioning and healthy society (Lapierre et al., 2008).

2.2 WORK-LIFE BALANCE

Since 1980s, professionals have been struggling to find time for their personal lives as a result of their unhealthy work-life choices they have made towards attaining professional goals which have compelled them to neglect leisure activities and friends (Kumar and Shivakumar, 2011). Dan Wheatley (2012) spoke about the ability of individuals to combine work, non-work responsibilities, aspirations and activities. Here "work" means paid employment and "life" means absence of work which allows for free time to spend on family and leisure activities. The balance between work and personal lives of employees can influence their retention and their focus on jobs along with their overall satisfaction with their personal and professional lives (Pookaiyaudom, 2015). Reduced physical and psychological well-being can be a result of an imbalance between work and domestic activities (Hyman, Baldry, Scholarios and Bunzel, 2003). Recently, there has been a rise in the work-life imbalances among both genders (Gronlund, 2007).

2.3 WORK-LIFE BALANCE OF PROFESSIONALS

In the construction industry, productivity expectations are very high due to the cyclical and volatile nature of its work and high turnover and skill shortage (McDonald, Townsend and Wharton, 2013). Rigid nature of the industry (Consdine and Buchanan, 2007), heavy workloads (Leung, Chan and Olomolaive, 2008), poor working environments (Yerkes and Dodson, 1998), insufficient opportunities available to acquire new skills (Ng, Skitmore and Leung, 2005) and absence of senior management support (Drew and Murtagh, 2005) affect the balance between personal and professional lives of professionals. Family commitments, demand on performance and productivity, career commitments, competencies and deadlines as well as gender discrimination, male dominated culture and sexual harassments at work affect the private lives and careers of female professionals (Adogbo, Ibrahim and Ibrahim, 2015).

Russel et al. (1999) highlighted that 57% of fathers undergo stress which affect their roles as fathers with 30% among them being affected by work commitments and workloads, 16% by time constraints and 11% from lack of income. They also identified that most male professionals because of their low involvement with household activities are addicted to alcohol leading which cause physical problems. For most females, especially for those with children, fulfilling career obligations in addition to shouldering family responsibilities has become a difficult task (Wilmerding, 2006). Most mothers have less negotiation skills compared to fathers and their domestic and childcare

responsibilities have become barriers to their career advancements (Gronlund, 2007).

2.4 WORK-LIFE BALANCE OF QUANTITY SURVEYORS

During construction estimation, quantity surveyors have to make many decisions with regard to direct and indirect costs, overheads and profits (Dysert, 2000). Quantity Surveyors find it difficult to balance their work and life due to their long working hours and inflexible working arrangements (Van den Broek, Breedveld and Knulst, 2002), poor health conditions (Zuzanek, 2004) and poor salaries and insufficient rewards (McDonald, Brown and Bradley, 2005).

2.5 CONSEQUENCES OF WORK-LIFE IMBALANCE IN PROFESSIONALS

Work related stress will be a major challenge to the health of a working individual (Houtman, 2005). Harnois and Gabriel (2000) indicated that professionals overloaded with work are not happy with their partners, friends and children and that they experience poor sleep, reduced job performance, a lower quality of life and physical and mental ill-health. Harnois and Gabriel (2000) stated that mental health can be a major problem caused by work pressure leading even to death and disability. Ronald, Burgess and Oberrlaid (2004) highlighted exhaustion, life dissatisfaction, poor sleep and fatigue as other causes which can affect employees' personal and professional lives. Southerton and Tomlinson (2005) stated that an imbalanced work-life makes individuals to become stressed and that in order to increase their commitment to work and reduce their turnover, employers need to implement work-life balance policies.

2.6 STEPS FOR A HEALTHY WORK-LIFE BALANCE

Organizations have to implement work-life balance policies (Wise and Bond, 2003). Ronald, Burgess and Oberrlaid (2004) indicated that increased support from the organization will help to minimize job pressure and job stress of an employee to help him attain work-life balance. Employers, large organizations and governments are nowadays interested in introducing work-life balance policies to increase employees' performance and productivity (Doherty, 2004). Sports (Quinn, 1996), part-time jobs (Pocock, Buchanan and Campbell, 2004), flexible firms (Frame and Hartog, 2003), substitute and finance services (Herta, 2005) will facilitate a balance in employees' work and life domains. Nickson, Warhurst, Lockyer and Dutton (2004) suggested that flexible working hours and term-time contracts, job sharing, career leave, adoption and fostering leave, maternity leave, dependency leave, and child break for children and paternity leave will also provide a balance between employees' work and life domains.

This literature review was first done on the construction industry and work-life

balance of professionals and quantity surveyors. Thereafter, a critical review was made of the factors that affect work-life balance of professionals including quantity surveyors and their consequences. Finally, a study was done on the steps that can be taken to help professionals to balance their careers and personal lives.

3. RESEARCH METHODOLOGY

Research strategy has to be selected as a function of the research situation (Yin, 1994). Therefore, qualitative approach was adopted for this research to obtain professional opinions and views which are considered as subjective data. According to Amaratunga 2002 et al, reliability and validity of subjective data may be determined more objectively with qualitative methods as compared to quantitative methods.

A detailed literature survey was carried out by making reference to books, journal articles, conference proceedings, previous dissertations and internet, to identify the factors that affect work-life balance of professionals and their reasons. With regard to semi-structured interviews, questions can be prepared in advance, interviewer can get prepared and reliable, comparable qualitative data can be obtained (Cohen, 2006). Therefore, to validate literature findings and to identify their suitability to Sri Lanka, interviews were carried among ten quantity surveying professionals. Data collected from these interviews were analysed through content analysis using NVivo 11 software. The interviewees consisted of four male quantity surveyors and four female quantity surveyors and their details are presented in Table 1.

Table 1: Profile of interviewees

Interviewee	Profession	Designation	Experience	Gender
R1	Chartered Quantity Surveyor	Managing Director	>30 years	Male
R2	Chartered Quantity Surveyor	Managing Director	>30 years	Male
R3	Chartered Quantity Surveyor	Managing Director	20-30 years	Male
R4	Chartered Quantity Surveyor	Senior Quantity Surveyor	10-20 years	Male
R5	Chartered Quantity Surveyor	Senior Quantity Surveyor	10-20 years	Male
R6	Chartered Quantity Surveyor	Director	20-30 years	Female
R7	Chartered Quantity Surveyor	Director	20-30 years	Female
R8	Chartered Quantity Surveyor	Director	20-30 years	Female
R9	Chartered Quantity Surveyor	Senior Quantity Surveyor	10-20 years	Female
R10	Chartered Quantity Surveyor	Senior Quantity Surveyor	10-20 years	Female

4. RESEARCH FINDINGS

4.1.1 Factors Affecting Work Life Balance

It was the view of all male interviewees that the rigid nature of the industry; heavy workloads; poor working environments; long working hours; job related stress; job performance and productivity expectations; career commitments; and competencies had an impact on work life balance. Three of them agreed that inadequate opportunities available to acquire new skills, lack of senior management support and family responsibilities too had an impact on work life balance.

All four female interviewees validated the factors identified through the literature review: rigid nature of the industry; heavy workloads; poor working environments; job related stress; job performance and productivity expectations; career commitments; and competencies. They considered lack of senior management support also as a key factor that impact on work life balance. Three of them validated long working hours, family responsibilities and child care. It appeared that the two genders have different opinions on the factors that could affect quantity surveyors. Traveling was a factor agreed upon by both male and female quantity surveyors.

Table 2 indicates the new factors identified by the respondents as having an impact on work life balance. These factors could not be identified from the literature. Travelling on professional work was indicated by both genders.

Table 2: Factors affecting work life balance of professionals

Male Professionals	Female Professionals
Personal wishes over family responsibilities	Social responsibilities
Travelling	Job security
Communication	Travelling
Employers' expectations	Absence of hobbies
Others' expectations	
Career adjustments during the early stages of the career	

4.1.2 Consequences of Poor Work Life Balance

The preliminary interview was focused on validating the consequences of poor work life balance that were identified from the literature. It appeared that quantity surveying professionals undergo difficulties mostly when balancing their family responsibilities with career responsibilities. Table 4 indicates these consequences indicated by the respondents.

Table 3: Consequences of poor work life balance for professionals

Consequences identified from the literature	Consequences identified from the interviews
Stress	Effect on relationships
Exhaustion	Unpopularity
Poor sleep	Professional and social rejection
Fatigue	Self-neglect
Depression	Loss of position/job
Absenteeism	
Dissatisfaction with life	
High blood pressure	

All interviewees validated stress, exhaustion, poor sleep, fatigue and depression as consequences of poor work life balance. Six interviewees validated absenteeism as a consequence while five respondents validated dissatisfaction with life and high blood pressure as consequences of poor work life balance. Five additional consequences were indicated by the interviewees, namely effect on relationships, unpopularity, professional and social rejection, self-neglect and loss of position/job.

4.1.3 Steps that can Minimize Consequences of Improper Work Life Balance

To avoid improper work life balance, it is essential to eliminate its causes so that their consequences could be minimized. The interviewees were provided with the steps identified from the literature as minimizing work-life imbalance and were requested whether they could validate them in addition to presenting their own steps. Table 4 indicates these steps.

Table 3: Steps that can minimize the consequences of poor work life balance

Steps found from the literature and validated by all interviewees	New steps suggested by interviewees
Parental leave	Increased time with the family
Child care allowances	Trips and get-togethers
Maternity leave	Restaurant facilities at office
Low work load	Music/Dancing
Job sharing	Counselling
Part time work	Meditation

Parental leave, child care allowances, maternity leave, low workloads, job

sharing and part time work were the steps identified from the literature. Several additional factors were also suggested by the interviewees.

5. DISCUSSION

The literature findings indicated several factors as having an impact on the work life balance of quantity surveying professionals. To validate these literature findings, ten qualified and experienced quantity surveying professionals working in the industry (five males and five females) were interviewed. The respondents agreed with the literature findings and validated the fact that the current working styles have an effect on work life balance. The rigid nature of the industry, heavy workloads, poor working environments and job related stress were all validated by both male and female respondents as factors causing poor work life balance. The male respondents indicated six new factors while female respondents indicated four. Travelling, expectations of the employers and too many responsibilities were some of these other factors.

The male respondents indicated eight consequences outside those identified from the literature while female respondents indicated five such consequences of poor work life balance. Similar results were obtained with regard to the final objective of the interviews- - finding solutions to minimize the consequences of poor work life balance. Six new solutions were suggested by the respondents while validating the literature findings. Thus, it is evident that poor work life balance undoubtedly has an impact on quantity surveying professionals.

6. CONCLUSIONS

The construction industry is quite complex and risky. Quantity surveyors find it difficult to maintain a balance between their personal activities and professional activities. Several factors affect work-life balance of professionals which have an impact on them both mentally and physically. The rigid nature of the industry, heavy workloads, working environments, long working hours, job related stresses, job performance, productivity, career commitments and competencies were identified from the literature survey as key contributors to poor work life balance and they were verified through the preliminary interviews conducted among eight quantity surveying professionals. Most factors are gender specific. Ravelling is a factor affecting both male and female quantity surveyors. Stress, exhaustion, poor sleep, fatigue and depression identified as consequences of improper work-life balance from the literature survey were validated by all interviewees. Parental leave, childcare allowances, maternity leave, low workloads, job sharing, and part time work are identified as the solutions that will minimize the consequences of poor work-life balance. Work life imbalance can create major consequences which can adversely affect

professionals and the professionals as well as organizations need to formulate solutions to overcome these consequences.

7. LIMITATIONS OF THE STUDY

These findings cannot be generalized since the study was conducted by interviewing only 10 quantity surveyors. There can be a detailed study which could be based on the results of this study which revealed the common reasons for work life imbalance and the actions that can mitigate that imbalance.

REFERENCES

Adogbo, K. J., Ibrahim, A. D., and Ibrahim, Y. M. (2015). Development of a framework for attracting and retaining women in construction practice. Journal of construction in Developing Countries, 20(1), 99-115.

Asquin, A., Garel, G., and Picq, T. (2010). When project-based management causes distress at work. International Journal of Project Management, 28(2), 166-172.

Bayraktaro lu, S., R.Ö. Kutanis, Y. Özdemir, S. Alpaslan and E. Dil, 2006. Information Congress in The Methodology Profile: Qualitative Research Method. 5. Information, Economics and Management Congress, Proceeding Books, 1: 594-601, Kocaeli.

Cohen, D. (2006), Qualitative Research Guidelines Project. Semi structured interviews, New Jersey: Robert Wood Foundation

Considine, J., and Buchanan, J. (2007). Workplace IR on the eve of Work Choices. Presentation to the National Industrial Relations Conference. Brisbane.

Dan wheatley. (2012). Work-life balance, travel-to-work and the dual career household. Personal Review, 41(6), 813-831.

Dilanthi Amaratunga, David Baldry, Marjan Sarshar, Rita Newton, (2002),"Quantitative and qualitative research in the built environment: application of “mixed” research approach", Work Study, Vol. 51 Iss 1 pp. 17 – 31

Doherty, L. (2004). Work-life initiatives: implications for women. Employee Relations, 26(4), 433-452.

Drew, E., and Murtagh, E. (2005). Work/Life balance: senior management champions or laggards? Women in Management Review, 20(3), 262-278.

Dysert, L. R. (2000). The organization of an estimating department. Cost Engineering, 42(8), 38-44.

Edum, F. T., and McCaffer, R. (2000). Developing project management competency: perspectives from the construction industry. International Journal of Project Management, 18, 111-124.

Frame, P., and Hartog, M. (2003). From rhetoric to reality. Into the swamp of ethical practice: implementing work-life balance. Business Ethics: European Review, 12(4), 358-368.

Gopinathan, S., and Raman, M. (2015). Ergonomic quality, playing a role in ensuring work-life balance among Malaysian workers. Social and Behavioral science, 1210-1215.

Gronlund, A. (2007). More control, less conflict? Job demand-control, gender and work-family conflict. Gender, Work & Organization, 14(5), 467-497.

Grzwacz, J. G., and Carlson, D. S. (2007). Conceptualizing work-family balance: Implication for practice and research. Advances in Developing Human Resources, 9, 455-471.

Harnois, G., and Gabriel, P. (2000). Mental Health and Work: Impact, Issues and Good Practices. Geneva: World Health Organization and International Labour Organization.

Hee, C., and Ling, F. (2011, October 29). Strategies for reducing employee turnover and increasing retention rates of Quantity Surveyors. Construction Management and Economics, 1059-1072.

Herta, T. (2005). Gendered dilemmas of the work-life balance in Hungary. Women in Management Review, 20(5), 361-375.

Houtman, I. (2005). Work related stress. Ireland: European Foundation for the Improvement of Living and Working Conditions.

Huston, D. M. (2005). Work-Life Balance in the 21st Century. Palgrave Macmillan: A division of Macmillan Publishers Limited.

Hyman, J., Baldry, C., Scholarios, D., and Bunzel, D. (2003). Work-life imbalance in the new service sector economy. British Journal of Industrial Relations, 41, 215-239.

Iresha, W., and Seneviratne, I. (2014). Review of Quantity Surveying designations practiced in the Sri Lankan construction industry, their qualifications and respective job functions performed. University of Moratuwa. Sri Lanka.

Kumar, A., and Shivakumar, P. (2011). A Research Study on Managing ork-Life Balance. International Journal of Knowledge and Research in Management and E-Commerce, 1(2).

Lapierre, L., Spector, P., Allen, T., Poelmans, S., Cooper, C., O'Driscoll, M., Kinnunen, U. (2008). Family-supportive organization perceptions, multiple dimensions of work-family conflict and employee satisfaction: a test of model across five samples. Journal of vocational Behaviour, 73(1), 92-106.

Leung, M., Chan, Y., and Olomolaive, P. (2008). Impact of stress on the performance of construction project managers. Journal of Construction Engineering and Management, 134(8), 644-652.

Lingard, H., and Francis, V. (2006, February 24). Does a supportive work environment moderate the relationship between work-family conflict and burnout among construction professionals? Construction Management and Economics, 185-196.

McDonald, P., Brown, K., and Bradley, L. (2005). Explanations for the provision-utilisation gap in work-life policy. Gender in Management, 20(1), 37-55.

McDonald, P., Townsend, K., and Wharton, A. (2013). The legitimation and reproduction of discourse-peactice gaps in work-life balance. Personal Review, 42(2), 205-222.

Mohyin, N., Dainty, A., and Carrillo, P. (2012). HRM Strategies for Managing Employee Commitment. In A. Javernick-Will (Ed.), Engineering Project Organizations (pp. 10-32). Netherland: EPOC.

Ng, T., Skitmore, R., and Leung, T. (2005). Manageability of stress among construction project participants. Engineering,Construction and Architectural Management, 12(3), 264-282.

Nickson, D., Warhurst, C., Lockyer, C., and Dutton, E. (2004). Flexible friends? Lone parents and retail employment. Employee Relations, 26(3), 255-273.

Nkado, R., and Meyer, T. (2001). Competencies of professional Quantity Surveyors: a South African perspective. Construction Management and Economics, 19(5), 481-491.

Ochieng, J. (2015). Predicting the future of Quantity surveying profession in the construction industry. Journal of Construction Poject Management and Innovation, 5(2), 1211-1223.

Pocock, B., Buchanan, J., and Campbell, I. (2004). Meeting the challenge of casual work in Australia: evidence, past treatment and future policy. Australian Bulletin of Labour, 30, 16-33.

Pookaiyaudom, G. (2015). Assessing different perceptions towards the importance of a work-life balance: a comparable study between Thai and international programme students. Social and Behavioral Science, 267-274.

Quinn, P. (1996). Identifying gendered outcomes of gender-neutral policies. Journal of Women and Social Work, 11, 195-206.

Ronald, J., Burgess, Z., and Oberrlaid, F. (2004). Do male Psychologosts benefit from organizational values supporting work-personal life balance? Equal Oppoetunities International, 23(1/2), 97-107.

Russel, G., Barclay, L., Edgecombe, G., Donovan, J., Habib, G., Callaghan, H., and Pawson, Q. (1999). Fitting Fathers into Families: Men and the fatherhood role in Contemporary Australia. Department of Family and Community Services.

Sang, K., Dainty, A., and Ison, S. (2007). A risk factor for ocupational stress in the architectural profession? Construction Management and Economics, 25(12), 1305-1317.

Southerton, D., and Tomlinson, M. (2005). Pressed for time-the differential impacts of a time squeeze. Sociological Review, 53, 215-239.

Van den Broek, A., Breedveld, K., and Knulst, W. (2002). Roles,rhythms and routines: towards a new script of daily life in the Netherlands. Basingstoke: Social Conceptions of Time.

Wiese, B. (2015). Work-Life Balance. Berlin: Springer.

Wilmerding, G. (2006). Smart Women and Small Business: How to Make the Leap from the Corporate Careers to the Right small Enterprises. Hoboken: John Wiley & sons.

Wise, S., and Bond, S. (2003). Work-life policy: does it do excatly what it says on the tin? Women in Management Review, 18, 20-31.

Yerkes, R., and Dodson, J. (1998). The relation of strength of stimulus to rapidity of habbit-formation. Journal of Comparative Neurology and Psychology, 18, 459-482.

Zuzanek, J. (2004). Work,leisure,time-pressure and stress. Routledge: Haworth.

Rajapaksha.U, et al (eds), 2017, "Design that cares"- multi disciplinary approaches to creating sustainable and meaningful built environment: *Proceedings of the 10th International Conference of Faculty of Architecture Research Unit (FARU), University of Moratuwa, Sri Lanka, (Vol. 01)* pp. 187-200 ©

ORDINARY HERITAGE: A CASE OF BORO BAZAAR, KHULNA

APURBA K PODDER[1], SHEIKH SERAJUL HAKIM & SHIBU PRASHAD BOSU
Khulna University, Khulna, Bangladesh.
[1]*akp39@cam.ac.uk*

Abstract
The motives behind the selection of heritage buildings for conservation are conventionally founded on an elitist sense of historicity and romantic nostalgia of the past. This paper argues that such an approach has a tendency to be temporally rigid, object focused and exoticism biased. Often many of the buildings selected as heritage are those built by extensive labour, expensive materials and wealthy patrons. Little, however, has been explored on the relation between heritage and aspects of ordinary life, where, in many cases, the latter continue to infuse meaning into the former's present heritage status. This paper uses a non-participant observational lens to examine an old market tissue in Khulna, an ex-colonial city in Bangladesh and proposes a new notion called 'ordinary heritage'. Ordinary heritage, as this paper argues, relies on historically persistent socio-economic transactions of the common and the ordinary in their everyday and occasional pursuit for livelihood. These transactions of ordinary people, which are also temporally non-static and evolving, take place within and around the architecture of the built environment, making the production of architecture to be fluid, dynamic and most importantly temporary. It forces architecture to constantly evolve, while negotiating the aspiration, need, aesthetic and reasoning of ordinary subjects. Ordinary heritage thus manifest as a socio-spatial-temporal assemblage innate to an urban tissue that runs as a single organism.

Keywords: *Ordinary, Heritage, Conservation, Khulna, Bangladesh*

Introduction

Conserving the historical edifice has remained part of a greater search for identity in modern cities that are becoming increasingly anonymous. This has been apparent especially in cities of the global south, where city fabric is undergoing a relentless state of flux to becoming something similar to those in the west. Modernising cities accept new stylistic elements and spatial imageries of world-class cities, but often at the cost of the 'local' and the 'authentic'. While this need to conserve heritage remains fundamental to construct city-identity against globalisation, definition of heritage remains a key area of debate in academia and praxis. Identifying heritage also plays a vital role in the ways the nature/type of identity is constructed for the city and its citizen. In a world where identity is fundamental to politics and class contestation, architectural heritage also moulds a form of collective aspiration that determines the overall city-aesthetic or the mode of aesthetic the city wishes to

embrace to construct its own identity. A framework for identifying heritage hence affects how heritage sites are selected, conserved and governed.

We have argued in this paper that the motives behind the selection of heritage for conservation in both public and intellectual domain remain deeply rooted in the thinking of antiquity and grandeur. Although the definition of heritage has transformed, we found through a genealogical analysis of the concept of architectural heritage that the notion of heritage is inherently biased by an elitist sense of historicity and romantic nostalgia of the past. The elitist bias relies heavily on the association of the past with buildings' monumentality, and views heritage as something that is temporally rigid. From a review of heritage literature, we argue that such an approach has a general tendency to be object-focused and exoticism-biased.

Through our exploration of a colonial market tissue known as *Boro Bazaar* in Khulna, Bangladesh, we have argued otherwise. In this market, which is also the genesis point for Khulna's proliferation into a thriving settlement, we have found that the everyday transactions of ordinary people, which are temporally non-static and evolving, take place within and around the architecture of the built environment, making the production of space to be fluid, dynamic and most importantly temporary. It forces spatialities to persistently evolve while negotiating the aspiration, needs and reasoning of ordinary subjects. Ordinary heritage hence manifests as a socio-spatial-temporal assemblage innate to this tissue that runs as a single organism.

We realize that our aim to critique the elite lens of heritage returns with the question of positionality. One thing we kept asking ourselves in this research was whether our values and preferences make our lens ordinary or elite? And if we belong to the latter, how we could investigate and comprehend ordinary heritage impartially. To remain objective, we have thus assumed a non-participant observation approach, meaning that we did not have to take an active part in the creation of ordinary heritage, but only acted as an observer. We used both covert and overt methods of observation, helping us gain an in-depth understanding of the dynamics of the production of ordinary environments. Despite our best efforts, our values could still have possessed our understanding, for which we triangulated our information with map/graphical analysis, interviews and literature survey.

Heritage: meaning and scopes

Before 1920s, heritage conservation approaches were confined to local level mostly, with an absence of any comprehensive 'global' framework. The concept of 'heritage' was first recognized internationally with the establishment of *International Museum Office* in 1926. Following the *Athens*

Charter drafted by Le Corbusier in 1933, a proliferation of conservation guidelines took place in the form of charters, conventions, resolutions, declarations, and recommendations, with particular focus on heritage conservation (Ahmad, 2006). One of the main concerns of these guidelines was to establish a universal definition and identify the scopes of heritage. After the *Venice Charter* of 1964, scope of heritage was broadened from physical establishments (i.e. historic monuments, groups of buildings, historic urban and rural centers, historic gardens and industrial sites) to non-physical heritage (i.e. environments, social factors and intangible values) (Ahmad, 2006).

Since 1965, international organizations including UNESCO, ICOM, and ICOMOS remained actively engaged in re-defining the scopes and concept of heritage (Jokilehto, 2005). In 1965, ICOMOS defined heritage as 'monument' and 'site' to distinguish the scopes of heritage from museum artifacts to the immovable built environment. In 1968, UNESCO defined heritage as 'cultural property' to include both movable and immovable entities; the movable cultural property was referred to as 'museum collections' while the immovable one referred to as 'architectural heritage'. Thus, the scope of heritage was interpreted uniquely across international organizations.

While UNESCO defined heritage as 'cultural property', ICOMOS saw it as 'monuments and sites'. But at *World Heritage Convention 1972*, this terminological difference was reconciled by defining heritage as something that should contain both cultural and natural components. The key focus was to recognize 'significant' cultural and natural heritage with 'Outstanding Universal Value'. Then, from 1970-1980s, international focus shifted toward the development of national and regional principles (Ahmad, 2006). This strategic shift is reflected in the *Amsterdam declaration* 1975 and the *Burra Charter* 1979. Amsterdam declaration recognized the importance of heritage settings/context, but its underlying intent was to promote heritage for cultural tourism and generate revenue (*Charter of Cultural Tourism* 1976). The *Burra Charter* on the other hand focused on the cultural significance of heritage objects, referring to their aesthetic, historic, scientific or social value and fabric; its later amendments included the intangible values and aspect of heritage. These, later became part of UNESCO's 2003 convention on intangible cultural heritage. Afterwards, countries like New Zealand, China and Vietnam adopted their own charter with reference to the guidelines developed by UNESCO and ICOMOS. South Asian countries, however, did not develop such guidelines for their own.

In short, the concept of heritage has from the beginning overlooked the ordinary subjects, their activities and the non-exotic/elitist elements. Buildings and spaces holding people's day to day activities, which are inseparable to the

making of any place, we will argue afterwards, should also be viewed as heritage. Because attempts to identify and preserve 'elitist' heritage in most cases aims to commercialize it with a largely tourist-centric attitude. Preserving the 'exotic' components of heritage hence becomes synonymous with the development of tourism as a 'product'. But, the apparently 'dirty' can also be an inseparable 'process' element of a society, which often disappears with the preservation of the 'exotic'. A detailed account of this will be elaborated in the case of *Boro Bazaar* through a critical exploration of its morpho-spatial history. This we hope should help pose some questions necessary for re-conceptualizing the meaning and scope of heritage.

A dilapidated historic landscape of *Boro Bazaar*

Boro Bazaar, the 200 years old historic settlement on the edge of *Bhairab-Rupsha* River confluence, is considered as the genesis point of Khulna – the south-western metropolis of Bangladesh (Figure 1). The settlement flourished with the establishment of a colonial market by an indigo merchant in 1842 (Mitra, 1914). Proximity to Kolkata and the Sundarbans (the single largest mangrove tract in the world) and a good river connection with sea-port quickly made Khulna a prospective one for the British colonial government. A railway connection with Kolkata in 1884 further propagated *Boro Bazaar*'s development into a thriving commercial hub (Shamsuddin, 1986) and its ongoing success as a "marketplace" led the *Marwari* (an ethnic *Hindu* business class) to emigrate from India and settle here in the later part of 19th century (Mia, 2002).

The strength of *Boro Bazaar* was in its periodic market system – the *haut* with shared and non-permanent system of space-use with little or no rent. This attracted peasants from across the region to sell cash crops like jute, rice and indigo. *Marwari* took advantage of this system to connect with common peasants and expand their credit business to a wider region. They established several temples bearing the imprints of traditional artefacts of the *Marwari* community, which also provided an episodic glue to connect and moralise their (often illegal) businesses under a religious cloak.

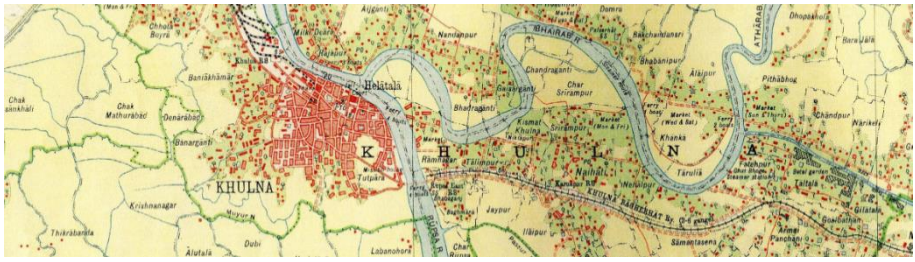


Figure 1: Khulna town in red and *Boro Bazaar* (*Helatola*) in 1929. Source: R.H. Thomas, '*Map of Khulna in 1929'*, (Calcutta: India Office, 1929), collected from Podder A K (Podder, 2017)

Eventually, this settlement transformed into a hybrid of residential, commercial and religio-cultural land use through the transactions of local and distant people. But between 1951 and 1955, following decolonization and partition between India and Pakistan as Bangladesh became *East Pakistan*, change in land ownership transformed the market's overall built environment fundamentally. Under the newly passed *State Acquisition and Tenancy Act 1950* (through *District Commissioner*'s office), Government attempted to acquire *Boro Bazaar* land. This act also empowered the local government (*Khulna Pourasava*, later to be promoted as *Khulna City Corporation*) to acquire the market land for the establishment of a *Bazaar*. Yet, it is due to *Boro Bazaar*'s overlapped authoritative interplay especially that regarding land t, the identification and demarcation of the market area would go on to become a part of a persistent contest between the residents, businessmen/shop-owners and these concerned government agencies.

With the mission to modernize Khulna, the establishment of *Khulna Development Authority* (KDA, the planning/development authority) in 1961 added another stratum of complexity to the already ongoing disputes over land tenure in *Boro Bazaar*. An intricate multi-ownership therefore would eventually be developed by a simultaneous but utterly un-coordinated effort from KDA, KCC and BIWTA (*Bangladesh Inland Water Transport Agency*). Fifty years of relentless greed of state agencies, political disinterest, and administrative ineptitude hence would force *Boro Bazaar* into an arena of ambiguity particularly in terms of land-ownership. An 'informalization' of land titling and its consequent land use through an unrelenting process of negotiation between the concerned actors hence would became the only choice for the ordinary owners and users.

These evolving socio-cultural dimensions however have over the years yielded a unique heritage value for the area. Although unrecognized in the conventional definition of heritage, this value has been significant for the settlement's and its inhabitants' sustenance. Although the original *haut* does no longer remains the only form of market today, its blended form with the densely occupied built environment has nevertheless retained the participation of the ordinary by enabling them to use spaces in different temporalities and by negotiating ownership. The overall language of the fabric therefore resembles that of a shapeless architecture upholding both a hereditary convention and a strategy of collective subsistence.

The three 'threads' of *ordinariness*

In lieu with these discussions, a context becomes apparent here in which the definition and meaning of heritage becomes something worth arguing. Although the cultural heritage discourses address these, one may still be

interested in the subjects of meaning, authority and ownership in the definition of heritage – especially in the specific context of *Boro Bazaar*. Some supplementary thoughts may be: "What could be viewed as heritage in *Boro Bazaar*, and why?"; "Should heritage be something frozen in time?"; "Whether only the tangible be viewed as heritage?"; "What role the non-elite commoners play in 'heritage' validation process?"; "How do common people identify heritage in relation to their everyday socio-economic-spatial transactions and realities?" The dilemma of modernity and those prevailing in the everyday and ordinary built environments of this ordinary transitioning city hence demands a closer, deeper and critical insight. For that, following three threads of themes narrate the findings from *Boro Bazaar*.

A. Temporality

Not many objects in *Boro Bazaar* are fixed in time; neither are they permanent in terms of activities that take place within and around them. Regardless of their scales and origins, and irrespective of actors and agents acting upon and behind the shaping of these forms and spaces, spatialities of most buildings, streets and alleys, idols and rituals, shops and shopfronts especially in *Helatola* and *West Mecot Road* (Figure 2) remain transient. Not only these changes take place in different hours in a day, they keep changing seasonally round a year. And while these spatialities and activities remain temporally dynamic and changing, this entire process of temporal dynamism has through the years endured. This, in a historical perspective, resembles a cultural heritage itself – a living system, and a diurnal negotiation run by the ordinary, and quite unique to this particular setting of *Boro Bazaar*.

A closer look at one of *Boro Bazaar*'s most vibrant sections – Helatola (Figures 2 and 3) shows a regular South Asian market street, flanked with permanent shops (of mostly Gold Jewellers and wholesale shops/grocery), while a number of non-permanent sellers sitting in front of these shops – on the street. This seller-commodity pairing, however, does change during the course of the day. As some villagers from the other side of Bhairab River are found selling home-grown fruits and agro-products in the early morning, a group of urban-living sellers on mobile rickshaw-vans take the afternoons selling imported fruits and vegetables they purchase from Boro Bazaar wholesalers – accumulated overnight from trains, trucks and boats coming in from different corners of the country. A number of these afternoon sellers finish selling before evening and leave the street, while a third group of sellers, although not many, with home-made snacks, sweets etc. join the remaining of the sellers on mobile van.

Figure 2: Figure-ground diagram of *Boro Bazaar*; circled is *Satya Narayan Mondir*, West Mecot Road (long red line) connecting Railway and BIWTA *Ghat* on one side, while *Helatola* – the entry point to *Boro Bazaar* on the other (short red line). (Source: Podder, 2017)

Before religious festivals, especially *Durga Puja* and *Eid*, *Helatola* street is filled with commodities necessary for *Puja* rituals (lotus, flowers, banana leaves, clay pots etc.) and vegetables for *Eid* respectively. Some occasional sellers, also often the day labourers at *Boro Bazaar*, can now be seen alongside the more regular ones as the spatial boundary of the street is pushed to its limit. Especially during *Durga Puja*, the largest of all *Hindu* festivals in *Bengal*, *Helatola* street and its surroundings assume perhaps its most important role. It is because of the presence of the *Marwari* and their patronization that this space has since its foundation back in the Colonial days been used as a site for *Durga Puja* (Figure 3 - right). Even in the present day, as Bangladesh has turned largely into a Muslim-majority country, *Durga Puja* still remains the most celebrated event in *Helatola* and one of the biggest, exclusive and most visited ritual sites in Khulna.

This sacred event in every *Bangla* autumn (September-October), hence replace the mundane and the everyday, while the users of these spaces, from everyday sellers and buyers, now accommodate religious pilgrims from Khulna and its hinterlands (a large number from the other side of *Bhairab*), and also visitors from other faiths. A similar transient but opposite role can also be seen in the temple called *Satya Narayan Mandir* at West Mecot Road. This is the oldest religious site in *Boro Bazaar*, which, right before *Durga Puja*, gives up its traditional (and formal) role of a place of worship and opens up portion of its second story to be used as a trading floor for ritual items (Figure 4). In temporal terms, sites of *Boro Bazaar* hence display a curious sense of non-permanence and ephemerality, resulting from the everyday and episodic while involving varying spatialities and agencies.

Figure 3: *Helatola* in *Boro Bazaar*: temporary shops selling home-grown vegetables in the morning at this entry point to *Boro Bazaar* (left). Same space used for *Durga Puja* as the goddess *Durga*'s deity is being removed after the week-long rituals are over (right). (Source: Podder, 2016)

Figure 4: *Satya Narayan Mondir* at *West Mecot Road*; the 3-storied building (left) with its claim of land ownership (circled). The topmost floor of *Mondir* is used for trading of ritual items prior to *Durga Puja* (right). (Source: Podder, 2016)

B. ELASTIC TERRITORIALITY

Alternative livelihood and religious activities within the same spaces of *Boro Bazaar* blur the boundaries between different spatialities. These everyday and episodic practices of spatial occupation especially by the ordinary challenge their formal thresholds. Time- and season-wise appropriation of the public street at *Helatola* questions the meaning of the established boundaries of the 'planned' i.e. the street. Drawing a territorial line for the street or the shopping becomes tricky, as the pedestrian, rickshaw vans and carts work their way through the sellers and shoppers on the streets. During the *Puja* occupation of *Helatola* street, the mobile sellers withdraw for about ten days to give way for the stage and audience area, while the more permanent sellers keep their

business 'going' as usual while making use of a narrow passageway (Figure 7). In the case of *Satya Narayan Mondir,* the spatial limits of the stable and static categories are challenged; these begin to appear fluid. The 'private' and 'sacred' of the temple transmute into 'public' and 'mundane' – one adapted to the trading of necessary ritual items and consequent financial transactions during most *Hindu* festivals in a year.

This 'elastic' aspect of space – the often-orchestrated shrinkage and expansion of spatial territoriality in reaction to different social, cultural, economic, political and environmental necessities, can also be seen in the 'permanent-temporary' intersection of shops on *West Mecot Road*. In the absence of a stable land tenure, hence underscored by a context of volatile 'formal', temporary shops 'grow' into the street from 'core' permanent shops (Figure 5). The extent of this growth, which is not absolute in territorial terms, involves at least three layers of economic activities (and actors) on each side of the street: permanent wholesale stores occupying the ground level of buildings, their owned or rented out 'temporary' front shops on bamboo-CI sheet structure, and occasional/seasonal floating shops on portable stands or tables. Where even the most permanent's disposition (i.e. wholesale shops) is formally unstable, two more expansions on the street lead to a complete dissolution of the boundary between shops and the street. The meaning and geographic positioning of the 'street', as found on *KDA Master Plan (2001-2010),* hence seem static, rigid and abstract.

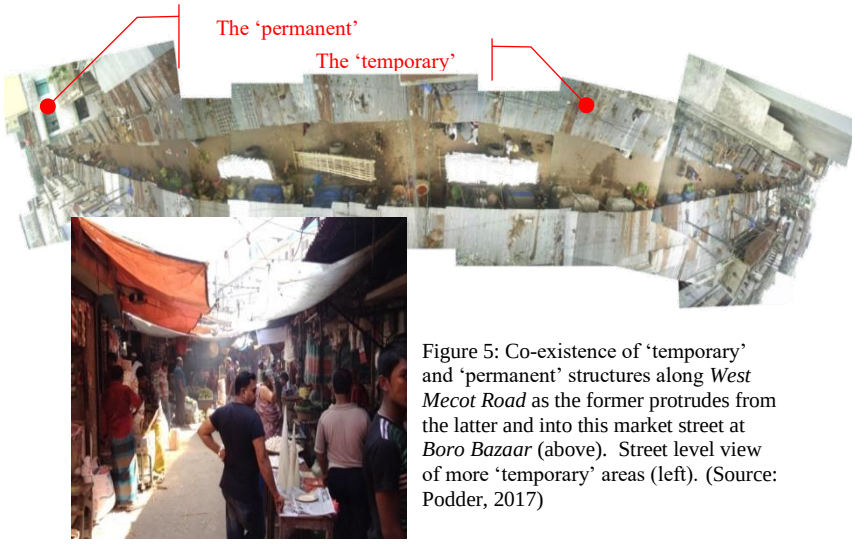


Figure 5: Co-existence of 'temporary' and 'permanent' structures along *West Mecot Road* as the former protrudes from the latter and into this market street at *Boro Bazaar* (above). Street level view of more 'temporary' areas (left). (Source: Podder, 2017)

A review of *Boro Bazaar*'s history of external interventions and evidence of *developmentalism* by the external actors (KDA's *Master Plan* and KCC's

planned market extension) shows that these top down and market-driven deterministic efforts for permanence not only has begun to disrupt and replace the original 'fluid' fabric of this urban tissue and reduced spaces and their flexibilities for such diverse activities to take place, they also have contributed to the loss of everyday participation and livelihoods of many – especially the 'temporary' and the 'floating' ordinary rural and urban sellers. A recent intervention at *Helatola* reveals that a 5-year long gradual construction of a shop-block by KCC (it says this was for its revenue increase), has not only reduced the space for *Puja* and wet market in an already scarce parcel of land, but at the same time affected the livelihoods of a number of these sellers and buyers (Figure 6). In heritage terms, and in particular in the context an ordinary city as Khulna is, this has been a significant cultural loss.

C. NEGOTIABILITY

The concomitance of the contradictory in *Boro Bazaar* (physical-social, permanent-temporary, formal-informal, legal-illegal, sacred-mundane, residential-commercial) can alternatively be viewed as a symbiotic coexistence of the binary elements, where they work together and remain valid simultaneously. As the informal take advantage of the formal and the temporary of the permanent, the opposite also holds true here.

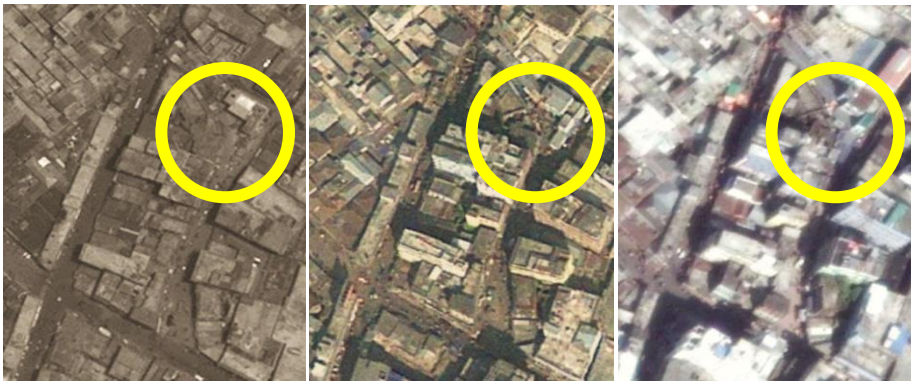


Figure 6: Gradual 'permanence' of part of *Helatola* Street carried out by KCC (images from 2009, 2010 and 2016 from left to right). (Source: *Google Earth*, 2017)

In the case of Gold Jewellers at *Helatola*, allegedly who are among the wealthiest of all Khulna businessmen and in most cases, are also involved in a number of illegal activities namely money laundering, gold smuggling and tax evasion, one might get interested about their co-living with the temporary and question whether this apparently chaotic and messy condition has anything to do with the businesses they involve into. A number of respondents tell us that for many Jewellers at Helatola, this is a conscious and strategic ploy for

distracting legal agencies – which they accomplish by maintaining a low, 'dirty' profile.

A similar story is also heard of the *Mondir* patrons – the once migrated *Marwari* businessmen from India during late Colonial times. The *Marwari* are also said to be one of the biggest launderers of money and tax evaders in this region. As seen before that portions of *Satya Narayan Mondir* space is used for trading, it is also not difficult to understand that such trading could have taken place anywhere in *Boro Bazaar*. In fact, the use of *Mondir* space to earn revenue has never been a priority. Rather trading on *Mondir* floor has been deliberately promoted by its *Marwari* patrons, who are also the richest among all businessmen in *Boro Bazaar* (and also Khulna). There is a common belief that patronization of religious activities certainly benefits the *Marwari* to earn a good name for themselves and hence for its associated *Boro Bazaar* community. Such reputation, coupled with the implicit leadership of a devout community, masks all the illegalities beneath.

This sense of a living community, where a large number of less-than-affluent (generally the temporary and floating sellers and all the day-labourers) is also a part of, certainly profit from the increase of their bargain capacity with legal (rule-making and implementing) public agencies like KDA, KCC, BIWTC and *District Collectorate* (DC). This, coupled with the presence of the *Mondir* building and its inscribed claim of legitimacy (Figure 4), further strengthens these actors' prerogative for this severely contested land and helps use it as an instrument for negotiation. This can be looked at as 'politics of community and religiousity', or the 'politics of the dirty' as seen before. Here, ongoing negotiations between the binary elements lead to the homogenization of 'class' – especially those between the subaltern and elite, and help satisfy their individual interests.

Figure 6: Negotiated (but layered) spatialities of *Helatola* Street. Circled is new permanent shop-block constructed by KCC (Source: Podder, 2016)

Nothing really comes to a cease at *Boro Bazaar*; the dynamic (informal, illegal) and accommodative (instead of static and rigid) hence signify a unique cultural trait where differences between religious affiliation and class are often flattened through the accepted overlapping of unstable spaces. In spatial terms, once

their territorial boundaries are compromised and the so called binary coexistences converge and overlap, a symbiotic system of the opposites begins to emerge. Adaptability through the many acts of mobility, reconfiguration, transformation, subversion, reinvention and recreation of existing typology and its largely incremental approach also portray the resilience of *Boro Bazaar* in the context of an ever-changing socio-economic-spatial condition. In everyday terms, this slipperiness that also makes the entire system adaptable and *Boro Bazaar* a site for relentless conciliation between actors moulded by a 'negotiated' form of urbanism.

Figure 7: Ascending stair of *Puja* stage leaving just enough space for adjacent businesses to retain as usual (left); an assemblage of sidewalks, selling, trading, walking, parking, promotion, transportation and religious symbolism (middle); dark and apparently shabby interior of famous *Indra Mohan Sweets* (right).
(Source: Podder, 2016)

ORDINARINESS AS ASSEMBLAGE

Christopher Alexander (1965), in his award winning "The city is not a tree" wrote about a street corner at Berkeley, where all its fixities and temporalities work "together" to become a 'street' as we know it. In assemblage terms (Deleuze *et al*, 1987), a street as such, for example, is not a thing or a mere collection of things. Buildings, houses, shops, signs, police, shoppers, cars, hawkers, rules, sidewalks, goods, trolleys – both tangible and intangible, and both static and mobile come together to become the street through dynamic connections/flows among them. Dovey (2012: 364) advances this with the idea that in "Complex Adaptive Assemblage", a dynamic and unpredictable pattern of self-organization emerges with certain levels of resilience, and that in order to understand it, one needs to apprehend the processes underlying its constructions of meaning, productions of space, socio-spatial practices, temporal rhythms, network connectivity, experiences of place etc. In Mehrotra (2008)'s terms, a reading of the 'kinetic' elements of urbanism (in relation to the 'static') is necessary to comprehend how a certain culture 'works'. In Robinson's (2002) terms, such dynamisms coupled with innovations, complexities and diversity that stem from the works of the ordinary are unique resources for the construction of city identity in today's increasingly globalized world. In heritage terms, such political economy of urban spatial appropriation

as we have seen in *Boro Bazaar* hence provides the necessary distinctiveness for it to be called a unique cultural heritage. An object centric (static) approach hence is inadequate to determine the evolving and negotiating cultural practices, even if they are often illegal and dirty.

Ordinary heritage approach opposes a sole preference for the static and the iconic 'Heritage' edifice often by the modern, market-proponent elite from 'another place'. In connection with the earlier questions on the ownership and agency of heritage, it becomes clear that in *Boro Bazaar*, a collective rather than solitary effort has historically led to the context of negotiability, or more precisely to an assemblage of the socio-religious-spatial-economic that has historically determined its spatio-physical. Ordinariness, therefore, occurs not only from the involvement of the ordinary or the subaltern. The everyday acts of negotiation and their associated spatialities, their temporalities and transience, the elasticity of spatial-territorial boundaries, pluralisms, dualities and contradictory coexistences, and above all the collective ownership of ordinary 'things' by both elite and subaltern, in all their shabbiness, insignificances and filth (Figure 7), that the citizen recognize as something which are authentic and identify themselves as an integral part of it – indicating to the ordinariness of the heritage in Khulna *Boro Bazaar*.

CONCLUSION

This paper aimed to explore the production of heritage in the everyday challenges, negotiation and evolving lives of the ordinary. We observed their heritage could neither live in a 'spectacular' urban form nor any historically 'significant' monuments. Instead, we found them living as a parasite in the developmental mission, who revolt quietly (Bayat, 2004) against the modern aesthetical cleansing and urban authorities' aggression to improve the 'functionality.' However, similar to what Simone (2004) observed in African cities, in Bangladesh, cities do not 'function', not at least in the conventional sense of 'functionality' (Podder, 2017). Here, each area of the city is inscribed by complex local histories of conflict and negotiation, that makes a collective way of living to be the way out for the ordinary subjects to fight against the odds. A critical examination to understand the principle of that living brought us to the concept of *ordinary heritage*. And we found that *ordinary heritage* is not a phenomenon or a collection of physical artefacts but an assemblage of systemic principles, which allow the ordinary to evolve and sustain within a given Bangladeshi reality.

References

Ahmad, Y. 2006. The scope and definitions of heritage: from tangible to intangible. *International journal of heritage studies*, *12*(3), pp.292-300.

Aikawa, N. 2004. An historical overview of the preparation of the UNESCO International Convention for the Safeguarding of the Intangible Cultural Heritage. *Museum international*, 56**,** 137-149.

Alexander, C. 2017. *A city is not a tree*, Pembroke, Sustasis Press.

Bayat, A. 2004. Globalization and the Politics of the Informals in the Global South. In: Roy, A. & Alsayyad, N. (eds.) Urban informality: transnational perspectives from the Middle East, Latin America, and South Asia. Lanham: Lexington Books.

Charter, V., 1964. International Charter for the conservation and restoration of monuments and sites, Venice, 1964.

Deleuze, G. & Guattari, F. 1987. *A Tousand Plateaus*, Minneapolis, The University of Minnesota Press.

Dovey, K. 2012. Informal urbanism and complex adaptive assemblage. *International Development Planning Review*, 34**,** 349-368.

Hakim S. S. and J. L. Ee Man, 2014. Scarcity, control and negotiations: an interpretation of urban form in Khulna. *Planum, The Journal of Urbanism*, Vol. 2(29), pp. 83-100

Jokilehto, J. 2005. Definition of cultural heritage: References to documents in history. *ICCROM Working Group 'Heritage and Society'***,** 4-8.

Jokilehto, J. 2007. History of architectural conservation, London, Routledge.

Kudva, N. 2009. The everyday and the episodic: the spatial and political impacts of urban informality. *Environment and Planning* 41**,** 1614-1628.

Mehrotra, R. 2008. Negotiating the Static and Kinetic Cities: The Emergent Urbanism of Mumbai. *In:* HUYSSEN, A. (ed.) *Other Cities, Other Worlds: Urban Imaginaries in a Globalizing Age.* Durham: Duke University Press.

Mia, S. G. 2002. Mahanagari Khulna - Itihasher Aloke (The big-city Khulna: in light of History), Khulna, Ali Hafej Fondation.

Mitra, S. C. 1914. Jessore-Khulnar Itihas.'. *Dasgupta and Company Pvt. Ltd*, 54**,** 18e28.

Podder, A. K. 2017. The Making of 'Illegal' Marketplace: State, Class and Space in Khulna c. 1951-2008 Unpublished Ph.D. thesis, University of Cambridge.

Shamsuddin, A. K. 1986. Khulna Shahorer Aadi Parba (The Early Phase of Khulna), Khulna, Shahetyo Majlish.

Simone, A. M. 2004. For the city yet to come : changing african life in four cities, DurhamDuke University Press.

UNESCO, 1972. *Convention concerning the protection of the world cultural and natural heritage: adopted by the General conference at its seventeenth session, Paris, 16 November 1972*. UNESCO.

World Heritage Committee, 2008. *Operational guidelines for the implementation of the World heritage Convention*. UNESCO World Heritage Centre.

Rajapaksha.U, et al (eds), 2017, "Design that cares"- multi disciplinary approaches to creating sustainable and meaningful built environment: *Proceedings of the 10th International Conference of Faculty of Architecture Research Unit (FARU), University of Moratuwa, Sri Lanka, (Vol. 01)* pp. 201-211 ©

IDENTIFYING EXISTING CONSTRAINTS IN CARBON FOOTPRINT CALCULATION TOOLS AND ADDRESSING THE IMPROVEMENTS TO BIM

RATHNAYAKE. K.K.N.D.[1], JAYASENA. H.S.[2] , MADUSANKA. H.W.N.[3] & WIJEWICKRAMA. M.K.C.S.[4]
[1,2,3,4] Department of Building economics, University of Moratuwa , Katubedda, Sri Lanka
nemashaqs@gmail.com

Abstract
The world faces "an inconvenient trouble" of global warming which is immensely catalysed through the emission of different forms of Greenhouse Gases (GHGs). Construction industry is a prominent sector which accounts for a higher percentage of GHGs emission to the globe. Buildings embody and consume a large fraction of energy and cause for more than 50% of the carbon emission of a building during the whole life span. Therefore, the need of curtailing embodied carbon emission from construction is essential. In order to address this issue, an emerging concept of "Carbon Footprint" has been introduced to the modern construction industry. The Life Cycle Assessment (LCA) is the method which holds number of tools to assess the carbon footprint of a product. However, these assessment tools enclose number of limitations which barricade the precise assessment of carbon footprint. Building Information Modelling (BIM) is an emerging technology which has an ability to optimize the energy efficiency in the buildings. Thus, the research aims to address the potential of using BIM to quantify the carbon footprint in the construction industry over the existing non-BIM LCA tools. To accomplish the aim, a qualitative research approach was followed. The topical study exhibits that, BIM can be identified as the most suitable option among existing tools which should be upgraded to improve the accuracy and reliability of final output by mitigating the existing shortfalls.

Keywords: *Building Information Modelling (BIM); Carbon footprint; Embodied carbon; Life Cycle Assessment (LCA).*

1. Introduction

Construction industry consumes variety of natural resources and energy to produce a large amount of waste and significant amount of toxic air emissions (Hendrickson & Horvath, 2000). Statistically, buildings contribute for 33% of all energy consumption, 40% of all resource consumption, 50% of Carbon dioxide (CO_2) emissions, and 20-30% of waste as a whole worldwide (Green

Building Certification System [GBCS], 2011). The Forth Assessment Report of the Intergovernmental Panel on Climate Change [IPCC] (2007) states that, the building industry would contribute more than 52% of carbon emissions by 2050.

Many researches have evidently proved that, the construction industry is playing a vital role in carbon emission as a whole (IPCC, 2007). Thus, there is a critical prerequisite of calculating the embodied carbon of a facility, in order to take further solutions to avoid it. Accordingly, an emerging concept has been widely discussed in the field of construction called "carbon footprint". As per Wiedmann and Minx (2008), carbon footprint is "a measure of the exclusive total amount of CO_2 emissions that is directly and indirectly caused by an activity or is accumulated over the life stages of a product" (p.5). According to Ortiz *et al.,* (2009), Life Cycle Assessment (LCA) is the sustainable technique widely used to assess the amount of carbon emission by a product. There are number of tools under LCA which can be used to assess the carbon footprint of a construction facility but with certain limitations.

Building Information Modelling (BIM) is the most revolutionary paradigm which espouses the modernization to the traditional construction practices. Many researches have been conducted in focusing on synergy between BIM and sustainable green construction. However, there is a lag in adopting BIM in green construction due to its lack of interoperability (Nisbet & Dinesen, 2010). There is a research gap on exploring whether BIM can be used to assess carbon footprint of a construction facility over the existing tools. Thus, this paper aims to identify the potential of using BIM to quantify the carbon footprint in construction facility over existing tools and to provide with necessary suggestions to improve the performance of BIM.

2. Carbon Footprint

The term carbon footprint refers to the total amount of Greenhouse Gas (GHG) emissions that produce directly or indirectly over the life time of an individual or organization (Carbon trust, 2007). According to Ranganathan *et al*., (2004), the direct emissions are gases, which emit from the sources controlled by the individuals or organizations, whereas indirect emissions are caused due to the activities conduct by the individuals or organizations.

The term carbon footprint does not refer only to the CO_2. Basically, there are six main GHGs other than CO_2, which make a considerable impact on global warming (Kelly *et al*., 2009; Eshel & Martin 2006). As per the Table 1, the

Global Warming Potential (GWP) of each GHG can be expressed in CO_2 equivalents.

Table 1: Different types on GHGs

(The GWP of a gas is its relative potential contribution to climate change over a 100 year period , where CO2=1.)

GHGs	GWP*	Example source
Carbon dioxide (CO2)	1	Combusting fossil fuels and from producing aluminium, steel, cement and glass
Methane (CH4)	23	Burning and/or decomposing biomass (organic material) and from producing and/or refining gasoline and natural gas.
Nitrous Oxide (N2O)	296	From incinerating solid waste, spreading fertilizers, and/or from various transportation means
Hydrofluorocarbons (HFC)	12-12,000	By-product of industrial processes making insulation, refrigeration and air conditioning
Perfluorocarbons (PFC)	4,800-9,200	By-product of aluminium production
Sulphur hexafluoride (SF6)	22,200	For insulation and current interruption in electricity transmission and distribution equipment

Source: Rao and Riahi (2006).

2.1. WHOLE LIFE BUILDING CARBON FOOTPRINT

Different authors have argued different ways referring to whole life carbon emissions. Eshel and Martin (2006) specified that, the carbon footprint of a product's life includes from raw material extraction to distribution. Furthermore, they have concluded that, the different stages of entire life-cycle consist with direct and embodied emissions.

With regard to the built environment, several authors have given an ultimate explanation for the carbon footprint associated with a building life cycle. Accordingly, the carbon emissions in a building consist with two categories

known as embodied and operational (Shipworth, 2002; Sturgis & Roberts 2010). The focus of this research goes to embodied carbon, whereas operational carbon emission calculation is out of the research scope.

2.1.1 Embodied emissions

According to Norman *et al.,* (2006), a building consists with approximately 30% of embodied carbon of total carbon emission of its life span. The initial GHG emissions of a building, which can be recognize in terms of embodied emission of building, are calculated from the stage of raw material extraction to handover the building (Hakkinen *et al.,* 2015). Furthermore, it consists emissions from planning and design, construction materials, and construction process. Hammond and Jones (2008) defined embodied carbon of building materials as, the total carbon release when a product is manufactured, shipped to a project site and installed. According to Humar *et al.,* (2011), it is the total carbon emissions as a result of total primary energy consumed during the life-time of a product. In advance, the embodied carbon emissions are generated from mineral extraction, construction product and material manufacturing, materials' associated transportation, and waste transportation. Apart from those, activities associated with site investigation are also account for a certain amount of resource and energy. Furthermore, emissions caused by the staff utilities and accommodations are also considered as embodied carbon.

2.2. LIFE CYCLE ASSESSMENT (LCA)

According to International Standard Organization [ISO] (2001), LCA is "a compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle" (p.23). This method has been used by many researchers in making decisions of environment related strategies including optimizing the environmental impact of a building's life cycle (Singh *et al.,* 2010). The LCA tool facilitates a "cradle to grave" analysis which means that, it analyses not only the direct effects but also the indirect effects which begin from acquisition of raw materials and end from the disposal of the product (Rebitzer *et al.,* 2004).

2.2.1 Constraints in existing LCA tools

There are several LCA tools in use as mentioned in Table 2. However, there are more works to be done on the development of quantitative life cycle oriented environmental assessment tools for the built environment. The tools studied have the same base but different ambitions on what objects to analyse. They have reached different stages of development and there is still need for further development of quantitative tools for environmental assessment of the built environment.

Table 2: Constraints in LCA tools

LCA Tools	Tool Type	Tool Developer	Users	Limitations
ANTHENA Impact Estimator	Whole Building Analysis Tool	ANTHENA Institute	Architects. Engineers, Designers, Environmental Consultants	$750 Software Cost
	Building Assembly Analysis Tool			Moderate Required User Skill
ANTHENA EcoCalculator	Building Assembly Analysis Tool	ANTHENA Institute	Architects. Engineers, Designers, Environmental Consultants	Limited Assembly Options
				Fixed assembly dimensions
BEES 4.0	Building Product Life Cycle Assessment (LCA) Tool	NIST	Designers, Specifiers, Builders, Product Manufacturers, Purchasers, Researchers, and Policy Makers	Limited Product Options
	Building Product Life Cycle Costing (LCC) Tool			Limited use for local/ regional impact analysis
				Devaluating weighing process

Adopted from: Finnveden, (2000)

Finnveden (2000) emphasized that, the main drawbacks associated with ANTHENA Impact Estimator are cost of the tool, requirement of expertise knowledge, limited options of designing high-performance assemblies, and the overall incomplete assessment. Moreover, he has distinguished that, ATHENA EcoCalculator is only allowing the evaluation of assembly options with fixed dimensions.

Additionally, various authors have identified the limitations in existing carbon footprint calculation tools such as tedious, difficult, time-consuming, and filled with ambiguity, high inconsistencies, lack of transparency, scalability, interoperability and consequentially significant inaccuracies (Padgett *et al.*, 2008). Furthermore, Ortiz *et al.,* (2009) emphasized that, the end output becomes impracticable to make strategic decisions due to the existing constrains such as lack of transparency in assumed parameters, calculation methods and carbon conversion factors. Moreover, Trusty and Horst (2012) stated that, these calculators generate an estimate of carbon footprint with a level of accuracy of ±25 percent only. Further to them, these tools do not take into account the distance between the different suppliers of products/construction materials and the location of the construction site. Similarly, Finnveden (2000) expressed that, these tools do not differentiate among various products which serve the same purpose, but have different manufacturing properties.

3. Building Information Modelling (BIM)

Building Information Modelling (BIM) is an emerging technology and it has attained a considerable attention in the Architectural, Engineering and Construction (AEC) industry. BIM facilitates the practitioners to build n-dimensional models to simulate the planning, designing, construction and operation of a facility. It helps AEC professionals to come up with a more stable solution without common errors by visualizing what is to be built in simulated environment and to identify potential design, construction or operational problems (Stumpf *et al.,* 2011). Wheatley and Brown (2007) simplified the concept of BIM as; “BIM is to build a building virtually prior to building it physically, in order to work out problems and simulate and analyse potential impacts” (p.67). Further, many researchers have devoted in identifying the potential use and scope of BIM in relation to the construction industry.

3.1. CAPABILITIES OF BIM IN CALCULATING CARBON FOOTPRINT

Numerous approaches have been focused on the application of BIM along with BIM-based LCA tools to make the building designers and architects capable of performing energy estimations and environmental impact assessments of the buildings in the early phases of the design process (Motawa & Carter 2013). Stumpf *et al.,* (2011) addressed the BIM’s potential in environmental sustainability and the development of green BIM as “immature, ad-hoc and unsystematic”. However, the implementation of green BIM is yet to be examined due to the narrow knowledge of the practitioners.

BIM facilitates the practitioners to exchange building information data throughout the different stages of the lifecycle. The data formats used in BIM environment to exchange data in between BIM tools and environment analysis tools are Industry Foundation Classes (IFC) and Green Building XML (gbXML).

Table 3: Comparison of data interoperability among design analysis tools and others according to data format

		Green Building Studio (GBS)	**Ecotect**
Revit	IFC	No interoperability	Partial interoperability
	gbXML	Partial interoperability	Good interoperability
ArchiCAD	IFC	No interoperability	Partial interoperability
	gbXML	Partial interoperability	Partial interoperability

Source: Díaz and Antön (2014)

Table 3 illustrates the capabilities of BIM based environmental analysis tools (GBS & Ecotect) in terms of interoperability with data stored in ArchiCAD and Revit. According to Ryu and Park (2016), 'gbXML' is data format which has been identically designed for energy performance assessments. It is supported by the main BIM-based modelling tools and developed into an industry-standard schema to improve intergraded modules. IFC is an international standard data model supported by International Alliance for Interoperability (IAI), which is another data format used to exchange and share building data in BIM-based tools (Ryu & Park, 2016). Nevertheless, IFC is not specifically designed for interoperability of energy analysis (Jeong, 2014). Furthermore, as per Jeong (2014), IFC contains a freeform representation. Thus, IFC data is more useful than gbXML in energy analysis. According to Song *et al.,* (2012), BIM allows extracting quantities of structural materials from the virtually constructed 3D models in spread sheet format. Further to them, the carbon footprint contribution for each quantity of materials can be achieved by multiplying it with respective conversion factor. BIM facilitates plugins to be installed to the system. Integrated Environmental Solutions' Virtual Environment Revit plug-in (IESVE) is used in environmental analysis in BIM based tools (Abanda *et al.*, 2015).

