# 1ST INTERNATIONAL DESIGN RESEARCH CONFERENCE 2020

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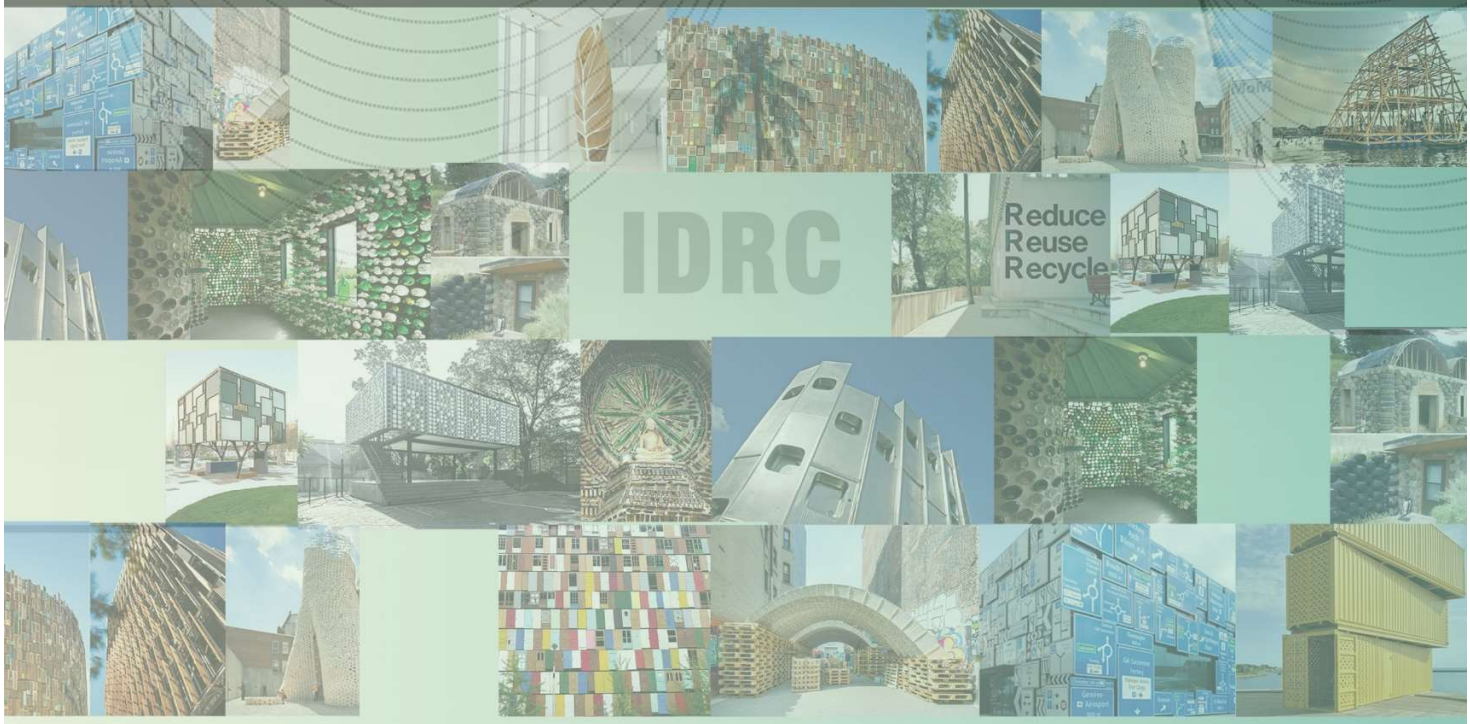



## ARCHITECTURE THROUGH REPURPOSE

IDRC ACA 2020

INNOVATION | EXCELLENCE | INTEGRITY | AGILITY | TRUST | MUTUAL RESPECT

# VISION, MISSION & QUALITY POLICY

## VISION

- *To be globally recognized as an epitome of learning and innovation.*
- *Imparting multifaceted architectural education driven by social sensitivity and supported by state of the art of infrastructure.*

## MISSION

- *To impart quality education that encourages students to be competent enough for best fit job roles.*
- *To provide faculty members with facilities to research, experiment and implement contemporary learning tools.*

## QUALITY POLICY

*" We, the Management, Faculty and Sstaff of Aditya College of Architecture are committed to offer excellence in architectural education, by pledging to our core value of Agility, Innovation, Integrity I our academic environment and state of the art facilities and infrastructure to our students, thereby ensuring mutual respect and trust for them.*

*We will work as a team and interact with the students in pro-active manner to achieve our institutional quality objectives and fulfill all academic , statutory and refulatory requirements to continually enhance the satisfaction of our students. "*

# ABOUT ACA

*Aditya College of Architecture established in 2013 is affiliated to Mumbai University, India. Since its inception, the college has continuously been working towards a vision to take architectural education ahead of traditional curriculum and achieve higher goals in grooming better professionals every year. The primary objective of the school is to create 'global practices with local concerns' to achieve excellence in architectural design, practice and profession.*

*The campus has infrastructure comparable to the best in the world. An ideal environment for exploring new ideas that encourage creative and independent thinking of young minds. It also provides platform for promoting innovation and research for students and faculty. The pedagogy of the school is building professional capacity and cherished individual interest of the student.*

*With the vision that educating professional requires close coordination of industry and academic the institute encourages collaboration with eminent academicians and industry professions in the way of conducting workshops, seminars, and webinars in the present pandemic situation. The Institute has collaborated with Sri Lanka Institute of Architects by the way of exchange program and combine studios.*

# ABOUT IDRC

*This year Aditya College of Architecture (ACA) brings its 1st International Design Research Conference (IDRC) with the theme, 'ARCHITECTURE THROUGH REPURPOSE', an attempt to investigate design outcomes through discarded and recycled materials. The present, everchanging lifestyle of today has driven our natural resources to the verge of depletion. It is reported that the global annual construction waste alone will nearly double to 2.2. billion tons by the year 2025. The exigent need to implement "reduce, reuse and recycle" policies is restrained by insufficient resources, lack of standardization and slim profit margins. IDRC endeavors to promote sustainable built environment by exploring 'repurposed' building materials that are economical, leave a positive footprint on the Ecology and provide waste management strategies.*