3.2. SHORTFALLS IN BIM TO CALCULATE CARBON FOOTPRINT

Even if, BIM has the capability to integrate with environmental assessment, there are some constraints which barricade this full integration. As per Jrade

and Jalaei (2013), lack of functional tools and the complex structure of existing tools are the most critical barriers for this integration. Furthermore, Bynum *et al.*, (2012) distinguished that, lack of qualified staff and allocated budget make BIM not to use frequently in sustainable projects.

Moreover, Salman and Justin (2009) have identified the major drawbacks of BIM based environmental analysis tools including AutoDesk Ecotect, Autodesk Green Building Studio and IES virtual environmental analysis are difficulty of developing IFC database and limitation of using current standards. Table 4 illustrates the main drawbacks associated with BIM tools which can be used for Carbon footprint assessment.

Table 4: Drawbacks of BIM LCA Tools

Product	Drawbacks
AutoDesk Ecotect	Difficult to understand user interface
	Analysis steps are unclear (No gbXML error check)
	Analysis run time are very long
	Some analysis types caused program instability
Autodesk Green Building Studio	Program becomes unstable when using large files
	Requires internet connection
	Requires password to link files and access analysis results
IES virtual environment	Limited model viewing capabilities
	Results are save separately from the main project file
	Inconsistent analysis

Source: Díaz and Antön (2014)

Apart from these constraints, one of the main challenges in using BIM is that, the material take off tool requires the composite materials to be manually disaggregated (Stadel *et. al.*, 2011). Nevertheless, the practitioners have elaborated the lack of chance to integrate current cloud computing technology and 'big data' management within the green BIM tool. Further, a survey conducted by McGraw-Hill Construction have identified the unavailability of user-friendly tools, completed models, less interoperability of BIM tools with other sustainability analysis models hinder the practitioners from adopting green BIM technology. Cost of software licenses is another factor that inhibits a wide adoption of green BIM tool (Pelsmakers, 2013). It requires the efforts of the practitioners and software vendors to deal with these challenges.

4. Conclusion

Calculating embodied carbon has not yet established in the industry. Currently, it is being practiced by some regions in order to minimize the emission of GHGs. Due to the emerging concern on sustainable construction, the practitioners are more intended towards the carbon footprint. Acquiring a carbon estimate is essential during the early design phase as most critical design changes are taken place during that period. There are several tools available under LCA to calculate the carbon footprint of construction. But, the existing tools contain some constraints including interoperability, lack of transparency, high inconsistencies, need of expertise knowledge and not taking distance between supplier and site. Practitioners have commented the issue of need of expertise knowledge and not taking distance between supplier and site as crucial.

By way of an emerging technology in the construction industry, BIM is having the capabilities of calculating carbon footprint with some limitations. Most of these limitations are technical oriented. Even if, BIM has some limitations, it can be considered as more reliable than the existing tools.

However, the study manifests that there is a set of constraints which are common to both non-BIM and BIM tools. Moreover, these common constraints play a vital role for the reliability over the final output of the results. Henceforth, there is no 100% accurate and very best methods to calculate carbon footprint in construction industry. Nonetheless, BIM can be addressed as the most suitable option among existing options even there are some shortfalls.

5. References

Abanda, F.H., Vidalakis, C., Oti, A.H. and Tah, J.H: 2015, *A Critical Analysis of Building Information Modelling Systems Used in Construction Projects*. Advances in Engineering Software, 90, pp.183-201.

Bynum, P., Issa, R.R. and Olbina, S: 2012, *Building Information Modelling In Support Of Sustainable Design and Construction*. Journal of Construction Engineering and Management, 139(1), pp.24-34.

Carbon Trust: 2007, *Carbon Footprint Measurement Methodology*. The Carbon Trust: 670 London, UK.

Díaz, J. and Antön, L.Á: 2014, *Sustainable construction approach through integration of LCA and BIM tools*. In Computing in Civil and Building Engineering (2014) (pp. 283-290).

Eshel, G., and Martin, P: 2006, *Diet, energy and global warming, University of Chicago study*. Chicago: University of Chicago.

Finnveden, G: 2000, *On the limitations of life cycle assessment and environmental systems analysis tools in general.* The International Journal of Life Cycle Assessment, 5(4), pp.229-238.

GBCS: 2011, "*Green Building Certification System"*, Available from: at:huri.lh.or.kr/ecohouse/index.asp (accessed 10 October 2017)

Häkkinen, T., Kuittinen, M., Ruuska, A. and Jung, N: 2015, *Reducing embodied carbon during the design process of buildings*. Journal of Building Engineering, 4, pp.1-13.

Hammond, G.P. and Jones, C.I: 2008, *Embodied energy and carbon in construction materials.* Proceedings of the Institution of Civil Engineers-Energy, 161(2), pp.87-98.

Hendrickson, C., and Horvath, A: 2000, *Resource use and environmental, emissions of US construction sectors*. Journal of Construction Engineering and Management, 126(1), 201-230.

Humar, I., Ge, X., Xiang, L., Jo, M., Chen, M. and Zhang, J: 2011, *Rethinking energy efficiency models of cellular networks with embodied energy.* IEEE Network, 25(2).

International Standard Organisation: 2001, ISO 14040. *Environmental Management. ISO Standards Collection on CDROM*, Genève

IPCC: 2007, Climate Change 2007 – *The Forth Assessment Report of the Intergovernmental Panel on Climate Change*, IPCC, Geneva.

Jeong, W.S., 2014, *Integrating Building Information Modeling with Object-Oriented Physical Modeling for Building Thermal Simulation* (Doctoral dissertation).

Jrade.A., and Jalaei F: 2013, *Integrating building information modelling with sustainability to design building projects at the conceptual stage*, Build. Simul. 6 (4).429–444. doi:10.1007/s12273-013-0120-0

Kelly, L. M., Shepson, P. B., Strim, B. P., Karion, A., Sweeney, C., and Gurney, K. R: 2009, *Aircraft-based measurements of the carbon footprint of Indianapolis*. Environmental Science and Technology, 43, 7816–7823.

Motawa, I. and Carter, K: 2013, *Sustainable BIM-based evaluation of buildings*. Procedia-Social and Behavioral Sciences, 74, pp.419-428.

Nisbet, N. and Dinesen, B: (2010), *Constructing the Business Case. Building information modelling.* British Standards Institution. London

Norman, J., MacLean, H.L. and Kennedy, C.A: 2006, *Comparing high and low residential density: life-cycle analysis of energy use and greenhouse gas emissions.* Journal of urban planning and development, 132(1), pp.10-21.

Ortiz, O., Castells, F. and Sonnemann, G: 2009, *Sustainability in the construction industry: A review of recent developments based on LCA.* Construction and Building Materials, 23(1), pp.28-39.

Padgett, J.P., Steinemann, A.C., Clarke, J.H. and Vandenbergh, M.P: 2008, *A comparison of carbon calculators. Environmental impact assessment review,* 28(2), pp.106-115.

Pelsmakers, S: 2013, January. *BIM and its potential to support sustainable building*, presented in the NLA/NBS 'Green BIM' conference, Spain.

Ranganathan, J., Corbier, L., Bhatia, P., Schmitz, S., Gage, P. and Oren, K: 2004, *The greenhouse gas protocol: A corporate accounting and reporting standard (revised edition).* Washington, DC: World Resources Institute and World Business Council for Sustainable Development.

Rao, S. and Riahi, K: 2006, *The role of Non-CO_3 greenhouse gases in climate change mitigation: long-term scenarios for the 21st Century*. The Energy Journal, pp.177-200.

Rebitzer, G., Ekvall, T., Frischknecht, R., Hunkeler, D., Norris, G., Rydberg, T., Schmidt, W.P., Suh, S., Weidema, B.P. and Pennington, D.W: 2004, *Life cycle assessment: Part 1: Framework, goal and scope definition, inventory analysis, and applications.* Environment international, 30(5), pp.701-720.

Ryu, H.S. and Park, K.S: 2016, *A Study on the LEED Energy Simulation Process Using BIM. Sustainability*, 8(2), p.138.

Salman A., and Justin B. M: 2009, *BIM for Sustainability Analyses*, International Journal of Construction Education and Research, 5(4), 276-292. doi:10.1080/15578770903355657

Shipworth, D: (2002), *A stochastic framework for embodied greenhouse gas emissions modelling of construction materials*. Building Research & Information, 30(1), 16-24.

Singh A, Berghorn G, Joshi S and Syal M: 2010, *Review of life-cycle assessment applications in building construction*. Journal of Architectural Engineering. 2010 Jul 29;17(1):15-23.

Song, S., Yang, J. and Kim, N: 2012, *Development of a BIM-based structural framework optimization and simulation system for building construction*. Computers in Industry, 63(9), pp.895-912.

Stadel, A., Eboli, J., Ryberg, A., Mitchell, J. and Spatari, S: 2011, *Intelligent sustainable design: Integration of carbon accounting and building information modeling*. Journal of professional issues in engineering education and practice, 137(2), pp.51-54.

Stumpf, A.L., Kim, H. and Jenicek, E.M: 2011, *Early design energy analysis using building information modelling technology (No. ERDC/CERL-TR-11-41).* Engineer Research and Development Centre Champaign Il Construction Engineering Research Lab.

Sturgis, S., and Roberts, G: 2010, *Carbon profiling as a solution to whole life carbon emission measurement in buildings London*: Royal Institution of Chartered Surveyors

Wheatley, B.T. and Brown, T.W: 2007, *An introduction to Building Information Modelling*. Constr. Law., 27, p.33.

Wiedmann, T. and Minx, J: 2008, *A definition of 'carbon footprint'*. Ecological economics research trends, 1, pp.1-11.

Rajapaksha.U, et al (eds), 2017, "Design that cares"- multi disciplinary approaches to creating sustainable and meaningful built environment: *Proceedings of the 10th International Conference of Faculty of Architecture Research Unit (FARU), University of Moratuwa, Sri Lanka, (Vol. 01)* pp.212-224 ©

A REVIEW ON TIME ESTIMATION METHODS FOR POST-EARTHQUAKE DAMAGE REPAIR OF BUILDINGS

KAHANDAWA K.A.R.V.D.[1], DOMINGO N.D.[2], CHAWYNSKI G[3,] PARK K.S.[4] & UMA S.R.[5]
[1,2,3,4]Massey University, Auckland, New Zealand
R.Kahandawa@massey.ac.nz
[5]GNS Science, Wellington, New Zealand
S.uma@gns.cri.nz

Abstract
Time is one of the three defining factors of a construction project. Due to the uncertainty of earthquake damage repair projects, a more accurate time estimation method is required. This paper focuses on the adaptability of Bromilow's time cost model (BTC model), critical path method, program evaluation and review technique (PERT) and Monte Carlo simulations to achieve this task. Monte Carlo method was identified as the best method out of methods above to estimate post-earthquake damages. Attributes such as accounting for uncertainty, use network diagrams, sequencing of work activities and current practical applications justify this suggestion. Further research is suggested to verify this theoretical suggestion.

Keywords. *Earthquake damages; Damage repair: Time estimation*

1. Introduction

Time is one of the three parameters considered when evaluating the success of a project. Failure to achieve the stipulated time estimates can dissatisfy clientele in the construction industry (Wickwire *et al.*, 2009; Žujo *et al.*, 2017). Accurate time estimation is required for the successful completion of a project. Time is defined as the irrevocable order of event occurrence in the past, present and future (Lamport, 1978; Weisstein, 2017). Thus, duration of a construction project is the total duration of events.

There are many events or activities in a construction project. According to the Royal Institute of British Architects (RIBA) (2013), construction project events can be divided into eight stages. Strategic definition, preparation and brief, concept design, developed design, technical design, construction, handover and close out, and in use. Some others like Ashworth & Perera (2015) divided it into six stages. The duration of a construction project depends on the completion of all these stages.

RIBA (2013) states that these stages or events do not follow in sequence but, tend to overlap or run concurrently. Thereof, it is difficult to calculate project completion time by simply adding up the duration of each stage. The duration of each activity and their sequence or concurrency should be known to calculate the total project duration.

When calculating project duration, most of the time estimation models for building projects are focused on the construction stage, which also known as contract time (Ng *et al.,* 2001). Special focus on construction stage is important because it has the most number of activities. Time overrun of the construction stage tend to increase cost for the contractor due to delay damages, litigation, adversarial relationships, time-related expenses and reduction in reputation (Senouci, Ismail and Eldin, 2016). Furthermore, additional project time tends to increase contractual charges, the opportunity cost of investment and loss of income (Ameh and Osegbo, 2011). Therefore, construction time estimation is more important in the project time estimation process.

Due to the high number of activities, time estimation methods use project work schedules to estimate construction project duration (Sousa, Almeida and Dias, 2014). Sousa et al. (2014) explains that probabilistic or deterministic are the two methods used. Deterministic methods use processes like critical path method (CPM) and probabilistic methods use program evaluation and review technique (PERT), Monte Carlo Simulation or probabilistic network evaluation technique (PNET) methods (United States Navy, 1958; Fondahl, 1961).

Alternatively, project time can be estimated using relationships between different variables in a construction project. Bromilow's time cost model (BTC) is a validated model that uses the relationship between cost and time to predict the construction project duration (Bromilow, 1969; Ng *et al.*, 2001).

In the context of earthquake damage, time estimation is difficult when compared with new building construction. In new construction, work is specified, and the work activities are mostly known. In earthquake damage repair, damage should be visually or instrumentally identified, and scope can vary upon detailed damage identification (Doebling, Farrar and Prime, 1998). Hence variations to the scope of work will occur during construction. Therefore, there is an uncertainty of work occurrence and extent.

In earthquake damaged buildings, only several of these methods are utilized for time estimation. Research shows that probabilistic damage estimation with Monte Carlo simulation (Federal Emergency Management Agency, 2012) and Bromilow's time cost model (Sun and Xu, 2011) are used for such estimation.

Yet, if the damage, scope and repair methods are identified, time estimation methods like critical path method (CPM) and program evaluation and review technique (PERT) can be utilized.

Therefore, this paper aims to examine different types of time estimation methods that can be used for post-earthquake repair time estimation.

2. Methodology

The methodology types outlined in this paper are based on interdisciplinary knowledge transfer (Swanson and Smalheiser, 1997). Journals articles, conference papers and reports published on the pre-earthquake time estimation models and new construction time estimation model are analysed. These include literature on Bromilow's cost and time model, critical path method, program evaluation and review technique (PERT) and Monte Carlo simulations. Critique on each method was summarised and compared to check the suitability for a post-earthquake time estimation model.

3. Current time estimation methods for earthquake engineering

Currently, to estimate potential earthquake damage, computer tools like Matlab Damage and Loss Analysis (MDLA), Performance Assessment Calculation Tool (PACT), Seismic Performance Prediction Program (SP3), Hazards United States for multi-hazards (HAZUS-MH) and Seismic Performance and Loss Assessment Tool (SLAT) have been developed (Molina, Lang, & Lindholm, 2010). These tools use Pacific Earthquake Engineering Research Centre (PEER) framework on performance-based earthquake engineering to estimate probable damage using parameters such as size of the earthquake, building type, building size, peak ground acceleration, storey drift, inventory on the building stock, and building geological area (Alani and Khosrowshahi, 2007; Bradley, 2009; Federal Emergency Management Agency, 2012; Ramirez *et al.*, 2012).

Amongst the aforementioned tools, PACT is the most utilized freely available time estimation tool. In PACT, all potential damage can be identified using the probability of occurrence of each form of damage, according to variables like floor acceleration or storey drift. From the theorized damage types, labour requirements for each is calculated using a database of past and experimented data. Hence, total requirement of labour is calculated by summing up the overall labour requirement per floor. Labour requirement for a floor is divided by the number of workers per floor, to calculate the time required to repair a floor. PACT tool assumes that the floor is repaired either concurrently or

sequentially. Thus, the time durations are either cumulated together or the longest time is the project time (Almufti *et al.*, 2013).

Yet in practice, some work activities are in sequence and some are done concurrently. Therefore, PACT method creates unrealistic time estimates (Almufti *et al.*, 2013). Almufti et al. (2013) states that in post-earthquake state, not all buildings are recovered to their original state. These building can be repaired as stages for sheltering purposes or to provide original functionality using back up services. Alternatively, there are activities that prevent the work flow. PACT method does not account for recovery stages of buildings, disruption to utilities, earthquake induces hazards (e.g. landslides, liquefaction, tsunamis, lateral spreading and seiches) and impeding factors that will prevent the work continuation of other activities (Federal Emergency Management Agency, 2012; Almufti *et al.*, 2013).

Alani & Khosrowshahi (2007) points out that even though there are a lot of approaches, methodologies and tools available for earthquake repair time estimation, they are all focused on earthquake scenarios rather than actual survey data. Therefore, the method used in PACT cannot be used as a reliable method for post-earthquake repair time estimation and alternative pragmatic methods are required.

4. Time estimation models

There are many time estimation models that are used in construction time estimation. Bromilow's time and cost model, critical path method, program evaluation and review technique and Monte Carlo method are some examples. There charateristics are discussed as follows.

4.1 BROMILOW'S TIME AND COST ESTIMATION MODEL

Bromilow (1969) researched on parameters to measure the scope of the construction project which will indicate construction time. Bromilow's research included 329 buildings. Depending on information collected, an equation was produced expressing the relationship between total construction time and final construction cost. Equation for model is as follows (equation 1)

$$T = K * C^B \quad (1)$$

T = Actual construction time in working days
C = Final cost of building in millions of dollars
K = A constant describing general performance for buildings
B = A constant indicative of the sensitivity of time performance to cost level

A number of researchers have concluded that the BTC model is considered the best time estimation model in preliminary stages of construction (Ng *et al.*, 2001; Sousa, Almeida and Dias, 2014). Thomas Ng et al. (2001), Sousa et al. (2014), Czarnigowska & Sobotka (2013), Stoy, Dreier, & Schalcher, (2007), Ogunsemi & Jagboro (2006) and Sun & Xu (2011) conducted further studies to validate the model. Thomas Ng et al. (2001) provided evidence that the equation is more accurate when divided into different project types and the constant values must be updated because productivity and other variables in the construction industry constantly change.

On the other hand, Kenley (2001), and Ogunsemi and Jagboro (2006) have questioned the abilities of the BTC model, expressing that it has no verified forecasting ability and it does not apply to all construction projects.

Many researchers have upgraded this model by using multiple regression models for different factors that affect cost time relationship. Suggestions were made to create different regression models according to project type (ex-residential, commercial), size (Ng *et al.*, 2001), project scope, complexity, environment and management (Chan, 1998), which will make the model more aggregable with each differentiation. This model is currently used as an indicator of design, documentation and construction time (Australian Institute of Quantity Surveyors, 2017).

4.2 CRITICAL PATH METHOD (CPM)

Critical path method uses work breakdown structures to identify each building activity and orders them in construction sequence (Newitt, 2009). Critical path method is used to estimate the minimum time required to finish a project (Project Management Institute, 2014). First, the construction work is decomposed to the smallest work sections called activities (Newitt, 2009). Then depending on the relationships between the activities, Network Program Diagram (NPD) is built, where one estimated duration for each activity is used (Wang *et al.*, 2014). The critical path is the sequence of activities in an NPD with the longest duration (Project Management Institute, 2014). This will be the shortest time to finish and this time will be the project duration.

As mentioned above, due to changes in scope and unforeseeable circumstances, duration of activities in a construction project is unpredictable and uncertain (Hinze, 2012). This is more evident in reconstruction projects. Thus, a definite time duration cannot be allocated for an activity. Yet, in CPM, a definite duration for each activity is allocated, that negates the uncertainty which creates unrealistic estimates.

4.3 PROGRAM EVALUATION AND REVIEW TECHNIQUE (PERT)

Program Evaluation and Review Technique (PERT) was developed by the Special Forces Office of the United States Navy for evaluating project progress (United States Navy, 1958). Showing similarities to CPM, the PERT method uses logical work flow diagrams or Network Program Diagram to develop project schedules (Newitt, 2009; Wang *et al.*, 2014). The major difference of PERT method from CPM is that, the PERT uses three time estimates for an activity, which are optimistic duration, pessimistic duration and most likely duration for an activity (United States Navy, 1958; Plebankiewicz, Juszczyk and Malara, 2015).

PERT is a probabilistic time estimation method (Fondahl, 1961; Zhong and Zhang, 2003). It uses three time durations and calculate the mean value of duration of each activity using the following formula 2 (United States Navy, 1958; Plebankiewicz, Juszczyk and Malara, 2015).

$$Te = \left(\frac{To + 4Tm + Tp}{6}\right) \tag{2}$$

Te = Mean duration of the activity
To = Optimistic duration
Tm = Most likely duration
Tp = Pessimistic duration

In the above equation, more weight is placed on the most likely value and the effects of the optimistic and pessimistic value are not significant. Therefore, to better express optimistic and pessimistic values and reduce uncertainty, equation 3 is adopted (United States Navy, 1958).

$$Variance = \sigma^2 = \left(\frac{Tp - To}{6}\right)^2 \tag{3}$$

To calculate the achievability of a certain time target, the sum of standard deviations (from formula 3) and the sum of durations of the activities (from formula 2) in the critical paths are used. These values are then applied to formula 4 and result of formula 5 is checked against a Standard Nominal Curve table to calculate the probability of achieving the target (United States Navy, 1958; Hinze, 2012). The Standard Nominal table contains the probabilities of the standard normal distribution.

$$X = \frac{Tt - \sum_{Start}^{End} Te}{\sum_{Start}^{End} \sigma} \quad (4)$$

X = standard deviation from the mean
$\sum_{Start}^{End} \sigma$ = sum of variances of the activities in CP
$\sum_{Start}^{End} Te$ = sum of mean durations of activities in CP
Tt = target duration

Optimistic and pessimistic time duration of an activity impact the project time estimation. Even though the total mean duration can be higher, the probability of a path achieving a target date may vary on the sum of variance (Hinze, 2012). Thus, it shows the uncertainty of activity duration is important to calculate the final duration of a project. Therefore the Critical Path Method has been proven to not always be accurate and highlights the importance of PERT method (Hinze, 2012; Nafkha, 2016).

4.4 MONTE CARLO SIMULATIONS

Monte Carlo method utilizes random sampling methods to generate random scenarios, repeatedly to obtain the outcome (Schuyler, 2001). It is a scientific method for validating theories using observations and theories as well as mathematical, computational and simulation techniques (Bielajew, 2013). Bielajew (2013) states that the more complex the problem, then the Monte Carlo method is the most suitable method due to its ability to understand relationships between objects through observations or trial and error.

Using these attributes, Monte Carlo simulation has been applied to scheduling and time estimation in construction. Project Management Institute in the United States of America (2014, p. 547) outlined the Monte Carlo process in construction as “A process which generates hundreds or thousands of probable performance outcomes based on probability distributions for cost and schedule on individual tasks. The outcomes are then used to generate a probability distribution for the project as a whole.”

To include variability of time estimation for each project, like CPM, Monte Carlo method break downs the project into activities. Similar to PERT, Monte Carlo method uses three time estimates per activity, optimistic, pessimistic and most likely time durations (Flanagan and Norman, 1993).

The difference between having a single value for a time duration, like in CPM, is that it will produce only single value as the estimated project time. In Monte Carlo method, random numbers are used to get different duration values for each activity, from the distribution created from above stated three-point values of each activity. Using the above method, project time is generated repeatedly using different values for each activity. Distribution created from these project times are used to predict the time with a percentage of certainty.

Currently, due to increased capabilities in computer processing, Monte Carlo simulations are practically used in the industry through software like Microsoft Project (Kwak and Ingall, 2009), @RISK, Risk+, Full Monte and Primavera.

Table 1 – Comparison of time estimation tools

Characteristic	Time estimation tools				
	PACT	Critical Path Method (CPM)	Program Evaluation and Review Technique (PERT)	Monte Carlo Simulation for project time estimation	Bromilow's time and cost model
Applicability in earthquake repair	Yes, but not yet proven in New Zealand	Not yet proven	Not yet proven	Not yet proven	Yes, not yet proven in New Zealand
Considers work breakdown	Yes	Yes	Yes	Yes	Not applicable
Considers sequence of work	No	Yes	Yes	Yes	Not applicable
Consideration of uncertainty	Not for time estimation	No	Yes	Yes	Not applicable
Considers all stages of construction projects	Only for construction	Yes	Yes	Yes	Only for construction
Can be used for earthquake-induced hazards	No	Yes	Yes	Yes	Yes
Impeding factors	Not considered	Can be included	Can be included	Can be included	Includes in the data used
Availability of software tools	Yes	Yes	Spreadsheet tools needs to create	Yes	No
Accuracy of estimates	High variation	Nominal variation	Depends on the input data and scheduling method	Depends on the input data and scheduling method	High variation

5. Discussion on suitable method to be used for time estimation to reconstruct earthquake damaged buildings

A unique feature in earthquake damaged building repairs is the uncertainty of the work activities to be performed, relationships between activities and time to be spent on them. To use a time estimation method in such a situation, it should be either validated in its ability to be used or have the ability to incorporate uncertainty. Table 1 compares the features in existing time estimation models.

Considering CPM, PERT and Monte Carlo simulations, each is an upgraded iteration of the previous, respectively. All methods use a bottom-up approach to predict the time estimates. Monte Carlo simulation has most of the advantages of the CPM, having work breakdown structures and activity relationships, and advantages of PERT, by having three-time estimates for each activity to incorporate uncertainty. Thus, Monte Carlo method has better ability to serve in post-earthquake damage repair time estimation than PERT and CPM.

Monte Carlo method can also address the limitation in loss assessment tools like PACT that prepares time estimates for each recovery stage of buildings, including disruption to utilities, damages by earthquake-induced hazards and impeding factors. It can include time estimation for all stages of construction projects according to the RIBA plan of work. Alternatively, PACT requires databases to be built for countries other than the United States. Work breakdown structures and activity sequencing make time estimation much more accurate by addressing each unique activity in each construction project. Loss assessment tools currently do not use activity sequencing for time estimation making these less accurate. This can be addressed by using Monte Carlo method.

Due to the uncertainty of the type of activities and its duration to be performed in earthquake damage repair, estimated time results will have a lower level of certainty. Therefore, Monte Carlo method should be used with other verification methods to reduce this uncertainty. By using a bottom-up method like BTC model with Monte Carlo method this uncertainty can be largely reduced.

BTC model, with its simplicity and accuracy, can be used as a time estimation model, by building multiple regression models on categories of public and private as well as subcategories of type and size of the building. This method uses top-down method for its time estimation. Research has also shown that BTC model can also be used in earthquake damage estimation (Sun and Xu,

2011). Due to its limitations of, non-verification as a forecasting method, variation in estimates and lack of research in New Zealand, it can only be suggested as a rule of thumb for verification of cost estimations or preliminary time estimation method.

Furthermore, the performance of the construction industry changes over time. Performance and cost variations will affect the model which will require the model to be upgraded. The author suggests that the upgrading of the model can be done concurrently with a post-construction cost analysis of each project. If the database of projects were to be developed, multiple regression models using this BTC equation could produce better preliminary time estimates as well as the model's validity being verified.

6. Conclusion

Accurate time estimation of a construction project is essential to its success. There are many methods used in the construction industry to estimate time of construction project. By comparing Critical Path Method, PERT method, Monte Carlo Simulation for time estimation and Bromilow's time and cost model, it can be concluded that each method has its own advantages and disadvantages. By measuring all the advantages and disadvantages it can be expressed that Monte Carlo method is the most suitable method to use in post-earthquake time estimation because of work of its capability to sequence all activities, incorporate uncertainties, availability of software. However, this method also has an inherent disadvantage of the lower level of uncertainty due to the use of probabilistic approach in estimation. Thus, BTC model is suggested as a top-down method to reduce this uncertainty. According to literature, there is no proven method to calculate the accurate time estimates for earthquake damage repairs. Therefore, further research is suggested to develop such a method either based on existing models or using a new approach.

References

Alani, A. M. and Khosrowshahi, F. (2007) 'Development of an effective methodology for assessment, repair and maintenance of the earthquake damaged buildings', *Facilities*. Emerald Group Publishing Limited, 25(1/2), pp. 32–47. doi: 10.1108/02632770710716920.

Almufti, I. *et al.* (2013) *REDi ™ Rating System*. Available at: publications.arup.com/publications/r/redi_rating_systemtions (Accessed: 27 March 2017).

Ameh, O. and Osegbo, E. (2011) 'Study of relationship between time overrun and productivity on construction sites', *International Journal of Construction Supply Chain Management*, 1(1), pp. 56–67. doi: 10.14424/ijcscm101011-56-67.

Ashworth, A. and Perera, S. (2015) *Cost Studies of Buildings*. 6th edn. Oxon, England: Routledge. doi: 10.4324/9781315708867.

Australian Institute of Quantity Surveyors (2017) 'AIQS Building cost index', *The Building Economist - The Journal of Australian Institute of Quantity Surveyors*, (The Resilience Issue June), p. A5.

Bielajew, A. F. (2013) 'History of Monte Carlo', *Monte Carlo Techniques in Radiation Therapy*, 1.

Bradley, B. A. (2009) *User manual for SLAT : Seismic Loss Assessment Tool version 1 . 14*. Christchurch, New Zealand: Department of Civil Engineering, University of Canterbury.

Bromilow, F. J. (1969) 'Contract time performance expectations and the reality', in *Building Forum*, pp. 70–80.

Chan, W. (1998) *Modelling construction durations for public housing projects in Hong Kong*. The University of Hong Kong. doi: 10.5353/th_b3123658.

Czarnigowska, A. and Sobotka, A. (2013) 'Time–cost relationship for predicting construction duration', *Archives of Civil and Mechanical Engineering*. Elsevier, 13(4), pp. 518–526. doi: 10.1016/j.acme.2013.05.004.

Doebling, S. W., Farrar, C. R. and Prime, M. B. (1998) 'A Summary Review of Vibration-Based Damage Identification Methods', *The Shock and Vibration Digest*, 30(2), pp. 91–105. doi: 10.1177/058310249803000201.

Federal Emergency Management Agency (2012) *Seismic Performance Assessment of Buildings Volume 1 - Methodology (FEMA P-58-1), prepared by the Applied Technology Council for the Federal Emergency Management Agency*. Washington, DC. Available at: https://www.fema.gov/media-library/assets/documents/90380.

Flanagan, R. and Norman, G. (1993) *Risk management and construction, Blackwell Science*. Oxford, UK: Wiley-Blackwell.

Fondahl, J. W. (1961) 'A non-computer approach to the critical path method for construction industry', pp. 2014–3. Available at: http://hdl.handle.net/2027/mdp.39015000453970 (Accessed: 31 July 2017).

Hinze, J. (2012) *Construction planning and scheduling.* Upper Saddle River, N.J. : Pearson Prentice Hall, c2012. Available at: http://ezproxy.massey.ac.nz/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=cat00245a&AN=massey.b2392788&site=eds-live&scope=site.

Kenley, R. (2001) 'The predictive ability of Bromilow's time–cost model: a comment', *Construction Management and Economics*, 19(8), pp. 759–764. doi: 10.1080/01446190110073490.

Kwak, Y. and Ingall, L. (2009) 'Exploring monte carlo simulation applications for project management', *IEEE Engineering Management Review*, 37(2), pp. 83–83. doi: 10.1109/EMR.2009.5235458.

Lamport, L. (1978) 'Time, Clocks, and the Ordering of Events in a Distributed System', *Communications of the ACM*, 21(7), pp. 558–565. doi: 10.1145/359545.359563.

Nafkha, R. (2016) 'The pert method in estimating project duration', *Information Systems in Management (2016)*, 5(4), pp. 542–550.

Newitt, J. S. (2009) *Construction scheduling : principles and practices.* Upper Saddle River, N.J. : Prentice Hall, c2009,c2008. Available at: http://ezproxy.massey.ac.nz/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=cat00245a&AN=massey.b1976428&site=eds-live&scope=site.

Ng, T. S. *et al.* (2001) 'The predictive ability of Bromilow's time-cost model', *Construction Management and Economics*, 19(2), pp. 165–173. doi: 10.1080/01446190150505090.

Ogunsemi, D. R. and Jagboro, G. O. (2006) 'Time-cost model for building projects in Nigeria', *Construction Management and Economics*, 24(3), pp. 253–258. doi: 10.1080/01446190500521041.

Plebankiewicz, E., Juszczyk, M. and Malara, J. (2015) 'Estimation of task completion times with the use of the PERT method on the example of a real construction project', *Archives of Civil Engineering*, 61(3), pp. 51–62. doi: 10.1515/ace-2015-0024.

Project Management Institute (2014) *A guide to the project management body of knowledge: PMBOK Guide*. 5th edn. Newtown Square, Pennsylvania: Project Management Institute.

Ramirez, C. M. *et al.* (2012) 'Expected earthquake damage and repair costs in reinforced concrete frame buildings', *Earthquake Engineering & Structural Dynamics*, 41(11), pp. 1455–1475. doi: 10.1002/eqe.2216.

Schuyler, J. R. (2001) *Risk and decision analysis in projects*. 2nd edn. Newtown Square, Pennsylvania: Project Management Institute.

Senouci, A., Ismail, A. A. and Eldin, N. (2016) 'Time and Cost Overrun in Public Construction Projects in Qatar', *Creative Construction Conference 2016*, pp. 231–236.

Sousa, V., Almeida, N. M. and Dias, L. A. (2014) 'Role of Statistics and Engineering Judgment in Developing Optimized Time-Cost Relationship Models', *Journal of Construction Engineering and Management*, 140(8), p. 4014034. doi: 10.1061/(ASCE)CO.1943-7862.0000874.

Stoy, C., Dreier, F. and Schalcher, H.-R. (2007) 'Construction duration of residential building projects in Germany', *Engineering, Construction and Architectural Management*, 14(1), pp. 52–64. doi: 10.1108/09699980710716972.

Sun, C. and Xu, J. (2011) 'Estimation of Time for Wenchuan Earthquake Reconstruction in China', *Journal of Construction Engineering and Management*, 137(3), pp. 179–187. doi: 10.1061/(ASCE)CO.1943-7862.0000277.

Swanson, D. R. and Smalheiser, N. R. (1997) 'An interactive system for finding complementary literatures: a stimulus to scientific discovery', *Artificial Intelligence*, 91(2), pp. 183–203. doi: 10.1016/S0004-3702(97)00008-8.

The Royal Institute of British Architects (2013) *RIBA plan of work, RIBA*. London, England. Available at: https://www.ribaplanofwork.com/Download.aspx (Accessed: 27 July 2017).

United States Navy (1958) *Program evaluation research task (PERT) summary report; phase 1*. Washington, DC: Special Projects Office, Bureau of Naval Weapons, Dept. of the Navy.

Wang, W. *et al.* (2014) 'Construction Duration and Cost Simulation via Network-Program-Diagram', *Frontiers of Engineering Management*, 1(2), p. 210. doi: 10.15302/J-FEM-2014028.

Weisstein, E. W. (2017) *Time*. Available at: http://scienceworld.wolfram.com/physics/Time.html (Accessed: 25 August 2017).

Wickwire, J. M. *et al.* (2009) *Construction Scheduling: Preparation, Liability and Claims*. 3rd edn. Aspen Publishers.

Zhong, D. H. and Zhang, J. S. (2003) 'New Method for Calculating Path Float in Program Evaluation and Review Technique (PERT)', *Journal of Construction Engineering and Management*, 129(5), pp. 501–506. doi: 10.1061/(ASCE)0733-9364(2003)129:5(501).

Žujo, V. *et al.* (2017) 'Time and cost interdependence in water supply system construction projects', *Technological and Economic Development of Economy*, 23(6), pp. 895–914. doi: 10.3846/20294913.2015.1071292.

Rajapaksha.U, et al (eds), 2017, "Design that cares"- multi disciplinary approaches to creating sustainable and meaningful built environment: *Proceedings of the 10th International Conference of Faculty of Architecture Research Unit (FARU), University of Moratuwa, Sri Lanka, (Vol. 01)* pp. 225-237 ©

SREVIEW OF BENEFITS AND CHALLENGES OF PREFABRICATED HOUSING SUPPLY CHAINS: AS A SOLUTION TO HOUSING AFFORDABILITY

SOORIYAMUDALIGE. N[1], DOMINGO. N[2], CHILDERHOUSE. P[3] & PARK. K[4]
[1,2,3,4]Massey University, Auckland, New Zealand
N.Sooriyamudalige@massey.ac.nz

Abstract
Over the last decade, housing affordability issue has gone through the roof creating a significant mismatch between supply and demand of the houses. Even though this national problem has been addressed by the government, an industry level approach is not sufficient. A collaborative effort of the construction industry is essential to encourage housing construction with cost reduction and quality enhancement. One innovative approach to significantly increase the supply of affordable houses is the adoption of prefabrication. Modern supply chain practices in the prefabrication housing construction would increase efficiency. Therefore, this paper aims to review the literature on the benefits and challenges of the prefabrication housing construction over the traditional counterpart.

The study identifies the need to improve collaboration among the supply chain participants and process integration to achieve the benefits of using prefabrication. Even though prefabrication has the ability to substitute traditional housing construction, it has its own limitations, including transportation of large modules and set up costs. Similarly, the bespoke nature of housing construction and attitudes of the customers limit the potential level of standardization through prefabrication.

Keywords: *Housing affordability, Prefabrication, Supply chain practices, benefits and challenges.*

1. Introduction

As emerging issues of the 21st century, housing affordability outstretches into perilous condition threatening to the people with median and lower household income in both developed and developing countries. Growing shortfall of affordable houses in countries like Australia, New Zealand, Hong Kong, United Kingdom and large parts of the United States clearly demonstrate the international scale of the issue (Bertaud, 2014). Moreover, the housing affordability issue in the United States is now the most important national housing policy agenda, replacing all other housing issues (Nelson, 1994). Similarly, house prices in Australia have been increased by 78% (Fox and Finlay, 2012) from 1980 to 2012 forming a relatively constant homeownership rate (Mostafa et al., 2014). In New Zealand, the intensive increment in housing prices deteriorate policies, social and cultural conditions in a country (Bassett

and Malpass, 2013). In light of this, construction industry seeks a green light to overcome this matter effectively. However, less profitability and high volatility of housing sector act as main barriers to several solutions (Masood et al.,2016). Among those solutions, adoption of prefabrication can be identified as one of the recommended and enduring ways to achieve housing affordability (Stroebele and Kiessling, 2017, Mostafa et al., 2014, NHSC, 2013, Mullens and Kelley III, 2004). The notion of prefabrication extensively offers numerous benefits to all stakeholders in the construction cycle (Blismas and Wakefield, 2009). Simply, it is the manufacture of modules or components off-site (Sparksman et al., 1999). In a practical, prefabrication processes begin with the confirmation of the client (Stroebele and Kiessling, 2017). Compared with manufacturing supply chains, the key difference becomes assembling the product on site and a higher degree of the supply chain is finalized during the production (Stroebele and Kiessling, 2017). In conventional housing construction, the entire work associated with the erection of a house is performed on the construction site (Kamali and Hewage, 2016). Contrastingly, prefabrication enables the application of modern manufacturing practices for much of the process, thereby increasing the quality, reliability and consistency of the process. According to Mostafa et al. (2014), the application of prefabrication in house construction has been endorsed to achieve a greater housing supply. In line with this, the US Department of Housing and Urban Development (HUD) stated the benefits of incorporating prefabrication in construction as faster, better and reduced cost of housing (PATH 2002). Similarly, in the UK construction industry, this technique has been used in house building to provide low to zero carbon homes at affordable prices (Goodier and Pan, 2012) while Japan is applying the same methodology for decades (Barlow and Ozaki, 2005).

Even though many academics and practitioners have strived to explore the insights of the prefabrication and residential construction, clients strongly resist such innovation on the grounds of standardization of their houses. This coupled with architect/designer perception barriers and the fragmented supply chain structures hinders the application of prefabrication. According to Zhang and Skitmore (2012), the adoption of prefabrication in housing construction is limited to two types of construction companies: renowned large scale residential property developer enterprises and certain proactive housing product manufacturing specialists. Thus, for many of those engaged in the construction process, the benefits of using prefabrication is not well realised (Lu and Liska, 2008).

To obtain the benefits of prefabrication in housing construction, coordination and collaboration of the partners of the supply chain of house building is a key

aspect in terms of delivering it on time, with low cost and high quality (Lessing, 2006). Therefore, a precise supply chain management is needed to optimise the complexity of house building supply chain (Stroebele and Kiessling, 2017). In order to develop the basis for supply chain integration, it is required to identify and analyse the supply chain in prefabrication housing construction. Therefore, this article is focused on to review the literature on the practices of prefabrication in housing construction with the aim of identifying the issues that hinder the application of prefabrication in housing construction.

2. Methodology

This paper is based on the findings from literature-based discovery, which is a formal method to derive a relationship in between issue in one discipline's literature and solution in another (Fellows and Liu, 2015). Literature-based discovery enables discovery and transfer of knowledge between different disciplines (Swanson and Smalheiser, 1997). Hence, this helps to discover a solution for housing affordability (one discipline) issue through prefabrication housing construction (another discipline). A detailed literature review has been done to derive the relationship in between housing affordability and prefabrication housing construction based on journal articles, governmental reports, conference papers and research studies.

3. Benefits and Challenges of Prefabrication Housing Construction

The successful completion of a construction project whether using prefabrication methods or traditional approaches depends on the clear identification of the key factors driving the project, as well as an appreciation of the constraints affecting its efficient completion (Gibb and Isack, 2001). Even though various industry and research initiatives have attempted to scrutinize the barriers and drivers of prefabrication methods, limited efforts are taken in adopting it into housing construction (Elnaas, 2014).

3.1. BENEFITS

In literature, benefits of using prefabrication in construction tend to focus on cost, quality and productivity (Jaillon and Poon, 2008). However, other significant advantages associated with the use of prefabrication, adds the value of the building is generally overlooked. Therefore, the combination of economic, social and environmental benefits of adopting prefabrication in construction is briefly discussed here.

3.1.1 Economic benefits of using prefabrication

Prefabrication allows shorter onsite construction time (Goodier and Gibb, 2007) as site preparation and building construction takes place simultaneously (Figure 1) (Kawecki, 2010). Besides, in prefabrication, construction time spent on site operations is minimal and it reflects on evading delays due to disruptions from weather extremes (Waskett, 2003). Similarly, inherent risks associated with traditional construction, like conflicting crews and interferences with ongoing operations is considerably low in prefabrication (Haas and Fagerlund, 2002). On the other hand, time reduction in prefabrication is replicated in lower site overhead cost, less interest on loans and early return on investment. On average, construction time is reduced by 40% in prefabrication constructions compared with traditional construction (Lawson and Ogden, 2010).

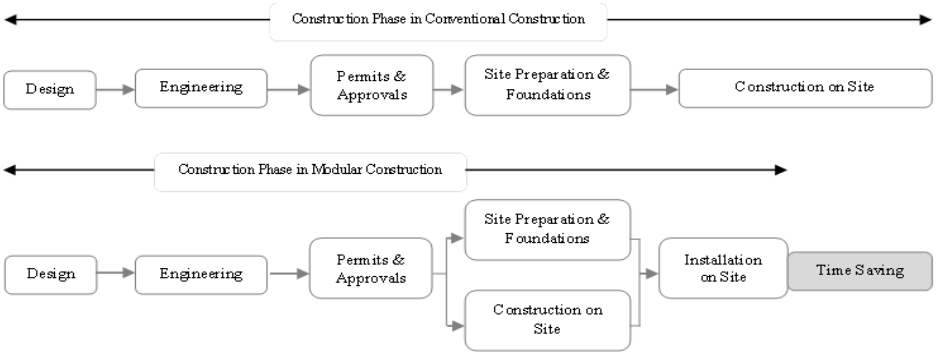


Figure 1: Time saving in prefabrication construction

By adopting prefabrication, problems related with poor workmanship and product quality can be achieved through controlled manufacturing environment in which the components are built (Kamali and Hewage, 2016, Haas and Fagerlund, 2002, Jaillon and Poon, 2008). As it facilitates repetitive process and operations with automated machinery, the quality of the product is easier to assure (O'Connor et al., 2014, Construction, 2011). In house building, prefabrication has the potential to improve quality and durability with reduced defects while product quality in traditional construction depends on the workmanship (Jaillon and Poon, 2008). Moreover, in a manufacturing environment, parallel activities are possible without disruption to the process, which enhance productivity (O'Connor et al., 2014, Lu, 2009). Improved quality reduces maintenance work and associated costs (Jaillon and Poon, 2008). On the other hand, prefabrication can offer opportunities for dealing with problems from the declining skilled labour shortages on site and thereby reduce the labour cost of the project. In house building, builders can be

benefited with the use of prefabrication through shorter construction period, reduction in life-cycle cost (Housing forum, 2002). Prefabrication could yield cost benefits over traditional constructional owing to many related factors. In line with the results of the Construction Industry Institute (CII), in prefabrication construction projects, cost reduction was 10% on overall cost and 25% on the on-site labour cost (Lu, 2007). Cost reduction could be achieved through other factors, like design standardisation, higher efficiency in installation and higher energy efficiency. Similarly, Badir et al. (2002) study reveals cost saving of labour and materials as the major benefit of prefabrication, while Mokhtar and Mahmood (2008), highlights the major benefit of waste reduction in the construction site.

3.1.2. Environmental benefits of using prefabrication

Prefabrication construction offers minimal site disturbance when compared with the traditional construction where the construction site operations are vulnerable to noise, dust, congestion and waste (Lu, 2007, Jaillon and Poon, 2008, Mah, 2011). According to Jaillon and Poon (2008) waste reduction is one of the highlighted environmental benefits of using prefabrication in which pollution can be easily controlled under factory environment. It contributes to waste reduction in timber formwork, plastering and concrete works by about 74%–87%, 100% and 51%–60% respectively (Tam et al., 2005). Similarly, in prefabrication, on-site greenhouse gas (GHG) emissions is minimal compared to traditional methods (Mah, 2011, Lu and Korman, 2010). Moreover, at the end of the life cycle of the building, prefabrication modules and components can be reused in another project. Thus, compared with traditional construction, prefabrication facilitates waste reduction and material conservation.

3.1.3. Social benefits of using prefabrication

Adoption of prefabrication in housing construction offers site safety, long-term job security with proper training to workers (Ross, 2002, Kamali, 2016). Further, it improves quality and technical performance in outdoor and indoor environments (Housing Forum, 2002) and ultimately leads to customers' satisfaction (Gibb and Pendlebury, 2006). Prefabrication also contributes to reduce noise and dust, which is benefited in both the employees and the neighbouring communities (Gibb and Pendlebury, 2006).

3.2 CHALLENGES

While the benefits of prefabrication encourage the use as an option, the decision is yet influenced by the challenges. Common challenges of using prefabrication construction are pointed out here under economic, social, environmental and other aspects.

3.2.1 Economic limitations of using prefabrication

The higher initial cost to set up the manufacturing plants is a major economic limitation in adopting prefabrication (Nadim and Goulding, 2010, Goodier and Gibb, 2007, Pan et al., 2007). The lack of skilful, knowledgeable and experienced experts in prefabrication construction makes economic disadvantages (Haas and Fagerlund, 2002). Besides, costs for transportation, handling and storage facilities is another limitation, appears in order to achieve a continuous order process (Stroebele and Kiessling, 2017). Transportation method of prefabricated elements can vary depending on size and weight of the modules and once the components reach the site, additional lift planning may be required, especially for heavier lifts (Haas and Fagerlund, 2002). Transportation and lifting of modules have an influence on construction schedule, site design, crane cost, availability and the cost of designing the plan (Boyd et al., 2012). However, these economic limitations could be offset by reduction of other factors, such as reduction in construction time, labour requirement on site, and waste and resources reductions (Jaillon and Poon, 2008). Though the construction cost likely to be volatile in prefabrication, it could reduce the construction cost (Taylor, 2010).

3.2.2 Environmental limitations of using prefabrication

In prefabrication construction supply chain, transportation plays a vital role in achieving the combined aspects of the delivery time and the cost (Stroebele and Kiessling, 2017). Even though it causes air pollution, the impact could be negated as the major building works are carried out in factory premises (Jaillon and Poon, 2008).

3.2.3 Social limitations of using prefabrication

Wider use of prefabrication could reduce in site labour requirement by 43% (Tam, 2002). In line with this, Jaillon and Poon (2008) highlight the negative effect on economy as the unemployment rate increases with the wider usage of prefabrication. Although it increases the unemployment rate, it is an inevitable worldwide trend to move towards an innovative and advanced technology in public house construction (Tam, 2002). Another limitation of using prefabrication found in literature is the public's negative perception which considerably hinders the development of this innovative and advanced technology in worldwide (Kamali and Hewage, 2016). The lack of awareness on the advantages and different opportunities offered by prefabrication could influence on the market demand (Chiang et al., 2006).

3.2.4 Other Aspects

Effective and efficient means of coordination and communication is needed to throughout the whole process of delivering a prefabrication building, including project planning, procurement, supply chain scheduling, assembling and construction, and delivery (Kamali and Hewage, 2016). In order to deliver the project in time, the communication between the participants of the construction process must be standardised (Stroebele and Kiessling, 2017). Based on the study they advocate the use of Building Information Modelling (BIM) as a way out to tackle the problem (Stroebele and Kiessling, 2017). In addition, it requires intensive pre-project planning and engineering as modular design, fabrication and assembly is different from the conventional building design and construction (Kamali and Hewage, 2016). However, this early design and fabrication hinders the flexibility in design changes with the market trends (Jaillon and Poon, 2008). Besides the aforesaid aspects, the degree of infrastructure preparation (like foundation setting on project site) might be critical with process optimization (Stroebele and Kiessling, 2017).

4. Discussion

Prefabrication construction has long been reported as an effective alternative to conventional construction, with wide-ranging benefits (Pan and Sidwell, 2011). It is one of the innovative and effective methods of delivering a sustainable construction when compared with the traditional construction (Zhai et al., 2014b). However, the barriers of using this innovative method have limited the wider take up in the construction industry specifically in housing sector. These identified barriers and benefits are summarised in the following Table 1 as a comparison between traditional housing construction and prefabrication housing construction.

Traditional drivers of the time, cost, quality, productivity, health and safety and environmental impact encourage the industry to make more use of prefabrication methods in housing construction compared to the traditional counterpart (Forum, 2002, Sparksman et al., 1999). All these predefined benefits are echoed in a recent cross-industry market survey (Goodier and Gibb, 2004) which states that the use of offsite technologies brings benefits centred on shorter onsite duration and increased quality, but real or perceived additional cost compared to traditional. Even though the initial cost of establishing prefabrication is higher than the traditional construction, cost savings are possibly achieved through efficiency learning, innovation, partnering, and ‘in-house’ build management (Pan and Sidwell, 2011).

The current manufacturing capacity and associated cost, inherent the uptake of the prefabrication construction in the housing sector, which seems to be influenced with the optimization of production capacity by the suppliers (Venables et al., 2004). The low level of partnering between builders and manufacturers and suppliers in housing construction appears to be one of the problematic issues (Pan et al., 2008). Thus, it is important to develop and use positive relationships between the developer and offsite suppliers to drive cost and design efficiency through collaborative working. It requires a long-term commitment to the organizations and continuous exploration of the offsite technology in collaboration with their supply chains.

Although prefabrication adds value in terms of onsite skill deficiency (Barker, 2003), the requirement for experts in technical aspects is still remain as a problem (Chiang et al., 2006). On the contrary, the craft-based traditional approach in housing construction; make difficulty in process control and the deficiency in supplying skilled workforce has worsened the issue (Roy et al., 2005). According to Womack and Jones (2010), technology development is not adequate; working practices including workforce training, process standardisation and attention to process control needs to be improved. Public perception is another inhabited barrier comes along with adoption of prefabrication in housing construction.

Table 1: Comparison between prefabrication and traditional housing construction

	Factor	Prefabrication Construction	Traditional construction
Benefits	Schedule	• Speed in construction process due to simultaneous site preparation and building construction, less disruption from weather and scheduling problems	• Time-consuming and delays can cause due to weather and scheduling problems
	Product Quality	• Greater controlled manufacturing environment including automated machinery, repetitive process skilled workers and fewer climate obstructions improve the product quality	• Exposure to climatic changes can result in less than expected quality in construction
	Cost	• Shorter on-site construction time results in fewer chances of cost overruns, less site overhead and congestion, on-site labour reduction, material wastage, less interest on loans and early return on investment • Greater control over manufacturing process improve the product quality which ultimately results in reduced maintenance cost	• Vulnerability to uncontrollable variables like weather, unforeseen and scheduling circumstances can increase construction cost
	Environmental influence and Site Safety	• Less waste generated at the site, minimal on-site disturbance from noise, dust & congestion and reduction in greenhouse gas emission • Reduction in dangerous and elevated activities	• A significant amount of waste produced on site and high chance of environmental pollution due to onsite construction • Vulnerable to on-site safety issues
	Workmanship and productivity	• Less on-site workforce requirement • Design standardisation, higher efficiency in installation and higher energy efficiency resulted in higher productivity	• More on-site workforce requirement
Challenges	Initial Cost	• A large amount of initial investment required to set up	• None
	Project Planning	• Need for extensive pre-project planning	• Pre-project planning requirement is less
	Coordination and Communication	• A detailed coordination in all stages of the project is required including a well-structured communication plan among all stakeholders	• Project coordination and communication requirement arises when of the onsite construction started
	Design Flexibility/ Versatility	• Less	• More
	Transportation and site constraints	• Transportation constraints due to module sizes and weights • Space availability in lifting, handling, assembling the modules for machinery and on-site • Lack of skilful, knowledgeable and experienced experts	• Less transportation constraints
	Negative Perception	• Public's negative perception towards innovation and standardisation	• Less negative perception due high chance of design customisation

Lack of knowledge of prefabrication methods and its benefits (Chiang et al., 2006) has influenced to this negative perception. This situation needs to be improved through industry and government level initiatives, to overcome the most problems related with innovation which arises from the mismatch between market demand and technological possibilities (Tushman and Moore, 1988). Moreover, early involvement of the builders and manufacturers in the decision-making process of prefabrication construction with long-term partnerships enables thorough and well-organized supply chain for utilizing prefabrication methods (Zhai et al., 2014a).

5.0 Conclusion

This paper has identified the benefits and challenges of adopting prefabrication in housing construction. Prefabrication has long been reported as an effective alternative to conventional construction, with wide-ranging benefits. It serves as a valuable source of providing time, cost, quality, productivity, health and safety and environmental benefits. However, a wider take-up in housing construction has been inhibited by cost barriers and negative perceptions. In addition to those, extensive project planning from early stage, lack of coordination and communication, and transportation constraints are found to be other barriers. However, integration of prefabrication housing supply chain could achieve these barriers. Cooperation, effective collaboration, information sharing, and inter-firm partnerships could mitigate these barriers while elevating the use of prefabrication. Therefore, this enables to construct high quality and affordable houses within shorter time periods.

Even though the literature has identified the benefits and challenges of adopting prefabrication in housing construction, there could be practical inefficiencies. Therefore, it is important to be confirmed these benefits and challenges through an appropriate research approach (quantitative or qualitative).

References

Badir, Y. F., Kadir, M. A. & Hashim, A. H. 2002. Industrialized building systems construction in Malaysia. Journal of Architectural Engineering, 8, 19-23.

Barker, K. 2003. Review of Housing Supply: Securing Our Future Housing Needs: Interim Report: Analysis, HM Stationery Office.

Barlow, J. & Ozaki, R. 2005. Building mass customised housing through innovation in the production system: lessons from Japan. Environment and Planning A, 37, 9-20.

Bassett, M. & Malpass, L. 2013. Priced Out: how New Zealand lost its housing affordability, New Zealand Initiative.

Bertaud, A. 2014. 10th Annual Demographia International Housing Affordability Survey: 2014. Belleville, Illinois.

Blismas, N. & Wakefield, R. 2009. Drivers, constraints and the future of offsite manufacture in Australia. Construction innovation, 9, 72-83.

Boyd, N., Khalfan, M. M. & Maqsood, T. 2012. Off-site construction of apartment buildings. Journal of Architectural Engineering, 19, 51-57.

Chiang, Y.-H., Chan, E. H.-W. & Lok, L. K.-L. 2006. Prefabrication and barriers to entry—a case study of public housing and institutional buildings in Hong Kong. Habitat International, 30, 482-499.

Construction, M. H. 2011. Prefabrication and modularization: increasing productivity in the construction industry. Smart Market Report.

Elnaas, E. 2014. The decision to use Off-Site Manufacturing (OSM) systems for house building projects in the UK. University of Brighton.

Fellows, R. F. & LIU, A. M. 2015. Research methods for construction, John Wiley & Sons.

Forum, H. 2002. Homing in on excellence: A commentary on the use of offsite fabrication methods for the UK housebuilding industry.

Fox, R. & Finlay, R. 2012. Dwelling prices and household income. Reserve Bank of Australia Bulletin, 13-22.

Gibb, A. G. & Isack, F. 2001. Client drivers for construction projects: implications for standardization. Engineering Construction and Architectural Management, 8, 46-58.

Goodier, C. & Gibb, A. 2007. Future opportunities for offsite in the UK. Construction Management and Economics, 25, 585-595.

Goodier, C. I. & Pan, W. 2012. Briefing: Future trends in UK housebuilding.

Haas, C. T. & Fagerlund, W. R. 2002. Preliminary research on prefabrication, pre-assembly, modularization and off-site fabrication in construction, Construction Industry Institute.

Jaillon, L. & Poon, C.-S. 2008. Sustainable construction aspects of using prefabrication in dense urban environment: a Hong Kong case study. Construction Management and Economics, 26, 953-966.

Kamali, M. & Hewage, K. 2016. Life cycle performance of modular buildings: A critical review. Renewable and Sustainable Energy Reviews, 62, 1171-1183.

Kawecki, L. R. 2010. Environmental performance of modular fabrication: Calculating the carbon footprint of energy used in the construction of a modular home, Arizona State University.

Lawson, R. & Ogden, R. Sustainability and process benefits of modular construction. Proceedings of the 18th CIB World Building Congress, TG57-Special Track, Salford, UK, 2010. 10-13.

Lessing, J. 2006. Industrialised house-building. Concept and Processes.

LU, N. 2007. Investigation of the designers' and general contractors' perceptions of offsite construction techniques in the United States construction industry. Clemson University.

Lu, N. The current use of offsite construction techniques in the United States construction industry. Construction Research Congress 2009: Building a Sustainable Future, 2009. 946-955.

Lu, N. & Korman, T. Implementation of building information modeling (BIM) in modular construction: Benefits and challenges. Construction Research Congress 2010: Innovation for Reshaping Construction Practice, 2010. 1136-1145.

Lu, N. & Liska, R. W. 2008. Designers' and general contractors' perceptions of offsite construction techniques in the United State construction industry. International journal of construction education and research, 4, 177-188.

Mah, D. 2011. Framework for rating the sustainability of the residential construction practice.

Masood, R., Lim, J. & Gonzalez, V. A. 2016. A Taxonomy of Construction Supply Chain for Affordable Housing in New Zealand.

Mokhtar, S. N. & Mahmood, N. Z. Approach in construction industry: A study on prefabrication method as a tool for waste minimization. International Conference on Environmental Research and Technology (ICERT, 2008.

Mostafa, S., Chileshe, N. & ZUO, J. 2014. Enhancing Australian Housing Affordability: Off-site Manufacturing Supply Chain Strategies. Akademika forlag.

Mullens, M. A. & Kelley III, M. E. 2004. Lean homebuilding using modular technology. Housing and Society, 31, 41-54.

Nadim, W. & Goulding, J. S. 2010. Offsite production in the UK: the way forward? A UK construction industry perspective. Construction innovation, 10, 181-202.

Nelson, K. P. 1994. Whose shortage of affordable housing?

O'connor, J. T., O'brien, W. J. & Choi, J. O. 2014. Critical success factors and enablers for optimum and maximum industrial modularization. Journal of Construction Engineering and Management, 140, 04014012.

Pan, W., Gibb, A. G. & Dainty, A. R. 2007. Perspectives of UK housebuilders on the use of offsite modern methods of construction. Construction management and Economics, 25,183-194.

Pan, W., Gibb, A. G. & Dainty, A. R. 2008. Leading UK housebuilders' utilization of offsite construction methods. Building Research & Information, 36, 56-67.

Pan, W. & Sidwell, R. 2011. Demystifying the cost barriers to offsite construction in the UK. Construction Management and Economics, 29, 1081-1099.

Pasquire, C. L. & GIBB, A. G. 2002. Considerations for assessing the benefits of standardisation and pre-assembly in construction.

Roy, R., Low, M. & Waller, J. 2005. Documentation, standardization and improvement of the construction process in house building. Construction Management and Economics,23, 57-67.

Sparksman, G., Groak, S., Gibb, A. & NEALE, R. 1999. Standardisation and pre-assembly: Adding value to construction projects. CIRIA Report, 176.

Stroebele, B. S. & Kiessling, A. J. 2017. Impact Analysis of Complexity Drivers in the Supply Chain of Prefabricated Houses. Journal of Management and Strategy, 8, 1.

Swanson, D. R. & Smalheiser, N. R. 1997. An interactive system for finding complementary literatures: a stimulus to scientific discovery. Artificial intelligence, 91, 183-203.

Tam, C., Tam, V. W., Chan, J. K. & Ng, W. C. 2005. Use of prefabrication to minimize construction waste-a case study approach. International Journal of Construction Management, 5, 91-101.

Tam, C. M. Impact on structure of labour market resulting from large-scale implementation of prefabrication. In: ANSON, M., KO, J. & LAM, E., eds. Advances in Building Technology: Proceedings of the International Conference on Advances in Building Technology, 4-6 December 2002, Hong Kong, China, 2002. Elsevier Science, 399.

Taylor, M. D. 2010. A definition and valuation of the UK offsite construction sector. Construction Management and Economics, 28, 885-896.

Tushman, M. & Moore, W. L. 1988. Readings in the Management of Innovation, Ballinger.

Venables, T., Barlow, J. & Gann, D. 2004. Manufacturing excellence: UK capacity in offsite manufacturing, Innovation Studies Centre.

Waskett, P. 2003. Current practice and potential uses of prefabrication. BRE (Building Research Establishment): DTI (Department of Trade and Industry), project report.

Womack, J. P. & Jones, D. T. 2010. Lean thinking: banish waste and create wealth in your corporation, Simon and Schuster.

Wood, G. D. & Ellis, R. C. 2005. Main contractor experiences of partnering relationships on UK construction projects. Construction Management and Economics, 23, 317-325.

Zhai, X., Reed, R. & Mills, A. 2014a. Embracing off-site innovation in construction in China to enhance a sustainable built environment in urban housing. International Journal of Construction Management, 14, 123-133.

Zhai, X., Reed, R. & Mills, A. 2014b. Factors impeding the offsite production of housing construction in China: an investigation of current practice. Construction Management and Economics, 32, 40-52.

Zhang, X. & Skitmore, M. 2012. Industrialized housing in China: a coin with two sides. International Journal of Strategic Property Management, 16, 143-157.

Rajapaksha.U, et al (eds), 2017, "Design that cares"- multi disciplinary approaches to creating sustainable and meaningful built environment: *Proceedings of the 10th International Conference of Faculty of Architecture Research Unit (FARU), University of Moratuwa, Sri Lanka, (Vol. 01)* pp. 238-251 ©

AN ASSESSMENT OF ROOFTOP SOLAR PV POLICIES AND DOMESTIC ENERGY USE: SCENARIO OF SRI LANKAN RESIDENTIAL SECTOR

PATHIRANA. S.M.[1] & HALWATURA. R.U.[2]
[1,2]University of Moratuwa, Katubedda, Sri Lanka
shakila205@gmail.com

Abstract
The net metering scheme in Sri Lanka has experienced a fast diffusion due to the economic, social and environmental benefits for the consumers and the country. This paper examines the changes in energy consumption behaviour of the solar PV consumers after the installation. Further, this analyses the reasons behind the consumption change and the issues associated with the change. According to the study results, 69% of the respondents have increased the consumption up to more than 400 kWh and the tendency of previously low consumed customers to have higher post consumption is significant. Although, the existing net metering scheme favours the social, environmental and economic conditions of the consumer, the increase in the night time peak is the main issue associated with it. The study proposed three policy options; time of use net metering, battery pack and net metering attached with payment scheme, which need to be integrated to achieve a sustainable net metering scheme

Keywords: *solar; energy consumption; rebound effect; energy efficiency; net metering*

1. Introduction

Renewable energy is widely used in both developed and developing countries to achieve national energy policy goals. For developed countries, where the greenhouse gas emission reduction is a key aim of the energy policy, the requirement of zero energy buildings can be practically and feasibly achieved through renewable energy adoption (Dávi *et al.*, 2016). In developing countries, the growing interest in the renewable energy is mainly towards improving the access to energy. Among the various renewable energy sources, solar PV is prominent in achieving the sustainable goals and this is extensively used to electrify the rural houses with limited grid access (Okoro and Madueme, 2004). In contrary, being a developing country, Sri Lanka experiences a different situation where 98% of the households are already electrified in 2014 with total installed capacity of 3500MW (Ceylon Electricity Board, 2015). With the rapid economic growth in Sri Lanka, the energy demand is rising at a rate of 6% per annum and more fossil fuel will be used to compensate that requirement. Hence, the energy policies in Sri Lanka should focus more on the greenhouse gas emission reduction, eradicating the dependency on non-renewable energy sources.

The first ever grid-connected solar PV system in Sri Lanka was installed in 2010 and was highly popular among domestic consumers due to the attractive tariff scheme associated with net metering (Public Utilities Commission of Sri Lanka, 2015). The rapid growth of the net meter installation can be attributed to the nearly zero marginal cost and the associated supporting finance schemes provided by banks. As per the national electricity demand forecast, the 2013 figure is expected to grow by ten times by 2030 (Ceylon Electricity Board, 2015). Net metering is an energy incentive policy which enables customers to generate energy from their own energy sources. This is widely applied in many countries due to the function of the main grid as the energy banking facility to the microscale generations. Various categories of net metering are available with different netting systems (time of use metering and market rate metering) and financial payout schemes. The main issue with the time of use metering is the consumer is paying for the night time consumption while the production is happening in daytime (Poullikkas, 2013). Further, this should be facilitated with a smart meter to determine the energy usage at any time of the day. This kind of arrangement would discourage the solar PV diffusion in countries like Sri Lanka since there will be a minimum impact to bill saving as the peak consumption occurs during the night. Current Sri Lankan practice can be related to the market rate metering where the difference between the export and import is calculated at the end of the month, and any excess amount will receive an export credit which can be credited to next month's bill.

The net metering policies can be designed such that there is no payment to the system owner and in some policies, some payment is made to the system owner (Coughlin and Cory, 2009). In the net metering system, the marginal value is almost zero as the consumption in most of the cases lower than the production and there is no financial payback. Therefore, the customers either try to size the system according to their electricity consumption requirement or they may adjust the level of consumption up to their electricity generation amount (Ito, 2012). However, if a payment system is involved in the net metering, buyback price is considered as the marginal value. In Sri Lanka, the policy which does not attach to a payment scheme is known as net metering where the payout scheme is known as the net accounting which is a novel policy to the country.

In addition to the net metering, there are other grid-connected renewable energy policies such as feed-in tariff schemes. In this scheme, the operator is providing a guaranteed premium price to the producer and the operator has an obligation to purchase the generated electricity. This policy is designed mainly to encourage the investment in renewable energy. In Sri Lanka, this scheme is known as a net plus where there is no connection between the power generation and the consumption. The producer will be paid for all the units supplied to the

grid and for the electricity consumed through the grid, he will have to pay at the existing tariff rate.

Various benefits of net metering schemes have been cited in the literature. The net metering schemes ensure a massive adoption of the rooftop solar PV systems which support the economic development and the structure of the country. Also, it will ensure the energy independence of the user through proper energy incentive and net metering schemes (Faiers and Neame, 2006). These net metering schemes are beneficial for both the utility and the customers (Eid *et al.*, 2014). For utility, this is a simple, easily administrable and low-cost method of dealing with the residential rooftop PV systems (Poullikkas, 2013). Also in case of rural areas, this will strengthen the distribution grid as well. When the electricity travels in long power lines, the voltage tends to drop and this grid-connected renewable energy systems will strengthen the voltage and improve the quality of the distribution. The customers are also ultimately benefited as they are provided with a long-term guarantee for the low utility bill.

The effect of solar adoption on the household energy consumption increase has not widely discussed in the previous research. McAllister (2012) has conducted a research on this matter for California region and developed a concept called solar rebound effect where a take-back effect occurs due to the reduction in the marginal cost of electricity after solar PV installation. Also, another research was carried out in the UK to study the behavioural response to the solar in the domestic sector. The research analyzed the effect of monitoring devices, electricity tariffs and the PV panel usage on the individual choice and behaviour of the people and discussed how it can lead to sustainable future using PV (Keirstead, 2006). Bourrelle (2014) has done a research on the rebound effect of zero energy buildings which include the use of renewable energy as well. However, the paper is much focused on the re-spending due to the operational energy saving of the energy efficient buildings. According to the previous literature, the post solar PV system adoption energy consumption tend to increase due to the impact of both sunk cost and the marginal cost. Although the decision makers usually ignore the sunk cost in the considerations, the solar owners tend to consider the sunk cost as they try to get as much as a value from the money they have already spent (Poullikkas, 2013). The solar PV systems tend to lower the marginal cost and as a result, the household is less concerned about energy efficiency.

The previous studies are mostly focused on the developed countries where the energy policies target the greenhouse gas emission reduction mainly. There is a research gap in the developing countries in this research area where the demand patterns and the consumer behaviour and the income are different. To fill this gap, the main aim of this study is to analyse whether the Sri Lankan households which have installed grid-connected rooftop solar PV systems have increased or reduced their electricity consumption after the solar PV system installation. The study further aims at identifying the main reasons behind the change in energy consumption and the issues associated with the consumption change.

2. Data, Methods, and Assumptions

The principal objective of this study is to assess the sustainability of the rooftop solar PV net metering policies in Sri Lanka. The analysis presented in this paper is based on the net metering policies and electricity tariffs of domestic sector offered by Public Utilities Commission, Sri Lanka. The primary approach associated with this study is a quantitative and qualitative analysis of two data sets. The first dataset includes information about the characteristics of a sample of residential rooftop solar PV installed customers and the installation and consumption details in Sri Lanka.

A questionnaire survey was conducted from April to August 2017 through email. The questionnaire fields include the location of the solar installed property, number of people in household, year of solar PV installation, energy storage model, average energy consumption (units) before installation, average energy consumption (units) after installation (including self-generation and from grid), excess units supplied to grid, equipment used before installation and equipment purchased after solar PV installation, reasons for increase in energy consumption, changes happened in the household after installation, and the motivation to have solar PV system. The questionnaire was sent to 100 rooftop solar PV customers and 52 valid responses were received. Table 1 presents the distribution of the respondents among various fields including location, number of people in the household, solar PV installation year, and energy storage model.

The second dataset is a supplementary dataset, obtained from the energy balance data of Sri Lanka Sustainable Energy Authority (SLSEA, 2017). The data fields include; the electricity consumption in each sector, Gross Domestic Production (GDP) at 1982 factor cost, electricity generation by various sources (hydro, thermal, wind, new renewable energy, and net metered projects) , and average electricity prices from 1976 to 2015.

Table1: Basic information on the respondents and PV installation.

Basic Information of the respondents

District of solar installed property		Number of people in household	
Ampara	2%	1	0%
Colombo	48%	2	2%
Galle	4%	3	23%
Gampaha	29%	4	37%
Hambantota	4%	5	29%
Kalutara	10%	6 or more	10%
kurunegala	2%		
Nuwara Eliya	2%		

Basic information on PV installation

Solar PV installation year		Energy storage model	
2012	2%	Net metering	85%
2013	8%	Net accounting	10%
2014	12%	Battery pack	4%
2015	44%	Net metering with battery pack	2%
2016	25%		
2017	10%		

3. Results and Discussion

3.1. CONSUMPTION CHANGE AFTER SOLAR PV INSTALLATION

The pre-post comparison of the electricity consumption of the respondents indicates a significant increase in consumption after the rooftop solar PV installation as shown in figure 1. Irrespective of the pre-installation energy consumption, 69% of the respondents consume more than 400 units after installation. Figure 2 indicates the percentage change in electricity consumption compared to the electricity consumption before installation. The respondents with lower electricity consumption prior to installation (less than 250 kWh) , do not show a distinctive pattern of consumption increase after installation, where the change varies from 0% to more than 200%. The percentage change of the high consumers (prior installation) varies from 0% to 50% and demonstrate a negative correlation among electricity consumption before installation and percentage of consumption change.

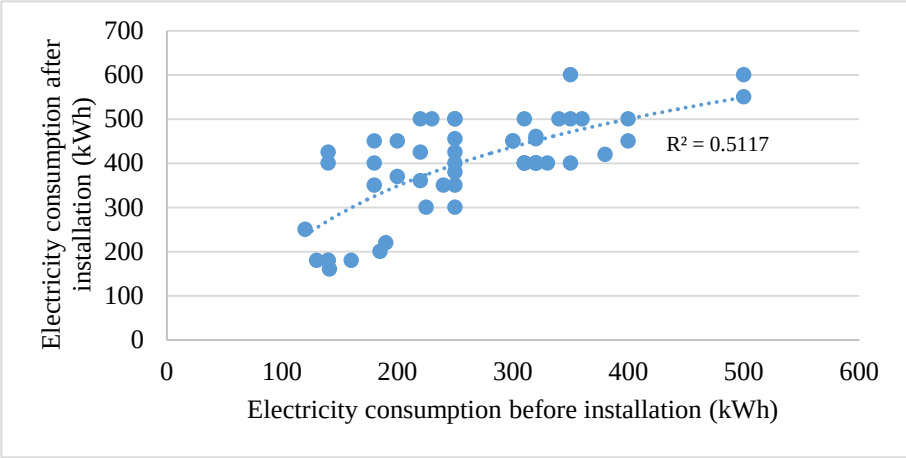


Figure1: Electricity consumption before and after solar PV installation

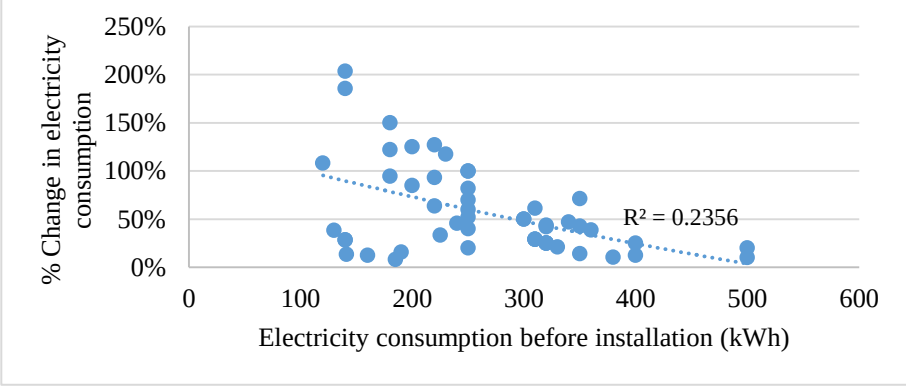


Figure2: Percentage change in electricity consumption compared to the electricity consumption before installation

3.1.1. Reasons for consumption increase

As per the results discussed above, the energy consumption significantly increases after the solar PV installation and the consumption is more than 400 kWh for the majority of the respondents. The higher energy consumption is mainly governed by high energy intensive equipment such as electric cars, air-conditioned units or hot water showers or baths. Figure 3 illustrates the equipment used before solar PV installation and purchased after installation by the respondents. According to the questionnaire results, the refrigerator, television and washing machine are the basic electrical equipment used and 50% of the respondents had air-conditioning units and 10% had electric cars before solar installation. The higher electricity consumption before solar PV installation is mainly due to the air-conditioning units and electric cars. After

the solar installation, 36% of the respondents have purchased an electric car and 50% have purchased air-conditioning unit which explains the reason for consumption increase after the solar PV installation.

Regardless the excess units produced by the solar PV system, nearly 80% the respondents were aware of the increase in the post-installation energy consumption. Fifty-five percent of the respondents indicated that purchasing of new equipment have contributed to the increase.

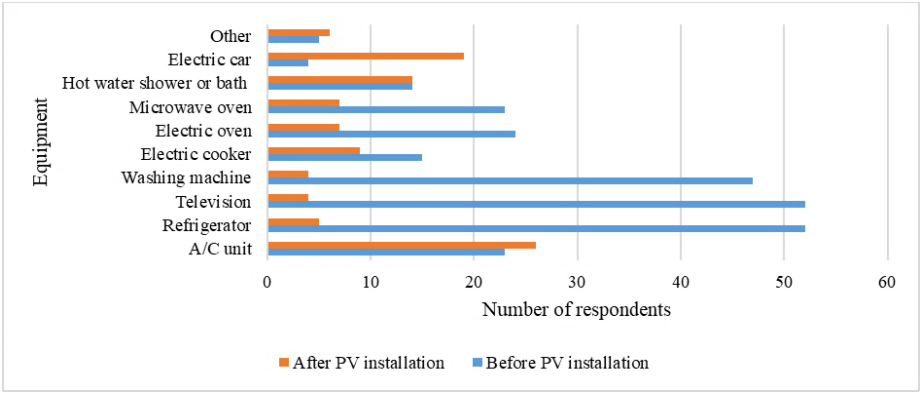


Figure 3: Equipment used before PV installation and purchased after installation

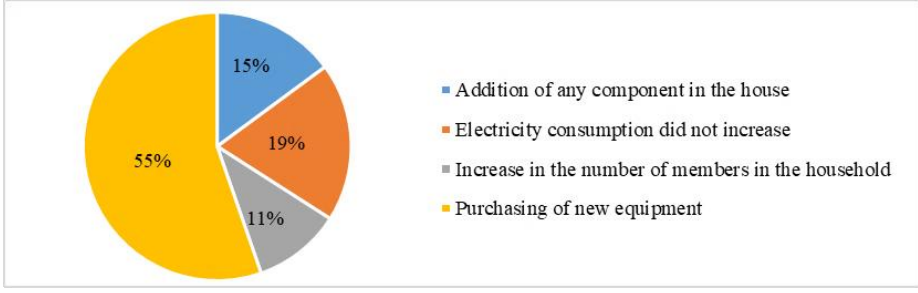


Figure4: Reasons for increase in total electricity consumption

In addition to the equipment purchase, some other factors such as the addition of components to the house and increase in the number of members in the household may have affected the energy demand. However, 19% of the respondents who have comparatively lower consumption rise are not aware of the increase.

3.1.2. Solar PV sizing decision

The solar PV sizing decision is the primary element of the installation transaction process. In addition to the current energy consumption, the factors such as; future requirements, customer behaviour, and the net metering policy directly affect the solar PV size. The larger system size correlates with increased energy consumption generally reflects inefficient subsidy or barriers that disfavour energy conservation and efficiency (McAllister, 2012). The most rational decision by a customer would be to select a solar PV system size which maximizes the internal rate of return. However, 96% of the respondents have selected larger system sizes than required to meet the past energy consumption and to provide enough capacity to meet energy demand by future equipment usage. As shown in figure 5, 61% of the respondents are not utilizing the total electricity produced and supply to the grid as excess units.

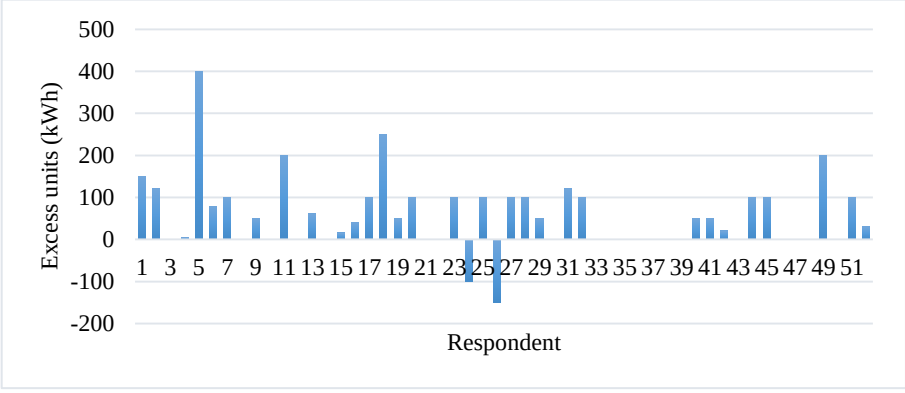


Figure 5: Excess units supplied to the main grid by the respondents

Table 2 presents the installation related decisions such as payback period, financing methods and method of deciding the system size by the respondent. Payback period is a significant criterion when selecting the system size and 69% of the respondents have got advice from solar company to decide solar PV system size.

Table 2: Installation related decisions

Payback period		**Financing method**		**System size decision**	
Less than 2 years	8%	Cash in hand	79%	Customer decided by matching own consumption	46%
2-5 years	54%	Solar power loan from bank	12%	Got advice from another person	4%
6-10 years	38%	Personal loan from a bank	13%	Got advice from solar company	69%

3.1.3. Rebound effect

The rebound effect or take back effect arises when the consumer takes back the energy saving of an energy efficiency investment due to higher consumption (Caird, Roy and Herring, 2008). This concept cannot be directly attributed to the solar PV system which is not an energy consuming device. As per McAllister, (2012), the rebound effect of solar PV directly attached with the income effect, where the consumers tend to increase the energy consumption with the decrease in marginal cost of electricity. In our case study, a clear sign of rebound effect is seen, since the difference between the post and prior installation energy consumption is significant as indicated in figure 1.

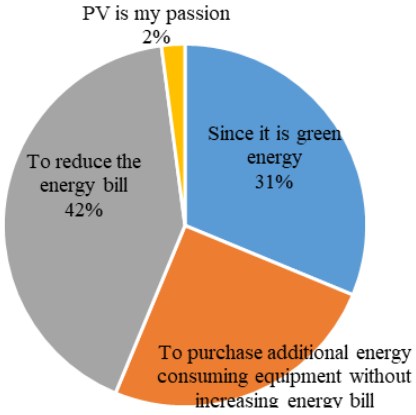


Figure 6: Motivation for installing rooftop solar PV system

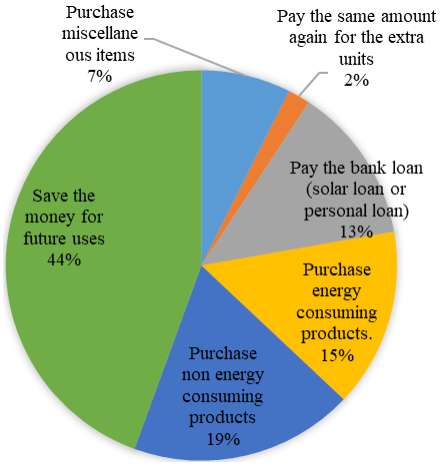


Figure 7: Utilization of the saved money from lower electricity bill

As shown in figure 6, the principal motivations for solar PV installation are to reduce the electricity bill and to purchase additional energy consuming equipment without increasing the energy bill which explains this effect. Indirect rebound effect can occur if the saved money is re-spent on energy consuming devices (Chitnis *et al.*, 2013). Figure 7 illustrates the modes of utilization of the saved money from lower electricity bill by the respondents. Forty-four percent of the respondents save the money for the future uses. Although savings do not indicate direct energy consumption, this may have embodied energy through investment by the relevant financial institutions on energy incentive investments.

3.2. ASSESSMENT OF THE IMPACT OF ELECTRICITY CONSUMPTION INCREASE

3.2.1. Social and environmental impact

The electricity consumption has a positive correlation with the economic development due to being at a higher tier of the energy ladder and higher economic capabilities that improve the ability to consume more energy intensive equipment. This is evident in case of Sri Lankan as indicated in figure 8. The demand for the electricity increases with the social and living status. Higher electricity cost appears as a main barrier for diffusion of the energy consuming equipment which improves the living conditions. The reduced marginal cost due to solar PV adoption would encourage such equipment purchases.

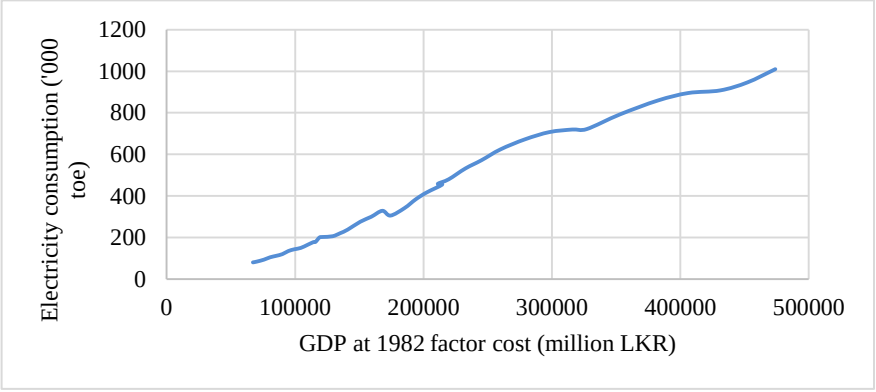


Figure 8: Electricity consumption compared to GDP (Source: SLSEA, 2017)

From the environmental perspective, this creates benefit for the environment as the electricity consumption after the increase is totally covered by renewable energy and more units will be contributed to the main grid. Figure 9 illustrates the electricity generation by various energy sources including hydropower, thermal, wind, new renewable energy and net metered projects of Sri Lanka. After 1996, the electricity generation from thermal sources has been increased rapidly. To cater the demand of more energy intensive equipment such as air-conditioning units which improve the living standards or the electric cars that minimize the greenhouse gas emissions, more fossil fuel would be burnt in the absence of solar PV system. Further, the purpose of encouraging electric cars would be effective only if renewable energy is used for charging purpose.

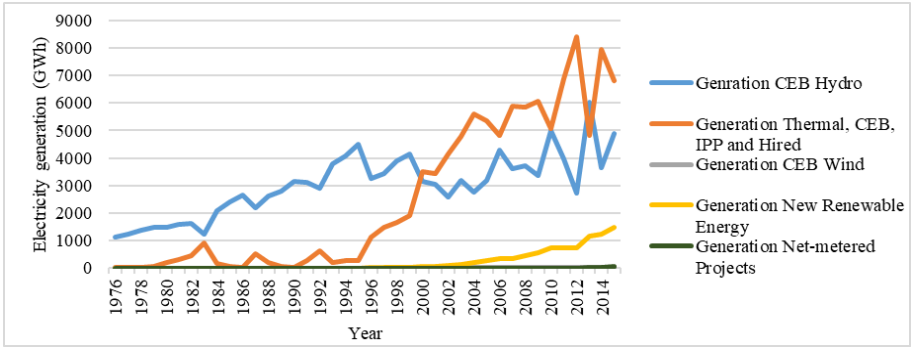


Figure 9: Electricity generation by various sources (Source: SLSEA, 2017)

3.2.1. Impact on peak load and load balance

Despite the social and environmental benefits directly associated with solar PV electricity, a significant adverse effect may occur on the peak demand of daily electricity load. Figure 10 illustrates the daily load curve of Sri Lanka on the day of the annual peak from 2007 to 2014. The shape of the load curve does not show a significant change during this period. However, the curve is shifted upwards year by year which has increased the peak demand and the maximum peak recorded in the year 2014 is 2152 MW (Ceylon Electricity Board, 2015). In Sri Lanka, the peak demand occurs from 19.00 to 22.00 hours daily where the electricity from solar PV system is generated only during daytime.

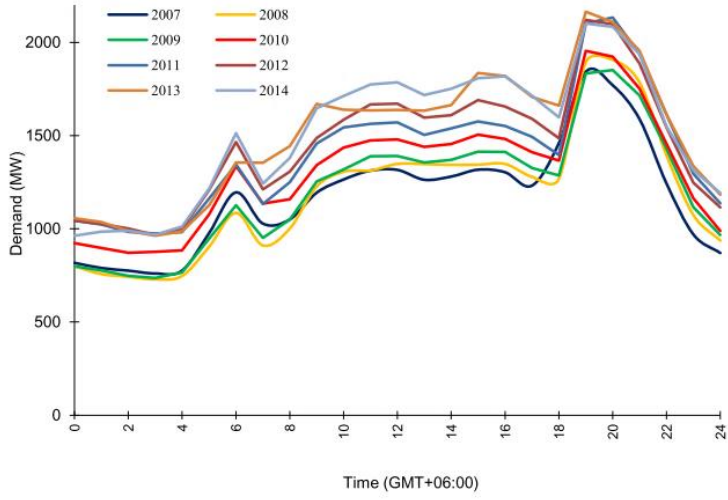


Figure 101: Change in daily load curves from 2007 to 2014 (Ceylon Electricity Board, 2015)

The solar electricity can be used to reduce the daytime peak and the increased use of energy consuming equipment during night time may further increase the night time peak. However, the number of net metering customers compared to the total electricity consumers is still negligible and would not have a significant effect on the peak demand in short term. Nevertheless, in the long run, there can be a considerable effect on the peak load as the rapid diffusion of the solar PV system in the country due to its potential to reduce the electricity cost and the incentives including loan schemes. As indicated in figure 9, the electricity generation from net metered projects still does not have a significant contribution to the main grid. With the increase in the net metered connections, a grid upgrade would be required since it will affect the system resilience (Bletterie *et al.*, 2011).

3.3. POLICY IMPLICATIONS

The net-zero energy target, which is a key element in the energy policy of most of the countries requires both energy efficiency and usage of renewable energy. Therefore, the policy development should consider the impact of individual programs on the overall energy goals of the country. The net metering system in Sri Lanka currently providing an environment friendly solution to achieve a higher living standard. However, the post-installation energy consumption increase may affect the night time peak load in the future which cannot be compensated by solar energy. In our case study, 69% of the respondents increased their electricity consumption more than 400 units after solar PV installation due to the purchase of energy-intensive equipment such as electric car and air conditioning units. Energy conservation has a positive correlation with the marginal cost of energy. The net metering policies without payout scheme reduce the marginal cost to a negligible amount and the consumers tend to increase the consumption to compensate the sunk cost.

One policy option to reduce the energy consumption increase during the peak time would be to introduce time of use net metering scheme. The time of use metering is attached with different rates for peak and off-peak hours and due to the increased rate during night time the consumers will move towards energy conservation behaviours such as charging the electric car during off-peak hours. However, this scheme will discourage new customers due to lesser economic value and will slow down the solar PV diffusion process which is not practical at this stage. The second option is to introduce battery storage with the net metering which allows the users to store the excess units during daytime and use them during the night time peak. The technology is still developing and incurs additional cost for the consumers which may discourage the investment.

The final option is already implemented in Sri Lanka in the form of another net metering scheme. The original net metering scheme introduced to Sri Lanka was a net metering without a payment scheme and in 2016, the government introduced two more schemes as net accounting and net-plus which are only related to rooftop solar PV production. The net accounting is another form of net metering which is attached with a financial compensation of LKR22 per unit for the first 7 years. From 8th year LKR15.50 per unit will be paid up to 20th year. In net plus system, the same amount will be paid as in net accounting. However, the consumption and the generation will be separated in the billing process unlike in the typical net metering scheme and can be considered as an extra income source which does not depend on the consumption. To control the consumption, net accounting would be a better option as the higher financial payout would increase the marginal cost of electricity use. Also, the consumption rise will reduce the profitability of the investment which will lead the consumers towards energy conservation. The compensation amount is more than two times the unit price for the consumer category of less than 90 units (LKR 10/unit). This will attract more customers foreseeing the benefit of the investment for 20-year contract period. Nevertheless, the effectiveness of the net accounting scheme cannot be measured in short-term and would become evident after few years. Moreover, for the long-term achievement of energy policy objectives, the balanced adoption of all three policy options would be required.

Conclusions

In this study, an assessment of the energy consumption behaviour of the solar PV installed customers was carried out. As per our case study of 52 solar PV installed customers, the PV installation would increase the electricity consumption up to more than 400 units. Purchasing of energy consuming equipment such as electric car and air conditioning units have contributed greatly to the consumption rise. This paper proposed three policy options; time of use net metering, battery pack and net metering attached with payment scheme, which needs to be integrated to achieve sustainable net metering scheme. A further study could be conducted studying the solar PV consumer patterns with monthly consumption data sets for several years to assess the impact of the net metering scheme and the new net accounting scheme in the future.

Acknowledgement

The authors would like to acknowledge the financial support from the Senate Research Committee (SRC/ST/2017/01), University of Moratuwa.

References

Bletterie, B. et al. (2011) 'Quantification, challenges and outlook of pv integration in the power system: a review by the european pv technology platform a', pp. 2937–2943.

Bourrelle, J. S. (2014) 'Zero energy buildings and the rebound effect: A solution to the paradox of energy efficiency?', Energy and Buildings. Elsevier B.V., 84, pp. 633–640.

Caird, S., Roy, R. and Herring, H. (2008) 'Improving the energy performance of UK households', Energy Efficiency, 1(2), pp. 149–166.

Ceylon Electricity Board (2015) Long Term Generation Expansion Plan 2015-2034 Ceylon Electricity Board. Available at: http://pucsl.gov.lk.

Chitnis, M. et al. (2013) 'Turning lights into flights: Estimating direct and indirect rebound effects for UK households', Energy Policy. Elsevier, 55, pp. 234–250.

Coughlin, J. and Cory, K. (2009) Solar Photovoltaic Financing: Residential Sector Development. Available at: http://www.nrel.gov/docs/fy09osti/44853.pdf.

Dávi, G. A. et al. (2016) Energy performance evaluation of a net plus-energy residential building with grid-connected photovoltaic system in Brazil', Energy and Building, pp. 19–29

Eid, C. et al. (2014) 'The economic effect of electricity net-metering with solar PV: Consequences for network cost recovery, cross subsidies and policy objectives', Energy Policy. Elsevier, 75, pp. 244–254. doi: 10.1016/j.enpol.2014.09.011.

Faiers, A. and Neame, C. (2006) 'Consumer attitudes towards domestic solar power systems', Energy Policy, 34(14), pp. 1797–1806. doi: 10.1016/j.enpol.2005.01.001.

Ito, K. (2012) 'Do Consumers Respond to Marginal or Average Price ? Evidence from Nonlinear Electricity Pricing Koichiro Ito Revised October 2012 Do Consumers Respond to Marginal or Average Price ? Evidence from Nonlinear Electricity Pricing Koichiro Ito ú', 104(October), pp. 537–563.

Keirstead, J. (2006) 'Behavioural responses to photovoltaic systems in the UK domestic sector for the degree of Doctor of Philosophy'.

McAllister, J. (2012) 'Solar Adoption and Energy Consumption in the Residential Sector', PhD dissertation, 1. doi: 10.1017/CBO9781107415324.004.

Okoro, O. I. and Madueme, T. C. (2004) 'Solar energy investments in a developing economy', Renewable Energy, 29(9), pp. 1599–1610. doi: 10.1016/j.renene.2003.12.004.

Poullikkas, A. (2013) 'A comparative assessment of net metering and feed in tariff schemes for residential PV systems', Sustainable Energy Technologies and Assessments. Elsevier Ltd, 3, pp. 1–8. doi: 10.1016/j.seta.2013.04.001.

Public Utilities Commission of Sri Lanka (2015) 'Net Metering Development in Sri Lanka'. Available at: http://pucsl.gov.lk/english/wp-content/uploads/2015/06/Net Metering Report Final.pdf.

SLSEA (2017) Sri Lanka Energy Balance. Available at: http://www.info.energy.gov.lk/ (Accessed: 9 June 2017).

Rajapaksha.U, et al (eds), 2017, "Design that cares"- multi disciplinary approaches to creating sustainable and meaningful built environment: *Proceedings of the 10th International Conference of Faculty of Architecture Research Unit (FARU), University of Moratuwa, Sri Lanka, (Vol. 01)*pp. 252-264 ©

HERITAGE URBANISM

Possibilities of Modification and Rejuvenation of Piary Das Road Area, Old Dhaka

TASMIA F.[1], TRINA N.A.[2] & RAHMAN M. M.[3]
[1]Bangladesh University of Engineering & Technology, Dhaka, Bangladesh
fatema.tasmia@gmail.com,
[2]Rajshahi University of Engineering & Technology, Rajshahi, Bangladesh
124arch0801046@gmail.com
[3]BORAK Real Estate Ltd., Dhaka, Bangladesh ayon.arch08@gmail.com

Abstract
Heritage must not only be a historic monument but also an active factor in contemporary life. The use of cultural heritage as a tool to respond to the rapidly changing socio-economic conditions becomes one of major focus points of historically rich cities. It has been proved from the claims of planners, conservationists, architect, historians, artists that the encouragement of and modernization of cultural heritage has a significant role in sustainability strategies that focus on responding to social and cultural needs to sort out conflicts and to actualize economic objectives through long-term vision and goal. Piary Das road, a historically significant street of Old Dhaka Bangladesh containing a number of historic buildings of Mughal and British Period. Vibrant, vigorous and vivid image of the daily activities surrounding this road, eventually tells a story of the past to the present. This paper aims at the possibilities of modifications, modifications, and rejuvenation of Piary Das road to uphold the scope of creating an arena that bears the flavour of its context and identity. It focuses on the acknowledgment of the value and potential of urban heritage. Also, emphasizes how heritage can be used as a trigger in socio-economic development in the neoliberal age.

Keywords: *Heritage Urbanism Old Dhaka Modification*.

1. Introduction

The city Dhaka is a growing city and has a history of more than 400 years. Being located by the river Buriganga the part of old Dhaka became a place of trade exchange. Traders from different countries of the world paid visits to this area and this place started to grow as a centre for multicultural and multidimensional space for living and trading. The architecture of this particular area is obviously started to have its significant character, going with people' lifestyle, regional culture and tradition. From the Mughal dome, Indo Sarasenic pilasters to colonial arches old Dhaka architecture has its own individuality and essence. But as time passes, user living condition-status changes and with the high demand of land and increasing land value, soon user focus

on piece meal approach and the overall synchronization vanishes. This heritage is our asset and a bridge in between the past and future generations. This heritage can also play a vital role in earning revenue from tourists which will ultimately assist in our financial solvency. So for the sake the protection of this asset and for financial up gradation this heritage need to be cherished, conserved and portrayed in a positive and constructive way**.**

2. The concept of Heritage Urbanism:

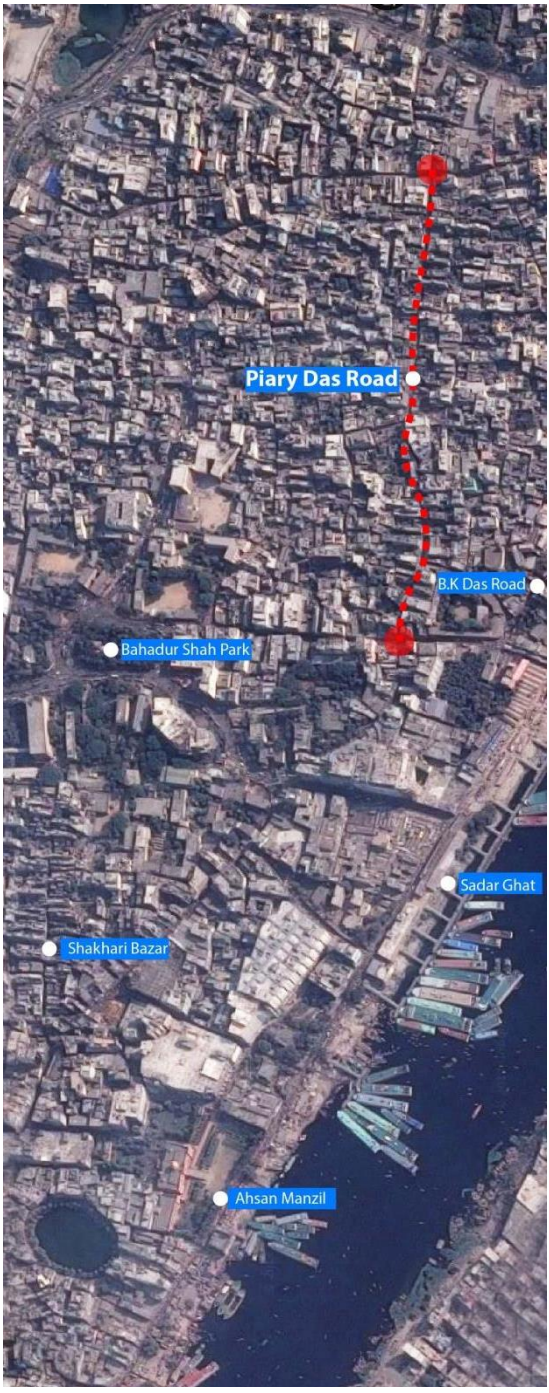
Heritage Urbanism may be defined as the study of the characteristic ways of the interaction of inhabitants of historical towns and cities (urban areas) with the historic built environment. One of the significant approach of heritage urbanism focuses on the protection and care of tangible cultural heritage through socio-economic sustainability, adaptability, modernization and cultural enhancement.

3. Morphological Dimension of Piary Das Road:

Piary Das road was named upon a renowned landlord and famous lawyer Piary Das of British-Colonial Period. He was rewarded as one of the "Rai Bahadur", a title of honor bestowed during British rule in India, for his excellent service and bravery. In 1916 he became the Chairman of Dhaka Municipality [1,4].

Piary Das road area is a part of Sutrapur Thana and group C of the Capital city Dhaka. This part of the traditional city of about half a km length is more than 200 years old and at present has a predominantly colonial flavor. Most of the buildings of the area were erected on the either sides of a narrow, serpentine road, which are mostly two storied. Other historically significant areas like Shakhari Bazar, Tanti Bazar, Bahadur Shah Park, Ahsan Manzil, B K Das road are situated in the walking distance (Figure-01).

Among all buildings of the area, 51 building are more than 150 years old and 12 buildings are historically significant (Figure-02). One of the most significant buildings is Beauty Boarding. It was the first press of newspaper Sonar Bangla and later used as boarding cum café (Figure 02.e). Eventually it became the gathering place of artists, authors, columnist, journalists and many more creative people [2].



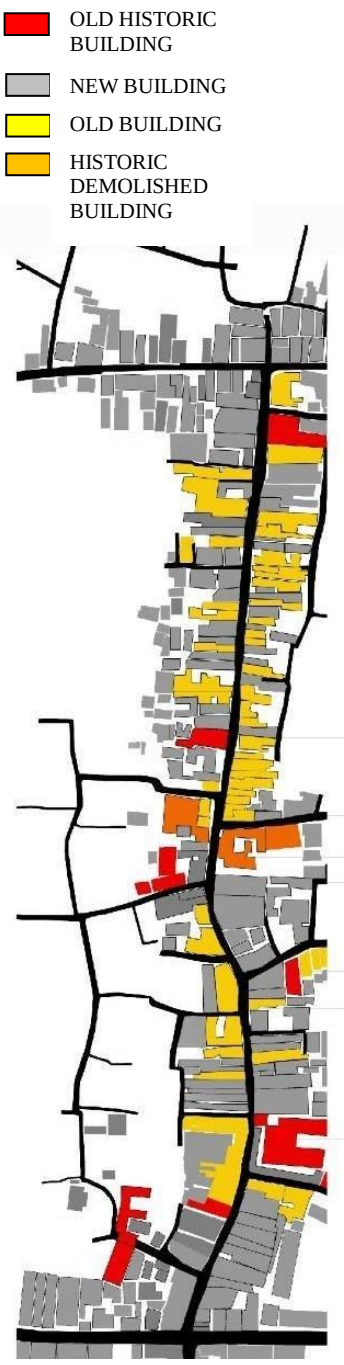


Figure 1, Location map (*Source: Google*). Figure 2, Street map (*Source: Author*)

Kachery Bari, the most well preserved historical building among all the buildings around Piary Das Road. Kacheri means court and bari means house, so cumulatively Kachery Bari means 'House of court'.It was the court-house of Zaminder Dhankora, a famous lawyer. But the house was abandoned at the beginning of Pakistan period. At present it is used as the store-house of vegetables and different raw materials (Figure-04.b). Gouro Nitay Bigroho Mandir, a 100 years old Hindu temple [1] and presently the ground floor is being used as advocate chamber and Temple. The first floor is used as the dormitory of priests.

While considering the visual properties like semi-circular arches, pilasters, wooden lattice, iron railing, battlement parapet, overhanging eaves, I joist Beam, decorative moldings and bracket, arched window, iron column etc ;we found those historic old buildings are very rich.

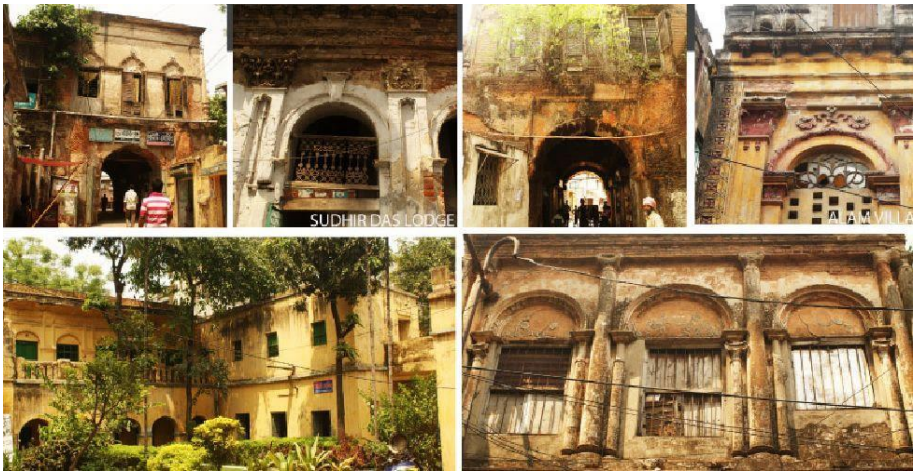


Figure 3, a. Shirish Das Lodge, b. Sudhir Das Lodge, c. Shirish Das Lodge, d. Alam Villa, e. Beauty Boarding, f. Bani Bhaban (*Source: Author)*

4. Social Environment and Socio-economic Condition of the residents:

Being a part of old Dhaka, Piary Das road definitely co-exist in the realm of diversified land-use and multi-faced character. According to ownership, here live two kinds of residents: the property owner and the working people (20% people are permanent residents; 55% are tenants' residents; and 25% are non-residents).Press and publication business is one of the pioneering trades of this area and its people. This business is continuing for more than three generations. Ground floors or the roadside/front side of the ground floor of building are used as commercial zone and it is seen in more than 90% buildings of this area. The commercial zone is mainly has book shops, press, grocery shop, flower

shop, hair salon, small café or tea stalls where residents as well as the visitors come to have their daily needs.

Figure 4, a. Bani Bhavan, b. Kacheri Bari, c. Aga Khan Mosque (*Source: Author*)

Due to the scarcity of open spaces, roofs of building are mostly used for the social gathering. The residents usually pass their leisure time for refreshment on roof in early morning, evening and even at the time of load shedding. Roofs are also the only plan for nurturing their hobbies such as gardening, pigeon flying, kiting, petting animals and playing indoor games. It is not only the feature of Piary Das road but also a significant characteristic of old Dhaka to use roofs as the breathing spaces.

5. Methodology

To understand the existing conditions and its prospect regarding up gradation we have conducted primary and secondary surveys. In the primary survey we have collected data of the buildings of Piary Das Road, their current conditions of facade, structure, use, activity and overall architectural pattern and a questionnaire survey was done among the people (one senior member and one junior member of every house/building) about their willingness and judgement regarding up gradation of their area to welcome tourists or visitors. In the second survey we compare the existing conditions of building and its scope of modifications thorough an intricate analysis and symbiosis among the available national building codes and foreign case study. This study is expected to provide a concept of form based coding, policies and guidelines for current

conditions and future development in this area as well as for areas which have similar aspects and characteristics.

6. Foreign Case Study

The main theme of conservation in Turkey, which was previously taken to be a museum-oriented phenomenon, has changed over the years; is now being conceived as a process of revitalization and integration of the entities having cultural, historical and architectural values with certain social, economic and functional potential. However, the perceived economic projection from the re-use of the cultural heritage invariably causes the transformation of the historic sites into large-scale development projects. The lacking in the realization of public policies, unrestrained urbanization, fast population growth, and choice bound resources and different appreciation of historic environment result in pressures for development, through a greater complexity of issues to be handled when compared to Europe. Within this context, ***Beypazari*** presents a unique heritage-led regeneration example to be a model for Turkey in balancing change and continuity with development policies [6].

The core of *Beypazari Yeniden Project* is the concept of heritage conservation as the basis of Beypazari development strategy. Beypazari Municipality has recognized that cultural heritage has a principal role in providing socio-economic development and environmental protection. By starting with the restoration of only 25 buildings, the project has had a major impact in sustaining historical and architectural pattern, embracing local cultures and identities, rising property values and increasing the awareness on conservation [6].

Figure 5, Tasmektep: a. in the 1930s, b. in the 1990s, c. in 2005 (*Source: Beypazari Municipality Archive*)

Besides physical conservation, Project has determined several regeneration programs including the protection and development of traditional handicrafts, local food and culture. As stated by the interviewees, the Project has not only respected to the suitable standards that are necessary for the protection of the

historic environment but also it has generated quality of life by providing re-use of historical buildings and environmental improvements by utilizing public space and public art and changing the image of the settlement. The interventions also provide the local community to comprehend and cherish the value of their properties [6].

7. Objective

The objective of finding possibility of modification and rejuvenation is to establish a dialogue in between the new and the old, to reinstate urban fabric and rebuild communities to work the way they are used to, to provide permeability, to create urban contrast and to enhancing the overall socio-economic condition by promoting tourism and other economic activities.

8. Level of Modification and its Impact

Heritage conservation focuses mainly on architectural heritage of historic buildings and structures in western cities.

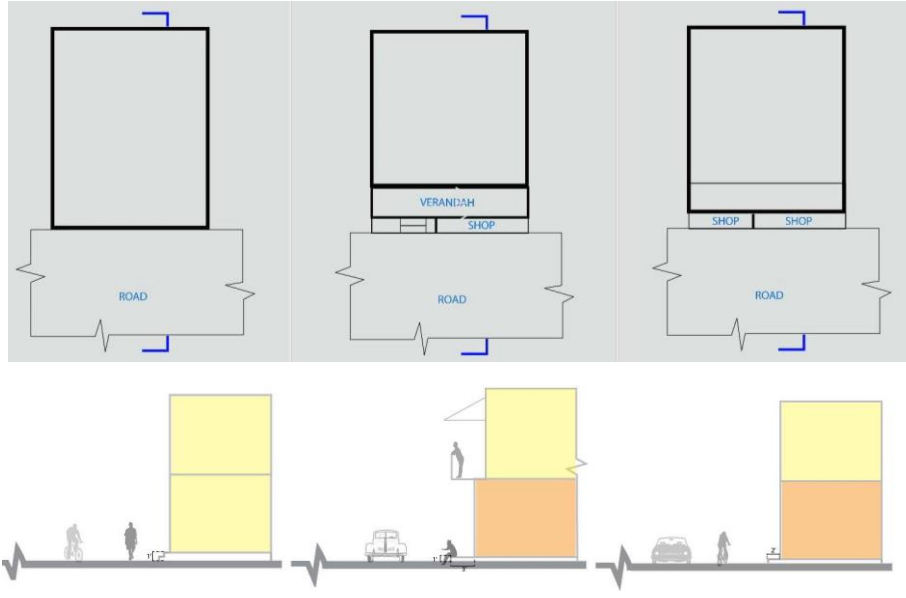


Figure 6, Spatial Connection between indoor, semi outdoor and outdoor

Sometimes, the surroundings of a heritage site turned into a ‘luxurious’ or too clean place for those who have used the place before heritage conservation and urban regeneration starts (Pendlebury et al., 2004). The heritage area becomes a kind of tourist-cantered place with the effect of external arrangement. Consequently, urban minorities have to seek a new place for themselves or be

subject to various restrictions which strive to control over their activities and behaviours. For securing the sustainable living conditions to original residents and users during the planning process of urban regeneration, an 'integrated approach' considering physical, socio-cultural and economic aspects is demanded. It would be a highly critical process if the plans reinforce the market demands without considering social mixing, which makes the community socially exclusive and spatially segregated from society [5].

Figure 06 describes the current situation and relationship among the adjacent spaces of buildings. As this road is a part of old Dhaka, generally its organic growth leads a very narrow setback in between road and a building. This threshold is basically used as the social interaction space for the community. So, these thresholds can be upgraded with landscape and proper treatment for functioning more lively and interactive.

8.1 FORM BASED CODING

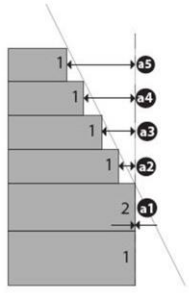
A form-based code is a land development regulation that fosters predictable built results and a high-quality public realm by using physical form (rather than separation of uses) as the organizing principle for the code. A form-based code is a regulation, not a mere guideline, adopted into city, town, or county law. A form-based code offers a powerful alternative to conventional zoning regulation (Form based code institution). Not to be confused with design guidelines or general statements of policy, form-based codes are regulatory, not advisory. They are drafted to implement a community plan. They try to achieve a community vision based on time-tested forms of urbanism. Ultimately, a form-based code is a tool; the quality of development outcomes depends on the quality and objectives of the community plan that a code implements [7] (CMAP-Form Based Codes).

To apply form based coding for future development in this particular heritage street three type of building type could be considered. Type 1 is Multi-family housing types such as apartments; Type 2 is Single family Housing and Type 3 is Main-street Mixed use. In type 1, the general use of buildings is residential. Ground floors of buildings could be used for parking by owner or given rent and no surface parking would be allowed. There may be low to moderate parking requirements to promote walk-ability and minimize the visual impact on the neighborhood. Buildings on the south side of the street should have been within (5 storey) 60' or a total height of 70' with 50% void of a floor for ventilation. Buildings on the north side of the street should have been within (6 storey) 70'. Building form and height details are in Table 1.

In type 2, the general use of buildings is residential. Ground floors of buildings could be used for parking by owner or given rent and no surface parking would be allowed. There may be low to moderate parking requirements to promote walk-ability and minimize the visual impact on the neighborhood. Building form and height details are in the Table 2.

In type 3, the general use of buildings is mixed where ground floor could be use as commercial spaces like restaurants, shops etc and upper floor could have been used as commercial or residential or commercial. A part of ground floors of buildings could be used for parking by owner or given rent while using upper floors as residential purpose and no surface parking would be allowed. There may be low to moderate parking requirements to promote walk-ability and minimize the visual impact on the neighborhood. Building form and height details are in the Table 3.

BUILDING FORM		
Height		
Adjacent street facade	30′ max	
Ground floor ceiling	12′ min clear	
First floor ceiling	12′ min clear	
Upper floor ceiling	10′ min clear	
Plinth	2′	
BUILDING PLACEMENT		
Setback (distance from property Line		
FRONT \ STREET SIDE		A
Floors 1 - 2	0′	a1
Floors 2+	5′ min	a2
Floors 3+	10′ min	a3
Floors 4+	15′ min	a4
Floors 5+	20′ min	a5
STREET SIDE	0′	B
SIDE	2′min 3′max	C
REAR	3′min 4′max	D
Miscellaneous		
If projected balcony is introduced the front setback is must		
FRONT	3′min 4′max	E
For plot fusion, no setback is required along the common property line		



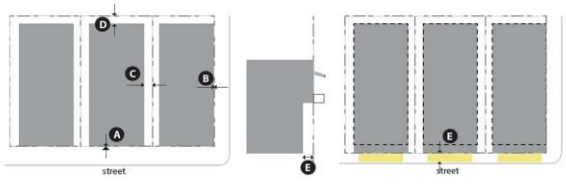


Table 1: Building form and building placement_ Multi Family Housing as

BUILDING FORM		
Height		
Total	30′ max	
Ground floor ceiling	12′ min clear	
Upper floor ceiling	12′ min clear	
Plinth	2′	
BUILDING PLACEMENT		
Setback (distance from property Line		
FRONT \ STREET SIDE	0′	A
STREET SIDE	0′	B
SIDE	2′min 3′max	C
REAR	3′min 4′max	D
Miscellaneous		
If projected balcony is introduced the front setback is must		
FRONT	3′min 4′max	E
For plot fusion, no setback is required along the common property line		

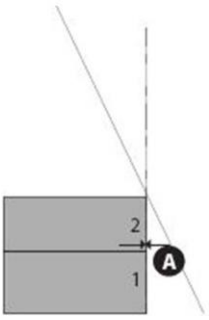


Table 2: Building form and building placement Single Family Residence

BUILDING FORM		
Height		
Adjacent street facade	30′ max	
Ground floor ceiling	14′ min (including plinth)	
First floor ceiling	12′ min clear	
Upper floor ceiling	10′ min clear	
Plinth	0′ min 2′ max	
BUILDING PLACEMENT		
Setback (distance from property Line		
FRONT \ STREET SIDE		A
Floors 1 - 2	0′	a1
Floors 2+	5′ min	a2
Floors 3+	10′ min	a3
Floors 4+	15′ min	a4
Floors 5+	20′ min	a5
STREET SIDE	0′	B
SIDE	2′min 3′max	C
REAR	3′min 4′max	D

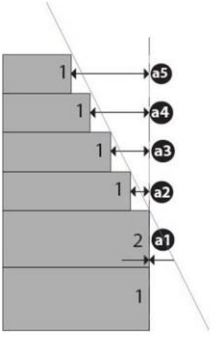


Table 3: Building form and building placement_ Main Street Mixed Use

8.2: CATEGORIZATION OF USE AND REUSE:

Typology	Probable Use
Large building complexes	Museums / Libraries
(e.g.: Kacheri Bari, Bani Bhaban	Hotels / Restaurants
Beauty Boarding, Gouro Nitay Mandir)	Schools
Buildings with internal courtyards	Exhibition spaces / Galleries
(e.g.: Kacheri Bari,Alam Villa,	Motels / Rest Houses
Shirish Das lodge)	
Small row houses	Shop houses
(e.g. : Radhakor Bhaban,	Residential Accommodation
Other old buildings)	

Figure 7, Refurbishment of old heritage buildings (*Source: Author*)

The revenue that can be collected from the reused spaces like café, rest houses, restaurants can help the owners financially. These places can be used by both the community living in this area and visitors. Galleries/exhibition spaces can be given for rent and then revenues can be collected from its use.

When the areas would be upgraded with proper designed open spaces adjacent to building the overall environment will help the users as well as whole community to live a better community, social and economically solvent life.

9. Conclusion

Since heritage is not only about the past but also about contemporary living, urban modification and rejuvenation that involve heritage are always sensitive. Involving the heritage sites, urban activities should be based on integrated urban contexts and also the needs of local residents must be considered. Otherwise, the sites lose their vitality and only exist as a stage setting cut off from the time flowing. Before the planning of large-scale developments, there is a need to grasp the meaning of heritage and its surroundings, characteristics of neighbourhoods and the socio-urban context. Place-based strategies of heritage conservation and urban regeneration often tend to lead to spatial division which misses the complexity and social interaction of the existing community. It is difficult to figure out particularity and historicity of neighbourhoods involving heritage in a large-scale plan. Therefore, heritage conservation plans should play an active role in bridging between the past and present, users and visitors and preserving historic values and recreating new values.

There is a need to re-think regeneration of social values relating to heritage conservation. It may cause more conflicts and leads to loss of heritage significances if heritage conservation is driven by capital and forced by authority. Heritage should involve more socio-political discourse to be socially inclusive and to bring more opportunities to the local community. There is a need for research on how heritage conservation can tackle negative modification effects and contribute to the process of social inclusion demanded in local context.

9.1. ACKNOWLEDGEMENTS

This paper was developed as a workshop term paper under M.Arch program of Bangladesh University of Engineering and Technology for *Urbanism and Housing in Developing Countries* (ARCH 6307) course and course Tutor was Professor Dr. Shayer Ghafur.
Studio project (Level 4 Term 1): Heritage Urbanism
Studio Teachers: Prof. Khaleda Ekram, Prof. Dr Khandaker Shabbir Ahmed, Amreen Shajahan,
Samina Mazumder Tuli
Group Members: Maherul Kader Prince, Mumtahina Kabir, Wasimul Alam, Fatema Tasmia,Nazia Afrin Trina,Mehnaz Tabassum
Department of Architecture, Bangladesh University of Engineering & Technology, Dhaka, Bangladesh.

9.2. REFERENCES

1. Mamoon, M. (2005). *Dhaka Samagra 3* (Dhaka In Total, Volume 3), in Bengali. Ananya, Dhaka. pp 149-152
2.D'Oyly, S. C; (2004) *Dhakar Prachin Nidorshon*, Translated by Alam, Shah Md Nazmul, *In Bengali*, Academic Press and Publisher's Library Dhaka.

3. Ahmed, S., U, Ed. (2009). *Dhaka: Past Present Future*. The Asiatic Society of Bangladesh , Dhaka.
4. *Changing World, Changing Views of Heritage: Heritage and Social Change*, Proceedings of the ICOMOS Scientific Symposium
5. Gunay, Z. (2008) *Neoliberal Urbanism and Sustainability of Cultural Heriatge*, Turkey
6. CMAP-Form-Based Codes: A step by step Guide for Communities, Form-Based Codes Institute, http://formbasedcodes.org

Rajapaksha.U, et al (eds), 2017, "Design that cares"- multi disciplinary approaches to creating sustainable and meaningful built environment: *Proceedings of the 10th International Conference of Faculty of Architecture Research Unit (FARU), University of Moratuwa, Sri Lanka, (Vol. 01)* pp. 265-275 ©

ARCHITECTURE AS A SOCIAL ENTITY

TANUSHKA GUPTA & DHRUV GARG
School of Planning and Architecture, Bhopal, India
tanushkagupta22@gmail.com, dgarg1719@gmail.com

Abstract
Everyone has right to an inviolable, decorous, and decent housing. And one of the most important aspects of that is affordable and social housing. But does affordable housing brings stability, economic diversity and improves the physical quality of neighbourhood?? The Indian government started a policy called " Pradhan Mantri Awas Yojna" or PMAY targeted at fulfilling the needs of low income groups and keeping the aspect of increasing population in mind. The main objective of this policy has been to provide a pakka house to all the houseless households living in kuccha and dilapidated house. For overpopulated countries like India it is necessary to change the concept of housing. It tends to originate wage employment and programs of national rural employment programs. Rural landless employment guarantee program has been one of them. But are the people able to adjust and accommodate to these changes and does these changes in quality of life of an individual necessarily mean improvement in that quality is a big question. The paper seeks to investigate and analyse and achieve a deeper and a better understanding of architecture as a social entity by citing the example of the rehabilitation of slum dwellers from Banganga slums in Bhopal, Madhya Pradesh, India through post occupancy survey. The case studies, for this research will be intended towards addressing questions like, Is architecture merely a house to live in or a home which connects people to their identity, tradition and culture?? The paper highlights the above mentioned aspects and seeks to set a stage for an expanding creative dialogue, and not offer a utopian solution for the damage caused by the segregation of this society over the past years. So in context of recent development, the community asks, how can architecture be conceived as a socio cultural design for people??

Keywords: *Decent housing; Pakka; Kuccha; Slums; Rehabilitation.*

1. Introduction

Architecture has often been perceived as bricks and walls but architecture and spaces have souls of their own which culminate from environment around it. Architecture is a feeling, a concept, a belief, an art. Architecture is an expression of feeling and conflicts, a belief to leisure our senses and an art to pacify us corporally and psychologically. It acquaints to the deepest part of our conscious and subconscious mind and elevates our senses, which then perceive this intangible art as realization that opens our mind to the magnificence of a rock pile from just a pile of rubble to a structure sustaining life on microscopic level. Eyes physically and aesthetically perceive it as astonishing, while the

acoustics of a building when in rhythm with the beating of our heart, gives us a serene awareness. The tongue tastes the vibrations in the air caused by sound of structure compelling to our consciousness, while the olfactory sense compels us to get absorbed in it forever. And feeling being the most extensively availed sense connects us to the soul of the structure.

The essence of architecture can be contained in two words, tangible and intangible. The former includes all the physical things that we can see and touch while the latter constitutes of feelings, sensations and responses. The impalpability and imperceptibility are part of the intrinsic nature of architecture. It is the diligence of all the five senses of human body that the essence of architecture is discerned by us. The eye perceives what's in front of it while the mind manipulates and amalgamates the various facades around it in order to apprehend more than what constitutes the building. The aura of structure when corresponds with our brain waves makes the entire theme of architecture unambiguous to us. Architecture is not seen. It is felt. Its intangibility is ascertained when the air flows through an edifice and touches our body, and our senses detect the repose and soundness in it.

And this intangibility, this tenderness and all these sentiments created by architecture are the conditions which form a society. Social architecture is architecture of the people, for the people and by the people.

"*Social architecture can be either fluid or persistent entirely according to the degree that people believe in it.*"

The outcomes of social architecture are fundamentally unpredictable. Social architecture is not always designed. Sometimes a fundamental set of rules or demonstrations are put together to provide a composition or an organization of items which are elaborated and revamped from time to time, getting over the mountain of critics and finally making their way through. Social architecture is dynamic and ever changing. It is the architecture which is not instituted by an architect but by people instead. An architect sets the wheel in motion but it is the people who push it forward. Social architecture creates a visual dictionary of its own.

This paper seeks to investigate this visual dictionary of social architecture in context of the capital of heart of central India(fig.1and2) that is the city of Bhopal(fig.3). In this city of lakes the transcendental incarnation of architecture is unaccounted for. Ranging from breath-taking Fatehgarh fort to the narrow lanes of new market, the essence of social architecture is embedded deep in its heart and veins.

Fig1, Map of India

Fig2, Map of Madhya Pradesh

Fig3, Map of Bhopal

(Source: Google Images)

2. Aim

This paper tends to analyse whether government policies like PMAY really are beneficial, fulfils the need of people for all types of economic backgrounds and professions, and does it help in promoting and maintaining, the social culture and traditions associated with people or is it making them loose their social and cultural identity?

3. Architecture as a social entity

The visual dictionary of social architecture cannot be studied or scrutinized. It can be perceived and sensed. It can be appreciated and recollected. It can be discovered and discerned but it can never be read. Architecture enters the deepest realms of our imagination and plays with our consciousness. But social architecture appeals both to the imaginative and practical domain of our mind. Its intangibility is brought about by the distinct emotions of the legion of people, who appreciate and contemplate it. Architecture is an art that derives its beauty from the soul of one and distribute it to the soul of many while social architecture derives its beauty from the soul of many and distribute it to more and hence considered as the divine form of architecture. It has a socio cultural existence which links it to people and their identities. Along with that the intangible sensation and response that it receives from people lays the foundation to this stepping stone.

“Social art of architecture” is something that develops with the people. It is the architecture “Of the people, for the people and by the people”. It works thoroughly on participatory planning and it is the people who develop the building from a stack of bricks and cement to an abode for human civilization. There is no fully developed or Utopian building which has been designed perfectly and without any defects. Utopian buildings are built and developed by the people and till time keep on developing every single day. Social

architecture is a type of art that represents the social aspects of a society. It showcases a blend of tangible as well as intangible architecture. A Utopian building never stops developing. A building gets its spirit from the people. Ranging from its architect to the visitors, it encases the souls and aspirations of them all. And it is with the development of people that the building develops. And a building which develops with the development of its people can be coined as social art.

In a country with a population of nearly 1.32 billion and habitable area of nearly three meter square for an individual, social architecture is prerequisite condition for survival. Keeping the needs of people in mind and the sustenance of the country the government started various policies related to the population. Most of these policies are started for the benefaction of common people and tend towards the betterment in living conditions of lower and poorer sections of the society. Many policies focus on increasing the quality of living for the poor. The government tends to shift people in brick and cement houses by destroying and seizing their old houses and lands. In a view of their own they try to create a world where everyone has a proper and permanent house to live in. The permanent houses might provide the poor with a lot of opportunities and increase their standards of living to far greater extent than they are now. It might give them a healthy lifestyle and walls to bring their children up inside. It might provide better security to the poor and homeless and decrease the death rate among the poor. But there is always a difference between might and does. The instant we use the term might two case scenarios arise. And when two case scenarios arise, both of them are never in favor of the existing situation. This gives rise to conflicts which ultimately affects the common people. These conflicts give rise to a lot of questions which the common people want answered. And for the answer to their questions they turn to the government. But is it really valid for the creator to judge its own creation or should it be left to the common folks to judge whether they want these policies in their lives or not?

This paper tends to answer such questions with respect to‘Pradhan Mantri Awas Yojna’ a policy started by the Indian government to provide permanent housing to the indigent sections of the society, in context to the city of Bhopal. After the formation of new government in the central many policies under the previous government were renamed or transformed. ‘Pradhan Mantri Awas Yojna’ (PMAY) is one of those many policies. Started by the name of ‘Indira Awas Yojna’ in the year 1985-86 this policy acted under rural employment guarantee program to provide uniformity in policy for rural housing. It was targeted to provide money to the people to make them self-sufficient and help them build their own houses. After being converted to ‘PMAY’ the focus was shifted on providing the poor with cement and brick houses to live in rather

than money. Their old living plots and houses were to be destroyed and in their place multistory houses with two rooms on each floor were to be built. No interest and a nominal amount of money were taken from them.

4. Case studies

To investigate further about the people's engrossment in this system a small field survey was conducted. Places where this policy was meant to be applied were identified and certain slum areas where rehabilitation of people was about to begin were surveyed by the authors. People were interrogated about their present living conditions and about the various policies that are being extended towards them. And the results were altogether unanticipated.

4.1. BANGANGA SLUMS

The area of our fundamental emphasis was Banganga slums in Bhopal India. The area is home for one of the largest slum dwelling communities in the entire city. It was divided into various localities. Some of them were already rehabilitated and some were about to be or proposed to be reintegrated. We were able to get information on some of them.

The motive for nominating Banganga slums as our topic of case studies is to provide some vision and focus to the policy makers, architects and planners so as to provide a better explication for the people of these slums as this community has not been rehabilitated yet and also the assembly operation has not been started yet.

People with diverse occupations live together in these territories. Some work as laborers while others work as small clerks in various institutes. Some sell vegetables while some are local tailors and shopkeepers. They practice different religions and speak different languages. Some of them are even migrants who came from other countries in search of jobs and for proper upbringing of their household. But it is their circumstances and requisites. Some of them are so poor that they cannot afford to travel via local transport. So these people laid foundations of small localities of their own on barren and unowned lands near market places and areas which were near to their workplaces.

The Banganga slums are situated near the biggest market place of Bhopal the New Market region. The average household size is four with the elderly of the family residing with their children. Majority of the women work as house wives taking care of households, the children and the elderly of the family. The children go to study in the nearby government and private schools. The field

trip gave the authors some insight about their present living conditions and the type of communities in which they live today.

"We have made our houses according to our own needs. The government wants to destroy these houses and shift us in permanent ones. But we don't want to go there. (fig.5)" (Respondent 1)

Yes. As shocking as it may sound the slum dwellers themselves told us that they didn't want to go in the government built pakka houses. On conversing more to these people we began to comprehend their circumstances and complications.

These people have been living in these areas for a long time. Some of them even said that they were their ancestral homes and their fathers and grandfathers were brought up and raised in these homes. They had developed these houses from scrap over time and all of these houses were constructed by these people themselves. And when the government uproots them suddenly from their homes and shift to new ones, then who won't hesitate. The government asks for a small amount of money from these people for new houses and without and interest. But some of them are people with temporary jobs who cannot afford even these prices and interest rates. What about them? Along with them there are certain communities of refuges there who came from other countries long ago in search of food and shelter. And then after all these years of hard work to settle in a country with a proper home and a job to live with, the government again wants to take this opportunity away from them.

"We don't want to leave our homes. We want the government to give this land to us in exchange for money. We are ready to make our own homes on that land. But we won't be able to sustain our families in small houses provided by the government." (Respondent 2)

The slum area had a community of nearly a thousand and more people(fig.4). This population was distributed in nearly four to five districts which were densely occupied (fig.6). Upon visiting to all of these districts and talking to four to five people in each district we concluded that, "Most of the people didn't want to vacate their old homes to relocate in the government built multistory buildings".

But the opinion of only one community might not prove sufficient for a project as huge as this. So we also enquired from people of other communities.

Fig 4, The Banganga slums *(Source: authors)*

Fig 5, Slum dwellings

Fig 6, Locality

4.2. POTTERS COMMUNITY

The potters community is one of the most distinguished and famed communities in Bhopal (fig.6). The tradition of pottery and handcrafts goes way back in this city of kings. This community resides in the heart of the city, in front of Maulana Azad National Institute of Technology, commonly known as MNIT. These people have been living in that area for decades. They make earthen pots and sell them in the local markets located near their houses (fig.7).

Fig 6, Potters working in their shops *(Source: authors)*

Fig 7, Potters selling pots roadside

"There is a separate room in our house for keeping mud used in pottery. But it is not like that in government houses. There are only two rooms. If we keep mud in one room then our entire family won't be able to live in another room." (Respondent 3)

The functionality of the government provided projects and houses can be questioned at large according to the necessities of the people and amenities provided to them. The potters require extra spaces for mud storage. Usually they use the roofs of their houses for this purpose but in multistory buildings

this privilege is taken away from them. There has been lack of alternatives for housing sizes, types and location. Slum dwellers seldom had choices other than to accept whatever has been provided. Generally policy framework doesn't have any regard for dynamics of life under scarcity, its composition, livelihood practices and socio cultural behaviour. The guidelines provided for housing development has been very rigid and unsupportive that forced people to live in such accommodations that have been contradictory to the ways of their living and livelihood.

4.3. RAHUL NAGAR

Keeping the view of pre occupancy in mind we now move on to post occupancy. Near Maulana Azad National Institute of Technology there is a post occupancy residence where people from all over Bhopal, from different communities and areas were inhabited (fig.8). Hundreds of families were shifted there five to six years ago. These people were living in multistory buildings built by the government all these years (fig.9).

"At first we thought that there will be special problems in government quarters but now after living for so many years it feels better." (Respondent 4)

Fig 8, Rahul nagar residence
(Source: authors)

Fig 9, Rahul nagar residence from road

In the quarters quite a lot of people have adapted to their new homes. They feel them to be better than their previous places. They get more ground area where children can play and people can sit and talk to each other. But is this the case with everyone? People were shifted on both ground and higher floors. The people on ground floor are satisfied with their situations but what about people on other floors?

"We were better off in our older homes. Climbing up and down the stairs is very problematic. The elderly suffer the most because of this. We also have to

take more care of children. Even the business has decreased a bit." (Respondent 5)

This statement proves that not everyone is happy with their new home even after all these years. The provisions provided are as promised but even with those facilities the living conditions have only worsened for majority of population. People who have lived in single storey houses, where they can extend their floors and living space and have a rooftop to enjoy the morning breeze, are not able to adapt to these small cuboidal boxes.

5. Conclusion

All together the entire research paper can be encapsulated in one statement- "The government built homes can sustain the body of an individual but not their spirit."

5.1 INFERENCES

The poor communities are the free folks of the country. They fabricate their own houses according to their culture and requisites. The magnitudes vary based on family size or profession or culture. The constituents vary according to the region and site maneuvered. All these attributes give each home its uniqueness and identity. And it is these homes which provide people with their solitary and expanse.

But the governments built projects take their uniqueness away from them. They are built for surviving not for living. They dearth the culture, tradition and freedom which the individuals pursue in their lives. They are made to fulfill their necessities not to provide them tranquility. They are devoid of the mental comfort and social heritage and knowledge that one desires in a home. The residents do not have any say in the construction of their own residences. They are just brick and stone structures, without any soul and spirit.

Their indigenous social culture is being taken away from them and their social identity is being reconstructed. The policy makers, planners and architects need a vision to look into the traditional craft and trades and the vernacular traditions which they have to incorporate in the contemporary planning of these structures. The designing of these settlements need a proper understanding of users way of life, Social and cultural values.

5.2 RECOMMENDATIONS

Architecture is the rhythm of the soul of an edifice, and it is this rhythm which connects our subconscious to the soul of a building. And when this rhythm attaches a hundred or a thousand souls to it, it is refined as social architecture.

Social architecture derives its existence from the people and hence for the proper sustenance and continuity of this methodology the involvement of local people is imperative. The designing of these settlements need the understanding of user's way of life and their social and cultural values. It is when architecture passes through the sieves of culture and tradition and values that it can be reborn as social architecture, and it is the local people who hold this sieve and help the architecture refine and evolve. The government should incorporate the aid of those who are going to live in these houses. The government and urban planners should ensure participation of people like under the Public Participation Plan, where public participation is a dynamic activity, and it empowers low income communities to participate in decisions and that affects them. There should be a proper dialogue between the government and the common people and often we should let them guide us into genuine and sustainable architecture. This will increase their quality of life and expound their existence in the society.

Oscar Niemeyer once compared architecture to a political struggle, and a way to express the technical and social progress of a country. An architect takes something ordinary and converts it to something remarkable and exceptional. And an architect's buildings further define the evolution and growth of a nation and its people.

6. Acknowledgements

The completion of this research paper could not have been possible without the participation and assistance of numerous people whose names may not all be enumerated. Their contributions are sincerely appreciated and gratefully acknowledged. However we would like to express our deep appreciation and indebtedness particularly to the following:

Ar. Sanjeev Singh and Ar. Abhishek K. Venkitaraman for their endless support, kind and understanding spirit during our paper. And to all the relatives, friends and others who in one way or other shared their support.

7. References

http://www.pmindia.gov.in/en/news_updates/implementation-of-the-rural-housing-scheme-of- pradhan-mantri-awaas-yojana-gramin-to-achieve-housing-for-all-by-2022/

https://www.mapsofindia.com/my-india/government/pm-awas-yojana-a-solution-to-slums

http://sehore.nic.in/sehore-maps.html

http://www.freestockphotos.name/wallpaper/3086/political-map-of-india-with-cities-images-photography.html

http://indianexpress.com/article/cities/mumbai/its-no-solution-to-mumbais-slum-problem/

https://en.wikipedia.org/wiki/Sociology_of_architecture

Shikha Patidat and Brishbhanlali Raghuwanshi:2014,Changes in Culture and Architecture from Vernacular to Modern: M.P., India,30th international plea conference, CEPT university, Ahmedabed

Shikha Patidat and Brishbhanlali Raghuwanshi:2015,The Reflection of Culture in Architecture of M.P. , India, Journal of Civil Engineering and Architectural Research, Ethan Publishing,

Prem Narayan Saxena and Rajesh Joshi:2015, Eradication of Slums in Bhopal City, IJSTE - International Journal of Science Technology & Engineering Volume 2 Issue 06 December 2015

A.K Vinodia:2016,A Thesis for Doctor of Philosophy, Framework for Priorotization of Parameters for context – specific interventions in Indian Slums

Rajapaksha.U, et al (eds), 2017, "Design that cares"- multi disciplinary approaches to creating sustainable and meaningful built environment: *Proceedings of the 10th International Conference of Faculty of Architecture Research Unit (FARU), University of Moratuwa, Sri Lanka, (Vol. 01)* pp. 276-287 ©

PROTOTYPE OF NET ZERO RESIDENCE FOR HOT & DRY CLIMATE IN INDIAN CONTEXT

JAIN A.[1], MUNDHE P. [2], SUNGER V.[3], BIST N.[4] & DIXIT M.[5]
[1,2,3,4,5] Centre for Environmental Planning and Technology (CEPT) University, Ahmedabad, India
arihant.jain1993@gmail.com, mundhepooja03@gmail.com, vasudha.15592@gmail.com, nikhilesh241192@gmail.com, maaz.dixit@gmail.com

Abstract
India is the seventh largest country in the world in terms of area and home to over a billion people. It is estimated that the total constructed built-up area would increase about 5-fold from the year 2005 to 2030. According to the Central Electricity Authority (India), residential sector accounts for 21% of the total electricity consumption. Energy efficient buildings are the future imperative for the proposed building stock in India. This paper presents a design process for developing a Net Zero Energy home prototype that is affordable for the higher middle-class families. It is an urban single-family home in the hot and dry climate which also achieves zero water discharge to respond to water scarcity in Jaipur, Rajasthan in India. The building works in mixed-mode operation providing comfortable & World Health Organization (WHO) suggested air quality standard, despite degraded outdoor air quality in Jaipur. It was designed by performing parametric analysis and assessing comfort hours by simulating different options for building form, envelope, passive and active cooling approaches. An Energy Use Intensity (EUI) of 20 kWh/m2/year was achieved, that is balanced by an 8-kW rooftop photovoltaic system. The designed home will act as an affordable energy efficient prototype that can be used by developers in India.

Keywords: *Affordable housing, Energy simulations, Mixed-mode building, Net zero energy home, Zero water discharge*

1. Introduction

Buildings use resources (energy, water, raw materials, and etc.), generate waste (occupant, construction and demolition), and emit harmful emissions. The Environmental Protection Agency (EPA) reported that buildings are responsible for 68% of total electricity use, 12% of total water use, 38% of CO2 emissions and 60% of total non-industrial waste (Committee, 2017). Sensitivity analysis studies have repeatedly shown key design parameters that can greatly influence the energy efficiencies: a change of a single unit of these parameters can lead to an increase or a decrease of thousands of MWh of electricity consumption in a year. Low energy designed buildings are imperative for the proposed building stock in India. A net-zero residence fits

perfectly in the Indian context given shortage of grid-supplied energy evidenced by frequent brownouts in most cities in the country. India's Paris Accord commitment includes producing 40% of all electricity from non-fossil sources.

In view of the above problems, this paper presents a design process for developing a residence in typical hot and dry climate (Jaipur in this paper) for Indian context. The proposed prototype is net zero in energy and water discharge. A Net Zero residence produces as much energy (through renewable energy sources) as it consumes over a period of one year. The water discharge by the home is also zero, which means that the waste water is recycled and reused and is not discharged into the sewer. By making it net zero home, we were able to reduce the reliance on grid supply for power and water. The scarcity of land, depleting ground water levels, and degraded air quality make this design very relevant to future development in tropical regions around the world. Jaipur, where the site is located, is the capital city of Rajasthan, and is renowned for its vernacular and historic monumental architecture.

2. Design Goals

The following goals were set to achieve Net Zero residence:

- Energy Performance – Improved energy performance with EUI of 20 kWh/m2/year without compromising the comfort of the occupants.
- Adaptability – The design would be flexible enough to adapt to the occupants evolving needs over time.
- Zero Water Discharge – All storm and waste water shall be captured for reuse on site and to recharge ground water.
- Affordability and Durability – For affordability, maintaining debt to income ratio of 40% for a target group of higher middle class, and use of durable construction technology to achieve life expectancy of 75 years.
- Indoor Air Quality – Meeting World Health Organization (WHO) standards for PM 2.5 and PM10 to improve indoor air quality.

3. Design Process

- The steps followed as part of the design process to reach an optimized design solution are:
- Predesign analysis- This was done using Design Builder simulation tool to optimize orientation, aspect ratio and Window to Floor area Ratio (WFR).
- Massing and Internal planning- Based on the results from the predesign analysis, massing and internal planning of spaces were carried out.

- Building envelope optimization- Various materials and assemblies were explored to understand their thermal properties. For all assemblies' used in the design, workability, cost and heat balance were given prime importance.

- Lighting and Daylighting optimization- With the help of simulations, optimum WFR was determined that helped reduce the overall heat gain, increase daylight usage and reduce lighting energy consumption.

- Equipment selection- By switching to Bureau of Energy Efficiency (BEE) star rated lighting and appliance from conventional ones, payback period from savings was calculated.

- Heating, Ventilation and Air Conditioning (HVAC) System and Indoor Air Quality (IAQ) optimization- The India Model for Adaptive (Thermal) Comfort has been used for comfort conditions. Based on the ton of refrigeration required for conditioned spaces, different systems were compared for efficiency, initial capital cost, and low maintenance cost.

- Life Cycle Cost Analysis (LCCA) for lighting and HVAC systems- An LCCA is performed for the photovoltaic system to determine its viability. For HVAC system, various systems were compared to understand the payback period based on the initial cost and performance of the system.

4. Site and context

The site is located in a medium density residential area in Jaipur. The street is lined with residences and commercial buildings. It was located at a corner lot open from south-east & south-west on primary road and the secondary road respectively. The 450.5 m2 lot was oriented at 19 degrees towards west from the north. Setbacks were taken as per the local standards. The two storey existing building on the west side of the building prevents afternoon heat gain.

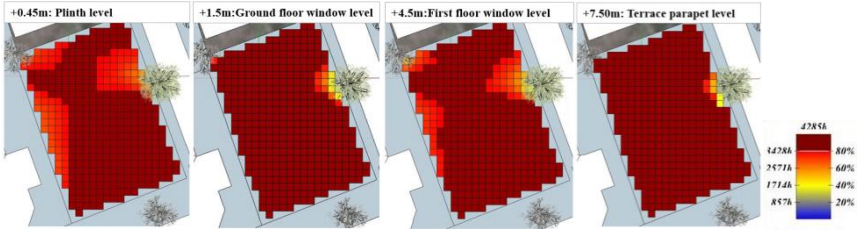


Figure 1. Sunlit Hours on the Site (Source: Self)

5. Energy Analysis

The analysis for design was done through a process as described below. Each step consists of various aspects of the building design that helped to achieve the goal of Net Zero residence.

5.1 PRE-DESIGN ANALYSIS

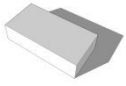
DesignBuilder v4.7 was used for energy modelling and simulation. The energy savings of the designed home was compared with a conventional home in Jaipur. The design was based on this analysis.

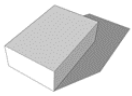
5.1.1 Parametric Analysis

Parametric analysis for aspect ratio, orientation and WFR was done. Due to site constraints, there were limitations for aspect ratios of 1:1, 1:2 and 2:3. Parametric analysis for a WFR of 5%, 10% and 15% were carried out. Comfort hours is the governing performance parameter which lead to the selection of appropriate building geometry.

A shoe box model of the building was simulated in mixed mode condition and the indoor dry bulb temperature and relative humidity were compared with 30-day running mean suggested in the Indian model for Adaptive (Thermal) Comfort. Further, the number of hours that fall in the comfort band were found as per IMAC model. After the analysis was done, it was clear that the most suitable geometry for the home is E-W orientation along with an aspect ratio of 1:2 and 15% WFR. The comfort hours obtained for such a geometry were 5597 out of 8760 hours in a year.

Table 1 Predesign parametric analysis

Model	Orientation	Aspect Ratio	WFR	Comfort Hours
	--	1:1	5	3058
			10	3075
			15	4396
	EW	1:2	5	5404
			10	5539
			15	5597
	NS	2:1	5	4995
			10	5087
			15	5124

Model	Orientation	Aspect Ratio	WFR	Comfort Hours
	EW	2:3	5	5440
			10	5549
			15	5475
	NS	3:2	5	5138
			10	5058
			15	5051

5.1.2 The optimized design solution

The constraints of the site are its orientation, longer side facing north-south axis, and the setbacks. The opportunities were maximized within these constraints in the design. Preliminary energy analysis gave a 1:2 aspect ratio elongated on an east-west axis. The building form was designed in such a way that it uses 2 building blocks (private and semi-private spaces) with this (1:2) aspect ratio connected by a transition space (staircase).

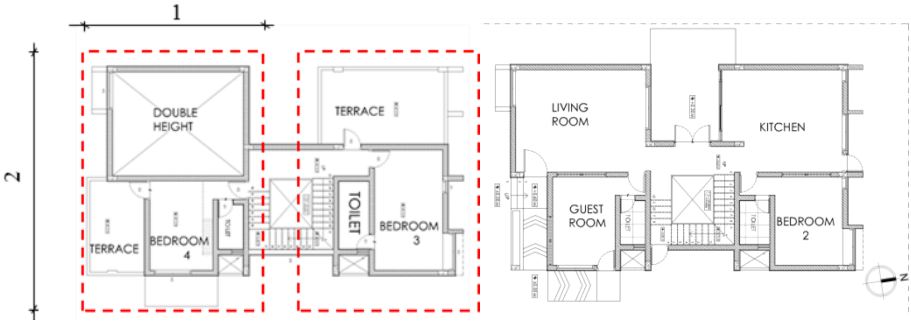


Figure 2 Ground floor plan (left) First Floor plan (right) (Source: Self)

The prayer (puja) area, which is an important space in Indian homes, is located within this connection at the center of the home. The window openings are designed to take advantage of the prevailing winds in the months of March, April and May with the building form. Fin walls created positive and negative pressures to drive the wind inside the house. This allows the building to be operated in mixed-mode condition.

Night use spaces like bedrooms are located on the east side to avoid the late afternoon sun. A shaded courtyard on the west creates a private outdoor space.

Adjacent rooms overlook and extend out in to this courtyard. A guest bedroom is designed with a separate entrance so that it can be rented out on Airbnb to supplement the family income and to use valuable real estate.

5.2 Energy Conservation Measures

The energy conservation measures were integrated throughout the design process. By using various energy conservation measures like building envelope, HVAC systems, lighting and appliances, major reduction was found in cooling and lighting energy. The cooling load was first reduced by optimizing building envelope, then energy efficient lighting & appliances were selected. After reducing the loads, the cooling energy was further reduced by using efficient Variable Refrigerant Flow (VRF) cooling system.

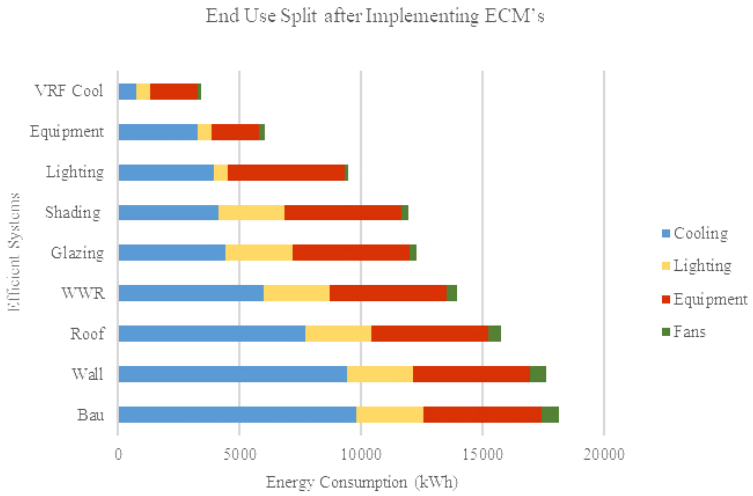


Figure 3 ECM comparative chart (Source: Self)

5.2.1 Building envelope optimization

The energy efficient construction assemblies were designed by considering the impact of materials on the following parameters: EUI, thermal comfort (comfort hours) and cost. The optimum thickness of insulation was selected based on its cost and impact on EUI. After comparing with different thickness of insulation, 25mm of Extruded Polystyrene (XPS) foam thickness was found to be optimum, since, beyond this thickness, the percentage reduction in EUI was very less. For finding the best-performing wall assembly in terms of energy and cost, different wall layers were considered. Their impact on EUI was found for two different types of residential buildings having same schedule and site conditions. For window assembly, different glass materials were

selected based on U-value, Solar Heat Gain Coefficient (SHGC), Visible Light Transmission (VLT). An envelope with high insulation, low thermal bridging, easy constructability, durable, termite/ insect resistant, moisture and mold resistant properties were used.

5.2.2 HVAC system selection

For designing the HVAC system, four simple goals were laid down: identifying efficient cooling system, achieving thermal comfort, providing minimum ventilation rates as per the codes & standards and reducing duct length by planning the space efficiently for equipment. For sizing the cooling system, American Society for Heating Refrigeration and Air-Conditioning Engineers (ASHRAE) Residential Load Factor (RLF) method was used. As per the tonnage of refrigeration required for conditioned spaces, different systems were compared based on the efficiency, initial capital cost, and maintenance cost. Finally, a cost-benefit analysis was done for which a conventional 5-star rated air conditioner was compared with a VRF system. Despite the high initial capital cost, VRF system has a payback period of 4 years, other advantages for the VRF systems are high Energy Efficiency Ratio (EER) and environment friendly refrigerant - R410A.

The ventilation inside the conditioned space was provided through 2 strategies, active and passive. The active strategy includes the ventilation through Heat Recovery Ventilator (HRV) system which can be operated at different flow rates and for passive strategy natural ventilation was used. The plan was designed to bring natural driven wind and to integrate stack effect. The staircase inside the home acted as a negative pressure zone, which drives the hot, stale air from the room and exhausts it out. This strategy gives two advantages: bring in fresh air from outside and reduce the heat ingress.

5.2.3 Indoor Air Quality

To maintain the indoor air quality for the occupants, two steps were followed. Firstly, ambient air quality of Jaipur was analyzed and in second step the concentration of pollutants was reduced while maintaining ventilation rates as per codes and standard. The data provided by Central Pollution Control Board (CPCB) and National Ambient Air Quality Standard (NAAQ'S) depicted that the concentration of PM 2.5 & PM 10 was more than WHO standard, i.e. 10 µg/m3 & 20 µg/m3 annual mean (Central Pollution Control Board, 2012). This concentration was reduced by supplying fresh air using HRV with Minimum Efficiency Reporting Value (MERV) 16 filter and air purifier with a Clean Air Discharge Rate (CADR) of 150m3/hr. Apart from this, various strategies like,

low Volatile Organic Compounds (VOC) material and point source strategy to remove combustion pollutants were integrated into the design.

5.2.4 Daylighting

Daylighting was optimized for the psychological well-being of the occupants and to reduce lighting energy requirement. Windows were sized considering ventilation, daylighting, and heat gains. The simulation was done using Velux Daylight Visualizer 3 software. The maximum window area was provided on north and south walls with shading device designed for maximum daylight. East and West walls were provided with minimum window area to avoid direct glare and heat gain. The zones with maximum occupancy like bedrooms, living room, and dining room were day lit with minimum illuminance levels of 200 - 300 lux.

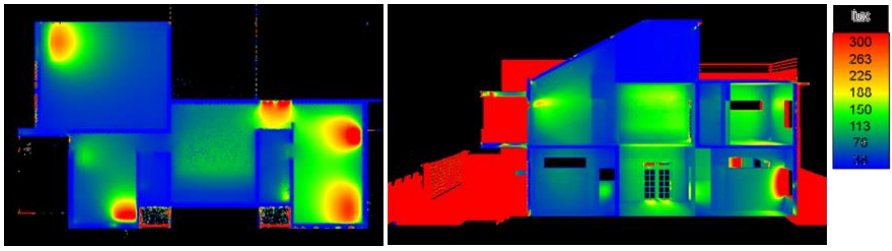


Figure 4 Ground floor level (left) & sectional (right) daylight analysis

5.2.5 Lighting

A task-ambient lighting approach was used with maximum luminous efficacy (lm/W) and optimum illuminance levels were provided for each space. Performance-The goal was to reduce lighting energy without compromising the required illuminance. The requirements for a residential building were

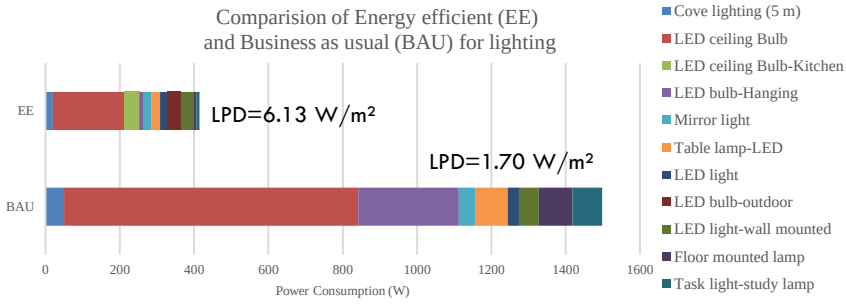


Figure 5 Comparison of LPD for BAU & EE scenario

obtained from Illuminating Engineering Society (IES). The approach was to calculate the illuminance required for each room using the tool -Lumen Method Calcs (Zonal cavity method). By using energy efficient lighting fixtures, the Lighting Power Density (LPD) was reduced by 72.2% when compared with Business as usual (BAU) scenario. Reduction in LPD further helped in reducing the EUI by 22%.

5.2.6. Energy efficient appliances

The intent while selecting the appliance was to minimize the energy consumption by implementing new technologies without compromising on the comfort of the occupants. The selection process was guided mainly by a two-step process:

1. Performance– The BEE rated appliances were selected and the ones which are not listed have been selected after a market survey through online portals.

2. Cost–The cost of lighting and appliances and its power consumption are compared with the conventional scenario. The payback period was estimated from the savings by switching to BEE star rated lighting and appliance. By using these equipment, the Equipment Power Density (EPD) was reduced by 40%.

5.3 RENEWABLE ENERGY INTEGRATION

5.3.1 Solar Photovoltaics (PV)

An LCCA was performed on the photovoltaic system to determine its viability for the occupants. Among the available options like PV fixed frame, PV tracking system (Manual and Automatic), a fixed frame system (300 Wp) was selected as it has minimum life cycle cost over 25 years.

5.3.2 Zero water discharge

The design aimed to achieve zero water discharge by providing a waste water treatment plant. The treatment plant consists of series of tanks, filters, and treatment systems which were connected in a water circuit (loop).

Rainwater and storm water was also harvested for reuse on site. The black water was discharged into the septic tank, which outflows in the distribution box and recharges the groundwater aquifers. Whereas, the greywater was discharged into the anaerobic baffled reactor and filter, wherein the waste water, after passing through the baffles root zone system, was purified. In order

to provide safe drinking water, a “Reverse Osmosis Filtration System” was installed, which filters and reduces the Total Dissolved Solids (TDS) in water.Additionally, the underground water tank would be connected to the municipal water supply line if the harvested rainwater storage falls below the demand. This recycled water will satisfy the water demand of the occupants throughout the year.

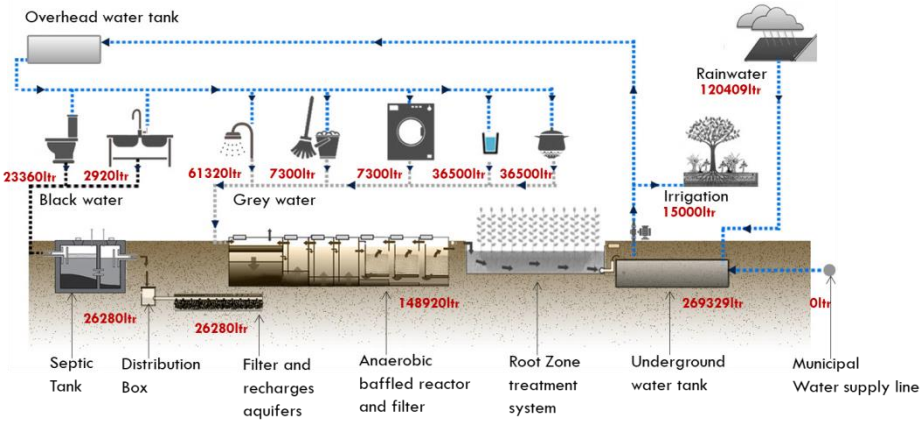


Figure 6 Water circuit (Source: Self)

6. Financial Analysis

Financial analysis was carried out to make the house more affordable by adopting several strategies that helped to reduce the debt and increase income.

6.1 CONSTRUCTION COST ESTIMATE

The target market for this particular project, was a small nuclear family earning approx. $60,000-65,000 per annum, which represents 8% of the families in Jaipur. The construction cost was $67,846 and the value of land purchased was $115,384. The resale value of the residence in Jaipur will lead to a profit of $80,000 over the initial cost. Thus, the total home cost was $2,50,769.

- Capital Cost-The guest room on the ground floor was rented on Airbnb, which generated a revenue of $3000- $3500per year (Renting period- 8 months per year).

Feasibility of PV system-A life-cycle cost analysis (LCCA) was performed on the photovoltaic system to determine its viability for the targeted market. An LCCA was performed over 25 years, which shows that purchasing a PV array will result in a net gain of $4,863 which will be beneficial for the homeowners.

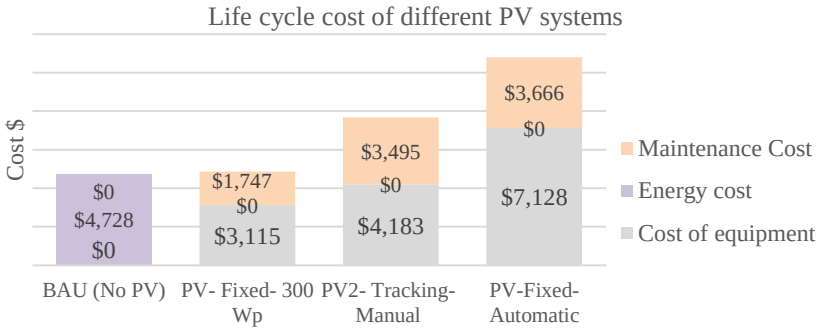


Figure 7 LCCA OF PV

6.2 PAYBACK PERIOD FOR END USES

Payback period of various energy conservation measures is as follows-

Table 2. Payback period for various ECMs

ECMs	Description	Payback period
Fenestration	Double glazed unit	3
Lighting Design	Energy efficient lighting-LED	1
HVAC system	VRF+ HRV	10
Equipment	Energy efficient fixtures	10

7. Conclusion

The EUI of the designed home was 20 kWh/m2/year, which was balanced by an 8 KW rooftop solar PV system. By incorporating all the ECMs, the energy consumption was reduced by 83% from the conventional scenario. The use of low flow fixtures helped in reducing the water consumption by 25%. The cost of this home is 35% higher than a typical house. The debt to income ratio of 39% was achieved for this particular study. The acceptable debt to income ratio by Indian bankers is 40%. This home will act as an affordable energy efficient prototype that can be used by the developers in India.

8. Acknowledgement

The authors are thankful to the faculty from M. Tech in Building Energy Performance program and colleagues from CEPT University who provided insight and expertise that greatly assisted the research. We would also like to show our gratitude to Prof. Prasad Vaidya for his valuable guidance throughout the research.

9. References

(BEEP), I.-S. B. E. E. P., 2015. Energy Efficiency in Residential Buildings. [Online]
Available at: http://www.beepindia.org/energy-efficiency-residential-buildings [Accessed 2017].
American Society for Heating, R. a. A. c. E., 2009. Rensselaer Polytechnic Institute. [Online]
Available at: http://www.ewp.rpi.edu/hartford/~scarzm/MANE6980/Other/ASHRAE_References/2009%20ASHRAE%20HANDBOOK%20FUNDAMENTALS%20-CHP17_HEAT_LOAD-CALCS.pdf [Accessed 2017].
CARBSE.ORG, n.d. Centre for advanced research in Building Science & Energy. [Online]
Available at: http://www.carbse.org/ [Accessed 2017].
CENTRAL POLLUTION CONTROL BOARD, M. O. E. &. F., n.d. NATIONAL AMBIENT AIR QUALITY STATUS & TRENDS IN INDIA. January 2012 ed. Delhi: Central Pollution Control Board.
Council, G., n.d. Green Rating for Integrated Habitat Assessment. [Online]
Available at: http://www.grihaindia.org/index.php?option=com_content&view=article&id=86&t=Green_Rating_for_Integrated_Habitat_Assessment [Accessed 2017].
Council, I. C., n.d. International Energy Conservation Code. [Online]
Available at: https://www.iccsafe.org/codes-tech-support/codes/2015-i-codes/iecc/ [Accessed 2016-17].
Government of India, M. o. P., 2015. Bureau of energy effciency. [Online]
Available at: https://beeindia.gov.in/ [Accessed 2017].
Govt. of India, M. o. N. a. R. e., February,2012. Solar/Green cities. [Online]
Available at: http://mnre.gov.in/schemes/decentralized-systems/solar-cities/ [Accessed 2017].
https://www.bijlibachao.com/, n.d. Bijli Bachao. [Online]
Available at: https://www.bijlibachao.com/
Plus, E., n.d. Weather Data Download - Jaipur 423480 (ISHRAE). [Online]
Available at: https://energyplus.net/weather-location/asia_wmo_region_2/IND//IND_Jaipur.423480_ISHRAE [Accessed 2017].
Rajan Rawal, Y. S., 2014. Residential buildings in India: Energy use projections and savings potential, Ahmedabad: Global Buildings Performance Network (GBPN).
Sanyogita Manu, Y. S. R. E. d. D., 2016. Field studies of thermal comfort across multiple climate zones for the subcontinent: India Model for Adaptive Comfort (IMAC). Building and Environment, 98(March 2016), pp. 55-70.
Society, I. E., 1906-2017. Standards, ANSI Standards. [Online]
Available at: https://www.ies.org/standards/ies-lighting-library/ [Accessed 2017].
Standards, B. o. I., n.d. National Building Code. 2016 ed. New Delhi: Bureau of Indian Standards.

Rajapaksha.U, et al (eds), 2017, "Design that cares"- multi disciplinary approaches to creating sustainable and meaningful built environment: *Proceedings of the 10th International Conference of Faculty of Architecture Research Unit (FARU), University of Moratuwa, Sri Lanka, (Vol. 01)* pp. 288-299 ©

DEMOCRATIZING THE CITY THROUGH PUBLIC SPACE

SHAMMI AKTER KEYA. A[1] & NAZIA AFRIN TRINA. B[2]
RUET, Rajshahi, Bangladesh
keya0801048@gmail.com, RUET, Rajshahi, Bangladesh,
124arch0801046@gmail.com

Abstract
A city may have billions of investments for its infrastructural developments but without a functional public space, the city can never be as enthusiastic as it can be. The history of mankind shows that all the great public buildings in antiquity had a vital and functional use of public spaces for community life which is missing now. In Bangladesh many groups-women, racial minorities, the homeless and street people have all suffered literal, physical marginalization. The people of Bangladesh are struggling to retain their rights against many odds, for example, the journey of 'Gonojagoron Moncho' (a platform made by mass people where they can raise their voice against injustice & for their rights) began at the busy Shahbag road intersection in Dhaka which eventually resulted in the serious traffic congestion. Despite the odds, this movement triggered the creation of more platforms in different districts of Bangladesh. This shows there is no settled position from which to make public awareness and protest, therefore the public spaces has to be invented again and again. There is no set formula but there are limitations. To increase overall individual well-being and freedom, it is necessary to assure free and unstigmatized access to the public spaces.

Keywords: *Democracy; public space; protest; public street; unstigmatized access.*

1. Introduction

The public sphere, that domain of political talk and activity between the state and society, burst out of the market and the cafe long prior, however lately even the pages of daily papers and the communicate media have been superseded. Presently, general society circle is virtual, advanced, and scattered crosswise over billions of desktops, portable workstations and cell phones. Subsequently, now the public sphere isn't only a middle class liberality however a global phenomenon.

It begins from the premise that while a growing extent of political communication uses digital means, the things that are communicated involve real people who take up, occupy, share, and challenge physical space. Often,

the individuals who deny the significance of physical space by concentrating on the methods of communication, they overlook what is communicated.

Democracy depends to a surprising degree on the physical accessibility to open space, even in our professedly computerized world. It additionally contends that in many regards the availability of space for democratic performance is under threat, and that by ignoring the requirement for such space – or contending against that need – we run the risk of undermining some essential states of democracy in the cutting edge world.

The possibility, that democracy relies upon physical space in different ways, runs counter to the present conventionality in majority rule hypothesis and more extensive political science. It is a useful prerequisite of democracy that coupling aggregate basic leadership happens in a solitary, obvious, and open scene; and it is a necessity of democracy that open cases be made in places that are helpful for being seen and considered important by whatever remains of the demos.

2. Background

Public spaces can be used as a tool for guaranteeing the right to the city and democratizing social, economic, political and cultural relationships in urban areas. At the local level, liberalization has resulted in increased surveillance and regulation of public space. Certain points for public space within the city connecting the important buildings or places which carry administrative importance can ensure democratic practice in the city.

Bangladesh is a democratic country which earned their independence through 9 month long liberation war against Pakistan in 1971. The people of Bangladesh are still continuing their struggle to retain their rights against many odds & in this process the major issue they are facing is the lack of public place as a democratic space. There are plenty of parks & open spaces in Dhaka but still those spaces are missing the whole point of democracy, which is to ensure mass accessibility without any constraint & to let people speak their rights on a platform. As a result people created some platforms within the city on important traffic street nodes to make themselves heard. This shows that if the people feel on edge of being unheard, they can literally burst into protest & the places for protest can be generated spontaneously based on the accessibility of those places which can either be a square or major street nodes. Public spaces represent a response to the problems of a modern, partly democratized linguistic world. The apparent spontaneous force of the public square implies it as something that should either be accepted or rejected in full.

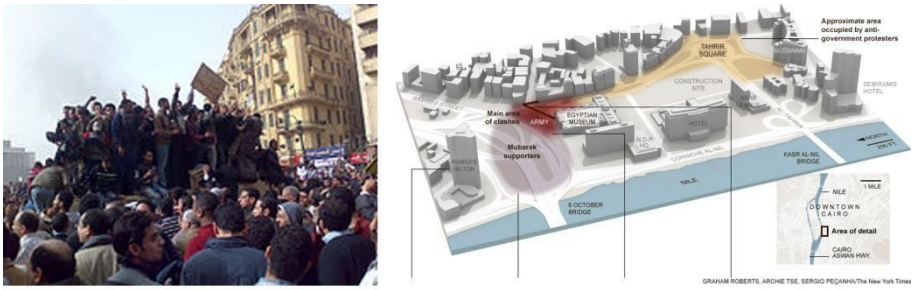


Figure 1, Demonstrators in Tahrir Square, 2011
(*Source: Photo by Ramy Raoof, Creative Commons Attribution 2.0 Generic license.*)

3. Objectives

The objective of this paper is to identify the necessity of public open space for democratic performance & how public sphere has to be invented to make public awareness. The necessity of public space for democracy is discussed here through some designed implementation of public space in the context of Dhaka city to minimize the failure of Dhaka city as a representative of democratic city.

4. Methodology

The study was conducted through content analysis which included relevant research works, books and literature that were reviewed to get a general overview how Public spaces represent a response to the problems of a modern, partly democratized linguistic world and also site survey which covered the survey of some particular areas of Dhaka city (such as: Shahbag Node, Osmani Udyan, Tejgaon Old Airport). We identified & aimed to develop the impact of these public spaces over the democracy of Bangladesh. All of these spaces represent the symbols of nation and authority.

5. Democracy and Public Space

The discussions of democracy can be started by picking apart the word etymology, ‘rule by the people’. Democracy is primarily a way of making collective decisions and that those decisions are primarily about three things: how to distribute scarce resources or, in Laswell’s famous phrase (1958), ‘who gets what, when and how’; the interests and power relations that structure that distribution; and the normative issues of who should get what, and how to structure society so that they get it. ‘Resources’ on this account might include familiar things like time, money, and various physical goods, but it can also include information and information technology; welfare-related goods like

health and happiness; or other abstract goods like ability, opportunity, autonomy, and liberty.

As the political definition diverges from the urban, some negotiation over the use of space is essential, because space is itself a resource that needs to be shared.

5.1. PERFORMING DEMOCRACY

We can consider the settings for making public claims in direct and indirect ways. In small scale groups where every individuals of the relevant demos can physically assemble in one place, public claims can be made directly in front of the assembled masses, as in the Athenian ecclesia or the Swiss Landsgemeinden. In large scale societies, the demos essentially won't fit into the discussion any longer, so claim makers either require interceded methods for making the whole public aware of their claims, in cases where the entire public still is the final decision-making authority or require ways of making representatives aware, in cases where leadership control is with a representative body of some sort. The stages for such action are not boundless. In any of these cases, simply 'talking among yourselves' in off the beaten path spots won't do – getting noticed and considered seriously is what matters, which means that cases should be made in freely noticeable and accessible places.

This paper will motivate us to look at public space from the point of view of the demands of democratic roles. This is important because it helps us understand why public space matters to democracy and why political theorists are wrong when they dismiss the value of the physical, giving all their attention to the virtual realms of public engagement.

5.2. DEFINING PHYSICAL PUBLIC SPACE

As John R. Parkinson (2011) has illustrated, physical space can be ‘public’ if it offers an idea of a four-fold definition confirming that space

1. is openly accessible; and/or
2. uses common resources; and/or
3. has common effects; and/or
4. is used for the performance of public roles.

5.3. FORM AND POLITICAL BEHAVIOUR

For what reason may we think that physical form matters to politics? There are some extremely evident cases that assistance enlightens the issues. First, there are walls: unless they are merely relics, pierced by openings like the walls around. Avignon or York, walls can avert access to administrations, fellow

citizens, and political forum. Such walls constitute a un-freedom in an essential liberal sense, and the wall building in Israel– Palestine is a prime example, with many Palestinian Israelis deprived of the ability to work, access administrations, or contact or engage with other fellow-citizens and representatives, constraining their capacity to work in significant ways as free members of the society. Notice that it is not the mere presence of a wall that is important here: they should be protected in some way or another, whether directly by people or indirectly by electronic means.

In any case, the fact of the matter is that such physical structures matter for legislative issues when they display hindrances to the statement of rights and freedoms. Examples are harder to find, but we might think of roads in this way: while it is physically possible to sit down in the middle of the road, the fact that it is dedicated to traffic means that it is most unwise without stopping the traffic first. Even when roads are used for political purposes – a walk, a demonstration – the norm is that people move down the road. Generally, we stand still for marshalling or speeches in parks and squares at the ends of roads, rarely in the middle of them.

6. Protest and the Plaza: Engaging the Formal Public Sphere

In Zócalo in Mexico and Washington's National Mall, for example, there are plenty of other examples from Bucharest to Buenos Aires, Bangkok to Beijing. All these spaces are full of the symbols of nation and authority. Standing in them, one is encompassed by the facades of presidential palaces and town halls; there are national flags flying from enormous focal flagpoles or from the roofs and balconies of the surrounding buildings. In some of them like Mexico– traffic circulates so that, standing in the middle of the square, one is at the centre of attraction. The traffic helps define these squares as the hub around which the nation revolves. They are not so much a 'still point of the turning world' but bustling places with no restrictions on access, full of tourists sometimes, but plenty of locals too, and are used as centres of protest so that people can cloak themselves and their claims with the same symbols and dignity that the powerful do when claiming the symbols and status of high office. In London, Parliament Square is small and almost completely cut off for pedestrians: there are no crossings to it, and no easy ways past the safety barriers. Even more restricted are Hong Kong's Chater Gardens and Statue Square, so small and so full of seats and tables, arcades and planters, and fountains and pools that only around 5,000 people can use the pair of them at any one time.

Thus, size matters – the number of people we can get into a square has an impact on the degree to which organizers can show the scale of popular

displeasure with a government, and in London's Parliament Square that scale can only ever be relatively small, making it easier to dismiss even those demonstrations that manage to pack the square as unrepresentative of popular opinion. In Hong Kong, one could pack Chater Gardens to the gunwales yet the crowd would barely be noticed through the thickets of vegetation and covered seating. By contrast, filling the Zócalo in Mexico is a much, much more impressive achievement. In several cities, there is a single traditional space for protest that is somehow divorced from the sites of the public sphere. In London, most protests gather not at Parliament Square but a mile eastwards in the larger and more accessible Trafalgar Square. Many very large protests in London occupy Hyde Park rather than the much smaller inner- Westminster spaces. This is because the buildings of the formal public sphere and the symbols of national significance are not all gathered together in one central location.

7. Historical Background of Democracy of Bangladesh

The Bengali nation had struggled for democracy, secular values and national rights for years. Bangladesh emerged as an independent nation in 1971 after breaking away and achieving independence from Pakistan in the Bangladesh liberation war. After independence, the new state endured famine, natural disasters and widespread poverty, as well as political turmoil and military coups. The restoration of democracy in 1991 has been followed by relative calm and economic progress.

We have passed around forty five years since independence yet our accomplishments in the spheres of democracy and development are not significant. Where we started our independence day at 26th March, 1971 in Ramna Race course with the famous speech by Bangabandhu Sheikh Mujib which was very vital step towards democracy, now every political leader or party, civil or military, popular or unpopular, big or small, in or out of power, talk about democratic incessantly. Even so the nation has failed to recognize the importance of accessible public open spaces for democratic purpose. Parties voted into power to strengthen democracy have all failed to encourage its values. Taking advantage of this situation, military leaders intervened to practice their own version of democracy, which only exacerbated the crisis. The country today is riddled with numerous issues threatening the development of democracy. Our society with an immature political culture and poverty ridden illiterate and incompetent masses is lacking democratic political organizations, institutions and practices.

Figure 2, Political movement in open spaces for democracy in 1952, 1971
(*Source: website)*

8. Dhaka City as a Democratic City

There is a great deal more that could be said about the way that democracy plays out in cities. Dhaka city needs to provide facilities for the performance not just of narrations of the demos, but of other public claims, other narrations, and even space for getting away from each other and persistent public claim-making. The degree to which different members of the demos can enjoy that space, depends very much on the background structures of social stratification of Dhaka city. Even different park configurations can have an important impact on people's ability to perform different roles. Indeed, space that is good for escape is not good for encounter or some kinds of play. Every public space ought to have a certain set of characteristics that encourage democratically valuable pursuits.

The following are the initiatives for making Dhaka a democratic city;

- An extensive and low-cost public transport system.
- The public provision of meeting rooms for citizens, fitted out with IT networks and projection equipment, perhaps at libraries, council buildings, colleges, and universities.
- Variety of parks and plazas such that the Dhaka city as a whole can meet all the different uses of parks without expecting each and every space to meet all of them. Where the Dhaka city's built heritage does not allow this, otherwise private space should be designated for public claim-making purposes.
- Direct accessibility from open spaces towards landmarks which at present is being interrupted by vehicular streets.
- Footpaths and streets designated as public space, not to be controlled by private security guards, business associations, or residents' associations, regardless of ownership.
- Identifying & segregating vehicular & pedestrian streets to ensure uninterrupted physical connection towards open spaces.

9. Democratic Protest in Dhaka

On February 5, 2013, public protests began in Shahbag, Dhaka demanding death penalties for the war criminals of Liberation war of Bangladesh . On that day, the International Crimes Tribunal had sentenced Abdul kader Mollah, a war criminal, to life in prison after he was sentenced on five of six counts of war crimes. Later demands included boycotting the Bangladesh Jamaat-e-Islami party from politics including election and a boycott of institutions supporting the party.

Protesters considered Mollah's sentence excessively tolerant, given his crimes. Bloggers and online activists called for additional protests at Shahbag Square in Dhaka. Ten thousands of people joined the demonstration & created 'Gonojagoron Moncho', which blocked the traffic system of Shahbag node. Later this movement triggered several more protest points in the different districts of Bangladesh.

All of those protest points had one thing in common which was they were located on major vehicular roads. This shows the failure of the existing open spaces in Bangladesh to act as active democratic spaces.

Figure 3, Demonstrators in Gonojagoron moncho, Shahbag in February 2013
(*Source: Wikipedia*)

10. Architecture of Democracy

Frank Lloyd Wright thought, it is possible that there is ‘architecture of democracy’, a building and planning style that embodies and embeds democratic values (Wright, 1939).

Not only is it the case that democracy requires physical space for its performance, the fact is that only certain kinds of spatial arrangements will do, or that certain arrangements intensify or mute particular behaviours that democrats discover significant.

10.1 STREETS AS PART OF DEMOCRATIC OPEN SPACE

Democratic street: Emphasizes on the social & economic diversity of large neighbourhood & city as well as the history while not excluding the automobiles but providing friendly space for pedestrians & residents. Street democracy recognizes the concept of 'publicness' through ensuring free & unlimited access to public places. If we look into the history, it shows that good streets are democratic streets that ensure the space for common people giving meaning & access to them while encouraging use & participation. Through the urbanization process, in Bangladesh, streets started to become only usable for vehicles with the help of traffic engineering that restrained the people to use it as their very own, people started to see streets as 'only part of the city'. This resulted in unattractiveness & undesirability of urban streets. But history shows us that, in 1960s streets were used as a stage for political & social change. Public space merged with street can play a major role in a democratic way to shape public culture.

Kevin lynch in his 'A Theory of good city (1981)' argues that we have five basic public space rights: presence, use & action, appropriation, modification and disposition. These rights, simply stated, are that the people should not only have access to public space but also freedom to use & even claim the space as well as to transfer their rights of use & modification to other individuals. For ensuring democratic space in streets, we need a healthy balance of freedom & control while bringing walking, talking, eating & sports back to the streets again. People need to feel a sense of ownness over the street to make any street democratic. This can include linking the ground floor of the buildings to the adjacent street space. The street has to be comfortable for the users along with ensuring healthy balance between public & semi public spaces.

10.2. OSMANI UDYAN AS A DEMOCRATIC OPEN SPACE

Osmani Udyan is century old park of Dhaka City which is located in a very positive place for democratic purpose as the 'Nagar Bhaban' (Dhaka City Corporation) confronts it. It was a railway property since the British period. Later it was given to PWD and they handed over the Osmani Udyan to Dhaka City Corporation Authority in 1998. Since that time the Osmani Udyan has been under threats from different government Departments and encroachers. Now a big portion of Osmani Udyan is being used for different purpose, sometimes for bus parking, sometimes for shops.

Based on site survey and theoretical analysis we took some design approach in our design studio to refurbish this open space and to develop this open space as an active democratic space.

Figure 4, studying present social & spatial dimension of Usmani Udyan (*Source: Author)*

In the figure we can clearly see that the present condition of Usmani Udyan to act as an active open space is almost impossible due to the encroachment of vendors, illigal structures & a boundary surrounding it. The primary objective of an open space to act as a public space is 'visibility' & direct access which is missing here. In our design studio, we surveyed the site & analyzed the social & spatial aspect of Usmani Udyan.

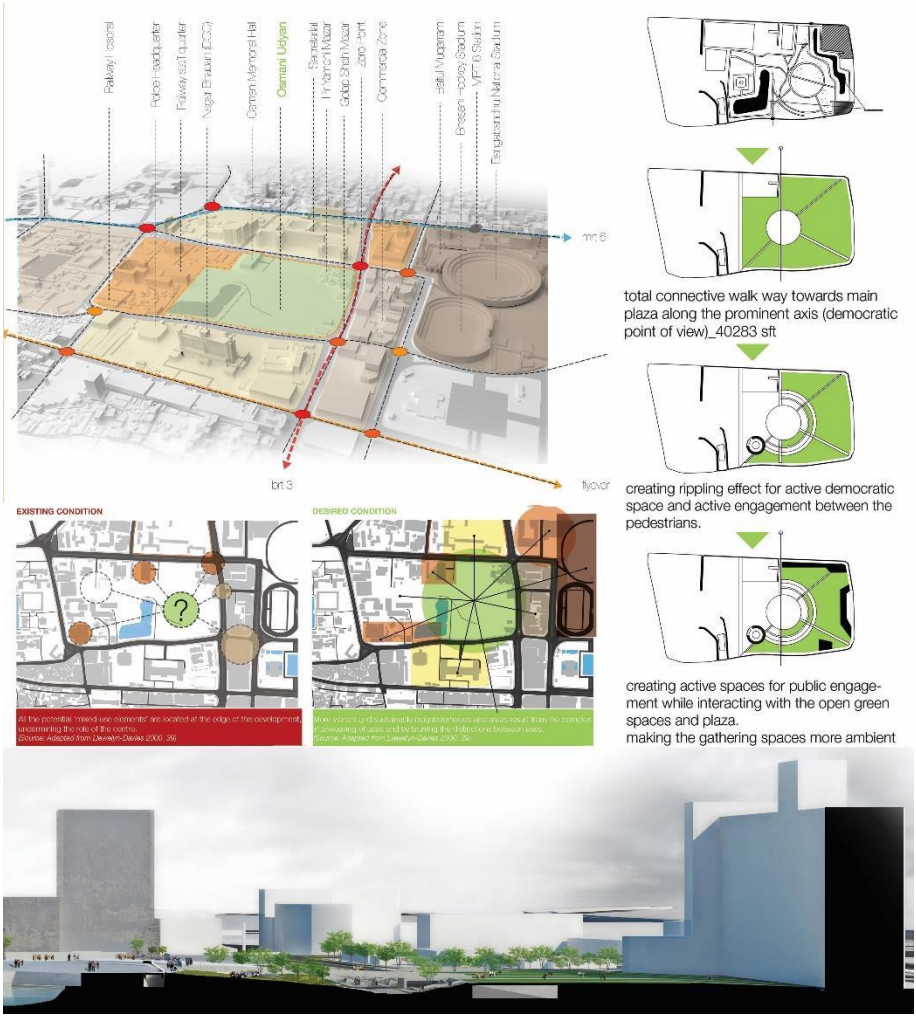


Figure 5, site analysis of Usmani Udyan and development process of desired conceptual section (*Source: Author*)

Here the concept of connecting the ground floor of public buildings with adjacent streets has come into focus as an inspiration for developing a democratic space. We tried to create physical engagement in the open spacefor democracy in four major ways. First, the narrative and deliberative phases of democracy work best when conducted face to face and allows all the non-verbal cues to be transmitted and received. Second, when it comes to making public claims, it is important that claim-makers be seen in dignified, symbolically rich public space so that their claim-making is made obvious to other citizens; to demonstrate to decision-makers the scale of public

displeasure; and so that claim-makers themselves get the efficacy benefits that come with being seen to share views with others. Third, a sense of inclusion and membership of the demos is enhanced when one sees one's narratives anchored in symbolic, physical form. Even the presence of the marginal in public places is a necessary (but not sufficient) condition for them to feel and be recognized by other members of the demos. Fourth, the physical performance of decision-making helps attentive publics perform their scrutiny role – virtual decision-making can too easily become hidden, back-room decision-making.

11. Conclusions

The availability of active democratic space within the city can inspire people to engage physically in democratic activities which is very much obvious to help democracy flourish. Dhaka city has been missing the whole concept of developing as an enthusiastic democratic city even after liberation war in 1971 that started by practising democratic performances to ensure the rights of people. Throughout the paper we focused on finding the reasons that are causing the open spaces of Dhaka city to fail as proper public spaces & look for the key aspects that can eventually transform those existing open spaces into active democratic spaces.

11.1. Acknowledgements

This paper was developed as a Studio Project of B.Arch program of Bangladesh University of Engineering and Technology, Dhaka, Bangladesh.

Studio project (Level 4 Term 1): Democratizing the City

Studio Teachers: Prof. Khaleda Ekram, Prof. Dr Khandaker Shabbir Ahmed, Amreen Shajahan, Samina Mazumder Tuli, Tahajibul Hossain.

Group Members: Shammi Akter Keya, Enam Rabbi Adnan, Onie Khondaker, Raihan Reza, Arif Uz Zaman

11.2. REFERENCES

John R. Parkinson (ed.): 2011, *Democracy and Public Space: The Physical Sites of Democratic Performance*, Oxford University Press, New York.

Anne Vernez Moudon (ed.): *Public Streets for Public Use*, Columbia University Press, New York.

M.M. Awal Hossain: 2015, *Democracy in Bangladesh: Problems & Prospects*, Research Gate, pg-9, 10

Allen, Edward. 2005. *How buildings work: the natural order of architecture*, New York: Oxford University Press.

Arat, Z. F. 1991. *Democracy and human rights in developing countries*, London: Lynne Rienner.

Matthew Carmona, Tim Heath, Taner Oc and Steven Tiesdell *(2010): Public Places-Urban Spaces: The Dimensions of Urban Design,* Architectural Press, United Kingdom.

Rajapaksha.U, et al (eds), 2017, "Design that cares"- multi disciplinary approaches to creating sustainable and meaningful built environment: *Proceedings of the 10th International Conference of Faculty of Architecture Research Unit (FARU), University of Moratuwa, Sri Lanka, (Vol. 01)* pp. 300-312 ©

MUD HOUSE: The Gradual Shifting of Traditional Vernacular Architectural Practice in Northern Bangladesh

NADIA MONZUR. A
Rajshahi University of Engineering & Technology, Rajshahi, Bangladesh
nadiamonzur@live.com

Abstract

The diversified vernacular architecture in rural Bangladesh is the result of a constant and gradual attempt to maintain sustainability and cultural identity by using knowledge of the local environment. However, factors like natural resource scarcity and economic viability of modern construction techniques is evidently causing a rapid change in the rural landscape. A physical and questionnaire survey carried out in the area under study, namely the village Kaligram in Manda upazilla, Naogaon, revealed that, nearly sixty-percent of houses built within the last decade is concrete and brick made with little or no regards to any traditional vernacular features. Investigation of various parameters such as mud wall construction techniques, availability and preference of building materials, socio- economic changes through surveys, has revealed that the loss of precious fertile top soil, high maintenance of mud structures added with the availability and affordability of more durable materials, are some of the prime reasoning behind revising their options to brick construction. This research aims to assess the factors causing gradual shifting in the indigenous practices of mud houses in the study area. The study further extends onto a discussion of an alternate design approach that will exemplify a more durable, low maintenance, energy efficient yet economic building technology while acknowledging the strengths of the indigenous architectural practices.

Keywords: *Mud architecture, Vernacular architecture, Indigenous material, Rammed earth, Bamboo.*

1. Introduction

Throughout centuries the portrayal of human endeavor towards developing a tradition and culture specific architecture has been consistent. The growth pattern of pastoral heritage in the history of Bangladesh reads no differently. The traditional vernacular architecture of Bangladesh has evolved through time according to the need of the users and is characterized by factors such as- climate, culture and resources. However the recent scenario of the rural landscape happens to dictate a wave of change in the age old traditional vernacular architectural practice.

Housing typology in the villages is experiencing a significant modification in terms of the use of materials, construction methods and spatial planning. The familiar rural landscape of the northern Bangladesh is no longer boldly characterized by modest mud houses topped by thatched roofs, built around a courtyard with a pond nearby. The folk architectural archetypes of the Bangladeshi villages are gradually being overtaken by a more modern approach to house building technologies that rarely correspond to the knowledge of constructing vernacular structures.

The question of whether this phenomenon is pointing to the right direction is being raised by the architects, planners and sociologists who are looking for ideas to initiate sustainable rural development in Bangladesh. To investigate this issue, a particular village in the North-West part of Bangladesh was selected as the study area which features a long history of traditional earthen architecture currently under radicalization by such mind sets. The field survey taken out across the village reveals that, about 60% structures that have been built in the last decade are all brick and concrete construction.

Identifying the factors contributing to such trend is a mandatory step in forming an insight towards an appropriate approach to sustainable development in the future. Therefore, after analyzing the root causes against the sustenance of mud architecture in the study area, this paper discusses an alternate design approach featuring earth and bamboo as the main building material; focusing on a durable, low maintenance, energy efficient and economic building technology.

2. The Study Area

Bangladesh is in general a hot and humid country with a prominent monsoon season and a short winter. The Northern region of this delta is particularly characterized by highest temperatures in the country accompanied by high humidity and a low rainfall rate. The studies area is a village named Kaligram, of the district Naogaon located in the Rajshahi division in Northern Bangladesh. The village is 15 square kilometers in area and is home to approximately 3000 people.

As any traditional architecture of a certain region, the vernacular practices in Naogaon, is the result of a cumulative knowledge of their local environment. The Deep mud walls on raised plinth, capped by thatched roofs of straw supported by beams of ‘Taal’ or Palm wood briefly describe the distinct characteristics of Mud architecture of rural Bangladesh that has been crafted by numerous generations. Hence Kaligram village is selected as a starting point of the exploration into the local Mud architecture and causes behind its steady abandonment.

3. The Aim and Approach

In view of Henry H Glassie (2000), currently building technology and sustainable design are considered fundamental to the growing field of contemporary architecture. Practicing architects have a challenging responsibility to design buildings that are environmentally sustainable with the change in the global concern regarding the use of energy and resources (Wines and Jodidio, 2000; Cox, 2009; Friedman, 2012). This new responsibility has prompted a sensible shift in trend from a biased preference of eye-catching, institutionalized building forms to more organic, humble, yet energy-efficient vernacular forms. Additionally, the local forms of construction capitalize on the users' knowledge of how buildings can be effectively designed to promote cultural conservation and traditional wisdom (Oliver, 2003; Rapoport, 2005).

3.1. THE SCOPE

In a developing country like Bangladesh the idea of environmentally sustainable development is farfetched unless the potential aspects of locality and context are realized and reconsidered by the practitioners. Looking into the causes of disappearing traditional building technology can open up new avenues towards developing a scheme that overcomes these limitations and makes way for an era of truly context-based, environment conscious, sensible and sustainable building design. The scope of this study, therefore, leads to the following consecutive aspects-

- By studying the root causes behind the ever changing rural landscape of the village Kaligram, the limitations of mud architecture can be identified in a more specific sense.
- Sequentially this research can be a guideline to identify some of the common fundamental issues behind the gradual disappearance of the indigenous practices in the other rural areas of this country.
- Finally the scope extends to provoking an argument towards the concept of sustainable architectural practices in the context to rural Bangladesh.

3.2. METHODOLOGY

This study examines a specific type of mud architecture focusing on its construction methods and limitations. Documentation the existing condition was structured around a volume of existing as well as collected data through means of literature along with physical, ethnographic, questionnaire surveys and interviews. The physical survey combined with interview sessions helped build up an idea about the mud house construction techniques in the area and the drawbacks of the process. The result of the questionnaire survey was twofold. The first set of questions that focused on the regular lifestyle of people and how it has changed with time, revealed an interesting insight into the socio-cultural and economic aspect of the research. Whereas the second set of

questions focusing on the benefits and demerits of living in a mud house, disclosed facts about the discontinuing preference of mud houses. In addition to that, case studies on a number of mud construction techniques were done to formulate an idea on the current researches ongoing in this aspect. The findings were then analyzed and scrutinized to take an attempt towards solving the research question. Overall, identification of the factors that are contributing to the gradual shift in the mud architecture practice in the study area, dictated paths to possible solutions that address the climatic and contextual factors keeping in mind the ever changing social dynamics.

4. The Site and findings

4.1. CLIMATE OF NAOGAON

The village under study in situated is the northwestern parts of Bangladesh. This region in particular is characterized by high temperature and high humidity defining a tropical climatic zone. The annual maximum and minimum temperature on average is found to be 37.8 °C and 11.2 °C consequently.

However, recordings have shown that during summer the temperature here can climb up to 40ºC or even more. In the year 2006 the highest temperature was recorded to be 44ºC. As for humidity, during the monsoon season from June-August, the air contains highest humidity up to 96%. During the summer, the humidity drops to an average of 60% in March-April.

4.2. THE VILLAGE OF KALIGRAM

An extensive field survey reveals that, the basic layout of the village Kaligram features rural houses grouped together adjoining a pond or any other water sources. Commercial infrastructures such as local shops are mostly found near the junction of highways. Usually the settlement pattern of the houses is directed by the roads and streets and generally these groups of houses are surrounded by paddy fields and Mango Garden.

4.2.1 The Land and the Water

In order to understand the spatial layout of the site more acutely, a cartographic survey of the study area was carried out which exposed an atypical growth of water bodies that seemed to be not only unplanned but also unfit to the regime of the settlement pattern in a village. This village having an area of 15 square kilometers has a greater than typical number of small to large scale ponds scattered across it. The questionaire survey and interviews with some of the local people revealed that, all of these ponds, 84 to be exact, were not dug out to fulfill the need of a waterbody in the community area. Rather they are the byproduct of soil cultivation during the construction of a mud house.

The water table data further explains the formation of these ponds some of which only have a depth of 3- 4m. Although the ground water table in this region is found to be as low as 7.8 meters, these water levels fluctuate depending on the pricipitation pattern. According to some of the local home owners, after the monsoon season when the ground water reservoires have recharged, excavating at a depth of even 3m eventually forms a waterbody. In Fig 1, two satelite images of Kaligram along with the settlements ,the waterbodies have been hilighted to illustrate this scenario.

After asking about the usage and management of these waterbodies, a farmer who has been living in the village for 28 years, expressed that, there are a number of ponds that have not been used since they have been excaved. As the population grew and more mud huts were erected and the number of ponds increased through years leaving them to be treated as a left over water reservoir. Some of these pond are as small as 5 square meter in area, and are insufficient to be used in any of the household needs as they dry out during the summer.

Figure 1, Settlement and Land use pattern of Kaligram (*Source: Wikimapia*)

Moreover, these waterbodies are a a result of permanent sacrifice of precious cultivable top soil that has been dug up to be used as building material. This had become a one way path for the local people who wanted to continue living in the village until they opted for a more current option.

4.2.2. The Mud House

A traditional mud house in Kaligram has a typical U or L shaped layout with a courtyard at the center. According to a report on Mud houses of Bangladesh published in 2007 as part of an initiative by Earthquake Engineering Research Institute (EERI), the construction does not include a proper foundation; instead, the ground is excavated with a width equal to the wall thickness before the wall is erected. Generally the wall is embedded to the ground, without footing and general depth of this embedment is about 0.3-0.5m. As a result no firm

connection exists between the building and the ground. Thus the building may fail easily due to severe lateral loading. The plinth of the house is either of raised mud platform or in some cases it is made of plastered brick.

The mud houses in Kaligram features mud walls of depth ranging from a minimum of 2 feet to even 4 feet in some older structures. This thickness not only provides the mud walls sufficient strength to act as a structural element, but combined with the pitched straw roofing; it also provides superior insulation from the great temperatures in the summer and the harsh cold in the winter.

The ceiling is made by placing 'Chatai' (sheets made of bamboo strips) over the beams and then mud is laid on it. Afterwards the ceiling is sometimes colored or covered with sealer to achieve moisture resistance. Roofing is completed by using thatched roof of straw or corrugated CI sheets or in some cases mud tiles, which are placed over a triangular framework of bamboo or wood.

The structural system consists of a column and beam frame of either 'Taal'(Palm), 'Neem'(Azadirecta) or 'Koroi'(Albizzia spp.), Bamboo or Mango tree. Sometimes precast concrete columns of 4-10 inches diameter are used to support the overhanging wooden veranda. In the two story mud huts, the beams underneath the first floor slab is extended up to 1 meter outside the exterior wall which act as a support to the shading device made of the same roofing material.

Figure 2,3, Structural Details of a Mud house in Kaligram

Though most of the mud houses are used as single-family houses, they are in many cases extended longitudinally to accommodate the growing family. Vertical extension is typically limited to two stories. Besides the living area, the attic space above the ceiling is used as storage space for seasonal and yearly harvests.

4.3. DEVIATION FROM TRADITION

As time progresses, the effortless and spontaneous attitude of being guided by nature no longer seems to be sufficient for the rural people. The village of Kaligram is following no separate path to this as it is becoming a village now more recognized by its brick and concrete structures than the distinguishable heavy walled mud houses.

The current method of construction starts with making a foundation using rat trap bond over sand compaction. According to necessity the walls are either load bearing with a thickness of 5 or 10 inch or sometimes a concrete column beam frame is constructed as the structure. Sill and lintels of concrete mix hold the wooden door and window frames in place. The structure in then capped off by corrugated CI sheets.

5. Reasoning the Transformation

A questionnaire survey taken among approximately 150 villagers helped to pinpoint some of the prime reasons behind this shift in trend. According to the findings throughout this study the causes behind the deviation from tradition in terms of building material and technology can be written off into a threefold synopsis.

5.1. SOCIO-ECONOMIC ASPECTS

- Owing to the social dynamics of the rural development, easy access to information and knowledge sharing has led people free from their tradition bound thoughts.
- Many people from the recent generations of the rural families that used to live in the village are gradually withdrawing their roots from the village to explore their opportunities in the city or elsewhere. The families that used to grow as a joint family are now becoming fragmented nuclear families with their separate households. Therefore the need to expand the household is becoming obsolete. And the new generations are opting for a more convenient and permanent building form.
- The traditional mud houses in the North might be a symbol of age old tradition, but the idea of it remains constrained to the lower income people of the society. If a family can upgrade to a semi-pucca brick house, it is considered as an achievement on their part and a symbol of solvency compared to their previous state.
- The availability and affordability of materials such as brick, cement, sand etc. has strengthened the trend of building brick made houses furthermore.

5.2. CONSTRUCTION AND MAINTENANCE

- The construction technique of the mud house can be time consuming and laborious. It takes about 60 days for 2-3 persons (120-180 person days) to

- complete the construction (Housing Report, 2007). Whereas the brick house construction may take less than half of that time, with the same number of labours. Collection of mud itself can be a very laborious task and a number of things can go wrong such as, finding the right type of soil. A brick and concrete construction does not require these additional efforts.
- Adding to that the maintenance of a mud house can be a critical job. The mud walls suffer from extended shrinkage cracks, which weaken the walls. Too much moisture can erode away the mud walls. Sometimes, the mud walls are covered with protective coating of animal dung that basically serve as a wearing surface. This layer requires continued maintenance and sometimes renewal almost every year
- Another menacing problem in mud houses is the occasional attack of rodents that burrows into the thick mud walls making it weak and prone to collapse.
- Water is the main harmful element in the lifespan of a mud house. So it limits the use of mud constructions to a less flood prone area with lower precipitation rate.

These drawbacks have led people to the misconception that mud houses are of inferior to brick construction.

5.3. ENVIRONMENT AND RESOURCE

- As stated previously, the field study has disclosed that the excavation of mud from any area in the village has fuelled the loss of precious top soil replacing the excavated area of land with an unwanted water body. In essence this has caused the villagers to lose the utility of parts of the land they own. In these parts of the country, 80% of the land cultivable with a nutrient-rich fertile soil. Therefore, allowing this land to be replaced by unnecessary ponds is under serious argument.
- Another issue with this type of construction is the use of wood to construct the beams and the frame below the roof. According to 90% of the villagers who took part in the questionnaire survey, the number of trees has visibly gone down through the years because they were used in construction of the mud houses and this has become a genuine concern among them.

8. Rethinking the Mud House

Prior investigation of various earth constructions such as Adobe, Straw bale housing, Rammed Earth and Compressed earth block has accentuated the understanding of material behavior and architectural practices. Some of these construction techniques are more suited to application in the context of developing countries for the following reasons-

- As these techniques are based upon earthen materials which do not require significant industrial processing. They permit houses to be built with much less damage on global system of energy and resource.

- These methods rely on materials which are locally available in vast majority of regions around the world, minimizing effort behind transportation.
- Furthermore, they are generally intermediate-technology solutions and do not require sophisticated machinery or expertise to construct. These factors not only make such construction technologies practical for developing countries in general, but also make them more compatible to economical, social and environmental constraints.
- Finally, unlike brick or other burned building units, adobe structures do not leave carbon footprint making it an efficient green building material.

Considering the benefits of the usage of local materials it becomes necessary to question the modernist trends in practice and to encourage a suitable method in both the dimensions of design and structure.

8.1. A RAMMED EARTH AND BAMBOO HOUSE

According to USC (2007), properly constructed rammed earth walls are unaffected by rain, wind, fire or termites. Load Bearing Rammed earth walls are generally 18 to 24 inches thick and Non-Load Bearing Rammed earth walls are generally 10-14 inches thick. Rammed earth compressive strength is approximately 300psi and Bamboo has high tensile strength and because of its micro fibrous properties it is flexible in character. So the idea is to introduce a structure that considers-

- The thermal property of Earth and structural strength of Bamboo in the form of Rammed earth structure with multiple bamboo culm column- beam structure that has the thermal mass of earth but can be of larger spans than the traditional mud house.
- Reduction in the use of Mud in wall and slab as required by the rammed earth construction method
- Low maintenance and durable finish

8.2.1. The Layout

Considering the growing need of accommodation in a typical rural family, the design of the house must have a scope for future expansion. In the case of a traditional U shaped house layout (*Figure 4*), future expansion often becomes incompatible to the transforming family structures in the rural and suburban areas. Newer generations prefer a household for a nuclear family to live in where they can share the some common space (toilet, crop storage) with the rest of the family but at the same time which allows them to maintain a separate house hold of their own. In most cases they move out of their traditional family house to a more compact and durable structure or in some cases the mud houses taken down and are replaced by brick houses. To compensate this scenario, an option can be proposed that allows a more

sustainable mud construction with a flexible future expansion opportunity. If the separate household blocks are arranged in a more linear manner with the smaller courtyard serving as the junction point. When future expansion is required, more blocks could be added perpendicular to the existing ones as shown in *Figure 4*. This flexible layout will-

- Firstly, accommodate the growing family and provide an interconnected household that will be a better alternate than moving to a completely separate household.
- Secondly, it will allow the expansions to be built using the same building materials but with better structural stability and durability.

The North- South oriented blocks will be the living space and the newer east west oriented blocks will work as the utility areas such as kitchen, toilets, storage spaces etc. As newer blocks are added to existing ones, they will creat more courtyards grouping the households together.

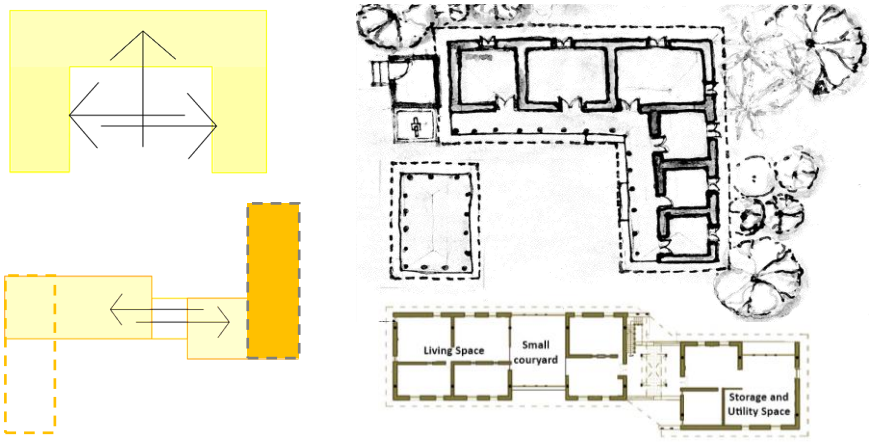


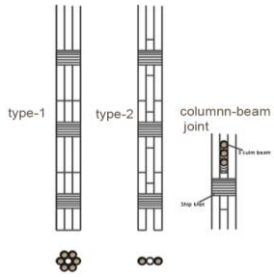
Fig 4, Existing and proposed layouts of Mud house

8.2.2. The Structure

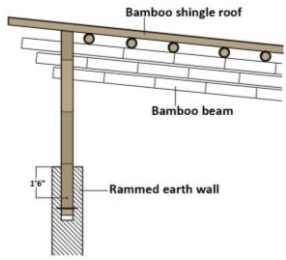
In majority of rural areas in Bangladesh, houses are built with bamboo as the primary load bearing elements of the structure. However these bamboos are usually placed close together so the footing acts as a combined one to stabilize the structure. After studying some of the examples, it is observed that single bamboo culms of 4”- 6”diameters are placed at a distance of no more than 4’ (centre to centre). Marking that as a standard of the load bearing capacity of a

single bamboo, a multiple culm bamboo column is suggested that can support larger spans.

The combination can range according to the necessity and the bonding pattern of the bamboos can also vary according to the design. As long as the bamboos are seasoned and the rope ties are done with good craftsmanship, the column will act as a single unit (*Figure 6,7*).



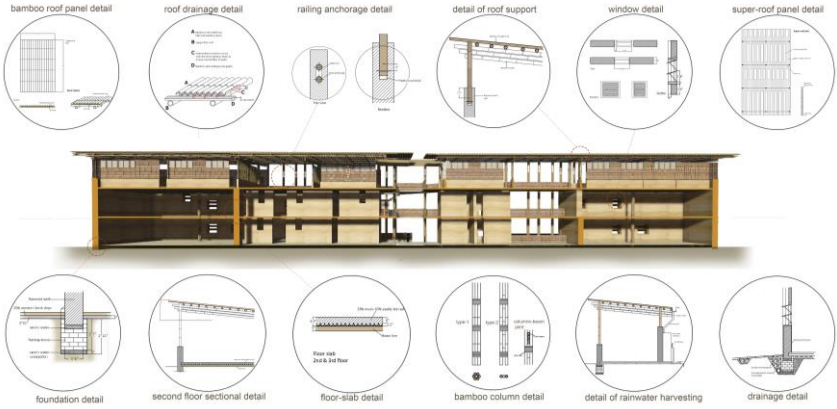
Figure, 6: Bamboo column and beam



Figure, 7: Roof detail section

Historically foundations were often absent in earth structures, with walls built directly onto bearing soil or very shallow footings or slabs. McHenry (1984) claims that this was due to an apparent resilience of earth walls not found in more conventional materials, which reduced the importance of foundations.

The foundation suggested for a two storied building can be of a minimum 3 feet depending on the soil condition. And the method will be somewhat similar to that of a brick wall. While starting with a sand compaction the rammed earth wall will be joined in a rat-trap bond with sand and water. A 25% cement and brick chips mixture over a 3" CC layer can form the ground floor finish over bare top soil (*Figure 8*).



Figure, 8: Possible structural details shown in section

The exterior walls having the thermal mass can be as thick as 18”-24” and can facilitate time lag cooling. A 12” thick rammed earth wall can provide up to 12 hours of time lag cooling. As for the partition walls, thickness should be a minimum of 12” if no more. Also, this will require less soil usage during construction.

Drawing on a comparison between same size (12’x 24’) of a traditional and a Bamboo and Rammed earth structure, it is concluded that-

- A traditional mud house requires 1120cft of soil (adding 15% cow-dung/ fibres). Maintenance requires more soil over time.
- A Rammed earth house requires 930cft of soil (7.5% sand + 25% gravel)

Therefore, this type of design can save up to approximately 56% soil than a traditional mud house.

As roofing material, bamboo shingles or mud tiles can be a better option than CI sheet as they will minimize heat builds up indoors. Bamboo shingle roof construction is simple and cost effective and durable if the bamboos are treated before hand with a solution of boric acid and borax powder solution.

Besides structural strength and insulation properties, rammed earth construction also has a great aesthetic appeal which the designer can use to their advantage.

9. Conclusion

The fact that architectural practice does not serve the majority of rural populace is a common concern not only in Bangladesh but also in most developing countries with vast rural demography. The researchers need to bring themselves to the same plane of perception on sustainability as these rural people in order to fabricate a sustainable future for the nation.

In the view of Christian Norberg-Schulz, architecture brings into presence the immediate meanings of the local earth and sky. In his words, it matches the “Genius Loci" of the place. Despite being functionally circumstantial, architecture expresses the fundamental inner identity of people. Thus, vernacular tradition usually has only a few models, which are constantly being adjusted and readjusted. It is through such variation that individual houses gain their uniqueness. And it is this uniqueness that grants them the key to their sustenance and succession into a better future.

10. References

Amrita Das, Mohammad Shariful Islam, Dr. Md. Jahangir Alam, Nusrat Hoque: 2007 *Housing Report: Mud House of Bangladesh*, Dominik Lang, World Housing Encyclopaedia, 2-13.

Crowley, M.:1997, *Quality Control for Earth Structures*. Australian Institute of Building Papers. 109-118.

C. Norberg-Shulz:1980 *Genius Loci: Towards a Phenomenology of Architecture*, Rizzolli Publications, New York

Henry H Glassie: 2000, Vernacular Architecture, Philadelphia, Pa.: Material Culture, United States

Houben, H. and Guillaud H.*:* 1994, *Earth Construction, A comprehensive Guide. Intermediate,*Technology Publications, London, UK .

Oliver, Paul: 2003. *Dwellings: the Vernacular House World Wide*, Rev, Ed. Phaidon, London.

Rapoport, Amos: 2005. *Culture, Architecture, and Design, Archi- tectural and Planning Research Book Series,* Locke Science Pub. Co, Chicago.

SAZS 724: 2001, *Zimbabwe Standard. Rammed Earth Structures*. Standards Association of Zimbabwe, Harare, Zimbabwe.

Standards Australia: 2002, *The Australian earth building handbook. Standards Australia*, Sydney, Australia.

Wines, James, Jodidio, Philip: 2000. *Green Architecture*. Taschen, Köln; New York.

USC: 2007, *Rammed Earth Construction; Construction*, Presentation Part I, Part II, Schools of Architecture and the University Of Southern California

Rajapaksha.U, et al (eds), 2017, "Design that cares"- multi disciplinary approaches to creating sustainable and meaningful built environment: *Proceedings of the 10th International Conference of Faculty of Architecture Research Unit (FARU), University of Moratuwa, Sri Lanka, (Vol. 01)*pp. 313-321 ©

COMMUNICATING FEMININITY

An Exploration of Wearer Experience and Communication through the Architected Dress

LIYANAGE. P[1] & HETTIARACHCHI. S[2]
[1]University of Moratuwa, Moratuwa, Sri Lanka
pitigalap@gmail.com
[2]University of Moratuwa, Moratuwa, Sir Lanka
shau.hettiarachchi@gmail.com

Abstract
The research in discussion is a pragmatic exploration of a previous study which identified methods architecting the dress. The dress was considered as a body attachment and the methods of architecting was three-fold. Architecting the dress with the body as layers, as elements and as volume based additions. Two main themes are found within the research. The architected dress, which allows a dialogue by using the dress and the body in isolation and in symphony to communicate a particular message and the wearer experience which behaves as a catalyst to the dialogue by enhancing the body movements adding more clarity and versatility to the message that needs to be communicated by the wearer. The work of Senarathna (2016) which focused on communicating femininity is used to critically study the afore mentioned two main themes in discussion. The research problem was recognized as an ill-structured problem (ISP) and uses the methods of progressing in ISP. The research was funded by the Senate Research Committee of the University of Moratuwa under the grant number SRC/ST/2016/26.

Keywords: *Architected Dress, Femininity, Fashion Communication, Ill-Structured Problems, Problem Space*

1. Introduction

Our societies requires that we appear *dressed* but the way we dress differs from the societies we belong to the individual self (Entwistle, 2000). Individuals gain their identities through a various social interactions that one may go through and the dress plays a prominent rule in this due to the fact that the dress represents our individual self even before any verbal communication (Higgins & Eicher, 1992). Therefore it can be understood that the communication of the dress of our individual self to the wider society holds significant importance and various possibilities in this area should be explored.

The research uses previously conducted work by researchers which recognized a method of communication through the dress via a dialogue between the body and the dress as opposed to a statement given through the dress which is a fit-on on the body (Liyanage & Hettiarachchi, 2016). The dress was understood of being capable of creating a dialogue by the virtue of being architected, due to the nature of its construction. The methods will be discussed in the following sections. The work of the current research begins with the attempt of trying to explore the method and the ability of the architected dress to communicate. This is assessed through the work of Senarathna (2016), final year design project, Department of Integrated Design, University of Moratuwa. In the work of Senarathna femininity is selected as the idea to be communicated through the dress. The used notion of femininity will be explained as Key Terminology.

An architected dress is created from in to out, therefore it creates the necessity of taking the wearer experience into consideration as well. The wearer experience adds further to the dialogue by enhancing the body movements of the wearer and therefore adding further versatility to the dialogue between body and dress. This finally results in a better expression of the idea that is required to be communicated.

The research is conducted through the methods of practice based research and uses the basis of creating an ill structured problem; a problem which is ill defined and has no clear progression also known as a wicked problem (Simon, 1973), to construct the research problem which will be considered as the problem space.

In this research paper the reader will first find definitions for key terminology that is used within this research. Then the research methodology is discussed and finally the work of Senarathna (2016) is critically analyzed while identifying future possibilities.

2. Key Terminology

In this section the researchers explain the understanding of prominently used terms in this research paper that have several different definitions used in different subjects and therefore explains the constituted idea for this research on a few terms.

2.1. FEMININITY

As Craik (1993) interprets, there is a clear differnce between beign female (resultant of biology) and being feminine (resultant of social strategy). Centered around the primary aspect of fertility, being female will include tratits

such as beung caring and nurturing and the ability of managing the socially constructed home. Traits of femininity will inclde the characterisation of the female body (Craik, 1993). When attempting to further understand the nature and depiction of femininity as stated by Stets & Burke (2000) and Stirms (1979) explains femininity as not being masculine and vise versa. Stets & Burke (2000) further explains that a gender identity scale that can be drawn is inherent to the sample it was drawn from. This is to say that terminology to depict femininity and its understanding will differ from the context or the society the attributing term was recognized. In stereotypical western society given differnces can be identified between male and female characteristics, traits and temaparements (Stets & Burke, 2000). Therefore this results feminine males or masculine females (Terman & Miles 1936, as stated by Stets & Burke (2000)). Moreover this clearly shows us that femininity or masculinity are qualities that can exist or be practised by either biological sex.

2.2. ARCHITECTED DRESS

Through the ages from the time of Vitruvius (circa 1 AD) or even earlier, fashion has been dependent on architecture creating periodically and professionally iconic dresses inclusive of menswear (Quinn, 2003). Clothes and architecture resonates each other especially in the aspect of providing shelter for the human body (Miles, 2008). A thorough study of chronological advancements of dressing, the works of Issey Miyake, Rei Kawakubo and the traditional Sari of the East, Liyanage & Hettiarachchi (2016) concluded that a dress can be consturcted from the interiors of the body to the extriors of the dress. This is made possible by realting to the method of envisioning the city by Giambattista Nolli (1701-1759) which highlights the dialetics of the city by considreing the positive spaces to be used by people and the negative structures made to define the spaces within (Tice, 2016). Three methods can be identified when creating the dress from the interior to the exterior. Progessing from the interior of the body to the exterior via the addition of layers, progressing from the interior to the exterior through the addition of element and progressing from the interior to the exterior through the addition of volume. Moreover, when the dress is constructed from the interior to the exterior, the wearer experience is also taken into consideration at the stages of constructing *–architecting-* the dress itself as opposed to a resultant interior of the garment when a dress is structured according to the general fit-on method (Liyanage & Hettiarachchi, 2016).

3. Research Methodology

The main aim of this research is to recognize the possibility of actualizing the theoretical framework of constructing the dress realized in a previous research.

Therefore, the researchers formulated the research problem as, “How and in what ways can we explore the degree of actualizing the architected dress?” The complexity of breaking down the problem without having any predefined steps of progression required the problem to be categorized as an Ill-Structured-Problem (ISP). An ISP is a problem which has no clear path of progression and each consecutive step is dependent on the previously taken steps and its results (Simon, 1973). Hatchuel (2002) discusses the possibility of choosing between a set of alternatives in an efficient manner and identifies the necessity of progressing through ISP and the definition of a problem space. The research tries to identify the possibility of realizing the degree of actuality of a previously recognized theoretical framework by the case study of Senarathna (2016). The inclusion of a collection of dresses as artefacts makes this research a practice-led research as explained by Smith & Dean eds. (2009). Therefore, the interpretation of the artefact and its analysis creates the basis of this research (Mäkelä, 2007). As it is explained above, the method of progression; the interpretation of the artefact, is also realized with the construction of the ISP related to this research.

3.1. PROBLEM SPACE

Figure 1 shown below represents the created problem space for the ISP of this research. The problem space includes considerations and breaking down of the research problem in the initial stage.

Stage 01 has infinite possibilities. And methods of converging is used to make the possibilities finite and move forward in this research. At stage 02 the researchers need to gather information to select a single topic to progress in the practice led research. Stage 03 provides the starting point for the pragmatic realisation of the architected dress to communicate femininity.

4. Communication and Experience of the Architected Dress

A collection of designs by Senarathna (2016) was categorized into 3 sections on par with methods of architecting the dress. Each section is considered as one artefact. The considerations of the artefacts are two-fold; experience and communication. When analysing communication it looks into the holistic idea of communicating while expressing. In that sense it makes the dress understandable as communicating to the wearer and as communicating to the greater society. Figure 2 showcases the dresses considered in the research in its respective categories. Artefact 01 represents architecting the dress through layers, artefact 02; by adding volume and artefact 03; by adding elements.

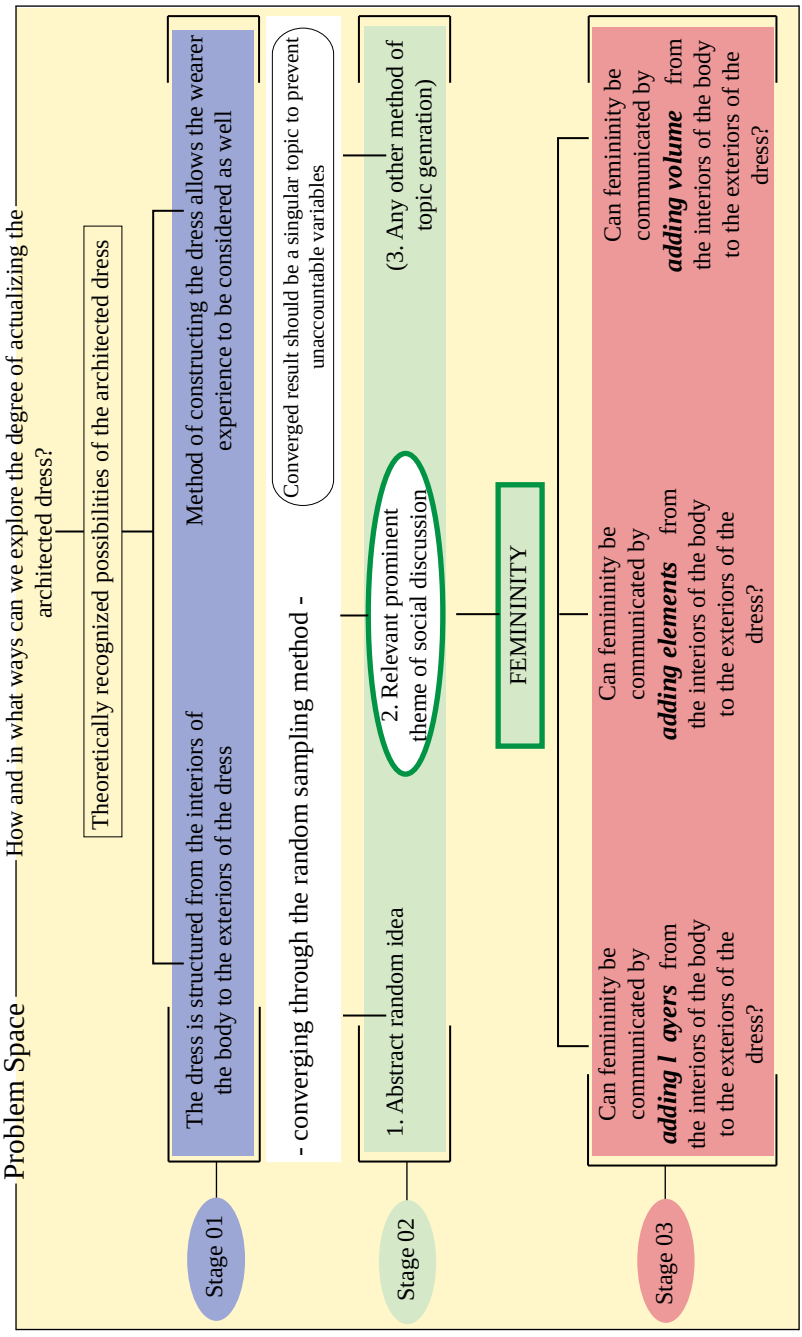


Figure 1, Research Problem Space

Figure 2, Artefact 01 – 03 *(Source: Senarathna (2016))*

4.1. EXPERIENCE AND COMMUNICATION OF MATERIAL, STRUCTURE AND COLOUR

The feel of the dress is the primary connection the wearer has with the dress. The way we feel affects our behavioural patterns and our movements (Davidson & Correia, 2002). Therefore the feel and the manner the structure of the dress feels upon the body plays a major role when the holistic wearer experience is considered.

The material has a blend of smoothness provided by the cords and an uneven feel created due to the knots of the layers in artefact 01. Artefact 02 mainly gives a soft and extremely light feeling against the skin from the used organza material. Yet the edging provides a weight and gives an extensive structure to the dress. Artefact 02 has contrasting methods of architecting with a similar top half and varying bottoms, soft and transparent organza and heavily knotted voluminous layers. Artefact 03 includes small macramé detailed patches placed around the waist and waist to knee length organza pleats with a contrasting hard edging.

The colours used in all artefacts are of variations of skin colour to dark maroon and the organza is a transparent white, which contrasts in colour as similar to the feel of the materials as well. In the case of the dress the fundamental and most prominent message to be communicated is individual identity. Dress is an aged-old medium of non-verbal communication which has a plethora of instances related to the communication of individual social standing and at times the resultant individual identity. For the viewer, as opposed to the wearer the most prominent and distinguishing element of the dress will be its colour. And as mentioned before the artefacts includes tonal colours of the skin and a contrasting white. The material colour achieves tonal differences through the knots and the depth of the placement of the layers.

4.2. FUTURE POSSIBILITIES OF ARCHITECTING THE DRESS

The created dresses as avant-gardes beginning from its conceptualization primarily creates benefit for future development. The point of connection of the dress to the body is the realized diagrammatic lines across the segregation points of the fashion figure. These lines while having a resemblance to the human proportions does not follow the muscle lines of the body in some instances. This at times results in an incoherence of the movements of the body and the attached dress. In an attempt to go beyond the idea of a ‘fit-on’ of the currently available dress, it becomes a necessity that the points of structuring, load bearing and connections of the dress to the body are able to additionally be systematic in inception, and must be coherently functional as well. It must be

mentioned that further breaking down of the afore-mentioned problem space will bring the creator and the researcher to the point of making the bodylines a requisite. Therefore, the researchers identify this as a consideration point for future progression.

Colour of the chosen artefacts plays within the area of tonal colours of the skin to reduce the amount of variables concerned for this research. The aspect of colour can be further explored.

5. Conclusion

The research explored the possibility of actualizing a previously recognized theoretical framework for architecting the dress. The research then aimed to define a problem space of the ISP. It was considered as an ISP due to the infinite amount of variables in its initial stage and the requirement of solving the existing stage to progress into the next stage.

The research proved that a required message can be communicated by architecting a dress. This message was selected as femininity for the purpose of this research. Through the research it came into light that the process of the complete research can be reiterated to understand further possibilities. The connection between a chosen idea of communication and its semiotics in relation to the wearer audience and the viewer audience should be used to further broaden the created problem space and as a result to converge the plausible variations of ideas that can be communicated through the dress.

The connecting lines of a dress to the body is the inception of the wearer experience. Coherence must be created with muscle lines for the better functionality of this. When a material feel such as smoothness is taken into consideration it can be expressed through opposite ideas such as smoothness of heavy materials and smoothness of lightweight materials. This creates an interesting platform for idea communication. The effect of colour of a dress to the wearer is an area that was not explored in this research and can be considered for future progression.

7. Acknowledgement

The researchers greatly thank the works of Senarathna (2016) which was submitted as the final year design project to the Department of Integrated Design, University of Moratuwa, under the topic “Creating a dialogue between body and dress”.

8. References

Craik, J., 1993. The Face of Fashion: Cultural Studies in Fashion. 1st ed. London: Routledge.
Davidson, J. W. & Correia, J. S., 2002. Body Movement. In: R. Parncutt & G. McPherson, eds. The Science and Psycology of Music Performance; Creative Strategies for Teaching and Learning. Oxford: Oxford University Press.
Entwistle, J., 2000. Fashion and the Fleshy Body: Dress as Embodied Practice. Fashion Theory, IV(3), pp. 323-347.
Hatchuel, A., 2002. Towards Design Theory and Expandable Rationality: The Unfinished Program of Hubert Simon. Journal of MAnagement and Governance, III(5).
Higgins, M. A. R. & Eicher, J. B., 1992. Dress and Identity. Clothing and Textile Journal, X(4), pp. 1-8.
Liyanage, P. & Hettiarachchi, S., 2016. Forming the Negative; Architecting the Space in Between. Moratuwa, Faculty of Architecture Research Unit, University of Moratuwa, pp. 398-412.
Miles, G., 2008. Skin & Bones: Parallel Practices in Fashion and Architecture. Los Angeles: The Museum of Contemporary Art.
Quinn, B., 2003. The Fashion of Architecture. Oxford: Berg.
Senarathna, D. L. S. C., 2016. Creating a Dialogue Between Body and Dress. Moratuwa: Department of Integrated Design, University of Moratuwa.
Simon, H. A., 1973. The Sturucture of Ill Structured Problems. Artificial Intelligence, IV(3), pp. 181-201.
Stets, J. E. & Burke, P. J., 2000. Feminity/ Masculinity. In: E. F. Borgatta & R. J. V. Montgomery, eds. Encylopedia of Sociology. New York: Macmillan, pp. 997-1005.
Tice, J., 2016. Nolli Map and Urban Theory. [Online]
Available at: http://nolli.uoregon.edu/urbanTheory.html
[Accessed August 2016].

Rajapaksha.U, et al (eds), 2017, "Design that cares"- multi disciplinary approaches to creating sustainable and meaningful built environment: *Proceedings of the 10th International Conference of Faculty of Architecture Research Unit (FARU), University of Moratuwa, Sri Lanka, (Vol. 01)* pp. 322-335 ©

TRANSFORMATION OF SINHALESE HAT AND HEADGEAR DURING MEDIEVAL PERIOD

BAKMEEWEWA. M.U[1] & MANAWADU. M.S[2]
Department of Architecture, University of Moratuwa, Sri Lanka
[1]*mihiribakmeewewa@gmail.com*, [2]*smaithama@uom.lk*

Abstract
From the ancient times, Sri Lankans had their unique way of dressing deeply influenced by their social system and culture. However, during the periods of South Indian occupation and colonial administration, there had been marked variations and witnessed a transformation in traditional costumes with the influence of alien cultures. Three colonial powers, namely Portuguese, Dutch and British, dominated the maritime provinces of the island well over four centuries, leaving behind remnants of their cultures for the Sri Lankan community. One of the most noticeable of them is the dress and more specifically, hats and headgears. In medieval times, hats and headgears had played a vital part in completion of the Sinhalese dress code and during this period, the hat or the headgear has been used to represent ones administrative rank, occupation, social states and caste. The kings had used a variety of crowns and headgears that signified their personal style and tradition, which have been influenced by both Buddhist and Hindu traditions. Colonial influences on hats and headgears have been first absorbed by the royalty and aristocrats, and then subsequently penetrated into commoners. However, one exception is that commoners had to strictly adhere to certain customary rules when wearing them. The purpose of this study is to identify transformation trends of hats and headgears, especially during the colonial period; and to access diverse foreign influences, which encouraged such changes. The allied information has been collected through examination of related artifacts, relevant historic records and visiting ancient temples, historical monument sites and museums.

Keywords: *Hats and headgears, foreign influences, tradition, design, transformation.*

1. Introduction

Clothing portrays a significant function in creating ones appearance. According to Ross (2008), by appearance, an individual announces their identity, shows their value, expresses their mood or process their attitude. The appearance of Sinhalese and their attire had changed throughout the civilization based on the living conditions, norms and traditions. Various influential factors had caused a differentiation on Sinhalese dress over the years. It is important to identify these influential factors along with the transformation trends occurred throughout the process. Moreover, it is essential to bridge them with modern day practices while conveying the magnitude.

The study setting of this research starts from the Anuradhapura, Polonnaruwa eras and extends through the colonial administrative period of Sri Lanka (16th century to 18th century). Existing literature indicates a scarcity of research into the subject area of studying this transformation. Though some information is available from secondary sources, they are fragmented, scattered and unauthenticated. As the direct information is unavailable, present research had to investigate the transformation of costume through examination of related artefacts and relevant historic records. Both locally available sources as well as international resources were used in the process. Observations were carried out with descriptive notes containing important features and details of relevant archeological materials, museum objects, photographs, sculptures and mural paintings. The secondary data were collected through accessing previously published books, archival materials, journal papers and research articles. The prime objective of this study is to identify the transformation trends of the hats and headgear in a formal setting.

2. Origin of hats and headgears

Clothes are considered as one of the basic needs of human beings. Over the years diverse clothing styles were formed amidst different groups of people based on their ways of living. Hats and headgears were created to fulfil the need of protecting the head. By definition, the meaning of the word hat denotes a shaped covering for the head worn for warmth, as a fashion item or as part of a uniform. The word headgear denotes hats, helmets, and other items worn on the head. Hats and headgears are and have been used to serve a number of purposes including protection, fashion, religious purposes, social convention and merit. The first evidence of a hat is found from an ancient painting found on a wall of a tomb in Thebes in Egypt, which belonged to 3200 BC. Additional evidence on hats and headgear can be found in artworks of ancient Rome, Greece and China. According to historians, hats and headgears have also been used to symbolize one's social status. In ancient Rome and Greece, the highest-level citizens had the privilege to wear hats and headgears and were offered with a hat upon achieving something.

In Europe, structured hats were not in women's fashion until the 16th century. Women had to cover their head by the church's demand with veils, kerchiefs, hoods, caps and wimples. In the 17th Century, women's' hats and headgear started emerging with wide brims, extravagant size and decorative ornaments. In the 18th century, imitation straws made from paper, cardboard, grass and horsehair, fabrics of cotton, silk, velvet and tulle along with ornaments made from ribbon, flowers, feathers and gauze trims were frequently used for hat making.

Indian Turban has been introduced to the English fashion in the 18th century. Sri Lankan attire similarly got inspired in numerous ways from Indian traditions. As explained by Coomaraswamy (1959), one thousand artisans were sent over in the Pandiyan princess's retinue who was the royal bride of king Vijaya. This group was consisted with a mix of goldsmiths, blacksmiths, brass-founders, carpenters and stonecutters. It is apparent that the Aryan influences on Sri Lankan crafts instigated with the assistance of these artisans. The Aryan influences shaped the Sri Lankan art and craft in the early civilization period of Sri Lanka. Moreover, "Bikkhuni Sangamitta" from India arrived in the country on a propagation mission of Buddhism. With her some royal family members and artisans including goldsmiths, potters and weavers came along, paving its way to a strong Buddhist foundation in Sri Lankan art and craft. However, Coomaraswamy (1959) explicates in his book, Mediaeval Sinhalese Art that, 'Mediaeval and modern Sinhalese art is essentially Indian art, but it is not modern Hindu, rather it is such an art as might have survived in some yet Buddhist part of the mainland, if Buddhism had not there been entirely merged in Hinduism.' A strong hold of the Indian traditions is attested during each phase of Sri Lankan civilization until the period of colonial administration.

3. Hats and headgears in Anuradhapura/ Polonnaruwa Periods

A gradual transformation of hats and headgears can be seen from Anuradhapura and Polonnaruwa periods to Kandyan period and then to Colonial era. The 'Sigiriya maidens' with their elaborated headdresses are an apt representation of aristocratic women in the 5th century. Their hair is arranged in a high up bun and the headdresses, which are in the coil form ornately adorned with precious and semi-precious gems and stones along with a combination of beautiful natural flowers. It is a famous custom that the women of the ancient times adorning their hair with beautiful flowers. The beauty of the ancient women was repeatedly conversed in ancient literature work. As mentioned in the *"Salalihini Sandesa"* the maidens' hair has been adorned with full-blown fragrant flower.

Figure 01: Sigiriya Frescos with elaborated headdresses *(Source: Chutiwongs, 1990)*

The sculpture of goddess "Tara" from 7th-8th century demonstrates strong artisanship and attention to detail. As indicated in the sculpture the headgear has been adorned with gems and stones with decorative carvings on it. The hair is tied in a bun and the coil-structured headgear is worn over the crown of the head. It can be assumed that the headgear is tied to the head with strings or ornamental ribbons. The Avalokithesvara Bodhisthwa sculpture found in late Anuradhapura period (8-9th century) is a bronze solid cast sculpture found during the excavations at Veheragala Sirisangabo Vihara. It is noticeable that the fine crown like head gear is adorned with gems and stones. These gem and stone studded headgears are an indication of the social status and the wealth of the wearers. Hence, it can be assumed that these sculptures have been provided with the highest social status applicable for the era.

Figure 02: Headdress of the sculpture of goddess "Tara"
(Source: National Museum Colombo)

Figure 03: "Avalokithesvara Bodhisathwa" Sculpture
(Source: Schroeder, 1990)

The headgear of the Shiva Nataraja sculpture, (12th century, Polonnaruwa) displays correlated niceties to Anuradhapura Period sculptures. The headgear is carved and adorned with gems and stones. One noticeable fact is that irrespective of the gender both male and female had adhered to an equivalent headgear style during the Anuradhapura and Polonnaruwa period.

Figure 04: Shiva Nataraja sculpture
(Source: National Museum Colombo)

4. Hats and headgears in the Kandyan kingdom during colonial occupation

The findings can be parted in to four major categories namely kings, elites, females and commoners. Each cluster has unique and different hats and headgear styles depicting their social hierarchy, occupation and caste. It can be observed that the most extravagant and prestigious design features are included in the aristocrats' categories while commoners ones are with very basic features.

4.1 HATS AND HEADGEARS OF THE KANDYAN KINGS

It is observed that the Kandyan Kings have used different types of crowns and headgears according to their personal inclinations. Furthermore, these personal choices had paved a pathway to create unique style and fashion among the elite community. Goonaratne (1995) explains that King Senerath had used three crowns made of gold, bronze and silver. According to Knox (1966) King Rajasingha II wore a gold crown at court ceremonies. However, he had always preferred wearing a cap instead of the crown. The King's golden crown has later been offered to Dodanwela Natha Devale after the famous battle of Gannoruwa, as a vow he made before the battle. Coodrington (1910) articulates about a small square hat of King Kirthi Sri Rajasingha, which is still preserved in Sri Dalada Maligawa. According to Davy (1821) the ordinary dress of King Sri Vikrama Rajasingha has been consisted of a high four-cornered cap of a particular form and ornamented with tussles. He also states that the royal throne has been made of plated gold and ornamented with precious stones. However, the golden crown has been worn occasionally and a cap has been substituted for general occasions.

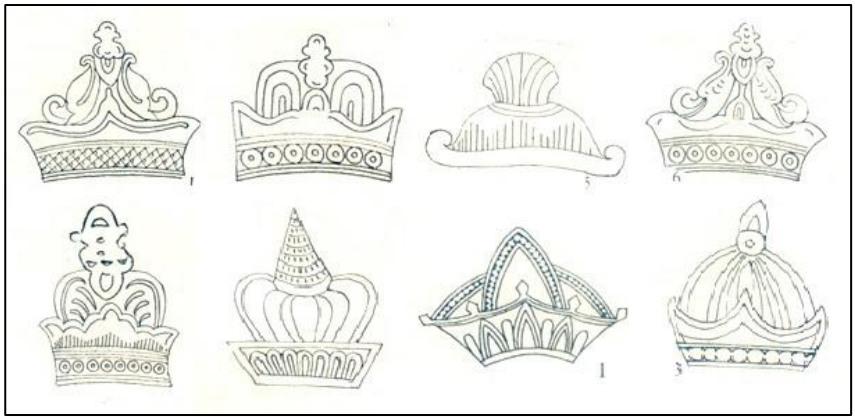


Figure 05: Different crowns of Kandyan kings, *(Source: Manjusri, 1977)*

4.2 HATS AND HEADGEARS OF THE ELITE

The elites had used a variety of hats namely the four-cornered hat (‘*hataramulu toppiya’*), the eight-cornered hat (‘*atamulu toppiya*’), the white round hat, the conical cap and the Jagalat thtoppi. According to Coomaraswamy (1959) the chieftains and palace officers wore a four cornered hat (‘*hataramalu toppiya’*) with a tassel (‘*boralaya*’) instead of ‘*mal-gaha’*. A wavy white frill around the top of the hat was reserved to royalty and adigars. Inferior officers wore a round hat (‘*vata thoppiya*’) and Codrington (1910) confirms that the white round hat was a part of the state officers’ dress.

The Jagalath hat has been introduced to Kandyan chieftains during the period of King Vijaya Raja Sinha. Codrington (1910) states that the word ‘*jagalath*’ must be derived from the Tamil word ‘*sakalattu*’ meaning the thick bright red cloth. Moreover it is possible however that the square hat may be a development of the ‘*jagalat toppiya*’. The conical hat is a country cap, in which two flaps tied up over the top of the crown. According to Coomaraswamy(1959) this could be the ‘*Ispayya*’ hat. Ispayya hat is an embroidered cap with quilted flaps, worked with colored silk. Codrington (1910) explains that King Narendrasinha’s officers wore these conical hats, with the bottom turned up all round. However, as clarified by Coomaraswamy these hats were no longer worn and they have been out of fashion in the 18th Century.

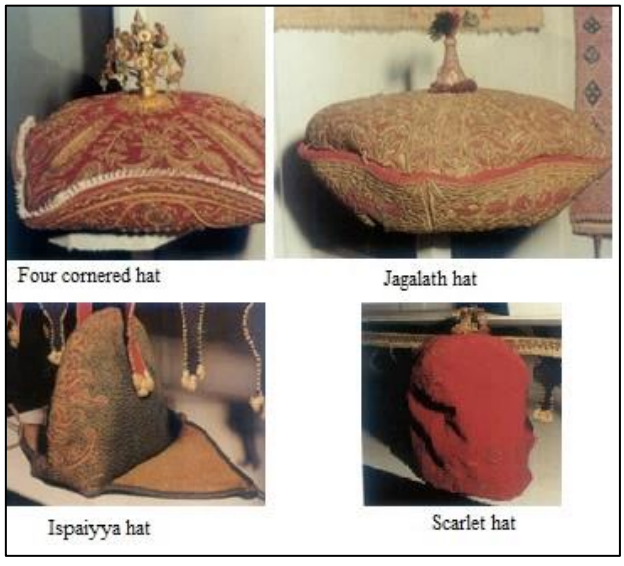
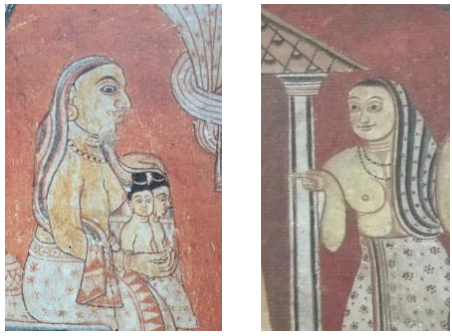


Figure 06: Different elite hats in Kandyan kingdom *(Source: Wimalaratne and Gomes, 2001)*

Figure 07: White round hat- Mural paintings of Madawala Vihara *(Source: Chutiwongs, Prematilleke and Siva, 1990)*

4.3 HATS AND HEADGEARS OF THE KANDYAN FEMALES

Rudimentary changes can be observed in the dress code of the native queens and noble women. As noticeable in the Kandyan period mural paintings, a kerchief *('lansoluwa')* was introduced to the women's fashion. This has been used to cover the head. Unlike the *mottakkiliya*, the *lansoluw*a only covers the head and the upper part of the body. The *lansoluw*a signifies connections to the South Indian fashion.



Mural paintings of HindagalaVihara
Figure 08: Lansoluwa in different Kandyan period mural paintings
(Source: Chutiwongs, Prematilleke and Siva, 1990)

Hair ornaments have been highly used to decorate and arrange the hair buns of Kandyan queens and elite women, which have been decorated with gems, pearls and precious stones. These hair accessories are noticeably shown in Kandyan period mural paintings.

Figure 08: Hair pins- Mural paintings of Suriyagoda Vihara
(Source: Chutiwongs, Prematilleke and Siva, 1990)

Based on the observations on the mural paintings, it can be assumed that the elite women were the only group who were privileged to use kerchiefs and hair accessories. The common women had mostly tied their hair in a simple bun without any hair ornaments.

4.4 HATS AND HEADGEARS OF THE COMMENERS

The common males mostly wore turbans which have been an influence arrived from south India; also some wore conical caps based on their occupation. Soldiers have worn the conical hats inspired by European military fashion. As depicted in Kandyan period mural paintings, '*lascogin'* soldiers had worn conical shaped hats.

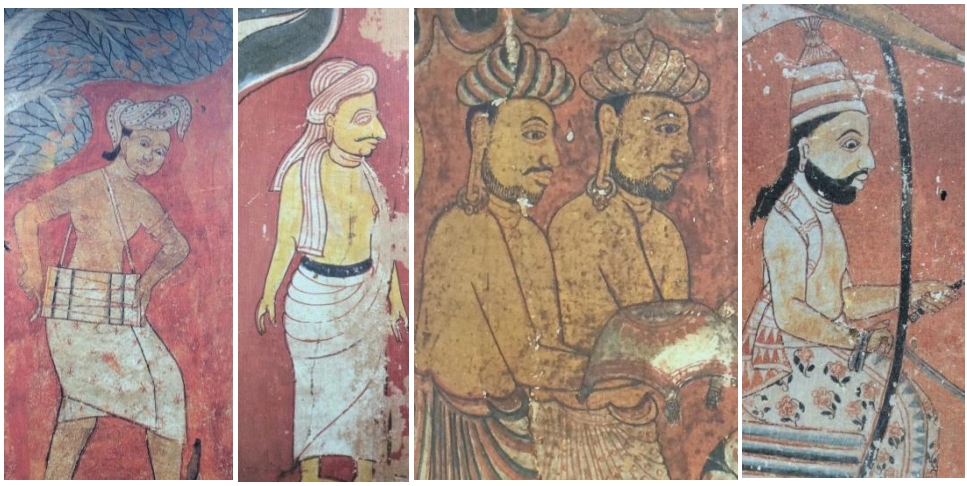


Figure 09: Commoners wearing turbans and conical shape hats - Mural painting of Hindagala, Suriyagoda and Ridi Vihara
(Source: Chutiwongs, Prematilleke and Siva, 1990)

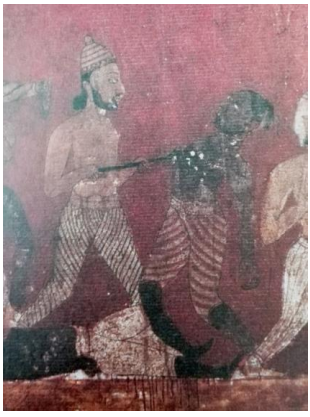


Figure 10: A Soldier in a conical hat- Mural painting of Hanguranketha Vihara
(Source:Chutiwongs, Prematilleke and Siva, 1990)

Figure 11: Lascogin soldiers wearing conical hats- Mural painting of Hanguranketha Vihara *(Source:Chutiwongs, Prematilleke and Siva, 1990)*

5. Hats and headgears in Low country during colonial occupation

Fewer interventions on headgear are perceived in the Low country regions compared to the Kandyan kingdom. The coastal parts of the country were invaded by the three colonial powers, Portuguese, Dutch and British over for four hundred years. During this period of time the colonial attire progressively influenced the native way of dressing. These variations were first absorbed by the king, then to the aristocrats and later subsequently penetrated to commoners. The shell comb was an imperative addition to the low country commoners' dress code. According to Wimalaratne and Gomes (2001), the comb was an endearing Dutch influence on dress. This had established itself after the insistence of Dutch women that if their male servants decided to wear their hair long, then they should neaten up it with a comb. Another opinion on the origin of the shell comb is that initially the native headmen used it as a demarcation of rank and, gradually the tradition had been penetrated to commoners. Out of these two opinions, it can be assumed that the second opinion must have been happened since the penetration usually starts from aristocrats.

Two types of combs can be identified namely the horse shoe shape bent head comb ('*Nami Panawa'*) and the upright comb ('*Kelin PanawaI'*). These combs have been made with tortoise shell and have been covered with intricate engravings. As stated by Deraniyagala (1939) Sri Lanka had been a main exporter of the tortoise shell to the ancient wealthy Romans, who used tortoise shell as a luxury item.

Figure 12: A Low country Sinhalese with a comb
(Source: Tennent, 1996)

Figure 13: A noble man wearing both upright and bent combs
(Source: The Sunday Times, 2015)

6. Social hierarchy depicted from hats and head gears

The ethnicity and the caste structure played a vital role in the formation of the dress culture of ancient Ceylon. As explained by Tillakaratne (1986) Caste, '*kula*', constituted the structural basis of Sinhalese society during the Kandyan period, as it had also been in earlier times. It is seen, in spite of the fact that it rested mainly on secular foundations, the institution of caste held control in the Sinhalese social set-up through centuries. Wimalarathne and Gomes (2001) state that in ancient Lanka, dress served to oppress or empower by virtue of wearer's caste status. According to the caste structure and the social hierarchy, the native dress code has been differentiated in terms of design, materials used and by the method of wearing it. The king who was considered to be the most perfect had the most fabulous dress code with elaborate decorations as he depicted the power and the status of king ship. The officials in different ranks as well had their separate dresses to depict their social status. The common tenants according to their caste order had their way of dressing highlighting the social ranking. (Coomaraswami, 1979)

According to Wimalarathne and Gomes (2001) Weather or not the upper half of the body is covered, the length of the cloth worn and the color of the cap donned were the symbolic determiners that defined the social hierarchy. Few different kinds of hats have been used in the Kandyan kingdom, and each of these hats varied in its shape, color and the material while symbolizing the hierarchical differentiation. Davy (1821) articulates that the eight corned hats were presented to adigars, four cornered hats to *disawas* and *Karupuss toppi* or white round hats were presented to *dukgannaralas* based on their administrative hierarchy.

The soldiers wore conical hats and the commoners mostly wore turbans. The Kandyan aristocrats were well attentive about their dress code. D'Oyly (1975) states that the '*adhikaramas*' also had a right to certain exclusive items of dress, which they jealously guarded against infringement. Hence, the commoners had to strictly act upon the customary rules decreed by the royalty based on their caste and occupation.

Figure 14: The King and his noble men, *(Source: D'Oyly,1975)*

The colonial power had spread upon the native administration officials including the king. The Dutch administrative system was systematic and powerful when compared to Portuguese. The Dutch first established an administrative system in the Maritime Provinces of the island, which they had ruled. Anthonisz (1929) states that the Dutch turned their attention to the establishment of a proper civil government and to the administration of justice among the people whom they found within their territory, mainly the Low-country Sinhalese. The head of the Dutch administrative pyramid was the Dutch governor. While their members hold the main responsibilities, The Dutch gave the authority to the native headmen to administer small geographical units. As explained by Wagenaar (2016) the third, outer region was the rural area under the direct authority delegated to the '*disawe*'. This high official was always a European and he always stood at the pinnacle of the administrative pyramid, with the higher and lower level indigenous headmen below him. The native headmen had a uniform, which was a mix of European and Sinhalese dress etiquettes.

Figure 15: Pilimatalava Adigar and General MacDowal at their meeting in Kandy. A Low country headman is present at the background.
(Source: Department of National Archives, Sri Lanka.)

7. Discussion

The ornamental headgears with coil structures of Anuradhapura Polonnaruwa period depicts influences from Aryan and Buddhist traditions. Sri Lanka was invaded by foreign nations and enormous impacts ascended throughout the period of the South Indian kings. Moreover, the South Indian traditions continued longer with the tradition of having a South Indian royal princess as the king's royal bride. Additions on the Sinhalese queens' attire such as '*mottakkiliya*' and '*lansoluwa*' were direct adoptions from South Indian queens' dress code. Similarly, the South Indian possessions on Sinhalese art, design and culture is noteworthy. It can also be observed that an enormous amount of colonial influences is immersed in Sinhalese traditions. The shape, design and the materials used in the Sinhalese king's crown had reformed with respect to European fashion. The simple coil structured king's headgear from the Anuradhapura Polonnaruwa period had transformed in to a completely enclosed crown. In the same way, the elite and commoners' headgears had changed in to round and conical shaped hats and shell combs were familiarized among the low country Sinhalese during the colonial occupation.

8. Conclusion

Hats and headgears have first originated as a utility tool yet; it had altered itself to a significant feature of modern day attire over the years. The hats and headgears evolved based on diverse factors such as climate, way of living, tradition and perception. Sri Lankan hats and headgears got inspired from Aryan, Buddhist, South Indian and Colonial traditions chronologically.

The crafts replicate the advancement of creativity of the artisans and some art forms are being practiced until present. In ancient times, fashion was for the well privileged. Hence, the alien influences were first absorbed by the royalty and then trickled down to commoners. One's hat or headgear was worn as a representation of his or hers social hierarchy, occupation and caste. Political, economic, religious, social and geographical factors lend a hand on the transformation trends of costumes. It can be witnessed that the shape, materials used and the designs of the hats and headgears have transformed with reverence to the foreign influences. The observed ancient practices on art and craft still prevails in some parts of the country and in aid of developing in to contemporary design concepts bridging past and future.

9. References

Amarasekara,M, 2000, Ancient Sinhalese dress, M.D Gunasena and Cooperation. Colombo.

Anthonisz, R.G, 1929, The Dutch in Ceylon, C.A.C. Press, Colombo, Ceylon.

Chutiwongs.N, Prematilleke.L, and Silva. R, 1990, Paintings of Sri Lanka, The archaeological survey of Sri Lanka, Colombo.

Codrington,H, W, 1910, Notes on Some of the Principal Kandyan Chiefs and Headmen and Their Dresses, H.C Cottle, Government Printer, Ceylon.

Coomaraswamy, A.K, 1956, Mediaeval Sinhalese Art, Museum Publications, Sri Lanka.

D'Oyly, J, 1975, A Sketch of the Constitution of the Kandyan Kingdom, Tisara Publications, Dehiwala.

Davy, J, 1821, An Account of the interior of Ceylon, long-man, hurst & co., London.

Deraniyagala, P.E.P, 1939, The Tetrapod reptiles of Ceylon, Colombo Museum, Colombo.

De Silva, A.V, 1952, Ceylon Ancient History, Colombo Museum. Colombo.

De Silva,D, 1995, Life cycle rituals among the Sinhalese, Colombo Museum, Colombo.

Goonaratne, B. 1995, The Epic Struggle of the Kingdom of Kandy, Argus publications, London.

Knox, R., 1966, Historical Relation of Ceylon, TissaraPrakasakayo, Dehiwala.

Manjusri, L.T.P, 1977, Design elements from Sri Lankan temple paintings, Archeological society of Sri Lanka, Colombo.

Ross, R, 2008, Clothing: A global history, Policy Press, Cambridge.

Schoreder, U.V, 1990, Buddhist Sculptures of Sri Lanka, Visual Dharma Productions, Hong Kong.

Tennent,J.E, 1996, Ceylon: An Account of the Island, Asian Educational Services, New Delhi

The Sunday Times, 2015, When our ancestors turned heads, 07th June

Tillakaratne, M.P, 1986, Manners, Customs and Ceremonies of Sri Lanka, Sri Satguru Publications, India.

Wagenaar, L, 2016, Cinnamon and Elephants, Rijksmuseum, Amsterdam.

Wickramasinghe, M, 1993, Dress and Ornaments in Ancient Ceylon, Thisara Publications, Dehiwala.

Wickramasinghe, N, 2003, Dressing the colonized body, Orient Longman Private Limited, India.

Wright, A, 1907, Twentieth century impressions of Ceylon, London Durban Colombo Perth (WA)/ Lioyd's Greater Britain.

Rajapaksha.U, et al (eds), 2017, "Design that cares"- multi disciplinary approaches to creating sustainable and meaningful built environment: *Proceedings of the 10th International Conference of Faculty of Architecture Research Unit (FARU), University of Moratuwa, Sri Lanka, (Vol. 01)*pp. 336-348 ©

GOOD READING LIGHT: VISUAL COMFORT PERCEPTION AND DAYLIGHT INTEGRATION IN LIBRARY SPACES

SWARIS, W.D.N.P[1] & PERERA, N.G.R[2]
[1,2]Department of Architecture, University of Moratuwa, Sri Lanka
[1]*nirma_swaris@yahoo.com*, [2]*nareinperera@gmail.com*

Abstract
Daylight creates an ambience of quiet tranquillity and visual comfort to link the modern library user, psychologically, with the space they occupy. In order to provide comfortable and glare-free light in reading spaces, volumes and surfaces illuminated with natural light have played a significant role. There should be optimum natural light which provides comfort for the user, albeit without the negative aspects of glare and heat. We Focus on 'Good Reading Light': Visual Comfort Perception and Daylight Integration in Library Spaces. Research problems evaluate the 'Perceived Reading Light Level', why and in what way daylight should be integrated into the indoor environment in a library space, to realize light-related goals of visual comfort. The research method consists of two parts; the Reading Light Test and the Perceptual Spatial Analysis (PERCIFAL). A group of twenty architecture students were surveyed for both components. The results show that Visual Comfort Perception depends on strategies adopted for daylight integration and that most reading spaces were perceived to be over lit. Conclusions drawn highlight that top lighting strategies and a combination of clerestory and side lighting are more effective than only side lighting via windows - as daylight control in public library spaces are difficult.

Keywords: *Visual Comfort Perception, Optimum Reading Light, Daylight Integration, Library Spaces*

1. Introduction

Defining Good reading light is difficult as people have perceptions, thus should be considered when integrating daylight into design. As Steany (2011) describes different visual tasks as;

- Casual seeing in order to navigate space or communicate with others.
- Concentrated seeing – seeing and thinking, reading, discriminating fine detail (need for few distractions, desire to define visual territory).
- Looking but not seeing (daydreaming, inwardly reflecting).
- Looking to find something: scanning the visual field and then locating an object within it (browsing).

We focus on the concentrated seeing aspect of the different visual tasks. The aim of library lighting strategy is to provide good reading light to create an intimate space for the reader, most importantly while catering to the visual

comfort perception. To design for daylight, it is imperative that we know the optimum reading light for the visual comfort of the reader and how it affects the user psychologically. Comfort of the reader depends on the cultural and social aspects which are interrelated to the context as well as user's psychology. Thus, the use of light and its effect on user psychology in library buildings is an essential focus. The study limits its primary user to students and library typologies in Sri Lanka.

The research questions that arise are;

1. What is the 'Perceived Reading Light level' – in Library spaces?
2. Why and in what way should daylight be integrated, for the indoor environment, in library spaces, to realise light-related goals of visual comfort?

Within this purview we pursue the following research objectives and outcome;

- To identify the visual comfort parameters for daylight integration
- To examine daylight in Library spaces and the impact on user's visual comfort.
- To examine the need for daylight through its quantitative contribution to the total illuminance and quality.
- To ascertain the 'Perceived Reading Light level' in library spaces in Sri Lanka.
- To develop design strategies and implications for daylight integration in library spaces.

2. Background

2.1 LIGHT AND COMFORT LEVEL

Visual comfort is intrinsically related to light, to light's interaction with architectural space, the properties of materials employed in forming the spatial membrane, and the elements placed inside for human inhabitation. (Lushington, Rudorf, & Wong, 2014). Creating a vision not only involves physiology but also psychology. Visual perception more than a visual task which is influenced by psychological process.

Physical comfort level

Physiological reactions in man to electromagnetic radiation outside the range of 380-780mm, where our visual system responds (Kronqvist, 2012). Light has a strong influence on circadian rhythms from short wavelengths and bright light (Cajochen, Zeitzer, Czeisler, & Dijk, 2000; Jung, et al., 2010). As Berman (2000), stated the sensation of brightness in an interior is dependent on both cone and rod receptor activity in the retina, and the scotopically enhanced

illumination will be perceived as brighter. As Cohen and Cohen (1979) states; library study areas where reading light is important should avoid dramatic lighting; an even lighting pattern is best to minimize glare, which may distract some readers (as cited in Mohanty, 2012).

Psychological comfort level

"But light does not only serve to render spatial bodies three-dimensionally, it is an excellent means for controlling our perception on a psychological level" (Ganslandt & Hofmann, 1992). Light setting effect of the emotional state and also influences cognitive performance and improves behaviour (Baron, Rea, & Daniels, 1992).

Yet, the standards and recommendations that guide general lighting practice bears no sensible relationship to providing for human satisfaction (Cuttle, 2011). As an example, illuminance standards define light levels for reading tasks, but when it comes to real world readers prefer less or more light level because of psychological comfort. According to (Fridell Anter, 2014), user psychology is affected on adaptive visual comfort and lower illuminance levels produced better emotional responses in order to adaptive standard light level well below the recommended light level. "Physical parameters relating to objects are influenced, at the perception stage, by the physiological response of the human visual system and, in addition by the psychological aspects of human learning, pattern, culture and tradition" (CIE, 2006 as cited in Fridell Anter, 2014). As it says psychological comfort level differ one not only one region to region but also one person to another.

Adaptation

Boyce (2014) notes a massive range of luminance can be handled by the human visual system. When there is much higher luminance it emerges as bright, whereas appearing as a dark shadow over much lower luminance. We can experience Architecture with our senses including vision. It is a responsibility of Architects to design spaces giving the ability for users to communicate with relative ease and comfort - albeit thermal, aesthetic or luminous. The ability of users to adapt, drastically change as users transit from the inside to the outside space. The human eye has physical, photochemical and neural mechanisms for the adaptation to changing light conditions (IESNA, 2000; Araji, 2008; Boubekri, 2014).

2.2 READING LIGHT AND DAYLIGHT INTEGRATION IN LIBRARY BUILDINGS

Reading is the main function in a library. Although libraries become digital still and forever reading never dematerialize. 'Good Reading Light' always makes

the reader alive and keep the connection with the book. Lighting is the main stimuli which makes the reader visually comfortable. Recommended light levels all over the world do not always cater the human perception. Daylight is the main source of light which is healthy, naturally attractive and productive. Daylight Integration also plays a major role in visual comfort.

Good reading light

Louis Kahn stated "a man with a book goes to the light. A library begins that way." (As cited in Shih, Liou, & Johanson, 2010). The problem of reading is more than a problem of the eye; a good reading light permits the use of many positions of the human body and every suitable relation between book and eye. Reading a book involves both culturally and physically a strange kind of concentration; the duty of the Architect is to eliminate all disturbing elements. (Alto, 1985. as cited in Steany, 2011)

"Boyce (1979) found that the most preferred form is to provide a uniform illuminance in a surrounding area of about 1 m2 and lower illuminances outside that area, since having high illuminances immediately outside the working area resulted in distraction and irritation. Another problem concerns the desk surface reflectance, relative to the reflectance of the task materials. Many studies analyses this aspect: Touw (1951) found that the preferred luminance ratio (desk/paper) was 0.4. Wibon and Carlsson (1987) studied the effects due to a repeated movement from a low luminance surface to a higher one, as it happens when watching a computer monitor and a piece of paper. The results showed a marked increasing in eye discomfort for a luminance ratio greater than about 15:1" (as cited in Carli, De Giuli, & Zecchin, 2008).

Achieving good reading light in library building is achieving visual comfort through daylight integration. Good daylight application, leading to a more pleasant surroundings of a higher quality.

Daylight in Library Buildings

Traditionally, using natural light or daylight in lighting up buildings has been a desirable feature and a hallmark in defining good building designs. Skilful daylight integration generates an setting of quiet contemplation and visual comfort, associating the modern library user psychologically with the pre-technological past. Striking library spaces have been enhanced by volumes and surfaces illuminated with natural light, creating glare-free light in reading spaces for centuries. (Dean, 1998).

Daylight impact on Reading

Lighting is the main concern in a public Library owing to the activity of reading. Daylight is natural and free resource and daylight situates a way of

life, enabling the occupants of a library to become a community of readers, therefore natural light is the basis for good reading light (Steany, 2011). The light in a library must be adequate for the user when reading a book. Enough light energy is the first important requirement to make the information on the area of the page or the information on the book readable. Therefore the light density or intensity on the reading surface must be an optimum amount (Dean, 1998). Generally, people favour variable light in the form of daylight and the link it provides to the natural setting. Maintaining constant light levels is important in libraries for the visual tasks in order to avoid distractions and inadequate lighting due to short term variability. This can be achieved by electric light fixtures to deliver a static level of comfortable light, in harmony with the available daylight.

Understanding the physical properties of daylight is needed prior to day lighting design. Knowledge on the media of energy through which daylight enters to a building is required for controlling and tailoring the daylight in lighting the library spaces. In order to avoid glare and excess heat gain careful manipulation and limitation of daylight is required. In using daylight, modifying aperture designs to diminish solar heat gain while attaining the illuminance levels is essential for visual acuity.

3. Method.

The research method adopted comprises of two parts; the Reading Light Test and Perceptual Spatial Analysis: PERCIFAL. (Figure 1.). The survey is conducted using a focus group of 20 students from the Architecture programme

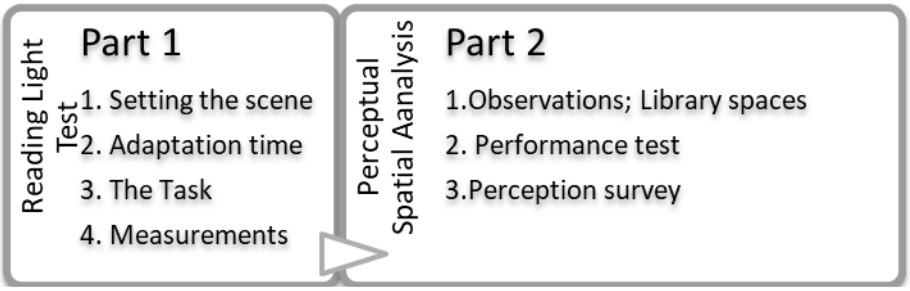


Figure 1. Research Design. (*Source-Author)*

at University of Moratuwa (UoM). The same subjects participate in both components and at the three selected Libraries used as case study sites. The UoM, University of Kelaniya (UoK) and British Council Library (BCL).

The objective selecting a focus group is such that the comparison of the selected case studies are deemed more valid with the neutralisation of much of the background differences - thus perceptions - of the test subjects.

3.1. PART 1

This component of the method adopts the 'Reading Light Test'. A detailed discussion of the process is found in Fridell Anter (2014) and the application of it in relation to this study in Swaris (2016). In this test, subjects are asked to use a dimmer on a reading lamp to choose the light level they prefer. The task is to read a book which was chosen for its general demands on vision. We identify the 'Perceived Reading light level', analyse perception on 'Good Reading Light' and ascertain user responses to lighting design using a questionaire, as utilised in Säter (2011). (Figure 2.) The test setting was the Library of the UoM.

Questionnaire 1; Test person's form to fill in

Date Subject No.

Personal data
Name:_____
Email:_____
Phone:_____

SUBJECT INFORMATION
Gender: Male / Female Age: _____
Known / actual vision problems?
_____

Do you wear glasses or contact lenses when you read?
Yes ☐ No ☐

Do you wear glasses or contact lenses during the experiment?
Yes ☐ No ☐

Is your glasses / lenses tinted?
Yes ☐ No ☐

If so, how? (Describe in your own words)

1. **How do you estimate that you are sensitive to strong light?**
Unusually unusually
Insensitive sensitive

2. **Please tick the description that best fits for you**
- Experiencing very often problems with strong light ☐
- Experiencing quite often problems with strong light ☐
- Rarely experience problems with strong light ☐
- Never experience problems with strong light ☐

3. **How do you estimate that you see in the dark?**
Unusually unusually
Well badly

4. **Please tick the description that best fits for you**
- Experiencing very often problems with low light ☐
- Experiencing quite often problems with low light ☐
- Rarely experience problems with low light ☐
- Never experience problems with low light ☐

5. **Overall, in everyday life: Is it easy or difficult to make up your mind?**
very easy very difficult

Questionnaire 2; Final questions to test person

1) When you sit and reading in everyday situations, do you usually adjust light level? How?
2) Can you describe what you think is a good reading light?
3) Do you think you would have set a different light level than the currently selected if you were reading another hour?
4) Did you think it was easy or difficult to decide which light level you would set?

very easy very difficult

Figure 2. Questionnaire 1 and 2. (*Source- Säter, 2011)*

3.2. PART 2

3.2.1 Case Study Selection

We select three case study libraries encompassing varying daylight integration strategies as elaborated below;

1. UoM – Side lighting strategies: Windows
2. UoK– Top lighting strategies: Saw-tooth roof
3. BCL – Side lighting strategies: combination of clerestory windows and side windows

3.2.2. Observations / Mapping the selected library space

We map the spaces by identifying Reading spaces (select 20 observer positions for 20 student participants). Next we identify daylight integration method adopted for reading purposes.

3.2.3. Performance test

Empirical and simulation methods are utilised to map the ambient light conditions, as opposed to daylight factor analysis.

Illuminance level mapping: at the selected points, we measure the horizontal and vertical illuminance level on the task plane (Reading desk) utilising a hand held lux meter. Each individual point is mapped according to a grid then analysed to generate the lux distribution. We augment these measurements with a simulation software LightUp, generating isolux contour plots to establish the ambient illumination level. The results are shown in Table 2.

3.2.4. Perceptual Spatial Analysis: PERCIFAL

We survey the user perception through a questionnaire - PERCIFAL: Visual analysis of space, light and colour - which includes perceptual questions in a semantic scale. (See Barbara et al, 2011). The primary areas covered are as follows;

1. Spontaneous total experience of the space
2. Light level
3. Light distribution
4. Shadows
5. Light patches
6. Specular reflections
7. Glare
8. The colour of light
9. Surface colours
10. Visual perception of objects, people and text

4. Results and Discussion

4.1 PERCEIVED READING LIGHT LEVEL

Preferences for ‘Good Reading light’ are daylight, glare free, warm-white, uniform, diffuse light and which provide visual comfort. “Natural light is therefore the basis for good reading light” (Steany, 2011). A good balance of daylight and visual comfort provide ‘Good Reading Light’.

Table 1. Shows the summary of the test, generating an overall 'perceived good reading light' level of 300lux on the book surface. According to IESNA (Illuminating Engineering Society of North America), standard light level for reading tasks in libraries is 500 lux and National Lighting Code India, it is 150-300lux, while the Energy Efficient Building Code (Sustainable Energy Authority, 2009) for Sri Lanka specify as 300+ lux. Thus, the test findings fall within the lux levels specified in the codes for the Asian region, yet differ largely from those specified by the IESNA. This bodes well for both for the applicability of the local codes as well as for overall energy efficiency in the ability to provide almost 200lux less while maintaining user satisfaction. The task at hand is to provide 300lux on the reading surface by daylighting strategies alone.

Table1. Reading Light Test - Illuminance Levels (Source: Author)

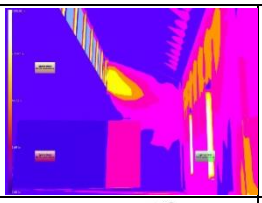
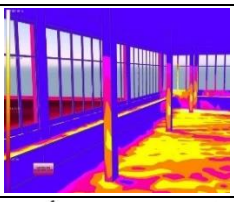
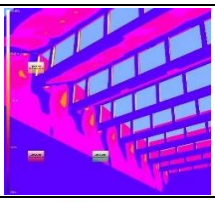
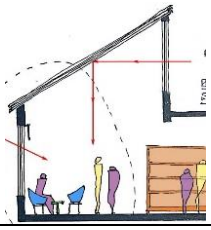
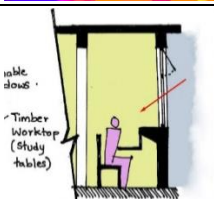
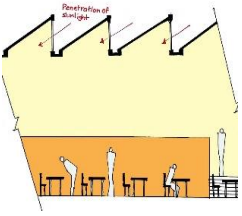
	Mean	Min	Max
Mean chosen illuminance on the table	177	98	305
Mean chosen illuminance on the book	297	168	430
Perceived Reading Light level: 300 lux (Approximately)			

The perception survey on 'Good Reading light' reveals that balanced light is always preferred. Results show that although low light can be endured, too strong light cannot be tolerated by most users.

4.2 PERCEPTUAL SPATIAL ANALYSIS: "PERCIFAL"

Table 2. Case Study Results (Source: Author)

	BCL	**UoM**	**UoK**
Daylight Integration	Side lighting strategies	Side lighting strategies	Top lighting strategies
Design	Clerestory windows and side windows	Windows	Saw-tooth roof
View			
Horizontal light level (ambient) on the reading plane	1200 lux (exceeds standard illumination levels)	1000 lux (exceeds standard illumination levels)	300 lux (meets standard illumination levels)

LightUp's Lux Contours			
Section			
Visual comfort Perception	Encoraging for reading More concerning space for reading Good light Great ambience Spacious Live Calm Full of daylight	Too bright/bright Well lit up Feel awake Comfortable Unattractive Calm and quiet Undisturbed view Not relaxing Good light for reading	Intersting space Lower light condition Empty Dead atmosphere, Maze Inactive and Gloomy Agitate Feel the volume because of the height and light Spacious
Conclusion	Most comfortable	Less Comfortable	Least Comfortable

According to Part 1; Reading Light Test, the 'Perceived Reading Light' level is 300 lux (approximately). Light levels on the reading plane selected case studies are BCL; 1200 lux, UoM; 1000 lux and UoK; 300 lux. BCL and UoM are over lit considering Perceived Reading Light level. But Light level is not only factor based on Visual Comfort.

Visual Comfort Perception is based on several parameters such as Illuminance, Glare, Luminance ratio, Reflectance and Brightness, Colour rendering and Colour of light, Modelling, Daylight factor, Light distribution, Direction of light and shadow. Table 3. Summarises the survey results of the selected case study library spaces.

Table 3. Perception Survey Summary. (Source Author)

Visual Comfort Parameters	**BCL**	**UoM**	**UoK**
Light Level	Adequate	Too bright	Adequate
Horizontal light distribution	Even	Moderate	Uneven

Vertical light distribution	Moderate	Moderate	Moderate
Shadows	No Contrast	No Contrast	No Contrast
Light patches	No Contrast	No Contrast	No Contrast
Specular reflections	No	Moderate	No
Glare	No	Yes	No
Surface colour	Cool	Warm	Cool
Surface colour: Distribution	Coherent	Varied	Varied
Surface colour: Contrast	No	Moderate	No
Visual perception: Object	Enhance	Moderate	Impede
Visual Perception: Text	Greatly Facilitates	Facilitates	Facilitates

In comparison UoM library reading space is effected by glare, which is caused by direct sunlight through east and west facing windows. Although the UoK reading space has diffused daylight through the saw-tooth roof form, thus devoid of glare, subjects prefer the UoM space due to the low lighting and non-uniform illuminance within the space. Due to the glare free and uniform diffused daylight, the BCL reading space is preferred. The BCL library reading space which utilises side lighting strategies with clerestory windows is perceived as the most comfortable. The space was evaluated as the brightest. Neither glare or nor specular reflections is perceived. Surface colour (white) with the combination of daylight was described as cool, which is advantageous to concentrate on reading, is soothing, has a sense of uniformity, provides a spacious impression, and excellent colour correlation due to daylight. The space has coherent surface colour distribution. Thus, compared to UoK and UoM, the BCL lighting condition, is deemed to greatly enable the function of reading.

Visual Comfort perception depends on design for daylight integration. Mostly reading spaces are over lit as Perceived Reading light is 300 lux. To increase the effective use of daylight and increase visual comfort top lighting strategies and combination of clerestory and side lighting are appropriate than side windows as daylight control is difficult (but not impossible) to effect visual discomfort.

5. Conclusion

The Formulated research problems seeks to understand – what is the ‘Perceived Reading Light level’ and why, and in what way should daylight be designed for the indoor environment in library spaces to realize light-related goals of visual comfort?

The objectives of this research were to identify the visual comfort parameters, study design strategies used in daylight integration in library buildings, determine the ‘perceived reading light level’ in a Sri Lankan context, analyze

daylight in library spaces and the impact on user's visual comfort, and examine the need of daylight through its quantitative contribution to the total illuminance and quality.

Reading is the main function in a library. Although recently libraries have increasingly become digital, the emphasis on books and reading still endure. Good reading light keeps the reader feel alive and enhances the connection with the book. Lighting is the main stimulus that makes the reader visually comfortable. Recommended light levels in the world do not always cater to human perception in a particular setting.

Reading light test, 'Perceived Reading Light level,' is approximately 300 lux. This quantum illumination corresponds to standards such as the EEBC of Sri Lanka, yet is below the standard set by the IESNA. Further, a majority of the subjects were sensitive to strong light yet rarely experienced problems with low light. Thus, the task seems to be to control the excess illumination in a space.
There are several ways of integrating daylight with design to achieve visual comfort from a good reading light source. Controlling the daylight is a main concern in design. It is relatively easy to get daylight into a building – given the daylighting possibilities in the Sri Lankan context - but it is difficult to design for the right amount of daylight. The results revealed that reflected and diffused daylight integration strategies take precedence over more direct methods. The top lit solutions that utilised innovative ceiling forms to direct and diffuse light into functional, reading spaces created a better ambiance in the perception of the users.

Perceptions of the users are critical to the discussion, an expanded user survey encompassing a wider range of users, in more varied spaces can extend the discussion to be more relevant, encompassing other strategies for daylight integration.

The challenge for the Architects of the future, is create interior volumes that bring light in appropriately, where a library space that inherits a roof form, - in an ever increasing multi-storey building typology - is rare. Further, in a tropical context, with abundant daylight integration opportunities, yet, brings with it the vagaries of solar heat gain into interior spaces. The balance of options adopted is key to creating architecturally rich, functionally sound spaces that cater to all senses of a user of library spaces - in light.

6. References.

Araji, M. T. (2008). Balancing human visual comfort and psychological wellbeing in private offices. Illinois: ProQuest.

Barbara, M., Arnkil, H., Fridell Anter, K. & Klarén, U. (2011). PERCIFAL: Visual analysis of space, light and colour. Visual evaluation of three spaces. Interaction of colour & light in the arts and sciences, (pp. 229-232). Zurich.

Baron, R. A., Rea, M. S., & Daniels, S. D. (1992). Effects of indoor lighting (illuminance and spectral distribution) on the performance of cognitive tasks and interpersonal behaviors: the potential mediating role of positive affect. Motivation and Emotion, 16(1), 1-33.

Berman, S. (2000). The coming revolution in lighting practice . Energy User News.

Boubekri, M. (2014). Daylighting design: planning strategies and best practice solutions (1 ed.). Basel: Birkhäuser.

Boyce, P. R. (2014). Human Factors in Lighting, Third Edition. NW: CRC Press.

Cajochen, C., Zeitzer, J. M., Czeisler, C. A., & Dijk, D.-J. (2000). Dose-response relationship for light intensity and ocular and electroencephalographic correlates of human alertness. Behavioural Brain Research, 115(1), 75-83.

Carli, M. D., De Giuli, V., & Zecchin, R. (2008). Review on visual comfort in office buildings and influence of daylight in productivity. Proceedings of Indoor Air 2008, 17-22 August 2008, Copenhagen, Denmark - Paper ID: 112

Cuttle, C. (2011). Perceived adequacy of illumination: A new basis for lighting practice: Proceedings of the 3rd Professional Lighting Design Convention. Madrid: Professional Lighting Designers Association

Dean, E. M. (1998). Daylighting design in libraries. Libris Design Project, supported by the U.S. Institute of Museum and Library Services

Fridell Anter, K. (2014). Daylight, Visual comfort and quality of light. Technical Report · May 2014 · Lighting Research and Technology

Ganslandt, R., & Hofmann, H. (1992). Handbook of Lighting Design. ERCO Edition, Vieweg.

Illuminating Engineering Society of North America. (2000). The IESNA lighting handbook (ninth edition ed.). (M. S. Rea, Ed.) New York

Jung, C. M., Khalsa, S. B., Scheer, F. A., Cajochen, C., Lockley, S. W., Czeisler, C. A., & Wright Jr, K. P. (2010). Acute effects of bright light exposure on cortisol levels. Journal of Biological Rhythms, 25(3), 208-216.

Kronqvist, A. (2012). Lighting Design in Computerised Offices. Göteborg: Chalmers tekniska högskola.

Lushington, N., Rudorf, W., & Wong, L. (2014). Libraries: a design manual. Birkhauser Architecture.

Mohanty, S. (2012). Physical comfort in library study environments: observations in three undergraduate settings. Master's paper for the Master of Science in Library Science Degree, University of North Carolina.

Säter, M. (2011). User responses to lighting design. Design Studies, 249-261.

Shih, C.-M., Liou, F.-J., & Johanson, R. E. (2010). The tectonic integration of Louis I. Kahn's Exeter library. Journal of Asian Architecture and Building Engineering, 9(1), 31-37.

Steany, M. A. (2011). The Architecture of Light: Recent approaches to designing with natural light. London: Routledge.

Sustainable Energy Authority. (2009). Code of practice for energy efficient buildings in Sri Lanka. Sri Lanka Sustainable Energy Authority.

GOOD READING LIGHT: VISUAL COMFORT PERCEPTION AND DAYLIGHT INTEGRATION IN LIBRARY SPACES

Swaris, N. (2016). Good reading light: Visual comfort perception and daylight integration in library buildings - A focus on university library buildings. Unpublished. B.Arch Dissertation, Department of Architecture, University of Moratuwa, Sri Lanka

Rajapaksha.U, et al (eds), 2017, "Design that cares"- multi disciplinary approaches to creating sustainable and meaningful built environment: *Proceedings of the 10th International Conference of Faculty of Architecture Research Unit (FARU), University of Moratuwa, Sri Lanka, (Vol. 01)* pp. 349-360 ©

SCHOOLYARDS' DESIGN AND GENDER ISSUES IN PALESTINE

AL-BISHAWI. M[1], SALHA. S[2] & AWAD. S[3]
[1]Department of Architectural Engineering, Birzeit University, Birzeit, Palestine
mbishawi@birzeit.edu
[2]An-Najah National University, Nablus, Palestine
[3]Department of Architectural Engineering, Birzeit University, Birzeit, Palestine
sqasem@birzeit.edu

Abstract
This research is about relationship between gender, students' needs and the physical form of schoolyards. It is aimed at investigating whether and how the needs of both male and female students influence the physical form of schoolyards in Palestine. The aim is to develop a better theoretical understanding of the relationship between students' needs in relation to gender, and the physical form of schoolyards. This will enhance the knowledge about how to design schoolyards that support students' needs, so that both male and female students can use these yards comfortably and conduct different types of activities without any restrictions.

To achieve the purpose of this study, different types of governmental schools from different cities in the north, middle and south of Palestine were chosen for investigations. Direct observations, questionnaire and interviews were used as main methods for data collection. The results showed that gender influenced different components of schoolyards' physical form which are interrelated with components of both curricular and non-curricular needs.

Keywords: *Schoolyards, Physical form, Students' needs, Gender, Palestine*

1. Introduction

Research in the field of urban design, including schoolyards' design, is generally based on identifying standard human needs without considering properly how these needs are influenced by gender, which is a cultural variable. Contemporary research and design works regarding schoolyards, lack a focus on students' needs according to their gender. The existing theories concerning this topic seem inadequate for the purposes of this study, which is concerned with the relationship between the physical form of schoolyards and students' needs according to gender. Therefore, this study aims at investigating whether and how students' needs according to gender influence the physical form of schoolyards in Palestine. This will contribute to the general knowledge about how to design and develop schoolyards that support students' needs according

to gender in general and in Palestine in particular. To achieve the objectives, the study followed an environmental approach which is based on the concept of behavioral setting to analyze the physical form of schoolyards in relation to students' needs.

1.1. EDUCATIONAL SYSTEM IN PALESTINE

Schools in Palestine, are categorized into three types based on gender: boys' schools, girls' schools, and educated (mixed) schools (Nicolai, 2007; MoE, 2000; Mustafa, Matar and Bisharat, 2008). In boys' schools all the pupils and teachers are males, while in girls' schools all pupils and teachers are females, and in the educated schools the majority of pupils and staff, including the director, are males. In general, there are 2430 public and private schools, 837 girls' schools, 878 boys' schools, and 288 educated schools. According to supervision and responsibility, the schools are distributed into 1833 school supervised by the Palestinian government, 309 school supervised by UNRWA and 288 school supervised by private sectors (Affouneh, 2010). Regarding the Palestinian curriculum, male and female schools have almost the same curriculum. Only few differences exist informally in both elective and physical education courses, due the society's traditions rather than formal instructions.

1.2. SCHOOLYARDS' DESIGN IN PALESTINE

In Palestine, the Ministry of Education and Higher Education (MOHE) is responsible for designing the governmental schools according to standards and regulations mentioned in the manual for designing schools in Palestine (MOHE, 2000). The focus is on the design of indoor spaces as classrooms and labs rather than the outdoor spaces or schoolyards. In general, the remaining area after determining the required area for classrooms and other indoor spaces is left for the schoolyards and later on the directors of the schools will be responsible for the design their schoolyards. In other situations, the construction of governmental schools is donated by independent organizations that may influence the design of schools and their yards based on the architects and planners of MOHE. The typical structure of the governmental schools has a rectangular, or L-shape, and multi-floors form with a corridor for classroom access. The structure is located in the middle or the rear of the yard, depending on the shape of the location, and surrounded by a wall. The yards are poorly designed. Elements in these yards are not the same. For example, some of the schoolyards have plants and green areas while others do not. Even the type of plants differs from one school to another. Also some of the schoolyards have seats and football or basketball playgrounds or volleyball; meanwhile others do not.

2. Theoretical framework

2.1. INDIVIDUALS' NEEDS AND GENDER ISSUES IN URBAN DESIGN.

Gender influences human needs and behavior in the built environment. Several studies conducted in this field showed that females have specific needs in urban spaces which are different from males' needs and from one cultural context to another. The needs for safety, security, play areas for children and comfort are found to be important needs to be considered in designing outdoor spaces for women's use (Polk,2003; Franck and Paxon,1989; Mozingo,1989; Bunston and Breton,1992; Greed ,2005; Tessin, 2005). Women generally spend more time than men in neighborhood, desire for social contacts, pronounced interest in nature and greater health consciousness (Klaphake et al., 2005). Women and girls appreciate places with a high level of sensuous and atmospheric quality, including a great variety of vegetation, a choice of sunny and shady areas, and attractive park furniture (Paravicini et al., 2002). There are still considerable differences between males and females in practicing outdoor sports where boys prefer competitive games, and girls movement games in small groups or pairs (Gender kompetenz zentrum, 2007). Also, football play is still the majority practicing outdoor sport by males (Zinnecker et al. 2002). Moreover, individuals' behavior, perception of and attitudes towards their built environment are depending on their gender. Moore (1983) shows that different people interpret their physical environment differently, depending on their lifestyle, gender, age, and ethnicity

2.2. SCHOOLYARDS' DESIGN AND STUDENTS' NEEDS

Schoolyard is defined as "space outside the building or the school's external environment. A school's buildings and grounds are also part of the surrounding community and each has an impact on the other. An unimproved or degraded schoolyard sends a negative message about the school and the neighborhood in which it is situated. A dynamic and active schoolyard adds to the vibrancy of both. All schools have schoolyards, whether big or small, beautiful or ugly, actively used or abandoned. The schoolyards should be designed to address three areas of activities: first; recreation and physical education, second; social development and third; academic learning (Education Development Center, Inc. and the Boston Schoolyard, 2000).

Outdoor learning should be linked to academic content, particularly a mix of outdoor instruction and indoor teaching leads to improved achievements. Several researches emphasized the importance of integrating outdoor learning into teaching through using the outdoors as both venue and content. Therefore, schoolyards must include spaces that could be used for breathing

life into concept learned in the classroom (Broda, Herbert W.,2011; Boston Schoolyard Initiative, 2011; Waite, 2011; Wagner, Cheryl& Gordon, Douglas,2010; Bristol, 2008; Meyer,2010). In addition to academic learning, schoolyards should provide opportunities for the physical challenges, exercise, sports and unsupervised play, which allow for healthy development and connection with natural environment. Accordingly, schoolyards should be safe places where children practice social skills and explore the natural world (Danks, 2010). The schoolyards should not be located near noise or pollution sources. Also, the location of schoolyards should allow for safe arrival and departure of students from the school facility. The location should be of dangerous elements as wells, unprotected edges, drop-offs and cliffs. The schoolyards should also include openings to storm sewer system (New Jersey Institute of Technology, 2007).

In the Middle-Eastern literature, there are no specific studies concerning schoolyards' design in relation to needs or gender. Most of the studies focus on the design of the school building rather than the schoolyards' design (Al-Soliman,1996; MOHE, 2000).The previous studies didn't deal with important issues, on the one hand, these studies concentrate on students' standard needs without considering students' gender. On the other hand, these studies do not consider cultural behavior properly and are limited to specific cultures, particularly to Western cultures.

3. Methodological approach

For analyzing the physical form of schoolyards in relation to students' needs, a comprehensive approach which allows for investigating students' needs in relation to space's components: design, use and rules, is used (Al-Bishawi & Ghadban 2011). According to this approach, students' needs consists of three main component, which are reflected in the physical form of schoolyards, as follows:

- Design components (physical components) that include the schoolyards where the students' activities occur; their boundaries, locations and elements.
- Use components (social components) that include students' activities in the schoolyards (curriculum and non-curriculum activities).
- Rules components (cultural components), which include both formal and informal rules that govern the physical form and the use of schoolyards. Formal rules include written rules that are concerned with the design and function of the schoolyards, informal rules include rules which govern students' behavior, such as: religious, society's and schools' restrictions.

For this study, students' needs are classified into two groups: the needs which are relevant to curricular activities and the needs which are relevant to non-curricular activities. To investigate the relationship between students' needs in relation to gender and the physical form of schoolyards, the study focuses on investigating different components of the physical form of the selected schoolyards and the needs to which these components are relevant.

3.1. DATA COLLECTION METHODS

Observations: direct observations were carried out to examine how students' gender influences their needs. The observations were conducted by the researchers and another trained observer in different governmental secondary schools in Palestine. The observed students were both males and females in the Grade 11 and 12, since gender differences appear clearly in this age The observations started with conducting a field survey, . in each school, the observations covered design, use and rules components. The main technique used in these observations was to take photos and written notes. The collected data from the observations was categorized into 3 main groups according to the established component type (design, use and rules), and then were matched with the relevant students' need.

Interviews: simultaneously with the observations, interviews were conducted with certain students to understand the need which was behind a certain behavior. Interviews with planners and architects in the MoE , who are responsible for the design of schools were conducted to understand their attitudes towards the design of schoolyards in male, female and educated schools. Interviews with directors of the selected schools, who are responsible for creation of many design elements and rules in schoolyards, were conducted to understand how they think about the physical form of their schoolyards.

Questionnaire: this method was conducted to examine the relationship between physical form of schoolyards and students' needs in relation to gender. The main focus in the questionnaire was on students' opinion towards different needs' components in schoolyards, particularly those which cannot be ascertained from observations. The questionnaire consisted of two sections: the first section consisted of personal data.The second section consisted of (3) domains and (35) items to explore the relationship between students' needs and schoolyards' components in relation to gender. The three domains are: use for both curricular and non-curricular activities, rules which govern the use and design. The statistics which were used are: frequencies and percentages to present variables, correlation coefficient to examine how the studied items are relevant to gender and chi-Square test for deep investigations to examine the relation between sub components of the studied items and variables. The study

included a total of (42.191) student at grades 11 & 12, for the scholastic year 2012/ 2013. A stratified random sample was chosen for the purpose of this study. The sample consisted of (1470) from the whole population, each district was presented proportionally to its size of students. Tables (1) below indicates the sample distribution in accordance with: Gender and Grade

Table 1: Distribution of sample according to gender and Grade

Gender	Frequency	Percentage %
Male	758	51.6
Female	712	48.4
Total	1470	100%
Grade	Frequency	Percentage %
11th grade	723	49.2
12th grade	747	50.8
Total	1470	100 %

4. Results

Results of the observations, interviews and questionnaire showed components of students' needs which are relevant to gender.

4.1. GENDER AND DESIGN COMPONENTS OF SCHOOLYARDS

Results of the observations and interviews showed that design components are influenced by gender. For example, female schoolyards are mainly located inside or near to the residential neighborhoods, meanwhile male and educated schoolyards, in most situations, are located outside the residential neighborhoods. Also, the gates of females' schoolyards are less transparent than the gates of males and educated schoolyards (Figure. 1a, b). Each of males, females and educated schoolyards are surrounded by walls, but in the case of female schoolyards the walls are higher than in the male and educated schoolyards (Figure. 1c, d). There are differences between elements of males', educated and females' schoolyards. For example, males' and educated schoolyards are always provided with football playgrounds, while the female schoolyards are not. More colors are used in females' schoolyards than in males' and educated schoolyards. In females' schoolyards more sitting and shading elements than in males' schoolyard. Gardens and plants are more available in females' schoolyards than in males' and educated schoolyards (Figure. 1e, f).

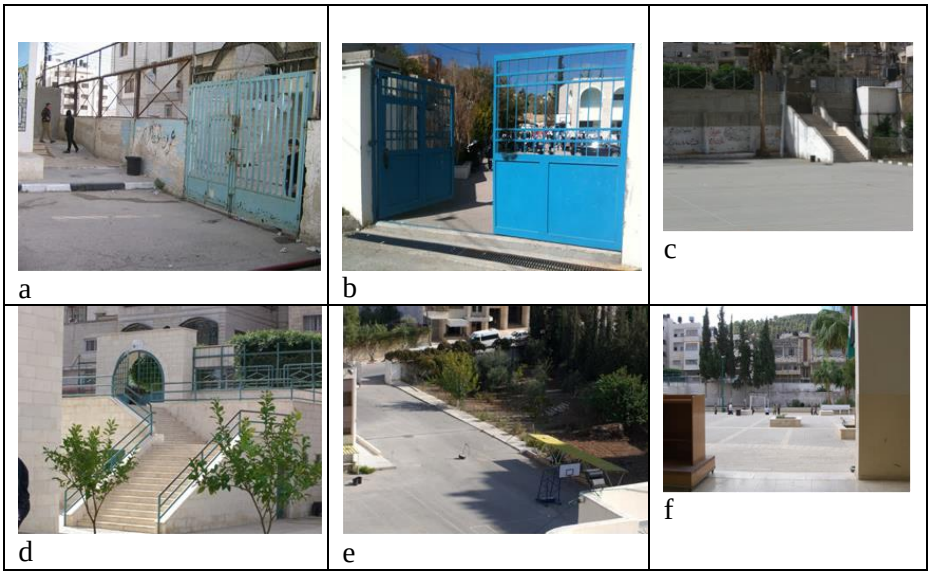


Figure 1, Illustrations showing results of the observations concerning gender and design components.

These results complied with results of the questionnaire which showed there is a significant positive relationship between design and gender (Table 2)

4.2. GENDER AND USE COMPONENTS OF SCHOOLYARDS.

Results of the observations and interviews showed that there are differences in behavior of male and female students in the schoolyards. For example, females use their yards for walking and sitting activities more than running and playing as males often do (Figure 2a, b). Male students use their schoolyards for curricular and cultural activities more than female students (Figure 2c, d). These results complied with results of the questionnaire which showed there is a significant negative relationship between use component and gender (Table 2). The deep analyses of the relationship between subcomponents of use and gender (Chi-Square test) revealed in some cases females showed more positive responses to activities which are relevant to males.

c d

Figure 2, Illustrations showing results of the observations concerning gender and use

4.3. GENDER AND RULES COMPONENTS OF SCHOOLYARDS

Results of the observations and interviews showed that a written sign is always fixed above the gate of schoolyard to indicate whether it is a female or male or educated school. Physical conditions of females' schoolyard are better than males' schoolyards. Female students behave in more quietly than male students do. In educated schools, the yards are used mainly by males. Although results of the questionnaire did not reveal a significant relationship between rule component and gender (Table 2), the deep analyses (Chi-Square test) of the relationship between subcomponents of the rules and gender showed that restrictions on females' use of their schoolyards are more than on males' , particularly concerning P.E activities and using specific areas of the schoolyards.

Table 2: The Relationship between gender and Schoolyards' Component

Schoolyard's component	gender
Design	*0.321
Rules	0.089
Use (curricular and non-curricular)	*0.058-
Curricular activities	0.092
Non curricular activities	*0.756

5. Discussion

The study showed that components of the physical form of schoolyards and students' needs are influenced by gender as follows:

5.1 REGARDING THE EDUCATIONAL NEEDS

Results of study revealed that male students use their schoolyards for curricular activities more than female students. These results are seen related to gender differences in curriculum, particularly concerning the elective courses, which

influenced the design and use of schoolyards in both male and female students. For example, elective courses for females about economy and housekeeping require indoor spaces, meanwhile elective courses for male students about environment and agriculture require outdoor spaces, which influenced the use components of schoolyards. Also, results of observations and questionnaire revealed that football playground is more relevant to males' schoolyards; meanwhile badminton playground is more relevant to females' schoolyards. These results are seen as related to differences in physical education practices in both of males' and females' schools.

5.2 REGARDING THE NON-EDUCATIONAL NEEDS

Results of this study revealed that design components of females' schoolyards (location, walls, and gates) caused them to be protected from the surrounding environment more than design components in males' schoolyards. Also, formal and informal rules restrict the access to females' schoolyards and restrict females' use of their schoolyards more than in males' schoolyards. These results are seen related to cultural need for females' privacy, which is based on the culture of gender separation due to Islamic and Arabic culture (Based on Al-Bishawi, 2008; Hakim,1986; Abue-Lughod,1987; Kenzari and Elsheshtawy,2003). This need caused the separation between males' and females' schoolyards and influenced different components of schoolyards' physical form in males' and females' schools. For example, choosing the location of female schools close to residential neighborhoods and faraway from males' schools as much as possible, increasing the height of surrounding walls and decreasing the transparency of gates in females' schoolyards decrease females' exposure to neighbors and passersby in the streets. The written signs which are put above the gates of schools control visitors' access to these schools. For example, female visitors to females' schools do not need permission and precautions as in the case of male visitors and vice versa, which was confirmed by the directors and planners during the interviews. In addition, results of the questionnaire showed that female students do not prefer to have playgrounds in their schoolyards and do not like to have their schoolyards opened to the streets as male students. Such things exposed female students to strangers in the surrounding environment and restrict their behavior either by being prohibited from using these opened areas or caused many of them to cover their hairs and bodies all the time, including physical education courses.

Also differences in social behavior between males and females can be seen as related to differences in their social needs, particularly the needs for socialization and comfort (KGSt 2004; Tessin 2005; Klaphake et al. 2005; Paravicini et al. 2002). For example, results of the observations showed that

female students use their schoolyards for, sitting, walking and gathering activities more than playing activities as male students do. This was reflected in the creation of shaded and sitting elements by directors in female's schoolyards more than in males' schoolyards.Although students' needs according to gender are considered informally by planners and directors of schools, results of this study showed that these needs are met partially.This influenced negatively the use, the aesthetic quality, the connotation and integrity of schoolyards. Results of observations and interviews showed that in schoolyards which do not comply with females' privacy need, female students are obliged to wear their veils during physical education courses or are not allowed to reach specific areas of the schoolyards because these areas are violated by neighbors. Also, in the case of educated schools, the schoolyards are mainly used by male students for curricular and non-curricular activities. Meanwhile, female students stay inside classrooms and are deprived from their right in using their schoolyards for different purposes, which influence the quality of education in these schools and contradicts with principles of democracy and equity between males and females in using schoolyards (Aslaksen, Bergh, , Bringa, & Heggem, 1997) . In addition, observations and interviews showed that the height of many walls surrounding the schoolyards, particularly in female schools, has been increased by using metallic or textile materials for females' privacy need, which caused degradation in the aesthetic quality of these schoolyards.

6. Conclusion

This study provides important findings to answer the question of this research concerning the relationship between gender, students' needs and physical form of schoolyards in Palestine. The study showed that there is a relationship between gender, students' needs and physical form. The results showed that gender influenced different components of schoolyards' physical form which are interrelated with components of both curricular and non-curricular needs. Therefore, components of schoolyards should support different needs of both male and female. Male students and directors of schools think about their schoolyards in a way that is different from female students and directors. Also, male students use their schoolyards in a way which is different from female students. This means that females' schoolyards should not be treated in the same way as males' schoolyards, and their needs should be considered and reflected in the physical environment of their schoolyards. Although gender influenced indirectly decision making process about schoolyards' design, results of this study showed that students' needs according to gender are met partially and differently in schoolyards which influenced negatively the aesthetic quality, the connotation, students' use of their schoolyards. Including gender issues in the formal rules that govern the design of schoolyards in

Palestine can help in providing schoolyards that meet needs of both male and female students and improve learning environment.

7. References

Abu-Lughod, J. (1987). The Islamic city: Historic Myth, Islamic essence and contemporary relevance. Middle East Study, 19, 155-176.

Affouneh, S. (2010). Towards the development of Palestinian Education Quality, a report issued in cooperation with pubic administration for governmental performance assurance in Palestine (in Arabic language).

Al-Bishawi, M. & Al-Ghadban, S. (2011). Methodological Approach for Reading Urban Open Space. International Journal of Architectural Research, 5(1), 73-85.

Al-Bishawi, M. (2008). Women's Behavior in Public Space and the Influence of Privacy/ the Case of Nablus/ Palestine, PH.D. Thesis, Norway- University of Life Sciences- Department of Spatial Planning and Landscape Architecture.

Al-Soliman, T.M. (1996). The Effect of School Size Upon Educational and Environmental Factors, JAPR.

Aslaksen, F., Bergh, S., Bringa, O. R., & Heggem, E. K. (1997). Universal Design, Planning and Design for All. Oslo: The Norwegian State Council on Disability.

Boston Schoolyard Initiative (2011). Design Workbook. and Planning Workbook

Bristol (2008). Reimagining Outdoor Learning Spaces: Primary Capital, Co-Design and Educational Transformation, Futurelab at NFER

Broda, H. (2011). Moving the Classroom Outdoors: Schoolyard-Enhanced Learning in Action, Portland: Stenhouse Publishers.

Bunston, T., & Breton, M. (1992). Homes and homeless Women. Journal of Environmental Psychology, 12, 149-162

Danks, S. (2010). Asphalt to Ecosystems: Design Ideas for Schoolyard Transformation, New Village Press

Education Development Center, Inc. and the Boston Schoolyard (2000). Schoolyard Learning: The Impact of School Grounds, Boston Schoolyard Funders Collaborative.

Franck, K. A., & Paxson, L. (1989). Women and Urban Public Spaces; Research, Design, and Policy Issues, in E. Zube and G. Moore (eds), Advances in Environment, Behavior and Design, 122-146 (Vol. 2), New York: Plenum.

Gender Competence at the Humboldt University of Berlin (2007): Aspects sports, (online) Available: www.genderkompetenz.info/genderkompetenz/sachgebiete/sport/aspekte/

Greed, C. (2005). An Investigation of the Effectiveness of Gender Mainstreaming as a Means of Integrating the Needs of Women and Men into Spatial Planning in the United Kingdom. Progress in Planning, 64, 243-321.

Hakim, B. S. (1986). Arabic –Islamic Cities :Buiding and Planning Principles. London: Kegan Paul International Limited.

Kassabri, M.& Astor, R. & Benbenishty, R. (2009). Middle Eastern Adolescents' Perpetration of School Violence Against Peers and Teachers\ A Cross-Cultural and Ecological Analysis, Journal of interpersonal violence, 24, 159-182.

Kenzari, B., & Yasser, E. (2003). The Ambiguous Veil on Transparency, the Mashrabiy'ya, and Architecture, Architectural Education, 65(4), 17-25.

KGST Local community agency for administrative simplification in cooperation with the Galke (Standing Conference of the garden officer at the German Cities) (2004):

Nation-wide internet survey to measure citizens' satisfaction with local green space, the final report, Cologne, (online) Available: www.galk.de/arbeitskreise/ak_orga_betriebswirt/ down / kgst_buergerumfrage_041027.pdf

Klaphake, A.& Mahlke, M. & Pieschel, U. & Schroeder, T. (2005). Citizens survey to prepare the landscape of ideas and design competition for the park on the triangle track, Berlin. Final Report.

Meyer,K. (2010). The Outdoor Classroom: A Jewel in the Crown of Public Education. Design Share, Minneapolis, MN.

Moore, G. (1983). Knowing About Environmental Knowing: The Current State of Theory and Research on Environmental Cognition, in J. Pipkin, M. La Gory& J. Blau (eds), Remaking the City, pp:21-50. Albany-State University of New York Press.

Mozingo, L. (1989). Women and Downtown Open Spaces (Vol. 6): http://repositories.cdlib.org/ced/places/vol6/iss1/LouiseMozingo.

Mustafa, Mohammed Matar and Khalid Bisharat (2008). "Palestinian National Authority" In Ina V.S. Mullis, Michael O. Martin, Joh F. Olson, Dbra R. Berger, Dana Milne, and Gabrielle M. Stanco ed., TIMSS 2007 Encyclopedia: A Guide to Mathematics and Science Education Around the World, Volume 2, Boston: TIMSS & PIRLS International Study Center

Nicolai, Susan (2007) Fragmented Foundations: Education and Chronic Crisis in the Occupied Palestinian Territory, Paris: UNESCO International Institute for Educational Planning and Save the Children UK

New Jersey Institute of Technology, (2007). Schoolyard Planning and Design in New Jersey Enhancing Outdoor Play and Learning, Center for Architecture and Building Science Research, New Jersey School Outdoor Area Working Group

Palestinian Ministry of Education and Higher Education (2000), Future Schools in Palestine, A manual for Designing Schools, Ramallah, The Ministry of Education.

Paravicini, Ursula / Claus, Silke / Münkel, Andreas / to Oertzen, Susanna (2002): redesign of public spaces. Research Report, Hanover

Polk, M. (2003). Are Women Potentially More Accommodating than Men to A sustainable Transportation System in Sweden? Transportation Research, D(8), 75-95.

Tessin, Wulf (2005): Stadtteilplätze im Urteil von Nutzern und Nicht-Nutzern, in: Stadt + Grün, 1, 18–23

Wagner, Cheryl& Gordon, Douglas,2010, Planning School Grounds for Outdoor Learning, National Clearinghouse for Educational Facilities, Washington, DC

Waite, Sue, 2011, Children Learning Outside the Classroom: From Birth to Eleven, Sage Publications

Zinnecker, Juergen / Behnken, Imbke / Maschke, Sabine / Stecher, Ludwig (2002): nil Zoff & fully busy. The first youth generation of the new century, Opladen.

Rajapaksha.U, et al (eds), 2017, "Design that cares"- multi disciplinary approaches to creating sustainable and meaningful built environment: *Proceedings of the 10th International Conference of Faculty of Architecture Research Unit (FARU), University of Moratuwa, Sri Lanka, (Vol. 01)* pp. 361-372 ©

VERNACURALIZATION OF ARCHITECTURE PLANNING

Towards Basic Theory for Dwelt Environment Design

KYOTA YAMADA. A
Center for Southeast Asian Area Studies, Kyoto University, Kyoto, Japan
yamadak@cseas.kyoto-u.ac.jp

Abstract
Urban and human settlement development in developing countries was a frontier of the twentieth century architecture, from where new thinking and practices which exceed modern movement emerged. Dwelt environment, a new research subject, was proposed from this field. Dwelt environment is important as a basis for lives of people yet how this should be comprehended, created or conserved is not necessarily clarified. By pushing ahead the idea of dwelt environment, this study aims to find a possible image of emerging architecture of our times. This paper first defines dwelt environment based on human–environment relationships and shows way to apprehend dwelt environment through participant observations. Secondly, this paper derives a method for local dwelt environment design from reflections of the practices of a local tutoring school foundation project, in which the author joined with the dwellers in the historic area of Colombo. Dwelt environment of the area is apprehended as a system consisting of local places, network of local places and "Viśvāsaya විශ්වාසය/Nambikkai நம்பிக்கை/ relationships of trust". The author presents a method of dwelt environment design, which controls the transition process of dwelt environment through the interaction between architecture planning activities on the site and the dwellers as "Field Design".

Keywords: *Dwelt environment, local place, network of local places, Viśvāsaya/Nambikkai/ relationship of trust, Field Design*

1. Introduction

Local tutoring school is a local cultural center that aims to hand down local history and support children's elementary learning. Since 2011, dwellers and the author have been carrying activities to find a local tutoring school as a project for regeneration of local dwelt environment in historic area of Colombo (Figure 1). Regeneration of local dwelt environment devastated under the civil war, which ended in 2009, is a critical problem in Sri Lanka.

Figure 1 Construction of Local Tutoring School (Sep. 2017)

Historic area of Colombo which is adjacent to the east of Pettah, a central area of Colombo, experienced conflicts between youth groups under disordered situations caused by the civil war. Lives of many youths were lost, and many dwellers fled to avoid the conflicts. Youth groups called “team” came to suppress dwellers by force, and day to day communications between dwellers were broken up. Teams were dismantled by the police with the end of the civil war. But the relationship between the families whose youth members’ lives were lost in the conflicts and the families whose youth members deprived the lives of others are not restored until today, and this makes regeneration of devastated local dwelt environment of the historic area difficult. Education of children who carry the future of the area at the local cultural center became a rare practice that people who opposed each other during the civil war can share. The area is popularly recognized by Colombo citizens as slums. Project site is in the squatter area in informal backgrounds.

Based on analysis of the experiences of local tutoring school project, this paper theorizes a dwelt environment design method for a small scale of interesting project, which is effective in the process of non-regularized and resource limited situations and which has its basis on the principle dwellers and the area they are dwelling in. For this purpose, this paper first defines dwelt environment based on human – environment relations theory and constructs a

spatial model of dwelt environment of historic area of Colombo from field work.

2. Dwelt Environment

Dwelt environment, the environment that people formed around their body through their dwelling activities, is the basis of the lives of people. The significance of dwelt environment was accepted during the late 1960s through the practice and writing of Turner and came to be received globally (Caminos, Turner and Steffian 1969). In the 1960s, physical developments of cities in developing countries by uniform and top-down ways which were globally carried for the sake of economic development which was the internationally shared supreme objective at that time, somewhat led to the destruction of the lives of the local dwellers. It was the framework of the world comprehension based on space which consisted only of physical things that gave basis for uniform and physical development theory. Through this experience, it became evident that people are not living in a mere space, but they are living in a concrete dwelt environment with a distinctive historical trail and a culture.

Turner showed dwelt environment as a complex of physical and social elements. As of today, natural environmental aspect is added to dwelt environment. Importance of dwelt environment is growing as a basis for human sustainability. But, Turner did not show what are the basic elements which constitute dwelt environment and how dwellers and elements of dwelt environment interact. To approach these questions on constitution and dynamisms of dwelt environment, this paper defines dwelt environment in reference to ideas of human – environment relations theories which have their basis on human activities. This paper treats environment of a person as a complex of humans, things and words (or symbols) as Maturana and Varela (1992), Latour (1999) or Krippendorff (2005) mentioned.

A Human has a body that acts, senses and recognizes (or connects).When the body is experiencing happenings actions, senses and recognitions are connectedly progressing. Humans, things and words come to be interlinked through this process actions, senses and recognitions connectedly progress. Environment of a person is a system that humans, things and words are interlinked (Figure 2). Person's action, sense or recognition changes through the experiences of new happenings. Therefor the interlinks between humans, things and words, viz, environment of a person, also changes with occurrence of new happenings.

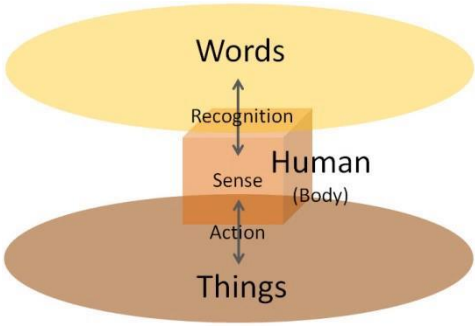


Figure 2 Environment of a Person

Environment of a person is not like homogeneous space. Through experiences of surrounding situations through happenings and inventions of adaptive relationships with them, a person loosely organizes spots where interactions of he or she, things and words are concentrated. If we identify these spots as places, dotted places and paths of movement of a person which connect the places with each other will appear as the major elements that constitute the environment of a person.

Dwelt Environment is a part of human environment which has become organized through dwelling activities. Many dwelling activities are not activities that are completed by one person but are activities that involve many other people. Interactions between people through words occur during dwelling activities. Interactions between people through words also bring changes in peoples' actions, senses or recognitions that lead to changes of personal environment and then to the changes of the dwelt environment.Dwelt environment is fluctuating through both the personal experiences of happenings through one's body and through interactions between people through words.

3. Historicity and Locality of Dwelt Environment and Its Dynamic nature

Dwelt environment has a specific order that has been formed through local situations and historical trails. From the observation of transformation of dwelt environment in historical areas of Colombo, following components, which have spread over different spatiotemporal scales, come out as sources of historicity and locality of dwelt environment and its dynamism.

3.1. A SET OF LOCAL PLACES

In historic areas of Colombo, one can observe specific spatial hotspots where people gather and activities concentrate. This paper identifies these spots where

interactions of people, things and words concentrate as “local places”. One can observe local places of dwelling (Lane), local places of beliefs and prayers (Mosque), local places of work (Wholesale market), or local places of adjustment of various activities (Teashop and Set that is shaped around teashop) (Figure 3). Characteristics of local places differ from one to another. Each local place has its own historical trail, criterion and function. Dwelt environment includes one set of local places that covers major activities of everyday life. Dwellers’ everyday lives are maintained through this set of local places. A set of local places falls into special extent of several blocks.

Figure 3 Local Places of Historic Area of Colombo

3.2. LOCAL PLACES AS CENTERS OF GATHERING

At some local places, many people gather and bring many topics on current events from various local places as converse topics with each other. Topics that people bring and converse differ owing to historical trails, criterions or functions of different local places. Through a conversation on a certain topic between people, different recognitions are exchanged and coordinated. Socialized recognitions appear from conversation, and then those socialized recognitions are brought out to other local places. Conversation itself is one happening that comes to connect people at local places.

3.3. NETWORK OF LOCAL PLACES

People come and go between local places. Each person spends one's own time of the day as a succession of staying at different local places and movements from one local place to another. A set of local places come to be interconnected through peoples' constant movements and accompanying movements of topics and things, and are organized into a loose and stable network of local places. The extent of the network of local places corresponds to the extent of the dwelt environment (Figure 4). Among local places that get categorized in to one set such as, wholesale markets, mosques and teashops, where non-dwellers can freely visit and join conversations are entrances for dwelt environment.

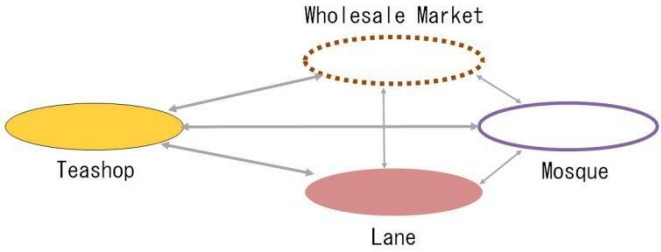


Figure 4 Network of Local Places

3.4. NETWORK OF TEASHOPS THAT CONNECTS SEVERAL NEIGHBORING DWELT ENVIRONMENTS

A network of one set of local places forms a dwelt environment. Another set of local places also exists around this dwelt environment and forms other neighboring dwelt environments. Among that set of local places, teashops have remarkably higher number of visits by people. Through people's movement a network of teashops is set up between one teashop and another teashop situated in another dwelt environment and that connects several neighbouring dwelt environments (Figure 5). Additionally, different from other local places, all kinds of topics are brought into highlight in teashops. Different topics and their social recognitions are brought into teashops through the movements of people of other local places relevant to both the inside and the outside of the dwelt environment. There also exists exchanges of topics and their social recognitions between teashops. Teashops coordinate various topics and recognitions on them coming from both inside and outside of their dwelt environments and then generate and distribute social recognition of their dwelt environments on these topics. These functions of teashops are recognized by dwellers and therefore teashops are sometimes called as street Congresses.

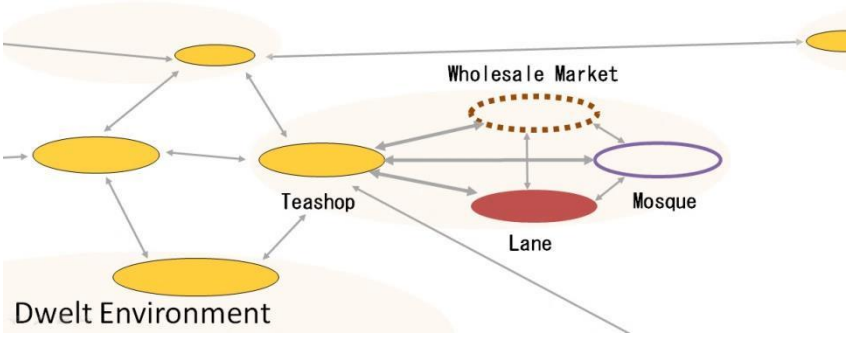


Figure 5 Network of Teashops that Connects Neighboring Dwelt Environments

3.5 VIŚVĀSAYA/NAMBIKKAI/ RELATIONSHIP OF TRUST: HISTORICALLY FORMED HUMAN RELATIONSHIPS THAT ARE ACCUMULATED INSIDE A PERSON OR A FAMILY

In addition to short-term connections of people intermediated by local places, there are also more stable networks of human relationships that arise from personal or family based long-term accumulations, selection and enhancement of short-term connections of people intermediated by local places. We call this, a long-term network of human relationships which is accumulated inside of a person or a family as, Viśvāsaya/Nambikkai /relationship of trust. Viśvāsaya/Nambikkai means the trust of a relationship with each other in Sinhala and Tamil. Viśvāsaya/Nambikkai /relationships of trust are not bonded to particular local places but are rather free from the spatial order. Spatial extent of Viśvāsaya/Nambikkai/ relationships of trust as networks are wide and do not always fall into that of a network of places which constitutes dwelt environment. The expanses of Viśvāsaya/Nambikkai/ relationships of trust are usually wider than that of networks of places which constitute gatherings of neighboring dwelt environments and often are wide as South Asia, Indian Ocean, or the globe. Viśvāsaya/Nambikkai / relationships of trust are other routes to visit topics and recognitions rather than a physical network of adjoining local places. Frequently intermediated by cell phones, topics and those recognitions are brought in to and brought out from distant local places, where ones' Viśvāsaya/Nambikkai/ relationship of trust is connected to acquaintances of the dwell, and influence each other's dwelt environment. From person to person the connection which forms a certain part of Viśvāsaya/Nambikkai/ relationship of trust has its own historical trail, criterion and function. A person who accumulates multiple Viśvāsaya/Nambikkai / relationships of trust becomes a local influential figure. This area has an

indeterminate lunch or dinner party called “Savan” at which local influential persons get together. Topics and recognitions given to the topics at Savan are quite influential to conversations at local places. Savan is also an important element of dwelt environment (Figure 6).

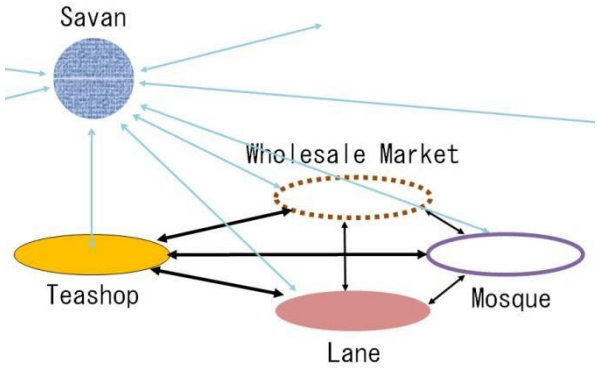


Figure 6 Savan that Configures Dwelt Environment

These local places, network of local places, and Viśvāsaya/Nambikkai/ relationships of trust configure dwelt environment as a spatiotemporal system which has a loose structure and behavioral characteristics. Irreversible change is also a characteristic of dwelt environment. Though dwelt environment can be projected on a space, it is distinct from a space. Dwelt environment is a framework that opens up comprehensive and dynamic understanding of our world in which humans are situated.

Local places, network of local places, and relationships of trust can be observed at anywhere on the earth as primal bases of people's lives according to the author’s observation.

4. Dwelt environment shift through integration of a new local place

Method of dwelt environment design through architectural planning focuses on local places and networks of local places that constitute dwelt environment. Basic method of architectural planning is composition or decomposition of physical things. As the elements of dwelt environment, local places and networks of local places have a close relationship with physical things. If one new local place is added to the existing set of local places and integrated into the existing network of local places, the former network of local places as a whole becomes a new system (Figure 7). Through this process, existing dwelt environments shift to new dwelt environments that offer a new basis for lives of dwellers. This section discusses the methods of dwelt environment transition through addition and integration of new local places to existing dwelt

environment as a practical way for local dwelt environment design through architectural planning.

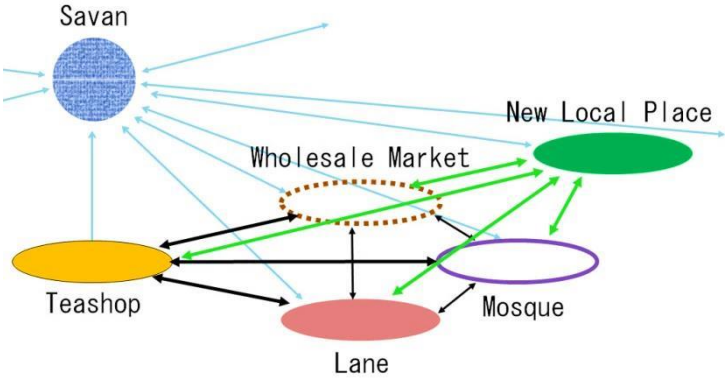


Figure 7 Integration of a New Local Place into Dwelt Environment

This section first refers to the experiences of local tutoring school project that is ongoing in historic area of Colombo, and then shows the temporary prospect on the process of dwelt environment shift, based on analysis on the process of the local tutoring school project. Lastly, a means for the transition process management is discussed.

It was by several interested people who started the local tutoring school foundation. After drawing a draft program for the local tutoring school, those interested people visited local places in and around their dwelt environment. They used plans, sketches and management concepts brought with them as communication mediums and conversed with people at other local places about tentative ideas and programs. From conversations, new recognitions, possibilities and problems were identified among the participants. New plans, sketches and management concepts were made to reflect outcome of the conversations. Ideas, programs and recognitions on the local tutoring school circulated around the dwelt environment as participants moved to other local places. Through the conversations at local places it was evident that, the local tutoring school project, though it was still ongoing and not yet recognized, was gradually accepted by dwellers as an emerging event that might be acknowledged in the future. As the local tutoring school project got accepted, dwellers brought new requests and showed their will of joining. The local tutoring school was still not materialized but came to be an imagined new local place where dwellers gather and enjoy new activities.

Based on these observations on the process of the local tutoring school project, the author is provisionally assuming that addition and integration of a new local

place to existing dwelt environment would progress through the following five phases.

1. Wish and concept on new activities and facilities for the activities of few dwellers would arise as the first step. 2. As the concept and recognition on the new activities and facilities are accepted by the dwellers, the new activities and facilities, though still not been materialized, come to be an imagined quasi-existing local place and that is added to the existing set of local places that constitute the dwelt environment. 3. The concept and recognition on the new activities and facilities are revised and updated to adjust themselves to various lives, social and natural environmental elements. Dwellers deepen their recognition on the new activities and facilities, and the degree of substantiality increases at every revise and update. 4. Through institutionalized procedures for starting the actual activities and materialization of a building through construction, the concept which got substantiality among dwellers proceeds to anchor into the dwelt environment as a new substantial local place. 5. Once the actual activities start and the building is materialized, new problems and possibilities in relation to the interaction between the activities, the buildings and the dwellers would start to emerge. Coping with these problems and possibilities, the new substantial local place should be firmly integrated into the dwelt environment. At present, the local tutoring school project is going to pass phase 1.-3 and is proceeding into phase 4. Throughout the all five phases, transition of dwelt environment continues and progresses only when the dwellers' imaginations and practices persist. The most important thing is the dwellers' leadership in collaboration with an architect to push the architecture project forward.

Another critical matter is management of transition process of dwelt environment from phase 1 to phase 5. At phase 1 the new dwelt environment formation project collapses if the link between the concept on new activities, institutions and dwellers is broken. At phase 2 and 3 the project collapses if the link between the new imagined local place and the existing local places is broken. At phase 4 and 5 the project may collapse if the link between the actual activities, materialized institutions and the dwellers is broken.

As long as the link between the elements appearing in each phase keeps connected, the new dwelt environment formation project can progress into substantiation. To manage transition of dwelt environment while maintaining a series of relations, it is necessary for practitioners to understand situations and prospects of dynamism of dwellers, places and dwelt environment. At the same time, preparation, selection and implementation of coping measures for the situations are also needed.

5. Field Design: Vernacularization of Architecture Planning

Followings are summary and considerations generalized from above participant observation and reflection of practices of local tutoring school project. A dwelt environment generated from local places, networks of local places, Viśvāsaya/Nambikkai/ relationships of trust and which has historical trail and behavioral characteristics, replaces space as an alternative concept for the basis for environmental design that accompanies dwellers.

Planning activities of an architectural project is usually carried out by a few specialists staying inside of a closed room and brought into practice after formal explanation to dwellers. In contrast, it is also possible for specialists to practice planning activities at the dwelt environment where the project will be realized. It is possible to progress architectural project while visiting local places which constitute dwelt environment, bringing planning of the project as one topic of conversation and sharing discussions of the plan with dwellers. Through discussions with dwellers, plan of the project will be revised while coping with multiple contexts of the field. The plan gradually gets into a desirable form in which both the dweller and the specialist can share the revising process (Figure 8). At the same time, through discussions of the plan, the project becomes a widely circulated topic at the scale of dwelt environment. The plan proceeds to anchor into the dwelt environment as an imagined quasi-existing local place as the plan is accepted by dwellers. New substantial local places emerge and get integrated into the existing dwelt environment and the dwelt environment shifts from the existing one to a new one starting from the time when the plan becomes materialized and actual activities get started. Every variation born during the revision of the plan is a figure of possible future which is coping with concrete problems and potency. As many variations are born, options to cope with fluctuating situations become broader and possible development paths of dwelt environment become more diverse.

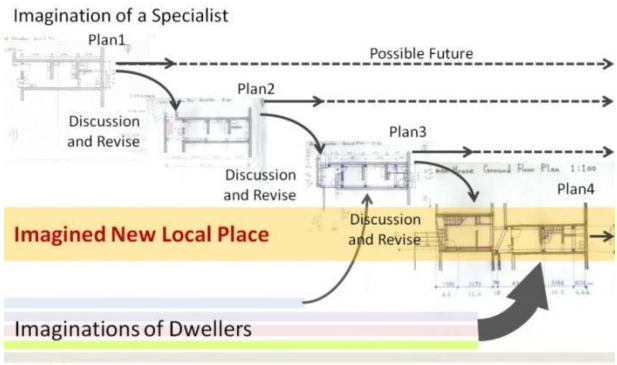


Fig. 8 Development of Plans and Appearance of an Imagined New Local Place

The author gives a name to the series of methods in which the architect practices design activity at actual dwelt environment, plans the architectural project with dwellers, anchors the plan into dwelt environment as an imagined local place and realizes dwelt environment transition from existing one to new one, as “Field Design”. Through Field Design, Architecture planning will be opened to the dwellers and will be a part of the dwelt environment design that accompanies vernacularization, enhancing the quality of the dwellers' lives. Field Design is a method which focuses on local places and networks of local places to find self-organizing systems which maintain local lives as a basis for dwelt environment design. Field Design will be an effective method for areas which have informal situations because as we have observed at historic area of Colombo, these areas are often developing local places based on sophisticated self-organizing systems. Of course, Field Design is also effective for areas based on formal situations since place based self-organizing systems are observed in these areas too. At the same time, Understanding of dwelt environment from view point of promoters of the project is only one aspect of dwelt environment. Limited resources of dwelt environment which the project needs are usually already shared by dwellers. Checking the project critically from diverse dwellers viewpoints is needed at every moment.

Acknowledgements

I owe an immense debt to Senior Professor Samitha Manawadu, Department of Architecture, University of Moratuwa, who supported me with his kindnesses and precious suggestions throughout this study. I thank Ms. Mihiri Hirdini for carefully proofreading the manuscript.

References

Bertalanffy, Ludwig von 1968 *General System Theory: Foundations, Development, Applications*, New York: George Braziller

Illich, I. 1981 *Shadow Work*, London: Marion Boyars Publishers

Caminos, H., Turner, J. and Steffian, J. 1969 *Urban Dwelling Environments: An Elementary Survey of Settlements for the Study of Design Determinants*, Cambridge, MA: The MIT Press

Krippendorff, K. 2005 *The Semantic Turn: A New Foundation for Design*, Philadelphia: CRC Press

Latour, B. 1999 *Pandora's Hope: Essays on the Reality of Science Studies*, Cambridge, MA: Harvard University Press

Maturana, H.R. and Varela, F.J. 1992 *The Tree of Knowledge: The Biological Roots of Human Understanding*, Boston: Shambhala

Oliver, P. (ed) 1969 *Shelter and Society*, London : Barrie & Rockliff, The Cresset Press

Schön, Donald A. 1983 *The Reflective Practitioner: How Professionals Think in Action*, New York: Basic Books

Rajapaksha.U, et al (eds), 2017, "Design that cares"- multi disciplinary approaches to creating sustainable and meaningful built environment: *Proceedings of the 10th International Conference of Faculty of Architecture Research Unit (FARU), University of Moratuwa, Sri Lanka, (Vol. 01)* pp. 373-384 ©

ENHANCING SECURITY BY REINSTATING "SHARED" SPACE AS NEGOTIATOR BETWEEN PRIVATE AND PUBLIC SPACES

SMITS. M.W.M.
Faculty of Architecture, Delft University of Technology, Delft, The Netherlands
M.W.M.Smits@tudelft.nl

Abstract
Searching for better opportunities and exponential population growth have forced many rural inhabitants in developing countries to urbanize. Thousands of new "informal" houses are built every day to accommodate these people around the world. Due to the lack of land, financial capacity and planning these areas become particularly dense informal housing districts. The scarcity of social and spatial organization in slums is leading to degradation of the living standard and security. This article argues that one of the main reasons for these problems seems to lie in the relation between private, semi-private and public spaces organization. The article starts by situating the problem within a global context and the magnitude of self-build informal housing. Secondly, explaining the different levels of public private relations found in rural self-build practice by observing a local family on Mt. Elgon. Here the importance of transitional spaces to the sense of security is explained. Thirdly, identifying the lack of spatial negotiation and organization in urban informal housing (Nairobi) in Kenya. The article concludes by describing the importance and possible improvements of reintroducing transitional 'shared' space into informal neighbourhood planning.

Keywords: *Security, privacy, spatial organisation, collective space, the role of architect*

1. Introduction

With a roughly 65% of the world population with an income below $2,000 per year, currently over 4 billion people are at the financial Bottom of the Pyramid (BoP) (Prahalad & Hammond, 2002). Exponential population growth has forced many rural inhabitants in developing countries to urbanize. According to UN Habitat, in most cases the search for better opportunities is the main motivation (United Nations Human Settlements Programme, 2014). Thousands of new "informal" houses are built every day around the world to accommodate these people. According to UN Habitat nowadays over 70% of Single-Family Housing (SFH) worldwide, is built informally and often by the inhabitants themselves Roughly 60% of the BoP SFH inhabitants are located in informal neighbourhoods (UN-Habitat, 2013), commonly identified as slums. Due to the lack of land, financial capacity and planning these areas becomes particularly

dense housing district. Although effort is being made to understand slum conditions and solutions, little attention is paid on how with minor interventions can improve the securety and general Quality of Life (QoL).

Global urbanization figures estimate that 60% of world population will live in cities by 2030 (Cohen, 2006). With African being under the most significant shift from rural to urban in the contemporary world (Raleigh, 2015). Namely the rapid and shear size and density of the slums will impose a great danger to the general QoL and safety of the urban BoP. The every day reality of slum dwellers is harsh (United Nations Human Settlements Programme, 2014). According to Raleigh (2015) the number of crime increases in urban areas, while decreasing in rural. The scarcity of social and spatial organization in slums is leading to degradation of the standard of living and security (United Nations Human Settlements Programme, 2014).

As this article will argue one of the main reasons for this degradation seems to lie in the availability and usage of private, semi-private and public spaces, which the author calls “transitional spaces”. African projections show that over half of the urban population (61.7%) currently lives in slums and by 2050, Africa’s urban dwellers are projected to have increased from 400 million to 1.2 billion (UN-Habitat, 2015; United Nations., 2012). Which only stresses the emergency of researching the main contributor to informal urbanization, namely: rural-urban migration (Tacoli, Mcgranahan, & Satterthwaite, 2014).
After describing the applied research methodologies, the first part of this article describes the different levels of public private relations found in this self-build practice in Sub-Sahara Africa are described. To understand how these relations evolve during the urbanization process, these levels are first analysed by an observation performed on Mt. Elgon in rural Kenya. Here the presence of “transitional spaces” is explained, moreover describing the inhabitants diffuse communication of this space. The usage of these spaces are derived from cultural traditions and living habits of each community represented by their type of communal organisation (J. Habraken, 1988). This part of the article argues that transitional spaces and their communal organization are of vital importance to provide with a safe living environment.

The second part describes the lack of transitional spaces and diffuse usage in urban informal settlements. In the current urban housing situation these spaces are compressed and in many cases even disappear. Here the absence of a transitional shared space; communal organization and diffuse communication are pointed out as the main contributors to the decrease of security in urban informal settlements. Which, also forms the main argumentation of the conclusion.

2. Methodology

To understand the differences in spatial organization between urban and rural Sub-Sahara family housing, this research starts with a day observation. Here the researcher had the opportunity to analyse every day spatial usage within the average family housing situation. This observation registered spatial dimension, typology, function, movement and communication during one whole week and weekend day. The outcomes were used to proof the importance and usage of shared outdoor living space in rural housing. The next step in the research explored how this space disappears comparing a rural and urban case. A comparative case-study was used to compare spatial dimensions of private, transitional and public space. Indicating how the spatial dimensions, usage and density changes. Here the sense insecurity is pinpointed to the lack of shared transitional space connecting the private and public.

3. Observing rural transitional space

To understand how different levels of public private relations evolve during the urbanization process, these levels are first analysed by an observation performed on Mt. Elgon in rural Kenya. Here the concept of “transitional space” is explained, moreover describing the inhabitants diffuse communication of this space. The usage of these spaces are derived from cultural traditions and living habits of each community represented by their type of communal organisation (J. Habraken, 1988). This part of the article argues that transitional spaces and their communal organization are of vital importance.

To gain sufficient understanding on functions and usage of space in a brief period of time participant observation was chosen. This form of observation allows to engage with the participants during the observation (Hennink, Hutter, & Bailey, 2010). Which enables the researcher to participate in every day activities and ask questions when needed. The family was selected randomly in the local community (the father of the family was passing by on the road). The family was informed on the goal of observation; to understand local everyday family life and how they use the family compound space. In the image below (Figure) the observed family on Mt. Elgon, the observation took place on 23-11-2018 from 4:30 in the morning, till 22:00 in the evening. Local social worker (Geoffrey Ngeywa) was present to make the family feel comfortable and translate anything when needed.

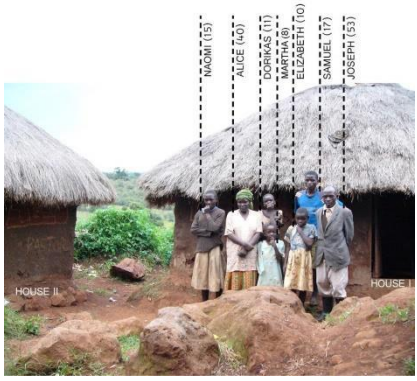


Figure 1, The Observed family on Mt. Elgon (*Source: M. Smits*)

The observation started with making a full inventory of the houses, the house on the middle (also see Figure) is the family house (Left image, Figure); this is the house where the parents live and Martha. The left side of the house is reserved for sleeping. Two beds are placed there and cloths are used to make a temporary separation between the two bedrooms (Parents' and Martha's). The sleeping/storage space almost covers half of the family house; the other half is used as living space.

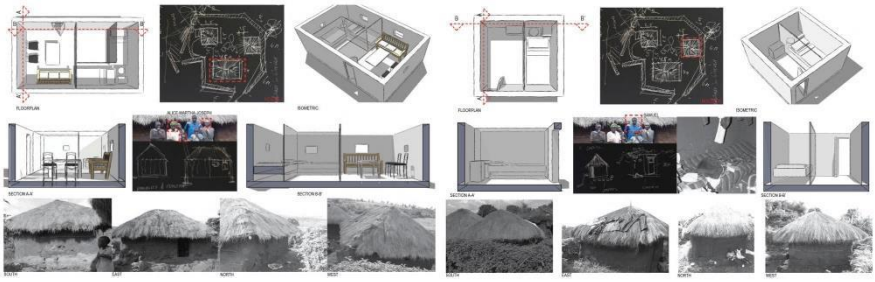


Figure2: Inventory of the houses: floor plan, sections and facades (*Source: M. Smits*)

The house on the left side (Right image, Figure) is the house of Samuel, he is seventeen thus supposed to live independently. His house is also divided into two parts by a thin cloth. The house on the right side (Figure, space 3.1) is the kitchen space, which also functions as residence for the girls. During the day sleeping materials are stored on the backside and the kitchen has full working space. At night mats are rolled out and a mosquito net is hung above the beds of the girls.

The compound is fenced with a low green hedge and has a small path leading to the main road (Figure). All around the family compound there are different outdoor functions. These are not visibly marked in the compound, but were observed as usages and are for that reason marked with a dotted line. The central circular space (Figure, space 4.10) is where the family gathers and eats. This place is also used to dry maize, prepare food or just to sit and talk. Behind the kitchen space there is an area to wash oneself out of sight of others and on the other corner a place to wash clothes. The right edge of the family compound is used for drying clothes, growing vegetables and for midnight sanitation emergencies.

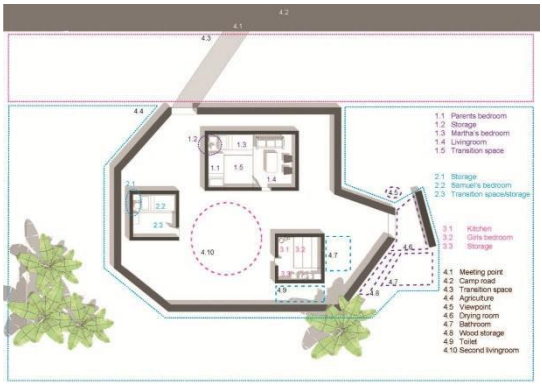


Figure 3, Family compound, with program and usages (*Source: M. Smits*)

From this observation some of the key components of movement and organization became clear, along with the relations with other families how, where and when they met. One of the key values is the main road that runs through the community. It is used by the farmworkers to go to work together in the morning, but also for children to walk to school together. Although the main house is positioned with its back to the main road the space between de various houses allows visual and verbal communication while being in the outdoors (Figure, space: 4.10). Because the houses are positioned around the central living space and oriented towards this space, it is creating a semi-enclosed courtyard.

The image below (Figure) visualizes communication, movement and usage of the families’ outdoor space. Indicating movement patterns of the individual family members during morning, afternoon and night. Here the physical movements are expressed in straight lines and visual/verbal communication in dotted lines. The figure shows that the central outdoor living area is most used. Their individual orientation plays a vital role in both their internal as external

routing and communication. The crucial conclusion from this observation is the great significance of having separate house structures so children from a young age are taught to be self-reliant and how to become an adult within the safe borders of the family. Moreover, do they enable an partial communication by the semi-enclosing the outdoor living space. People passing by can see a glimpse of the family or hear them talk. Making it easy for people to engage with the family. This transitional space between the public (road) and private (inside the houses) is what could be called a shared space. Shared not only by the family members, due to it low visual threshold (low fence & open air activities), with community members.

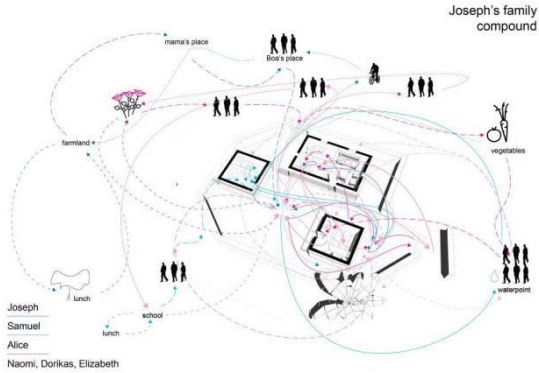


Figure 4, Patterns of movement and communication on compound
(*Source: M. Smits*)

Similar orientation, usage and transparency can be observed in most of the family compounds on Mt. Elgon. Therefore the shared space can potentially play a vital role in the community's social fabric and sense of security. In the next section we compare the availability and usage of the shared space.

4. Transitions by shared space: Comparative case-study

In this section a comparative case-study is used to reflect the differences in house typology, orientation and spatial usage. Moreover, how these sustain or obstruct (orientation & communication) a shared transitional space between private and public space. To proof that similar tendencies can be observed another family was randomly selected on Mt. Elgon. For the urban location Mathare was chosen as it has been extensively studied. In the previous section the spatial quality in the rural case was identified as a spatial negotiation (between the private and public space) enabled by the compounds "shared space". This semi-enclosed space is closely related with the public space, but acts as a security buffer with the private space. Below an overview of these

three types of spaces (private, shared and public) are analysed and explained in relation to safety.

Figure 5, Left image - the Mt. Elgon case (*Source: M. Smits*); right image the Mathare case (*Source: Slum Dwellers International & Pamoja Trust*)

4.1 INDIVIDUAL/PRIVATE SPACE

The images below (Figure & 7) show the two cases: a family located on Mt. Elgon and a family located in Mathare (Nairobi). Comparing the cases reveals similarities in typology: dimensions, layout/usage, materialization and construction. Particularly the usage and division made inside the house (private/semi-private) here a cloth is used to make a light and flexible separation between private functions (sleeping, storing and changing clothes) and more public usages (receiving visitors, eating, cooking and washing). It enables the inhabitants to obtain flexibility of the interior and is of great importance in everyday usage.

Figure 6, Location on Google map, living conditions and compound morphology (*Source: M. Smits*)

Figure 7, Location on Google map, living conditions (*Source: Slum Dwellers International & Pamoja Trust*) and compound morphology (*Source: M. Smits*)

In the Mathare case this proves a bigger challenge due to the spatial constraints having only one structure available for all usages. Here the program is spread over a larger area (building and plot), where in the Mathare case the different functions are compressed into one house unit. According to Hall (1990), certain amount of square meters per person in house (varied culturally), increases (double) the possibilities of social and physical pathologies may occur (**Error! Reference source not found.**), indicating that spatial densification might correlate to the increased criminality.

Many private usages such as laundry, personal hygiene or cooking on Mt. Elgon are performed in the perimeter around thehouses, while in the slums these are often forced inside. The Mt. Elgon case indicates that a sense of security enables inhabitants to pursue private and semi-private usages in the perimeter of their house. The Mathare housing lacks the space and sense of safety due to the physical distance between private and public usages. Which, according to Hall (1990) has a direct relation between physical distance, level of private/public and socially desirable positioning of functions. As a consequence this decreases the sense of security in and around the house of the Mathare family. Due to the spatial compression undesirable usage is forced inside, spending most of the family time inside. The inhabitants of the Mt. Elgon engage more outside in the shared space. For the Mathare family in particular the loss of shared space seems to play an important role.

4.2 SHARED SPACE

The shared space terminology is derived from the analysis of the Mt. Elgon case. Here an informal zone (**Error! Reference source not found.**) within the family compound enables various usages and more importantly establishes communication with the public space. This area is owned by the family, but due to the low perimeter fence and many possible entrances, is easy to access by visitors (Figure). This passage is offered via small informal infrastructural network connecting to the main public space. In daily life this means that neighbours, friends and family often stop by for a chat or for a shared activity (cooking, washing, etc.). Due to this unofficial, low barrier between the public and private space and high amount of common activities this zone has been identified as a “shared space”.

Figure 9, Left; shared space in the Mt. Elgon case, right; scheme of connectivity between shared and public space (*Source: M. Smits*)

In the rural context most of the family life and an intrinsic part of communal life are spent outside, in the urban case this is minimized or not existent and as a consequence most activities have moved inside. In this article the lost shared space in community is perceived as the crucial problem to the decreased sense of security. Due to the loss of spatial awareness as well as decreased communication between private and public life, the feeling of safety declines. Common values and principles are unknown, creating a state of individualism opposing community sense (N. J. Habraken, 2014). Which could be solved by the commonly owned, but publicly accessible shared space. Figure 102, shows the spatial conditions and relations in the Mathare case. Here the little shared usages (sitting, chatting, washing, etc.) is spend in front of the house, however now colliding/interfering directly with the public space. Here the usages are no longer partially communicated to the public space, but fully exposed, making participants exposed and vulnerable

Figure 102, Left; “shared” space Mathare (*Source: Thinklink*), right; scheme of connectivity in the shared/public space (*Source: M. Smits*)

4.3 PUBLIC SPACE

Due to this exposur anything happening in the public realm has an almost immediate impact on the private space. The type of activity can vary, but is strongly connected to the type of public space. To compare the public space of the two cases, three main types of public space (see Figure 113) are distinguished: necessary activities, optional/social activities and leftover space (Gehl, 2011). Three tendencies in the organization of the SFH compound in relation to their type of public space can be inferred from the rural case: firstly all houses connect directly to a shared space and connect via informal paths to the main infrastructure, secondly most compounds next to public space have sufficient distance from it, thirdly unused spaces are equally shared for growing crops.

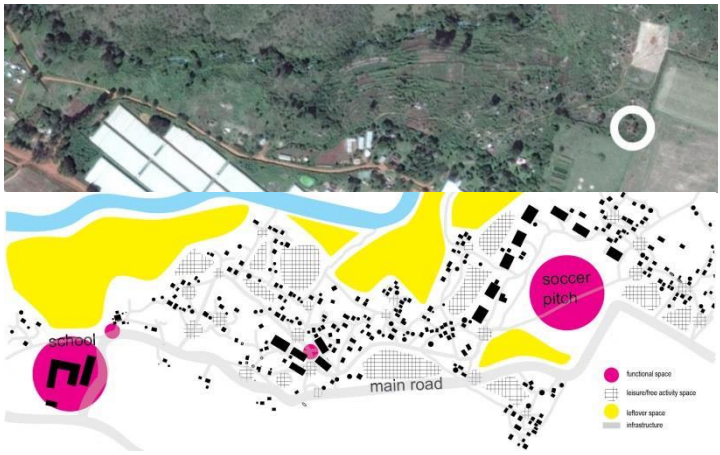


Figure 113, Google Map & Map settlements Mt. Elgon (*Source: M. Smits*)

Opposite tendencies are observed in the urban case (Figure). Firstly most houses are connected directly to the public space, secondly the houses do not have sufficient distance from the public space. Unused spaces are scarce and in most cases used for sanitation or garbage disposal. While in the rural case trespassing is easy to spot the absence of shared space disables or diminishes the mediation between the public and private spaces. This means that the people passing by the house are actually moving in the area that from tradition was shared space of the family (Alexander, Ishikawa, & Silverstein, 1977).

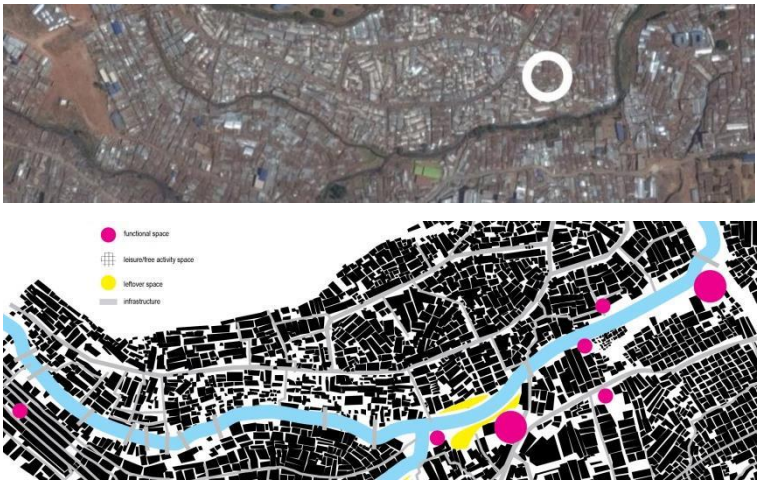


Figure 12, Google Map & Map informal settlements Mathare.

According to Gehl (2011) optional activities in the public realm are vital to a good physical living environment. Therefore, by providing shared space, room will be given for optional activities enabling social and household activities in and around the house (United Nations Human Settlements Programme, 2014). Due to the lack of communal organization and spatial planning, the slum community is largely unable to make any changes towards their private, shared and public space.

5. Conclusion: Lack of cultural (spatial) organization

In the rural case the SFH inhabitants are owners of the private and shared space, together with their neighbours and community they decide where and how the various spaces connect/intertwine with the public space. Although there is no formal "system" a continuous transition from private to shared space and from shared to public space can be observed. In most slums there is little communal regulation, the board and chairman are replaced by a complex informal network of owners and renters (Slum Dwellers Internastional & Pamoja Trust, 2009). Due to the lack of space there is no or little shared space. A spatial change can only be made with community activation planning and a reappointment of an community based organization. In the rural case a board and chairman act as negotiators between, individual and community values, but more importantly negotiating public and private spaces. Amongst the urban poor there is a need of social organization, which can only be carried by the inhabitants themselves. Reinstating shared space will play a vital role as spatial negotiator and could potentially improve the inhabitants' sense of security and quality of life.

6. References

Alexander, C., Ishikawa, S., & Silverstein, M. (1977). *A Pattern Language: Towns, Buildings, Construction*. OUP USA. Retrieved from https://books.google.co.ke/books?id=hwAHmktpk5IC

Atkinson, R., & Kintrea, K. (2001). Disentangling Area Effects: Evidence from Deprived and Non-deprived Neighbourhoods. *Urban Studies*, *38*(12), 2277–2298. http://doi.org/10.1080/00420980120087162

Cohen, B. (2006). Urbanization in developing countries: Current trends, future projections, and key challenges for sustainability. *Technology in Society*, *28*(1–2), 63–80. http://doi.org/10.1016/J.TECHSOC.2005.10.005

Gehl, J. (2011). *ç: Using Public Space*. Island Press. Retrieved from https://books.google.co.ke/books?id=X707aiCq6T8C

Habraken, J. (1988). Type as a social agreement. In *Asian congress of architects*. Soul. Retrieved from http://www.habraken.com/html/downloads/type_as_a_social_agreement.pdf

Habraken, N. J. (2014). *The Appearance of the Form: Four Essays on the Position Designing Takes Between People and Things*. BookBaby. Retrieved from https://books.google.co.ke/books?id=IFZZDQAAQBAJ

Hall, E. T. (Edward T. (1990). *The hidden dimension*. Anchor Books.

Hennink, M., Hutter, I., & Bailey, A. (2010). *Qualitative Research Methods*. SAGE Publications. Retrieved from https://books.google.nl/books?id=rmJdyLc8YW4C

Prahalad, C. K., & Hammond, A. (2002). Serving the World's Poor, Profitably. Retrieved from http://barnabys.blogs.com/files/serving-the-poor--prahalad-hammond-.pdf

Raleigh, C. (2015). Urban Violence Patterns Across African States. *International Studies Review*, *17*(1), 90–106. http://doi.org/10.1111/misr.12206

Slum Dwellers Internastional, & Pamoja Trust. (2009). *Inventories Nairobi's slums*. Retrieved from http://www.citiesalliance.org/node/430

Tacoli, C., Mcgranahan, G., & Satterthwaite, D. (2014). WORLD MIGRATION REPORT Urbanization, Rural–urban Migration and Urban Poverty. Retrieved from https://www.iom.int/sites/default/files/our_work/ICP/MPR/WMR-2015-Background-Paper-CTacoli-GMcGranahan-DSatterthwaite.pdf

UN-Habitat. (2013). Global Reports on Human Settlements. Retrieved October 24, 2017, from http://mirror.unhabitat.org/content.asp?catid=555&typeid=19&cid=12336

UN-Habitat. (2015). HABITAT III ISSUE PAPERS 22 – INFORMAL SETTLEMENTS. In *Habitat III Issue papers: 22- informal settlements* (p. 9). Retrieved from https://unhabitat.org/wp-content/uploads/2015/04/Habitat-III-Issue-Paper-22_Informal-Settlements.pdf

United Nations. (2012). *State of the world's cities 2012-2013 : prosperity of cities.* United Nations Pubns. Retrieved from http://mirror.unhabitat.org/pmss/listItemDetails.aspx?publicationID=3387

United Nations Human Settlements Programme. (2014). *Streets as Tools for Urban Transformation in Slums : a Street-led Approach to Citywide Slum Upgrading*. UN-HABITAT. Retrieved from http://mirror.unhabitat.org/pmss/listItemDetails.aspx?publicationID=3552

Rajapaksha.U, et al (eds), 2017, "Design that cares"- multi disciplinary approaches to creating sustainable and meaningful built environment: *Proceedings of the 10th International Conference of Faculty of Architecture Research Unit (FARU), University of Moratuwa, Sri Lanka, (Vol. 01)*pp. 385-395 ©

RESEARCH ISSUES IN ANALYSING EMBODIED CARBON IN BUILDINGS

PERERA. S, SENARATNE. S[1] & BRADY L.
Western Sydney University, Sydney, Australia
[1]*email of corresponding author s.senaratne@westernsydney.edu.au*

Abstract

In recent years, there has been an increased focus on creating sustainable buildings that have a reduced carbon footprint. The primary method to achieve this has been through incorporating strategies to reduce the operational carbon of the buildings, which is found to be easier to analyse and address. However, as the industry aims to produce 'carbon neutral' buildings with extremely low operational carbon, the embodied carbon is typically not considered. As a consequence of this, there has been a net increase of embodied carbon within low energy buildings. Typically, embodied carbon accounts for 20% of the total life cycle carbon of a building. However, it is found that in low energy and sustainable buildings, embodied carbon accounts for a larger percentage thus increasing the importance of understanding and mitigating embodied carbon. Therefore, the aim of this paper was to synthesise relevant literature in order to discover research issues related to embodied carbon in buildings. Key literature findings revealed the importance of concurrently addressing embodied carbon with operational carbon, the complexities associated with analysing embodied carbon and ways to address reduction of embodied carbon in buildings. These findings will eventually help to shape future research that will focus on achieving zero carbon targets globally.

Keywords: *Sustainable buildings; Embodied carbon, Carbon footprint*

1. Introduction

On the 12th December 2015, through the Paris Agreement, nearly 200 countries globally agreed to take increased action on climate change (Government 2017). This historic agreement establishes framework for all countries involved to take further actions to reduce their CO2 emissions, with a common goal of limiting global temperature warming to less than 2 degrees. One important step to achieve this could be a reduction of CO2 emissions from the construction industry (ASBEC 2016). The construction industry is an enormous contributor to CO2 emissions accounting for 18.1% of total CO2 emissions for example in Australia in 2013 (Yu et al. 2017). The construction industry generates CO2 emissions through Life Cycle Carbon, which encompasses all the energy consumed during the life cycle of a building (RICS 2012). The high amount of carbon emission from the construction industry

highlights the importance to develop a better understanding of life cycle carbon emissions which includes both embodied and operation carbon (Ashworth & Perera 2015).

The current problem is that the construction industry has put an increased focus on reducing the carbon footprint of buildings through reducing the operational carbon and neglecting on the equally important embodied carbon reductions in buildings (Ashworth & Perera 2015). There are scenarios where design features that were implemented to lower the operational carbon of a building, inadvertently cause an increase in the embodied energy for that building (Mithraratne & Vale 2004). This highlights the need to reduce embodied carbon whilst concurrently reducing the operational carbon to diminish the environmental impact of buildings (Ashworth & Perera 2015).

This paper aims to review key literature to order to discover research issues related to embodied carbon in buildings. The paper first explains the methodology and presents the literature findings with a critical analysis and discussion. Finally, the conclusions are presented with research implications.

2. Research Method

The aim of this paper was to discover research issues related to embodied carbon in buildings. The paper synthesises relevant literature such as key seminal journal publications on this topic including key influential reports. Firstly, a review was carried out to investigate key terminologies and the impact of carbon emissions from buildings. Next, the review seeks to clarify the concepts related to building life cycle carbon emissions. A further objective of the review was to identify trends in the current research on embodied carbon in buildings and identify reasons for limited research. Finally, research findings that offer ways to minimise embodied carbon emissions are analysed, which lead to conclusions and research implications.

3. Key Literature Findings

The literature findings are discussed in five sub-sections. The first section defines the key terms related to carbon emissions and discusses the global impacts of carbon emissions. The second section describes the importance of concurrently focusing on operational carbon and embodied carbon that contribute to life cycle carbon of buildings. This is followed by the next two sub-sections, which explore current research and the complexities of analysing embodied carbon in buildings. Finally, the literature directs to studies that identify ways to reduce embodied carbon in buildings.

3.1 CARBON EMISSIONS AND ITS IMPACT

Greenhouse Gases (GHG) are types of gases that act to weaken the earths atmospheric ozone layer resulting in an increased amount of solar radiation arriving on the earth's surface, resulting in a global temperature rise (Ashworth & Perera 2015). The primary greenhouse gases are; water vapour (H2O), Carbon Dioxide (CO2), Methane (CH4), Nitrous Oxide (N2O), Ozone (O3) and chlorofluorocarbon (CFC). Parts Per Million (PPM) is a measurement term and Equivalent Carbon Dioxide CO2-e describes the global warming potential of a greenhouse gas contribution. The carbon footprint measures the total amount of carbon dioxide emissions that are directly and indirectly created through an activity or accumulated during the life of a product (Wiedmann & Minx 2008).

A major global study conducted by Solomon (2007) concluded that global CO2 levels were previously 280 PPM before the industrial revolution and have now increased nearly 40% to 384 parts per million by 2007. Carbon dioxide within the earth's atmosphere has increased 25% from 270-280 parts per million to 360 parts per million in 1998. The increasing CO2 emissions have seen a correlation of the global average temperatures rising 0.5 degrees over the past 100 years (Hansen, JE 1998; Walther et al. 2002). There has been two main warming periods between 1910 and 1945 and 1976 until today, the second warming period had double the increase of the first (Walther et al. 2002). This is supported further by current data, which also suggests that the global average temperature increased more than previously thought. Increasing Carbon Dioxide emissions is a highly complex issue, for which each of us is responsible for. The construction industry has an obligation to reduce their carbon dioxide emissions, which currently accounts for 18% of carbon emissions (Yu et al. 2017).

3.2. LIFE CYCLE CARBON: OPERATIONAL VS EMBODIED

Throughout the entire life cycle of a building, energy will be consumed while emitting CO2. This is known as the cradle to cradle of the building (Ashworth & Perera 2015). Life cycle carbon is a term that encompasses the total amount of all energy consumed during the production of products (Ashworth & Perera 2015). This would therefore comprise both the operational carbon (energy associated with heating/cooling, lighting, ventilation) and the embodied carbon (Ashworth & Perera 2015). Operational energy is the primary contributor of carbon emissions, typically between 70-80% of emissions is produced during the operational phase, with embodied carbon producing the remaining emissions (RICS 2014). The operational carbon contributes between 70-80% typically of the total life cycle carbon, making it the primary contributor while

the other emissions are associated with embodied carbon (RICS 2014). However, in recent years there has been an increased focus on reducing operational carbon emissions, therefore making embodied carbon more important as it now accounts for a larger portion of total carbon emission for the building (Gan et al. 2017).

For example, through adding insulation to traditional light framed houses, it was shown to significantly improve the thermal performance of the house, therefore reducing heating energy expenditure (Mithraratne & Vale 2004). However, as can be seen in Figure 1, the same study exemplified that increasing the thermal mass will result in increased amount of embodied energy within the building, as can be seen the super insulated house will have a greater amount of embodied energy than the light framed house (Mithraratne & Vale 2004). Initially, the embodied energy of concrete and super insulated houses is 30% greater than a light framed house, however over 100 years the concrete house has an 8% increase of embodied energy and the super insulated house has a 14% increase in embodied energy.

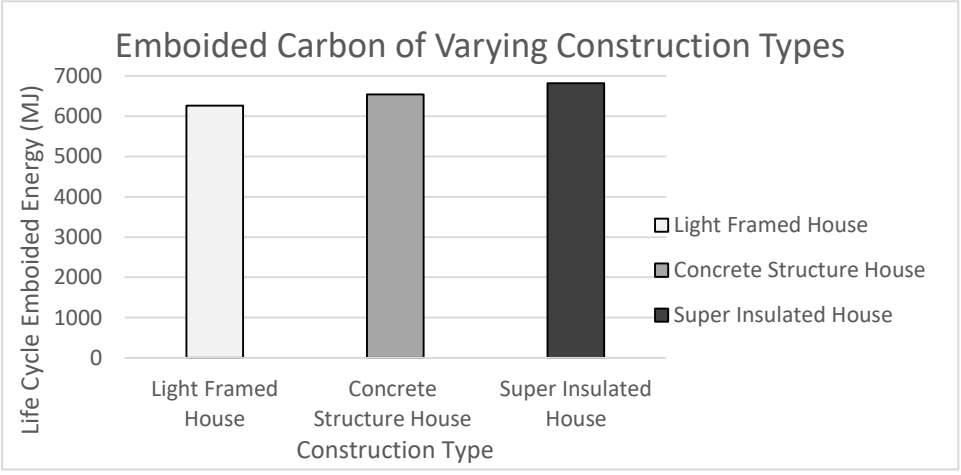


Figure 1, Embodied Energy Emitted from Common Construction Types Over 10 Years (Source: Mithraratne & Vale 2004)

The total sum of all energy consumed during the production, transportation, assembly, demolition and reuse or recycling of the material is the embodied energy (Ashworth & Perera 2015). The production of energy will produce GHG's, which is measured in CO2-e, therefore embodied carbon is measured as kilograms of CO2-e per kilograms of material, exhibiting

the amount of carbon emitted during the total life cycle, (Ashworth & Perera 2015). Ashworth and Perera (2015) discussed that embodied carbon is the carbon emitted throughout, extracting the material from the ground, transporting the material to factories, manufacturing the material, distribution the material to site, construction, and demolition of the building, and recusing or recycling building materials. However the carbon emitted through heating, cooling and lighting a building in the use phase is measured as operational carbon (Ashworth & Perera 2015). RICS (2014) discussed, embodied carbon typically accounts for 20% of the total carbon emissions of a building. However, this can vary depending on the type of building, for example industrial style buildings such as warehouses, the operational carbon could only be 20% whilst the embodied carbon could account for 80% of the total carbon emissions (RICS 2014). The components of embodied carbon against operational can be seen in Figure 2.

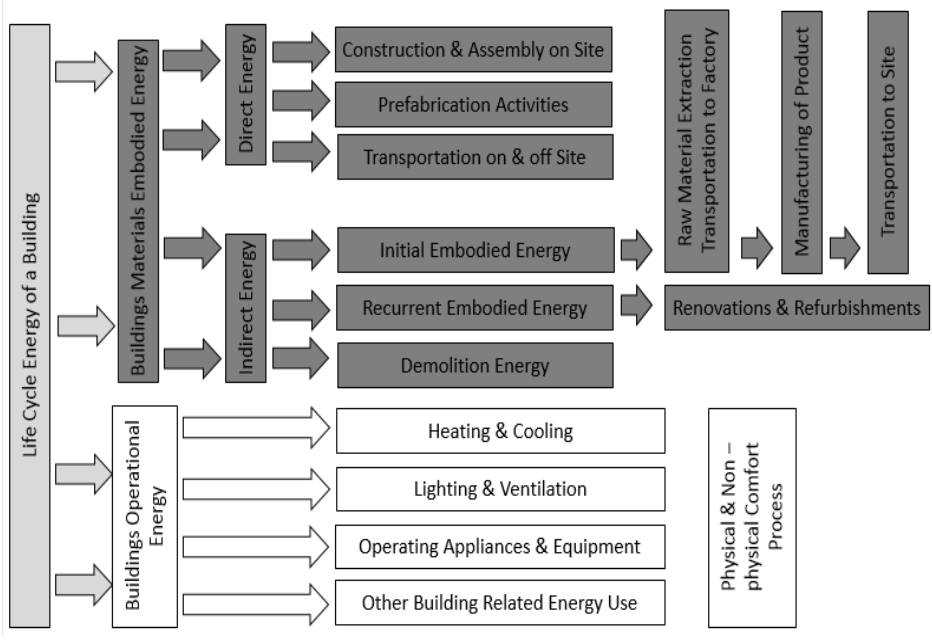


Figure 2, Life Cycle Energy of a Building (Source: Dixit et al. 2010)

3.3. RESEARCH ON EMBODIED CARBON IN BUILDINGS

Common building materials such as concrete, aluminium and steel are the primary contributors of embodied carbon (RICS 2014). The elements with the highest embodied carbon will vary between different types of buildings, Victoria, Perera and Davies (2016) discussed that within office buildings,

frame, upper floors and roof (super structure – structural) had the highest embodied carbon followed by sub structure and building envelope contributed for 80% of the total embodied carbon of a building. Whereas in educational buildings, the building envelope, substructure and internal finishes will account for 80% of the total embodied carbon (Victoria, Perera & Davies 2016). Concrete, in particular, is extremely high in embodied carbon and it has been estimated cement is responsible for 5-8 % of global carbon dioxide emissions (Teh et al. 2017). The high embodied carbon of concrete is demonstrated by Yan et al. (2010) through a comparison of manufacturing virgin concrete reinforced steel and with materials that were manufactured from recycled products in Hong Kong building projects. It was found that embodied GHG emissions of concrete and reinforced steel account for 93.99% to 95.11% of all building materials within a 20-30 storey concrete high rise building. Using recycled building materials such as reinforced steel would result in a considerable reduction of GHG emissions (Yan et al. 2010). However, this study was conducted on a reinforced concrete framed building, which means the results will not be reflective of steel frame high rise buildings or other framing systems.

Conversely, Gan et al. (2017) completed an analysis into the carbon emissions from materials through a case study of a 60 story composite core out rigger building in Hong Kong and found that structural steel and steel rebar accounted for 80% of the total embodied carbon emissions for the building whereas ready mixed concrete only accounted for 18% of the total embodied carbon emissions. These results are supported by Chen, Burnett and Chau (2001) who conducted a study on two 40 storey residential buildings in Hong Kong constructed in the 1990's. It was found that steel and aluminium were the largest contributor of embodied carbon within the buildings. In the Harmony Block building, they accounted for 77.4% of the total embodied carbon emission from the building and 77.6% for the New Cruciform Block building (Chen, Burnett & Chau 2001).

The high amount of embodied carbon reported within timber that was reported by Chen, Burnett and Chau (2001) does not correspond with other studies. For example, RICS (2014) discusses that through carbon sequestration, the amount of energy emitted during the manufacture of timber will be outweighed by the carbon dioxide they remove from the atmosphere. Therefore, timber has extremely low levels of embodied carbon. This is supported by Milne and Reardon (2013), who discussed that within residential houses within Australia, concrete, steel, plastic, masonry and ceramics are the highest contributors of embodied carbon, whereas timber is relatively low in comparison to these materials.

3.4. COMPLEXITY OF ANALYSING EMBODIED CARBON IN BUILDINGS

Even though, the literature review established the importance of focusing on embodied carbon of buildings in addition to operation carbon, the lack of attention could be due to complexities associated with analysing embodied carbon in buildings. Measuring the operational carbon of a building is relatively straightforward as the energy consumed by buildings can be quantified and forecasted accurately (Ashworth & Perera 2015) whereas measuring the embodied carbon is quite complex. This had led to inconsistencies and variations in current research findings related to embodied carbon in buildings.

For example, Dixit et al. (2010) conducted a literature review of 17 studies that measured the embodied energy within buildings and found following factors that resulted in the inconsistency between results from the 17 studies.

- The system boundaries that each study choose to measure, such as ‘cradle to gate’ or ‘cradle to grave’
- The geographical location of the study
- Production process, whether the manufacturing plant was powered by renewable energy or primary energy sources such as coal
- Distance of transport of materials
- Energy use in transport
- Whether raw materials were bought from overseas for assembly or locally soured.

This is further supported by Stephan, Crawford and De Myttenaere (2013), who discussed that for studies which have measured embodied carbon, the margin of error within their results increases the further into the building life cycle they measure as a ramification of increased uncertainty within these life cycle phases. Akbarnezhad and Xiao (2017) discussed that there is less published data on the later phases of a building life cycle leading to inconsistencies, whereas the ‘cradle to gate’ system boundary is typically used, as it is easiest to accurately quantify. Studies are often susceptible to under estimating the amount of embodied energy associated with additional materials required throughout a construction project, and the increased energy demand (Stephan, Crawford & De Myttenaere 2013). De Wolf, Pomponi and Moncaster (2017) discussed that as a ramification of the numerous variables and inconsistences across studies, the individual building assessments from studies results are incomparable. De Wolf, Pomponi and Moncaster (2017)

further supports the notion that lack of transparency within methodologies, varying carbon data sets and calculators used and varying life cycle phases measured result in inconsistent results between studies.

Hence, to improve the accuracy and validity of result from studies measuring the embodied carbon, Dixit et al. (2010) suggest a uniformed method should be introduced for future research. Rather than to wait for uniformed government approaches to measuring embodied carbon, top level stakeholders within the industry should agree to a unanimous approach to quantify these results (De Wolf, Pomponi & Moncaster 2017).

3.5. METHODS TO REDUCE EMBODIED CARBON IN BUILDINGS

Replacing energy intensive building products with wood, will lead to significant embodied carbon reduction within a building (Ibn-Mohammed et al. 2013). Timber can produce large CO2 reductions, Yu et al. (2017) discusses that substituting reinforced concrete for engineered wood products for new domestic construction projects within Australia could achieve a carbon reduction of 119 Mt CO2, when considering carbon sequestration. Guo et al. (2017) conducted a study across two seven storey residential buildings, where they used cross-laminated timber to reduce the total Life Cycle Carbon compared to a typical reinforced concrete building. They achieved a 24.6% reduction in carbon emissions. This is also supported by Darby, Elmualim and Kelly (2013) who measured the embodied carbon of a multi-story residential building with a cross laminated timber (CLT) super structure with a traditional reinforced concrete (RC) multi storey residential building. They found the cross-laminated timber building to have 1006 tCO2e less embodied carbon than the reinforced concrete structure (Darby, Elmualim & Kelly 2013). However, reducing embodied carbon through the use of timber has shortcomings as increasing the amount of timber required will further contribute to global deforestation. Hence, an appropriate balance needs to be maintained.

Embodied carbon reductions can further be achieved through re-use and recycling of building materials. For example, Thormark (2000) used recycled locally sourced materials for a Swedish housing project which saw 55% reduction of environmental impacts comparatively to constructing the same house out of new materials. Reusing clay bricks and clay roof tiles were the primary contributors of reducing environmental impacts even when transported long distances, there will still be benefits (Thormark 2000). However, this study was only conducted on one housing project and the same comparison would need to be carried out on multiple houses to confirm these results. This is supported by Bribián, Capilla & Usón (2011), who concluded that the best

method to reduce the environmental impacts of building materials is to encourage the re-use and recycling of building materials and where possible minimise the distance building materials are transported. RICS (2014) also discussed that materials that are recycled or can be re-used such as reclaimed bricks, demolition debris and locally recycled aggregates within a concrete mix should be used where possible to reduce the embodied carbon of buildings.

During the early stages of designing a building, it is crucial to consider employing environmental sustainable design features that not only focus on operation carbon but also embodied carbon (Schlueter & Thesseling 2009; Basbagill et al. 2013). Substantial reductions of the embodied CO2 can be achieved by selecting alternative materials with lower embodied carbon contributions at early stages. For example, Basbagill et al. (2013) found alternative cladding materials such as vinyl, wood, limestone could achieve a 49% reduction in embodied carbon. The importance of selecting materials with low embodied carbon content is further exemplified through González and Navarro (2006), who constructed three terrace houses in Valladolid, Spain using low environmental impact materials and passive solar design principles and then compared the embodied carbon emissions with a similar building with conventional building materials. They achieved a reduction of 38 tons of CO2, which was a 27.28% reduction comparatively to the conventional house (González & Navarro 2006). This is further confirmed by Reddy and Jagadish (2003), who conducted a comparison between two multi storey buildings in India; a conventional building with load bearing masonry walls compared with a similar building constructed using soil cement block and alternative building materials was able to achieve a 50% reduction in total embodied energy.'

The next section summarises and priorities conclusions of this review.

5. Conclusions

Within this literature review, it was discovered that the current efforts to reduce the carbon foot print of the construction industry is primarily focusing on reducing operation carbon. Whilst this is effective, it is inadvertently seeing a small net increase in embodied carbon. For example, in low energy buildings with reduced operational energy, the embodied carbon will account for a large percentage of the life cycle carbon. This highlight the importance of addressing both embodied carbon and operation carbon reductions concurrently to manage life cycle carbon of a building. It was discovered that carbon estimating is hugely complex and the accuracy of estimates are greatly affected by multiple variables. Studies consider different stages of the building life cycle, varying carbon data sets and the practice is hugely unregulated leading to mix results between buildings.

Further, the current research on carbon reduction methods are scattered and generally focus on one-side of the coin either operational or embodied carbon, neglecting the holistic implications. The importance of carrying out more studies to analyse embodied carbon hotspots in buildings was established through this review which then enables to find alternative methods and designs that reduce total life cycle carbon. In doing so, complexities in analysing embodied carbon hotspots should be mitigated by developing universal approaches and transparent methodologies. Agreement on a consistent approach should enable embodied carbon measurement to become more widespread. Government intervention in terms of policy, incentives and taxation is equally essential in the standardisation of embodied carbon measurement and tools.

6. References

Akbarnezhad, A & Xiao, J 2017, *'Estimation and Minimization of Embodied Carbon of Buildings: A Review*', Buildings, vol. 7, no. 1, p. 5.

ASBEC 2016, *Low Carbon,High Performance, How buildings can make a major contribution to Australia's emissions and productivity goals*, Climate Works.

Ashworth, A & Perera, S 2015, *Cost Studies of Buildings* 6th edition Taylor and Francis, Oxon.

Basbagill, J, Flager, F, Lepech, M & Fischer, M 2013, *'Application of life-cycle assessment to early stage building design for reduced embodied environmental impacts*', Building and Environment, vol. 60, pp. 81-92.

Bribián, IZ, Capilla, AV & Usón, AA 2011, *'Life cycle assessment of building materials: Comparative analysis of energy and environmental impacts and evaluation of the eco-efficiency improvement potential'*, Building and Environment, vol. 46, no. 5, pp. 1133-40.

Chen, Burnett, J & Chau, C 2001, *'Analysis of embodied energy use in the residential building of Hong Kong'*, Energy, vol. 26, no. 4, pp. 323-40.

Darby, H, Elmualim, AA & Kelly, F 2013, *'A case study to investigate the life cycle carbon emissions and carbon storage capacity of a cross laminated timber, multi-storey residential building'*, SB13 Implementing Sustainability-Barriers and Chances.

De Wolf, C, Pomponi, F & Moncaster, A 2017, *'Measuring embodied carbon dioxide equivalent of buildings: A review and critique of current industry practice*', Energy and Buildings, vol. 140, pp. 68-80.

Dixit, MK, Fernández-Solís, JL, Lavy, S & Culp, CH 2010, *'Identification of parameters for embodied energy measurement: A literature review*', Energy and Buildings, vol. 42, no. 8, pp. 1238-47.

Gan, VJ, Cheng, JC, Lo, IM & Chan, CM 2017, *'Developing a CO 2-e accounting method for quantification and analysis of embodied carbon in high-rise buildings*', Journal of Cleaner Production, vol. 141, pp. 825-36.

González, MJ & Navarro, JG 2006, '*Assessment of the decrease of CO 2 emissions in the construction field through the selection of materials: practical case study of three houses of low environmental impact*', Building and Environment, vol. 41, no. 7, pp. 902-9.

Government, A 2017, *Paris Agreement Department of Environment & Energy* viewed 15/3/2017 2017 <http://www.environment.gov.au/climate-change/international/paris-agreement >.

Guo, H, Liu, Y, Chang, W-S, Shao, Y & Sun, C 2017, *'Energy Saving and Carbon Reduction in the Operation Stage of Cross Laminated Timber Residential Buildings in China'*, Sustainability, vol. 9, no. 2, p. 292.

Hansen, JE 1998, *'Sir John Houghton: Global Warming: The Complete Briefing*', Journal of Atmospheric Chemistry, vol. 30, no. 3, pp. 409-12.

Ibn-Mohammed, T, Greenough, R, Taylor, S, Ozawa-Meida, L & Acquaye, A 2013, *'Operational vs. embodied emissions in buildings—A review of current trends*', Energy and Buildings, vol. 66, pp. 232-45.

Milne, G & Reardon, C 2013 *Embodied energy*, environment.gov.au viewed 3/5/2017, <http://www.yourhome.gov.au/materials/embodied-energy>.

Mithraratne, N & Vale, B 2004, *'Life cycle analysis model for New Zealand houses'*, Building and Environment, vol. 39, no. 4, pp. 483-92.

Reddy, BV & Jagadish, K 2003, *'Embodied energy of common and alternative building materials and technologies'*, Energy and Buildings, vol. 35, no. 2, pp. 129-37.

RICS 2012, *'Methodology to calculate embodied carbon of materials'*, RICS Professional Information, UK.

RICS 2014, *Methodology to calculate embodied carbon*, vol. 1st edition RICS Professional Guidance, Global, RICS Professional Guidance, Global.

Schlueter, A & Thesseling, F 2009, *'Building information model based energy/exergy performance assessment in early design stages'*, Automation in construction, vol. 18, no. 2, pp. 153-63.

Solomon, S 2007, *Climate change 2007-the physical science basis: Working group I contribution to the fourth assessment report of the IPCC*, vol. 4, Cambridge University Press.

Stephan, A, Crawford, RH & De Myttenaere, K 2013, *'A comprehensive assessment of the life cycle energy demand of passive houses'*, Applied Energy, vol. 112, pp. 23-34.

Teh, SH, Wiedmann, T, Castel, A & de Burgh, J 2017, *'Hybrid life cycle assessment of greenhouse gas emissions from cement, concrete and geopolymer concrete in Australia*', Journal of Cleaner Production, vol. 152, pp. 312-20.

Thormark, C 2000, *'Environmental analysis of a building with reused building materials*', Lund Institute of Technology, Department of Building Science, Sweden.

Victoria, M, Perera, S & Davies, A 2016, *''A pragmatic approach for embodied carbon estimating in buildings'*, International Conference on Sustainable Built Environment, Torino, Italy.

Walther, G-R, Post, E, Convey, P, Menzel, A, Parmesan, C, Beebee, TJ, Fromentin, J-M, Hoegh-Guldberg, O & Bairlein, F 2002, *'Ecological responses to recent climate change*', Nature, vol. 416, no. 6879, pp. 389-95.

Wiedmann, T & Minx, J 2008, *'A definition of 'carbon footprint*'', Ecological economics research trends, vol. 1, pp. 1-11.

Yan, H, Shen, Q, Fan, LC, Wang, Y & Zhang, L 2010, *'Greenhouse gas emissions in building construction: A case study of One Peking in Hong Kong*', Building and Environment, vol. 45, no. 4, pp. 949-55.

Yu, M, Wiedmann, T, Crawford, R & Tait, C 2017, *'The Carbon Footprint of Australia's Construction Sector'*, International High- Performance Built Environment Conference – A Sustainable Built Environment Conference 2016 Series (SBE16).

Rajapaksha.U, et al (eds), 2017, "Design that cares"- multi disciplinary approaches to creating sustainable and meaningful built environment: *Proceedings of the 10th International Conference of Faculty of Architecture Research Unit (FARU), University of Moratuwa, Sri Lanka, (Vol. 01)*pp. 396-405 ©

CONCEPTUAL FRAMEWORK FOR DESIGNING AND PLACEMENT OF OPEN SPACES IN A RESIDENTIAL NEIGHBORHOOD

MANJARI RAI
SA&D , Manipal University , Jaipur, India
Ar.manjari.rai@gmail.com

Abstract
Open spaces are the breathing outlets in the anatomy of any residential neighborhood. The play generated in the plan through these voids ad mist the vast jungle of concrete is the ingredient of a well-planned layout. They connect the society through their varied social usage and act as a refresh command in the life of people from all age groups, finding ways to cure a large number of mental ailments and crimes majorly caused due to seclusion and odd family structures.

In the changing times, however, the definition and need of the subject has taken a new shape. People prefer watching a cinema in a home theater than watching ramleela in open ground. With the change in the economic stature, many things in the society have changed generating new modes of comfort and relaxation. This eventually has given rise to a society which is highly gentrified. People prefer living in their own niche, which seems to be cozy but is actually a socially secluded environment. It is therefore important to understand the changing trends and reorient the spaces, to make it more acceptable for all.

The concept of open spaces in a residential area needs therefore needs a makeover. This paper would thus aim at analyzing the open spaces and their hierarchy in some selected residential areas of Jaipur city (India). Major aspects of the study would be to understand the type of open spaces, their paucity, usage and location, study of changing trends and needs and arriving at certain planning proposals and design guidelines to improve the urban form and active living of the people.

Keywords: *open spaces, residential areas, changing trends, urban form.*

1. Introduction

Open areas are all those parcel of land which do not have any third dimension, structurally. No massive or considerable built up can be seen in such spaces.

The neighborhood squares, parks, play grounds, mela / fair grounds, community gathering spaces are some of the examples of open places in a residential area. A well laid out road section or a community parking lot can also be a part of such spaces. One can always call them connecting spaces and sometimes separators in an urban fabric. These spaces are responsible for enhancing the social life of people in any residential area and are accessible for

people of all age group and type, regardless of discrimination of any type. They are spaces which provide an opportunity to see, hear and meet others.

1.1 TYPES OF OPEN SPACES

Open spaces in any residential areas are the most happening or alive spaces. They are multifunctional in nature gathering masses throughout the day. Their shape, location and attributes may vary distinctively, yet they act as a bridge between the human activities and physical environment. They can be broadly classified in two heads, active and passive spaces. There is one more classification possible; they are the derelict spaces, which are basically the result of misuse and neglect of a parcel of land over a period of time.

The hierarchy of open spaces starts from the front gardens, lawns, trellises spilling over to the streets and parks of small scale within the block to larger neighborhood level greens.

Standards talk a lot about the percentage of open spaces in any developed area. According to the guidelines, 20-25% of the total land area should be reserved for open spaces. Apart from this, the areas left as setbacks within a plot also add up few numeric values to the above stated percentage. There are certain other additions to this, like the open spaces along the circulation networks, the chowks or chowrahas etc. this definitely varies with the plan ideas and design methodologies, by and large, outcome remains same. With so much of open spaces around, we still feel like living in a concrete jungle! a big question for the planners to answer. Before searching for the answers, lets first diagnose the problem or as said survey before plan.

1.2 DIAGNOSTIC STUDY OF THE OPEN SPACES IN FEW EXISTING RESIDENTIAL NEIGHBORHOODS

Before throwing solutions, problem area should be clearly studied and analyzed. Case study should be of varied nature. A single track approach can never view the issue three dimensionally. A study was therefore done of two different residential areas of Jaipur city (capital city of Rajasthan state), having varied development pattern and character. First case study was of the old city of Jaipur which has a typical mohalla planning concept. The second case study is selected down south, the Malaviya Nagar area. A well maintained residential colony having serene and calm environment. There are however few sectors in this area which are under threat and is facing deformation with time and urbanization.

2. Case studies

2.1 THE WALLED CITY OF JAIPUR

The old city of Jaipur was established by Sawai Jai Singh in the year 1728. The basic plan was evolved keeping in mind the topography of the site. This was the reason for the division of the city into 9 squares of 800x800sqmt. These blocks were further divided into sub blocks by the internal minor roads.

Open spaces in the fortified city of Jaipur have a character which is very bold and suits the life style of people from all the sectors of the society. It has huge temple complexes, stadiums and most important, the *'chaupars'*, which act as major nodes for the city. These spaces were designed to observe gatherings of all scale, from huge processions to daily chit chats, they provided an environment and space for people to gather and interact. The road cross sections of all the major market stretches were also designed keeping in mind the pedestrian movement. The shaded pathways gave an opportunity to talk and interact, making the commercial stretches lively. The residential sectors of the walled city observe a compact planning and are further based on the caste and occupational structure. The wall to wall construction was majorly done keeping in mind the climate of the area.

The *havelis* of walled city had courtyards as the major interaction spaces. They developed to contend with the extreme climate and to satisfy the socio cultural requirements. They were however the flexible spaces with multiple usages tagged in them. The pattern which they were planned was iconic. From a single courtyard house form to an assemblage of multiple courts, they were weaved in a fashion which suits families of all level and structure.

Most of these *havelis* had multiple courtyards depending upon the position of the owner in the society and also the family structure .It may vary from one to seven. These *havelis* were therefore named after the number of courtyards they had, like the char *chowk ki haveli* etc.

Courtyards were however an essential element of all the residences in the dense residential structure of the mohallas. Absence of small community green patches was thus not felt in the entire network. These chowks were further maintained by the group of residents having the shared ownership of it, and hence they were the maintained spaces. Some of them had small temples inside them, which again acted as a collection point for people of near vicinity, during religious ceremonies or even for daily *aarties.*

Fig 1. Courtyard of one of the havelis of jaipur city, having a small temple in the central area for residents to gather for aartie sessions.

2.2 MALAVIYA NAGAR, JAIPUR

It is a residential area down south of Jaipur city, has a good connectivity with all the major nodes and junctions of the city. It is divided into sectors of varied population and density figures. Some of them had regulated development creating a serene and healthy environment for the residents of that area, while few of the sectors were facing major setbacks due to unregulated commercialization of the area. Open spaces of both the type of development were studied to analyze the situation and major drawbacks.

Fig 2. Land use map of areas having regulated development in Malaviya Nagar, Jaipur

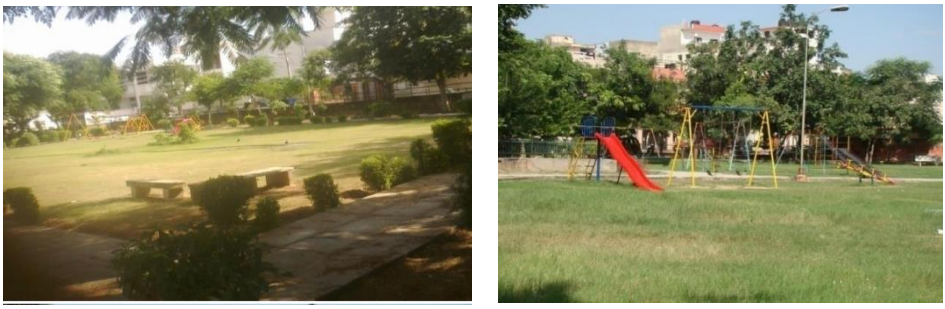


Fig 3. Images showing some maintained green areas of Malaviya Nagar, Jaipur.

The Open spaces of the areas having regulated development were majorly located in the vicinity of school and community spaces. The responsibility of maintenance of such spaces was taken by the school authority and in return these green areas were used by the students of the school as their play ground in the day time. As a result, these areas were never dead and isolated. They always had activities going on inside them.

The unregulated part however lacks such attention. Open spaces were encroached by illegal commercial activities or parking lots in most of the areas.

Fig 4. Land use map of sector 2 of Malaviya Nagar showing UN regulated development and lack of planned green spaces.


Fig 5. Ill-maintained open spaces, surroundings and approach are all littered and encroached by illegal activities.

3. Observations and Analysis

Many planners have discussed about the relationship between human activities and physical environment to analyze the quality of public spaces within the city and residential areas. Certain general observations are:

a. In today's fast moving and busy life, comfortable and multifunctional spaces are the need of the day. Dead spaces are neither safe nor affordable, when the land rates are sky rocketing.
b. The concept of mixed land use should be kept in mind while designing open spaces also. A system thus should be made to make its users feel a sense of belongingness.
c. The design approach of Public spaces should be public-oriented, catering to the needs of citizens of all age group. Architects and planners should be very much specific about the issues like safety, public facilities, traffic system, approach and accessibility.

4. Conclusions and Planning Considerations.

4.1 DETAILING OF OPEN SPACES IN THE CLUSTER LEVEL

It is rightly quoted that "Only that architecture which considers human scale and interaction is successful architecture." *(Prof. John Gehl, Life Between Buildings)* For any public space to become attractive, it is important that it should be able to generate a strong sense of belongingness amongst its inhabitants. It actually attains life through public participation. Good neighbor relation arises when people start taking out their joys and sorrows in public and these shared spaces then becomes the medium. A system should thus be derived from the ancient pole structure of Ahmadabad or the char *chowk ki*

havelies of Jaipur.A slight twist in the overall layout might change the basic setup of the society. Instead of providing isolated and fragmented open areas in the residential neighborhoods, planners should think of green areas, nested in between the housing units, eventually forming a common courtyard in between. It would act as an extended open space for the residents. An open space that gives every person and family, a common living and working access within convenient walking distance, eventually forming a courtyard. *All the residential units should be connected to the central core or the other important zones through a shaded pedestrian network.* Such common spaces, directly or indirectly add life to the hectic and monotonous schedule, rejuvenating the bond between the neighbors. The elderly, children and disabled person are the most vulnerable group of the society .they needs a very appropriate and soft design treatment to get easy access to public space. They are the most frequent visitors of public spaces. It is thus required to make the public space attractive and easy accessible in the residential neighborhoods. A semi transparent fence around these back gardens should mark the boundary between the private property and the public spaces.

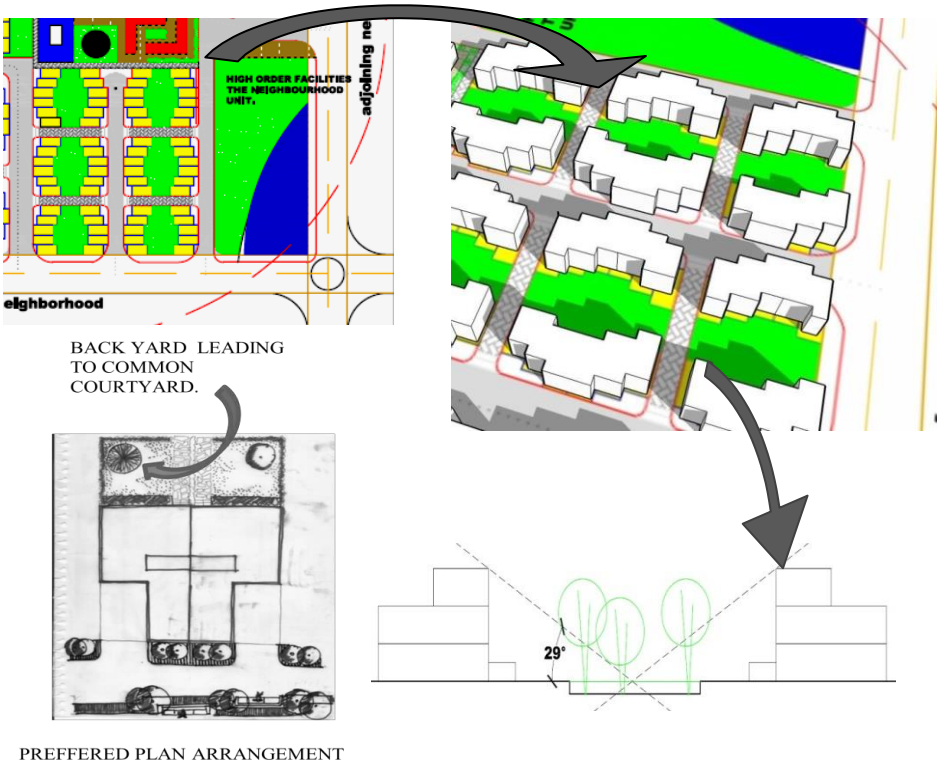


Fig 6. Units share common courtyard for social contact. Section through common courtyard.

4.2 DETAILING OF OPEN SPACES IN THE NEIGHBORHOOD LEVEL

Spaces within a neighborhood used by the entire community together as for socializing are called an open space in the neighborhood level. These spaces however are barren at the dull hours of the day, generally night and afternoons, which eventually give rise to anti social activities. However, in today's time, where high population density and economic land use are the major issues in an urban area, assigning a single use to any piece of land is unadvisable. The concept of multiuse and integrated spaces should be the most important aspect of design.

Strategic placements of related spaces are important. School, community hall, market place etc all need open spaces but at different time of the day. Such Places can be clubbed around an open space, which would act as a central facility core for the neighborhood. Parking lots provided for schools and community halls can also be shared, reducing the load on the land.

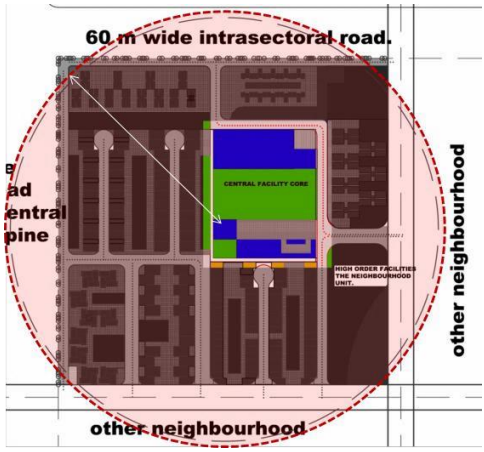


Fig 7. Plan showing the central open space shared by school, temple, community hall at different time in a day.

4.3 ROAD SECTIONS SHOULD BE DESIGNED WITH ADEQUATE SPACE FOR PEDESTRIANMOVEMENT.

Green areas of road sections add a considerable percentage in the overall open space statistics. Well planned road sections and street network having spaces of public interest, a variety of seating arrangements and public facilities act as a mode of interaction amongst the passersby.

Neighborhood streets of various types should be designed to provide equitably

for pedestrian comfort and automobile movement. wll laid out parking spaces provided in the organized manner can organize the residential areas more effectively and reduce the nusance caused by vehicles front of all the open areas and public places.

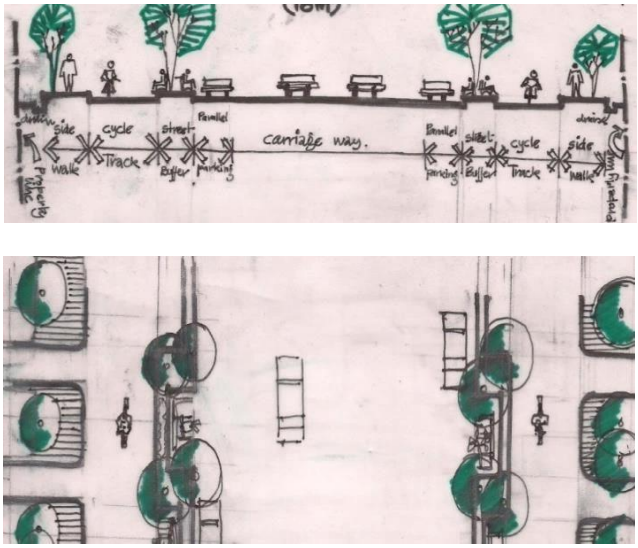


Fig 9. Section of well laid out road and street used as interaction spaces when designed accordingly with space left for basic public facilities.

4.4 SAFETY AND SECURITY SHOULD BE ONE OF THE MOST IMPORTANT FACTORS WHILE DETAILING OUT THE OPEN SPACES.

Almost all the residential neighborhoods, be it an urban setup or a rural area , has a similar kind of setup where the day times are usually very silent with only children, women and elderly people in the area. These are the times which are most vulnerable and the isolated open spaces become highly unsafe. All sorts of anti social activities start cropping up in these silent corners. Here comes another reason for providing multi usable spaces.

Safety and security of children is also a critical issue as they are not capable of anticipating any sort of danger around them, while playing. Hence, the Play grounds for children should be away from streets with busy traffic to avoid traffic accident and pollution and should be designed to accommodate people of different age groups also who accompany these children to such areas for the surveillance and protection.

To keep a check on any sort of criminal activities in the near vicinity by the residents, clustering of houses, sharing a common open space and reducing the number of entries inside this cluster becomes an important issue. Cul-de-sacs and loop streets should be provided to avoid making the streets, thoroughfare for other neighborhoods.

Last but not the least is the landscaping of streets. They need an expert eye while designing to avoid accidents of all sorts. Utmost care should be taken while placing vegetation, light poles, seating arrangements, street furniture etc.

5. References:

Newman, O 1996, Creating Defensible Space, DIANE Publishing, Darby.
Jacobs, J 1961, The Death and Life of Great American Cities, Random House, NewYork.
Gehl, Jan, 'Life Between Buildings: Using Public Space'1986.
Ar. Khurram ashraf and Ar.zeba nisar, the art of design, architecture time space and people, April2012
Jain, Shikha, (2004), Havelis: A Living Tradition of Rajasthan, Shubhi Publications, Gurgaon
Carmona, M, Heath, T, Oc, T & Tiesdell, S 2003, Public Places Urban Spaces: The Dimension of Urban Design, Architecture press, Oxford.

Rajapaksha.U, et al (eds), 2017, "Design that cares"- multi disciplinary approaches to creating sustainable and meaningful built environment: *Proceedings of the 10th International Conference of Faculty of Architecture Research Unit (FARU), University of Moratuwa, Sri Lanka, (Vol. 01)* pp. 406-417 ©

SUSTAINABLE BIM-BASED INTEGRATED PROJECT DELIVERY SYSTEM FOR CONSTRUCTION INDUSTRY: THEORITICAL FRAMEWORK

ROSAYURU, H.D.R.R.[1], WAIDYASEKARA, K.G.A.S[2] & WIJEWICKRAMA, M.K.C.S[3]
[1,2,3]Department of Building Economics, University of Moratuwa, Sri Lanka
dulitharosayuru@gmail.com, anuradha@uom.lk, mkcsw.mora@gmail.com

Abstract
The construction industry is an open and dynamic system, and the construction project procurement systems practised in the industry are subjected to changes resulting in many newly-innovated procurement systems, which is one of the best solutions for existing issues of conventional procurement. A new era of construction began with the technological improvements with Building Information Modelling (BIM), which is a novel advancement to establish a sustainable construction industry. Several countries have implemented BIM-based approaches to public procurement in recent years, among them, the Integrated Project Delivery (IPD) is an innovative procurement system that facilitates easy BIM adoption. It is evident that the establishment of an innovative procurement system such as BIM-based IPD is essential to adopt sustainable procurement successfully. Hence, this paper presents the drivers, benefits, challenges, and remedial measures, concerning the BIM-based IPD procurement when implementing the sustainable procurement concept to the Sri Lankan construction industry. Accordingly, comprehensive literature review was carried out to identify the above existing gaps in the literature and finally developed a theoretical framework to achieve sustainability targets via BIM-based IPD in construction projects, bridging the challenges of conventional procurement methods.

Keywords: *Building Information Modelling (BIM), Conventional Procurement, Integrated Project Delivery (IPD), Sustainable Procurement (SP).*

1. Introduction

The construction industry is one of the most productive industrial sectors which is becoming more complex with the improvements of modern technology (Molavi & Barral, 2016). As per the theoretical approach of construction management, a project may be regarded as successful if the project is completed as scheduled, within the budget and the required quality standards while achieving a high level of client satisfaction (Naoum & Egbu, 2016). Achievement of these project objectives becomes challenging due to the issues

of current Conventional Procurement (CP) systems (Hui et al., 2011). Gunawardhane and Karunasena (2015) emphasised that, concept of Sustainable Procurement (SP) is one of the best solutions to overcome issues and gaps in CP. Moreover, CP has also been subjected to considerable transformations which consist of changing the focus from lowest cost to best value achievement and revised agenda for delivering socioeconomic and environmental sustainability goals, objectives, policies and procedures in recent years (Oyegoke et al., 2009). Thus, Naoum and Egbu (2016) found out sustainability and Building Information Modelling (BIM) can be considered as two of the modern selection criteria for CP.

BIM is a new advancement to establish a sustainable construction industry, while achieving the triple bottom line of sustainability (Nagalingam et al., 2013). Liu et al. (2015) argued that, BIM design to be the central hub of sustainable building practices, due to the allowance for multi-disciplinary information and sustainability measures in to one model. According to Holzer (2015), BIM can be applied to different existing procurement systems for generating tender documents, designing, constructing, subcontracting and Facilities Management (FM). Integrated Project Delivery (IPD) is an Innovative Procurement (IP) system which facilitates BIM adoption heavily (Bolpagni, 2013). Furthermore, Howard and Ashcraft (2011) emphasised that, it is easy to achieve sustainability targets via BIM based IPD. Chong, Lee and Wang (2017) suggested that, establishment of IP systems such as BIM based IPD is essential to adopt sustainability successfully. Therefore, it is required to address the knowledge gap for the implementation of SP concept while considering IPD as a tool. Therefore, this paper aims to review the existing gaps in literature and develop a theoretical framework to achieve sustainability targets via BIM-based IPD in construction projects, bridging the gaps of conventional procurement methods.

2. Research Methodology

This paper is based on findings of the literature review, conducted to synthesis the current knowledge level regarding the research area and to gain new perspectives to establish the research gap clearly. In order to ensure that the literature review is completed and comprehensive, the authors have critically reviewed journals, books, conference proceedings, reports and websites which are related to the subject area: CP, SP and BIM based IPD.

3. Procurement in Construction Industry

With the evolution of construction procurement, many different types and categories of procurement routes have been developed (Oyegoke et al., 2009).

Naoum and Egbu (2016) identified four major categories of procurement systems based on the contractual relationships and the critical interactions between design and construction responsibilities. They are separated and cooperative system, integrated system, management oriented system and collaborative systems. Bolpagni (2013) has categorized them as CP systems with respect to advanced systems such as IPD, project alliancing, cost led procurement, integrated project insurance and two stage open book system which promote collaboration much more than CP.

Since, several procurement paths are available at present, analysing the trends of procurement is beneficial (Jayasooriya, 2010). With respect to the time period 1977-2009, in the Sri Lankan Architecture, Engineering and Construction (AEC) industry, separated procurement system was dominant. The second most popular was the integrated procurement system, third was the management oriented and final was the collaborative system (Jayasooriya, 2010). In addition, the procurement trends in the United Kingdom (UK) was almost similar to the above described pattern during the same time period (RICS, 2010). Thus, up to 2009, the CP systems were dominant in the industry. However, the non-availability of literature with respect to the time period of 2010-2017 is a significant gap. It is because, the entire world is changing rapidly in the current status.

3.1. ISSUES OF CONVENTIONAL PROCUREMENT SYSTEMS

CP has significant issues, in order to achieve project specific goals. These issues have a compounding effect on one another (Ruparathna, 2013). The identified deficiencies in the literature review have been broadly sorted into 11 number of categories (Refer to Figure 2: Theoretical Framework).

3.2. EVOLUTION OF PROCUREMENT SELECTION CRITERIA

Several procurement selection criteria have been developed to choose the most appropriate procurement systems during past three decades (Ratnasabapathy & Rameezdeen, 2007). Most researchers have been guided by the previous studies and these criteria have been subjected to be changed with respect to the evolution of the AEC industry. Hence, criteria for procurement selection can be summarised in to; certainty of time and duration, certainty of cost and available funds, quality (material/ workmanship/ design), tendering method and contract type, project type (industrial/ infrastructure/ building), project scale, project complexity, flexibility on design changes, project category (public/ private), influence over the Project Life Cycle (PLC), disputes like hood, owners' willingness to take risks, owners' available personnel, owners' willingness to

be involved, contractors' capacity and responsibility, market competitiveness, regulatory feasibility, technological availability and political consideration (Chen, et al., 2011; Love, et al. 2012; Mathonsi & Thwala, 2012; Li, et al. 2015; Chanudha, 2015). Naoum and Egbu (2016) suggested the following modern criteria for selecting the appropriate procurement method which can help practitioners to develop a wider and deeper perspective for procuring the project. They are supply chain, lean construction, sustainability, innovation, value engineering, e-procurement and BIM.

4. Procurement and Sustainability in Construction

Traditional design practices are obsoleted and have performed poorly in managing the flow or meeting clients' requirements (Naoum & Egbu, 2015). Sustainable development approach as one of the best remedial measures to eliminate the issues of the public procurement process and works towards the development objectives of the country (Gunawardhane & Karunasena 2015).

4.1. SUSTAINABLE PROCUREMENT IN CONSTRUCTION

The Brundtland Report defined the sustainable development as "meeting the needs of today without compromising the needs of future generations" (World Commission on Environment and Development [WCED], 1987, pp.27). Baker (as cited in Ruparathna & Hewage, 2015a) stated that, balance among the triple bottom line of sustainability namely environment, social, and economic factors is essential to achieve sustainable development.
Chartered Institute of Purchasing & Supply [CIPS] (2011) defines the concept of SP with more explanations as follows;

> *SP should consider the environmental, social and economic consequences of design; non-renewable material use; manufacture and production methods; logistics service delivery use; operation and maintenance; reuse recycling options disposal and suppliers' capabilities to address these consequences throughout the supply chain (*p.02)

However, there are still no holistic achievements in SP to be observed within the AEC industry (Ruparathna, 2013). Additionally, Ruparathna and Hewage (2015b) explained government regulation, competitive edge in the market, client requirement and cost of ownership as drivers for SP. Piyasena and Devapriya (2015) identified, limited resource availability, clients' requirements, awareness on importance of sustainability, marketing strategy, increase of global heat and polices of the government as the influencing factors for sustainable building procurement. Sourani (2008) conducted a survey to identify the agreed sets of the major sustainability criteria (41) that

should be addressed by UK public clients in developing a procurement strategy (Refer to Figure 2: Theoretical Framework). The same survey was conducted by Ruparathna (2013) for Canadian construction industry and identified 22 major sustainability criteria. In UK, Office of Government Commerce (OGC, 2007) has issued a guideline to the construction industry comprising SP aspects in different stages of construction PLC. Royal Institute of British Architects (RIBA) integrated sustainability concept in to RIBA plan of work stages while

adding sustainability check points for each stage which should be concerned by the initiators of procurement pathway (RIBA, 2013).

4.2 BENEFITS OF SP IN CONSTRUCTION

The findings from literature on benefits of sustainable construction procurement are presented in Table 1.

Table 1: Benefits of SP in construction

No	Benefit	Source of Reference				
		A	B	C	D	E
1	Reducing use of natural and nuisances' resources (land, water and air) and increasing use of renewable/ reusable and native resources		•	•		•
2	Meeting existing and forthcoming social legislation and environmental legislations (climate change agenda) both internally and externally.		•	•	•	
3	Reducing in harmful emissions and waste generation		•	•		•
4	Improving in working conditions - labour standards, health and safety		•	•		•
5	Assisting disadvantaged groups in society		•	•		•
6	Up skilling your workforce to meet the future needs of your organisation		•	•		
7	Saving the long term by considering the whole life costing	•	•	•	•	•
8	Meet international obligations and standards (e.g. Kyoto protocol)		•	•	•	
9	Improving the efficiency and transparency of procurement procedures		•	•		
10	Stimulate the market for green technologies		•	•	•	
11	Enhance corporate image in market place	•			•	
12	Minimize business risk	•			•	
13	Innovative solutions	•				
14	Improved aesthetic appearance of site					•
15	Reduction of energy use and high energy embedded materials					•
16	Reduction of the traffic aroused due to works					•
17	Preservation of cultural values					•

Adapted From: (A: CIPS, 2011; B: Ruparathna, 2013; C: Ruparathna & Hewage, 2015a; D: Interagency Procurement Working Group (as cited in Gunawardhane & Karunasena, 2015; E: Piyasena & Devapriya, 2015)

4.3 CHALLENGES IN THE IMPLEMENTATION OF SP IN CONSTRUCTION

Even in the global trend towards the sustainability in construction procurement, there are forces that present themselves as factors mitigating against the successful achievement of SP in a given procurement system of a country (Mensah & Ameyaw, 2012). Such kinds of forces identified by different researchers are presented in Table 2.

Table 2, Challenges of implementation of SP in construction

No	Challenge	Source of references							
		A	B	C	D	E	F	G	H
1	Lack of funding and unwillingness to incur higher cost	●	●	●	●	●	●	●	●
2	Lack of awareness, understanding, information, commitment and demand	●	●	●		●	●	●	●
3	Insufficient policies, regulations, standards and lack of leadership including government involvement	●	●	●		●	●	●	●
4	Insufficient/confusing guidance, tools, demonstrations and best practice	●		●		●	●	●	●
5	Vagueness of definitions and diversity of interpretations	●		●			●	●	
6	Separation between capital budget and operating budget	●		●	●		●	●	
7	Lack of sufficient time to address sustainability issues	●		●			●	●	●
8	Resistance to change due to less motivation	●	●	●	●		●	●	
9	Insufficient research and development with innovations	●		●			●	●	●
10	Complicated procedures, skilled staff for execution						●	●	
11	Less staff involvement and insufficient incentives, rewards for staff				●				●
12	Benefits only for end-users				●				
13	Lack of long-term perspectives	●		●					
14	Wrong general perception (Always greater capital cost)	●		●					
15	Insufficient integration and link-up in the industry	●		●		●			
16	Low level of demand in the market for sustainable products		●			●			
17	Less amount of suppliers in the market for sustainable products		●			●			
18	Lack of proper employment								●

Adapted from: (A: Sourani, 2008; B: Hanks, et al, 2009; C: Sourani & Sohail, 2011; D: Belfitt et al., 2011; E: Mensah & Ameyaw, 2012; F: Ruparathna, 2013; G: Ruparathna & Hewage, 2015a; H: Piyasena & Devapriya, 2015)

Sourani and Sohail (2011) found four parties who were considered as the most capable parties of removing the barriers including government and regulatory bodies, supply chain, professional/educational bodies and users.

Piyasena and Devapriya (2015) found out the following measures in order to overcome SP challenges in Sri Lankan context.

- Encourage innovative solutions
- Enhance the awareness of individuals on sustainability
- Integrate sustainability standards with the procurement process

- Create a proper environment (authority) to implement policies on sustainability
- Include subject matters on sustainability to school syllabus
- Maintain quality policy
- Produce new policies on sustainability
- Create a cultural belief on sustainability

5. Procurement and Building Information Modelling (BIM)

Jayasena and Weddikkara (2013) suggested that, BIM will be the primary industry standard for AEC industrial information exchange in near future. Thus, BIM is emerging as an innovative way to manage and deliver projects in the AEC industry (Nagalingam et al., 2013). IPD is a delivery method that could most effectively facilitate the use of BIM for construction projects (Kent & Becerik-gerber, 2010).

5.1. BUILDING INFORMATION MODELLING

BIM is based on a strong information outline which makes the building design fully automated, while comparing with the conventional Information Technology (IT) developments in the construction field (Jayasena & Weddikkara, 2013). The technology component of BIM helps project stakeholders to identify any potential issues of design, construction or operation by visualizing the built environment. “BIM is a digital, three-dimensional model linked to a database of project information which can combine among other things, the design, fabrication information, erection instructions, and project management logistics in one database” (American Institute of Architects [AIA], 2007b, p.10). Succar, (2009a) and Succar, (2009b) suggested BIM capability stages which are the major milestones to be achieved while adopting BIM technologies and concepts. BIM stages identify a fixed starting point (the status before BIM implementation), three fixed BIM stages and a variable ending point which allows for unforeseen future advancements in technology (Figure 1).

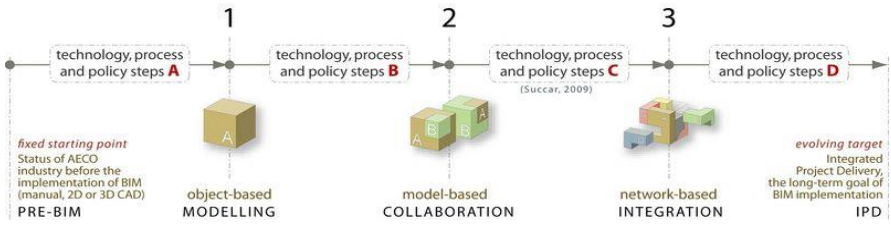


Figure 1, BIM stages *(Source : Succar, 2009a: Succar, 2009b)*

5.2. BIM BASED IPD

IPD can be defined as "a project delivery approach that integrates people, systems, business structures and practices into a process that collaboratively harnesses the talents and insights of all participants to optimize project results, increase value to the owner, reduce waste, and maximise efficiency through all phases of design, fabrication, and construction" (AIA, 2014, p. 04). AIA (2007a), AIA (2007b), AIA (2014) and AIA and AGC of America (2011), have demonstrated essential principles of IPD which are almost similar but updated with the development of project delivery concept. Further, the authors concluded that, the entire process of IPD can be categorized under conceptualisation, criteria design, detailed design, implementation documents, agency cord/ final buyout, construction and closeout as the main steps. Jayasena and Senevirathna (2012) synthesised 37 requisites to implement IPD by reviewing the current knowledge and constructing arguments. Based on the above available literature, 24 number of BIM based IPD principles have been identified (Refer to Figure 2; Theoretical Framework).

5.3 INTEGRATION OF BIM WITH CONVENTIONAL PROCUREMENT SYSTEMS

IPD is not the only BIM based project delivery method. There is an opportunity to merge BIM with existing CP systems. Few models have been generated to implement BIM within the public procurement in PLC (Holzer, 2015). BIM integrated project delivery can be known as "the project which is based on BIM applications spans over the entire of a facility such as project programming, design, preconstruction and post-construction phase" (Nagalingam et al., 2013, p.83). According to the literature findings, Bryde et al. (2013) argued that, the application of CP systems developed for ordinary projects have been found to be inappropriate for complex projects, and the usage of BIM, which can be classed as an 'unconventional system' has potential benefits to the management of construction projects than such CP systems. Further, Porwal and Hewage (2013) emphasised that, the implementation process of BIM with CP systems is not successful as expected at the conceptual stage. Thus, it is concluded IPD is the best project delivery method to implement BIM according to the literature.

6. Possibility of Using BIM Based IPD as a Solution for Sustainable Procurement

BIM is a new prototype in the booming sustainable construction industry. BIM has an excessive possibility of integrating construction PLC which is becoming the industry standards for construction projects and hence would be a key tool in project procurement in the near future with the concept of IPD (Nagalingam et al., 2013). Moreover, Jayasena and Weddikkara (2013) distinguished the intelligence of BIM increases the possibility of adapting lean approaches for

project delivery, minimising the risks and uncertainties and at last enabling SP systems for the building industry.

Chong et al. (2017) identified, certain aspects of sustainability that have been highlighted in recent BIM studies. However, to achieve social sustainability, an entire project procurement strategy need to be changed, since the current practices involved with BIM are not aligned with the separated nature of CP of construction projects. Finally, the authors found out four insights for effective adoption of BIM for sustainability as follows.

- BIM adoption for standard sustainability assessment
- Establishment of the IP system
- The BIM uses of demolition and aspects of refurbishment have to be streamlined
- The need for an improved interoperability among BIM software and energy simulation tools

BIM based IPD and sustainability are related forces that are widespread through the AEC industry. All are growing to some extent by their own, but maximising the potential of any of these items will depend on each other. (Becerik-gerber et al., 2010). There is a direct relationship between the Leadership in Energy and Environmental Design (LEED) credits requirements and the functionalities provided by BIM solutions. Therefore, integrating BIM and the LEED rating system to achieve LEED certification is feasible (Wu & Issa, 2010). Furthermore, integrated processes of IPD are being allowed and encouraged in sustainable ratings systems such as LEED (AIA, 2007b). Wu and Issa (2013) recommended that, the IPD is the preferred project delivery method for green building projects. The authors introduced two level of process mapping for IPD and LEED rating system. As the significance of BIM has become considerable, most of the activities in the AEC industry have been focused on BIM with sustainable design strategies. IPD promotes BIM based sustainable designs for the entire project design stages (AIA, 2014). AIA, (2007b) elaborated that, collaborative processes of IPD are acknowledged as the best sustainable results in meeting increasingly aggressive goals for energy and carbon reduction.

AIA (2014) concluded that, a well-established IPD leads to better outcomes, whether it is measured in value, aesthetics and sustainability while targeting profits. However, organisations are not much interested to use BIM in green building project delivery, since BIM is still a growing technology (Wu & Issa 2013). Becerik-gerber et al., (2010) suggested sustainable practices in the AEC industry and sustainability during construction are two of the emerging research directions and trends relating to BIM based IPD that researchers should further be concerned about.

7. Theoretical Framework

The framework (Refer to Figure 2) has illustrated relationships and the gaps of SP and BIM based IPD. AEC industry is searching for possible solutions for the identified issues in CP. IP systems have been developed as one solution while promoting collaboration among stakeholders. Consideration of advanced procurement criteria (sustainability, BIM) is another solution. CP systems were tried to be merged with BIM initially. However, the mismatch of principles created an unsuccessful integration between CP and BIM. Collaborative procurement system was the only CP method that showed some positive reactions during the BIM implementation. IP systems have been tried to be merged with BIM as the next step and IPD became the most successful project delivery method with BIM integration. Now, there is a clear gap of evaluating whether the criteria of SP and principles of BIM based IPD are matching to achieve Sustainable BIM based IPD.

8. Conclusions

The trend of procurement selection criteria has being moving towards the advanced objectives such as sustainability and BIM from traditional view points of time, cost and quality as a solution to the issues of CP. This paper is focused on available literature on procurement, sustainability and BIM based IPD and finally developed a theoretical framework while highlighting the research gap of merging SP and BIM based IPD.

9. References

American Institute of Architects, 2007a. Integrated Project Delivery : A Working Definition.

American Institute of Architects, 2007b. Integrated Project Delivery: A Guide.

American Institute of Architects, 2014. Integrated Project Delivery: An Updated Working Definition.

American Institute of Architects Associated General Contractors of America, 2011. Primer on Project Delivery.

Becerik-gerber, B., Asce, A.M. & Kensek, K., 2010. Building Information Modeling in Architecture, Engineering, and Construction : Emerging Research Directions and Trends. Journal of Professional Issues in Engineering Education and Practice, (July), pp.139–147.

Belfitt, R.J. et al., 2011. Sustainable Procurement – Challenges for Construction Practice. In TSBE EngD Conference.

Bolpagni, M., 2013. The implementation of BIM within the public procurement 1st ed., Espoo: Julikaisija Utgitgivare Publisher.

Bryde, D., Broquetas, M. & Volm, J.M., 2013. The project benefits of building information modelling (BIM). International Journal of Project Management, 31(7), pp.971–980.

Chanudha, R.A.C., 2015. A procurement system selection model to Sri Lankan construction industry. University of Moratuwa.

Chartered Institute of Purchasing & Supply, 2011. CIPS Sustainable procurement.

Chong, H.-Y., Lee, C.-Y. & Wang, X., 2017. A mixed review of the adoption of Building Information Modelling (BIM) for sustainability. Journal of Cleaner Production, 142, pp.4114–4126.

Gunawardhane, K. & Karunasena, G., 2015. Conceptual framework for sustainable public procurement process in construction industry. In The 4th world construction symposium Sustainable Development in Built Environment: Green Growth & Innovative Directions. Colombo: Building Economics and Management Research Unit (BEMRU), Department of Building Economics, University of Moratuwa, pp. 192–202.

Holzer, D., 2015. BIM for procurement - procuring for BIM. In R. H. Crawford & A. Stephan, eds. Living and Learning: Research for a Better Built Environment: 49th International Conference of the Architectural Science Association 2015. Melbourne, pp. 237–246.

Howard, W. & Ashcraft, J., 2011. Negotiating an Integrated Project Delivery Agreement. The Construction Lawyer, 31(3), pp.1-34.

Hui, W.S. et al., 2011. Procurement issues in Malaysia. International journal of public sector Management, 24(6), pp.567–593.

Jayasena, H.S. & Senevirathna, N.S., 2012. Adaptability of integrated project delivery in a construction industry. In Proceedings of World Construction Symposium 2012: Global Challenges in Construction Industry. pp. 188–195.

Jayasena, H.S. & Weddikkara, C., 2013. Assessing the BIM maturity in a BIM infant industry. In The Second World Construction Symposium 2013: Social-Economic Sustainability in Construction. Colombo, pp. 62–69.

Jayasooriya, W., 2010. Trends of construction procurement in Sri Lanka : Priotising procurement selection parameters. University of Moratuwa.

Kent, D.C. & Becerik-Gerber, B., 2010. Understanding construction industry experience and attitudes toward integrated project delivery. Journal of construction engineering and management, 136(8), pp.815–825.

Mathonsi, M.D. & Thwala, W.D., 2012. Factors influencing the selection of procurement systems in the South African construction industry. African Journal of Business Management, 6(10), pp.3583–3594.

Mensah, S. & Ameyaw, C., 2012. Sustainable procurement: the challenges of practice in the Ghanaian construction industry. In S. Laryea et al., eds. 4th West Africa Built Environment Research (WABER) Conference, 24-26 July 2012. Abuja, Nigeria, pp. 871–880.

Molavi, J. & Barral, D.L., 2016. A Construction Procurement Method to Achieve Sustainability in Modular Construction. Procedia Engineering, 145, pp.1362–1369.

Nagalingam, G., Jayasena, H.S. & Ranadewa, K.A.T.O., 2013. Building Information Modelling and future Quantity Surveyor's practice in Sri Lankan construction industry. In The Second World Construction Symposium 2013: Social-Economic Sustainability in Construction. Colombo, pp. 81–92.

Naoum, S.G. & Egbu, C., 2015. Critical review of procurement method research in construction journals. Procedia Economics and Finance, 21(5), pp.6–13.

Naoum, S.G. & Egbu, C., 2016. Modern selection criteria for procurement methods in construction A state-of-the-art literature review and a survey ". International Journal of Managing Projects in Business, 9(2), pp.309–336.

Office of Government Commerce, 2007. Achieving Excellence in Construction Procurement Guide 11: Sustainability, Norfolk: Office of Government Commerce.

Oyegoke, A.S. et al., 2009. Construction project procurement routes : an in-depth critique. International Journal of Managing Projects in Business, 2(3), pp.338–354.

Piyasena, T.D.A.L. & Devapriya, K.A.K., 2015. Challenges and Measures of Sustainable Building Procurement in Sri Lankan Construction Industry. University of Moratuwa.

Porwal, A. & Hewage, K.N., 2013. Building Information Modeling (BIM) partnering framework for public construction projects. Automation in Construction, 31, pp.204–214.

Ratnasabapathy, S. & Rameezdeen, R., 2007. A decision support system for the selection of best procurement system in construction. Built-Environment Sri Lanka, 7(2), pp.43–53.

Royal Institute of British Architects, 2013. RIBA Plan of Work 2013 overview D. Sinclair, ed., London: RIBA Publishing.

Royal Institute of Chartered Surveyors, 2010. Contracts in use: A Survey of Building Contracts in Use during 2010, London.

Ruparathna, R.J., 2013. Emergy based procurement framework to improve sustainability performance in construction. University of British Columbia.

Ruparathna, R.J. & Hewage, K., 2015a. Sustainable procurement in the Canadian construction industry : challenges and benefits. Can. J. Civ. Eng, 42(May), pp.417–426.

Ruparathna, R.J. & Hewage, K., 2015b. Sustainable procurement in the Canadian construction industry : current practices, drivers and opportunities. Journal of Cleaner Production, 109, pp.305–314.

Sourani, A.I., 2008. Realising Sustainable Construction in Procurement Strategies. Loughborough University.

Sourani, A.I. & Sohail, M., 2011. Barriers to addressing sustainable construction in public procurement strategies. Proceedings of the ICE: Engineering Sustainability, 164(4), pp.229–237.

Succar, B., 2009a. Building information modelling framework: A research and delivery foundation for industry stakeholders. Automation in construction, 18(3), pp.357–375.

Succar, B., 2009b. Building information modelling maturity matrix. Handbook of Research on Building Information Modeling and Construction Informatics: Concepts and Technologies, IGI Global, pp.65–103.

World Commission on Environment and Development, 1987. Our Common Future 1st ed., London: Oxford University Press.

Wu, W. & Issa, R., 2013. Integrated Process Mapping for BIM Implementation in Green Building Project Delivery. In Proceedings of the 13th International Conference on Construction Applications of Virtual Reality. London, pp. 30–31.

Wu, W. & Issa, R.R.A., 2010. Feasibility of integrating building information modeling and LEED certification process. In W. Tizani, ed. Proceedings of the International Conference on Computing in Civil and Building Engineering. Nottingham University Press.

Rajapaksha.U, et al (eds), 2017, "Design that cares"- multi disciplinary approaches to creating sustainable and meaningful built environment: *Proceedings of the 10th International Conference of Faculty of Architecture Research Unit (FARU), University of Moratuwa, Sri Lanka, (Vol. 01)* pp. 418-428 ©

IMPACT OF URBAN CONFIGURATIONS ON AIR TEMPERATURE IN KUALA LUMPUR

LIN YOLA[1] and HO CHIN SIONG[2]
[1] Universiti Teknologi Malaysia, Johor Bahru, Malaysia &
UCSI University, Kuala Lumpur, Malaysia
lin_yo_la@yahoo.com
[2] Universiti Teknologi Malaysia, Johor Bahru, Malaysia
ho@utm.my

Abstract
Rapid population growth causes the trend of high-rise buildings in the urban area. The modification of urban surface generates the poor scenario of microclimate, which mainly contributes to the increase of Urban Heat Island (UHI) intensity. UHI mitigation strategy is urged among planners and designers to ensure urban development meets the climate change adaptation agenda. Urban climatology studies mostly focus on the urban canyon geometry of the Height to Width (H/W) aspect ratio and Sky View Factor (SVF). There is lacking justification on the relationship of urban configurations and microclimate in the hot and humid region, especially in Kuala Lumpur. This study aims to investigate the impact of urban configurations on the air temperature. Four urban configurations; Courtyard, U, Courtyard Canyon and Canyon were simulated by using ENVI-met 3.1. The urban configurations study was set in two sites located in Kuala Lumpur with the East – West and North – South canyon directions. The results showed that the urban configurations generate impact on the mean of air temperature. The drop of nocturnal air temperature indicated that the UHI was worse in Courtyard configuration in both East – West and North – South canyon directions. The results also confirm that the reduction of the Sky View Factor (SVF) in urban configurations encourage the increase of the UHI intensity. The finding of this study stresses that the solar radiation was majorly influenced by the urban configurations which was significantly correlated to the results of air temperature. The finding suggests planners and designers to strategise the urban configurations according to the setting of the canyon direction during the preliminary design and planning stage.

Keywords: *Urban Configurations, Air Temperature, Microclimate, Sky View Factor, Urban Simulation*

1. Introduction

The climate and urban development are inseparable components in sustainable city framework. The current urban climatology issue is mainly discussed as the result of unsustainable city development. Temperature increase and Urban Heat Island (UHI) trend in big cities are the real threat that contributes to the climate change. Elsayed (2012) pointed out that compared to 1985, an increase of UHI intensity in Kuala Lumpur reached up to 1.5 ^{O}C. As a result, the trend generates urban issues on thermal comfort, cooling load and health. Climate change mitigation and adaptation agenda are stressed to overcome this global issue. However, the agenda still faces scientific challenges (Masson et al., 2014). Therefore, the discussion on the climate change mitigation agenda continues to pinpoint the comprehensive strategies and actions among the planners and scholars.

It is stressed that the rapid population and uncontrolled city development play the significant role to the issue. Carter et al. (2015) point out that city plays a central role in this scenario; one of them is generating modification of urban microclimates. Kuala Lumpur was reported reaches 100 per cent urbanisation. The significant growth of urban development transforms Kuala Lumpur vertically. The increase of numbers and height of high-rise buildings is the clear form of the transformation. Kuala Lumpur was reported has the highest number of high-rise buildings in Malaysia (Emporis, 2012). The compact development changes the nature of the urban environment which creates the modification of urban microclimates between buildings. The current urban climatology studies mostly discuss the modification of urban microclimates and UHI as result of the urban geometry of spaces between buildings. However, the transformation of the city development creates the variety of urban configurations, which also influences the quality of spaces between buildings especially the urban microclimates. Therefore this study investigates the relationship between the urban configurations on the urban microclimates.

2. Role of Urban Configurations in Urban Climatology

The increases in the temperature as the result of the urban microclimates modification mainly influences the thermal comfort (Radhi et al., 2015) and cooling load (Kalz et al., 2014). Erell et al. (2011) stressed out that the urban configuration is one of the most influenced factors in determining the urban energy budget. Ng (2010) emphasised that the physical attributes in built environment interconnect the urban microclimate, thermal comfort, and energy consumption which in this study is called ‘Climatically Responsive Urban Configuration”. It is the physical strategy of the mitigation agenda in achieving

the city sustainability by closely considering the climatic context (Refer to Figure 1).

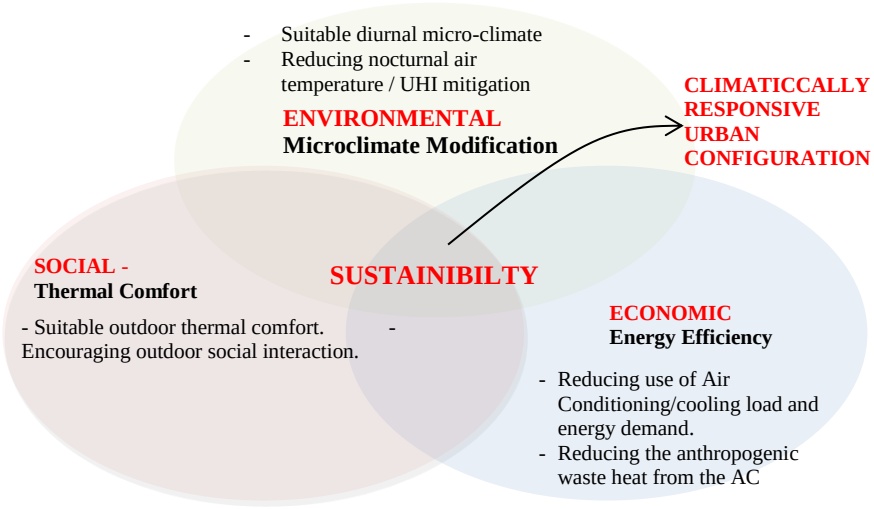


Figure 1, Interconnection of urban microclimate, thermal comfort and energy efficiency in "Climatically Responsive Urban Configuration" framework

The discussion on the relationship between urban configuration with microclimates and UHI has been explored by scholars. However, most of the studies investigate the impact of the geometry of the urban canyon or urban street canyon on the microclimate or UHI. One of the pioneer studies on UHI by Oke (1981 and 1982) has generated the mathematical models (Eq. 1 and Eq. 2) which are the basic concept frequently used in the outdoor microclimate and UHI studies. The equations formulate that the maximum expected UHI to be influenced by the Height to Width (H/W) aspect ratio and Sky View Factor (SVF) (See Figure 2) of the urban canyon configuration (Givoni, 1998). These equations justify that increase of H/W aspect ratio, and the reduce of SVF generate the maximum UHI. As the equations are widely used in urban climatology studies, this study used the model (Eq. 2) to compare with the urban simulation.

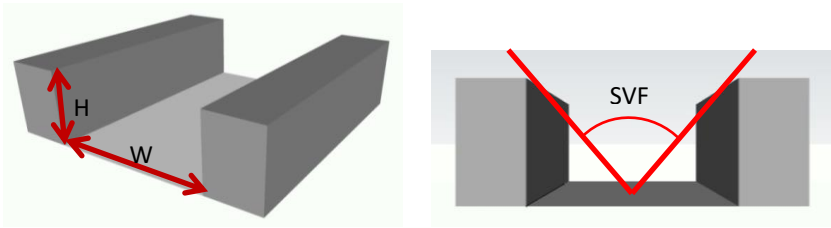


Figure 2, Height to Width (H/W) aspect ratio and Sky View Factor (SVF) in urban canyon

$$dTmax = 7.45 + 3.97 * \ln (H/W) \quad (1)$$

$$dTmax = 15.27 – 13.88 * SVF \quad (2)$$

However, Oke's models were formulated for urban canyon configuration. This study aims to explore the equations on other types of urban configurations. Studies show that besides the geometry of the spaces between buildings, the SVF value could vary in different types of the urban configuration. Kostof (1999) pointed out that urban structures are mainly in organic and grid pattern. Due to the setback rules, road structures, and land issues in the city area, most of the urban configuration in the modern urban area apply grid configuration. Therefore, most of the studies (Cavallo et al. 2014; Ng, 2010; Ratti et al. 2003; Martin and March, 1972) on the urban climatology and configuration investigate the grid configuration instead of the organic. Therefore, the investigated urban configurations in this study are the most grid-based used urban configurations, especially in Kuala Lumpur context.

3. Methodology

The relationship of urban configurations and the air temperature was investigated through urban configuration simulation. ENVI-met 3.1 was used to generate the air temperature image and hourly data. The microclimates data from the site were used as the ENVI-met 3.1 input data. The initial temperature was recorded 300 ºK, the relative humidity was 83%, and the wind direction was at 225 (South West). The simulation was set on 21 June 2015.

The empirical sites (FBTS and SM) data were set in Kuala Lumpur (3º8'N 101º41'E), located in the hot and humid region. The empirical urban configuration was Courtyard Canyon, 19-storey and 15-storey residential blocks which were situated with East-West and North-South canyon directions (Refer to Figure 3). The East-West and North-South canyon directions were set to analyse the modification of urban microclimates in parallel and perpendicular with the sun path as solar radiation intensity is high in Kuala Lumpur. However, this study simulated four urban configurations, which were the empirical and hypothetical; Courtyard, U, Courtyard Canyon, and Canyon (Refer to Figure 4 and 5). These urban configurations were set from lowest to highest SVF value. .

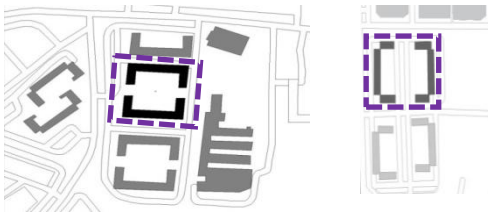


Figure 3, Empirical sites with courtyard canyon urban configuration; FBTS with East-West canyon direction (left) and SM with North-South canyon direction (right).

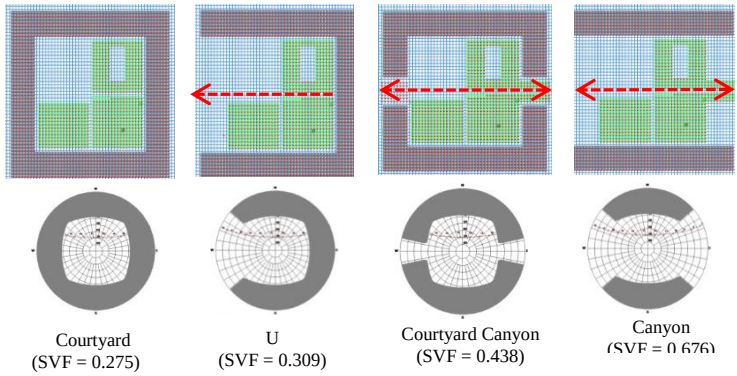


Figure 4, Simulated four urban configurations with East-West canyon direction, arranged from smallest to biggest SVF

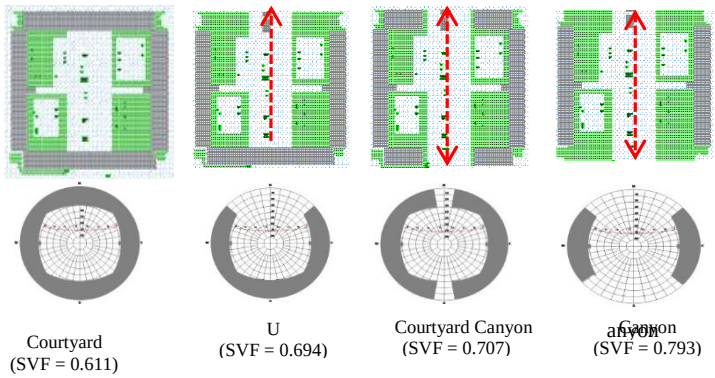


Figure 5, Simulated four urban configurations with North-South canyon direction, arranged from smallest to biggest SVF

This study justifies the results by comparing the air temperature of the Oke's model (Eq 2) and ENVI-met, to investigate the impact of the SVF in different types of urban configurations. As this study and Oke's model concern is on the UHI, the ENVI-met data is presented in the context of nocturnal air temperature drop. This study investigates the impact of the reduces of SVF value with the change of urban configurations to increase the UHI intensity as confirmed by Oke's model.

4. Results and Discussion

The simulation results show that the hourly air temperatures were varied in four urban configurations. However, the trends are almost identical in both scenarios (See Figure 6 and Figure 7). In East-West scenario, the diurnal air

temperatures were recorded high in Canyon and U configuration while the Courtyard and Courtyard Canyon generated high nocturnal air temperatures. In the North-South scenario, even though it presents the identical trend, the results show the quite big gap of the air temperatures among the four urban configurations. Courtyard Canyon and Canyon generated high diurnal but low nocturnal air temperatures, while the Courtyard and U configurations resulted in low diurnal but high nocturnal air temperatures. The image data of the air temperature at 3 pm indicate that the air temperatures are vary in each urban configuration for both scenarios (Refer to Figure 8 and Figure 9). The images data justify that the configuration of the building blocks toward the source of solar radiation mainly influences the air temperatures.

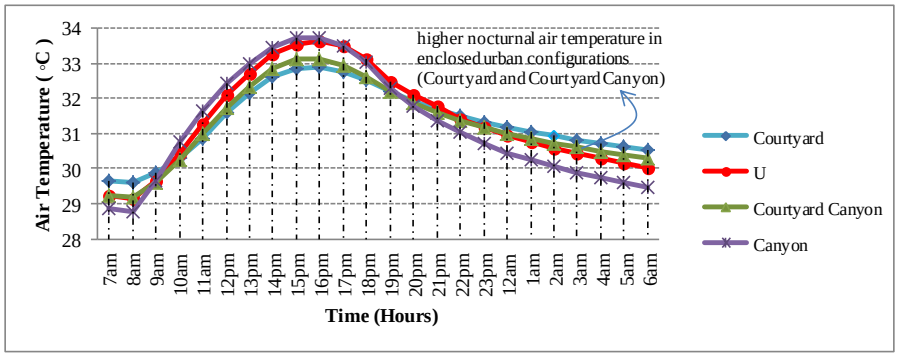


Figure 6, Hourly air temperature in four urban configurations with East-West canyon direction

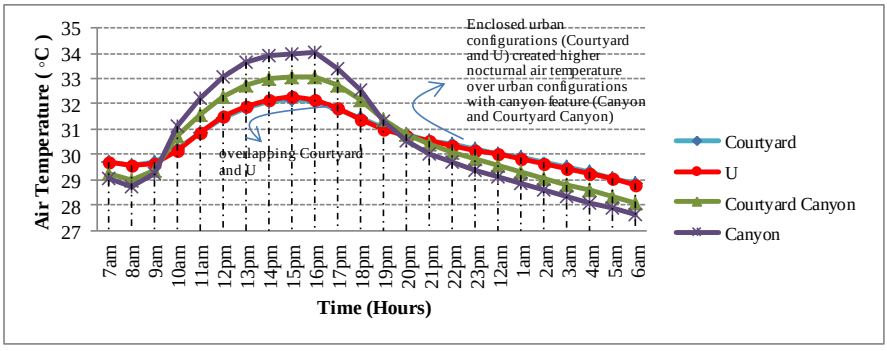


Figure 7, Hourly air temperature in four urban configurations with North-South canyon direction

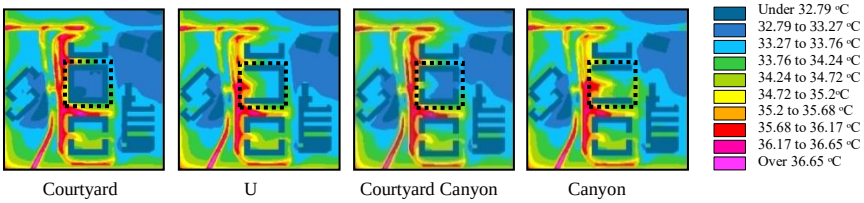


Figure 8, Air temperature image at 3 pm in four urban configurations with East-West canyon direction (investigated urban configuration is marked in black)

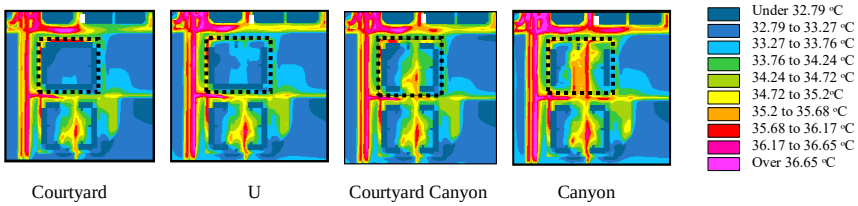


Figure 9, Air temperature image at 3 pm in four urban configurations with North-South canyon direction (investigated urban configuration is marked in black).

Table 1 and Table 2 present the comparison between the air temperatures in Oke's model and ENVI-met. The SVF value of each urban configuration was used to calculate the maximum temperature with respect to UHI intensity in Oke's model. Meanwhile, in ENVI-met air temperatures, the nocturnal drop was used. In both scenarios of East-West and North-South, the results show that the ENVI-met air temperature confirm Oke's model that the reduce of the SVF value generates higher UHI. However, the U configuration in East-West scenario shows a different trend, the nocturnal drop was recorded higher than the Courtyard Canyon which has bigger SVF. This study justifies that the U configuration was widely exposed to West direction which received the high intensity of evening solar radiation.

Table 1. Air temperature comparison of Oke's model and ENVI-met in four urban configurations with East-West canyon direction

Urban Configurations	**Oke's Model** Expected Tmax (UHI) (dTmax = 15.27 – 13.88 *SVF) (° C)	**ENVI-met** Nocturnal Air Temp. Drop (° C)	**Remarks**
Courtyard (SVF: 0.275) 	11.45	0.27	Result was as Oke's model, smallest SVF, smallest nocturnal temperature drop
U (SVF: 0.309) 	10.98	0.78	The urban configuration that faces East receives highest solar radiation
Courtyard Canyon (SVF: 0.438) 	9.19	0.45	Result in line with Oke's model, big SVF, big nocturnal temperature drop
Canyon (SVF: 0.676) 	5.89	1.32	Biggest SVF, biggest nocturnal temperature drop as Oke's model

Table 2. Air temperature comparison of Oke's model and ENVI-met in four urban configurations with North-South canyon direction

Urban Configurations	**Oke's Model** Expected Tmax (UHI) (dTmax = 15.27 – 13.88 *SVF) (° C)	**ENVI-met** Nocturnal Air Temp. Drop (° C)	**Remarks**
Courtyard (SVF: 0.611) 	6.79	1.13	Result was as Oke's model, smallest SVF, smallest nocturnal temperature drop

U (SVF: 0.694) 	5.64	1.19	Result in line with Oke's model, small SVF, small nocturnal temperature drop
Courtyard Canyon (SVF: 0.707) 	5.46	2.5	Result in line with Oke's model, big SVF, big nocturnal temperature drop
Canyon (SVF: 0.793) 	4.26	2.96	Biggest SVF, biggest nocturnal temperature drop as Oke's model

The results show that the change of the air temperature is significantly influenced by the urban configuration. It can be seen that the change of the air temperatures is mostly influenced by the design of the urban configuration and the canyon direction. In East-West scenario, the urban configurations with big exposure towards the high intensity of morning and evening solar radiation generate high diurnal but low nocturnal air temperature. Meanwhile, the enclosed urban configuration generated low diurnal but high nocturnal air temperature. It justifies that the shading generated by the building blocks reduced the diurnal air temperatures but the urban configurations trapped the long wave radiation that increased the nocturnal air temperatures. In the North-South scenario, the same trend also occurred. However, this study justifies that even though the open spaces were shaded from East and West solar radiation, in Kuala Lumpur context, the North area is also highly exposed to the solar radiation. Meanwhile, the results also show that the impact of urban configuration in relation to the urban wind speed is found weak in this study. It can justify that this issue is due to the poor urban wind in Kuala Lumpur area which is very dense with high-rise buildings.

The Oke's model expressed by the two equations (Eq. 1 and Eq. 2) is mainly discussed in the context of theoretical concept in studies of the relationship between urban configurations and urban climatology. This study, however, refers to the Oke's model to compare with the numerical simulation of the existing urban configuration. The scale barrier between the Oke's model which was formulated from the city model and this study which investigates the unit block could be the area to be further investigated. However, even though the Oke's model was formulated from the temperate city urban canyon, the results of this study still confirm the finding of the impact of SVF on the UHI intensity.

5. Conclusion

This study concludes that the urban configurations significantly influence the urban microclimates and UHI. The results present that the planning and design of the urban configuration should be strategized to shade the open spaces from high solar radiation exposure. About the UHI concern, this study presents that reduce of the SVF in the urban configuration significantly reduce the nocturnal air temperature which contributes to the increase of the UHI. The finding of this study fulfils the outcome from Oke's model that together with the SVF, the choice of the urban configuration also significantly influences the UHI. The strategy of urban configuration is suggested to apply by designers and planners in the planning and design process of residential block, neighbourhood or the urban structure in city planning.

6. Acknowledgement

The support from School of Architecture and Built Environment, UCSI University to this paper publication is gratefully acknowledged.

7. References

Carter, J. G., Cavan, G., Connelly, A., Guy, S., Handley, J. and Kazmierczak, A. (2015). Climate Change and the City: Building Capacity for Urban Adaptation. Progress in Planning. (95), 1–66.

Cavallo, R., Komossa, S. and Marzot, N. (2014). New Urban Configurations. IOS Press.

Elsayed, I. S. M.: 2012, A Study on the Urban Heat Island of the City of Kuala Lumpur, Malaysia. JKAU: Met., Env. & Arid Land Agric. Sci., Vol. 23, No. 2, pp: 121-134 (2012 A.D./1433 A.H.).

Erell E., Pearlmutter D., Wiliamson T., 2011, Urban Microclimate: Designing the Spaces between Buildings. Earthscan, London, UK.

Emporis. (2012). Building Data and Construction Worldwide. Retrieved from www.emporis.com.

Givoni B., 1998, Climate Considerations in Buildings and Urban Design. Van Nostrand Reinhold, New York, USA.

Kalz D., Pfafferott J., 2014, Thermal Comfort and Energy-Efficient Cooling of Nonresidential Buildings. Springer International Publishing AG, Cham, Germany.

Kostof, S. (1999). The City Shaped-Urban Patterns and Meanings Through History. London: Bulfinch Press.

Martin, L. and March, L. (1972). Urban Space and Structures. Cambridge: Univesity Pers.

Masson, V. et all. (2014). Adapting Cities to Climate Change: A Systemic Modelling Approach. Urban Climate. (10), 407–429.

Ng E., 2010, Designing for Daylighting - Designing High-Density Cites for Social and Environmental Sustainability. Earthscan, London, UK.

Oke T.R., 1982, The energy basic of urban heat island, Journal of Royal Meteorology Society, 108(455), 1-24.

Oke T.R., 1981, Canyon geometry and the nocturnal urban heat island: comparison of scale model and field observations, Journal Climatology, 1, 237-254.

Radhi H., Sharples S., Essam A., 2015, Impact of urban heat islands on the thermal comfort and cooling energy demand of artificial islands - a case study of AMWAJ islands in Bahrain, Sustainable Cities and Society, 19, 310-318.

Ratti., C., Raydan, D. and Steemers, K. (2003). Building Form and Environmental Performance: Archetypes, Analysis and an Arid Climate. Energy and Buildings. 35 (2003), 49–59.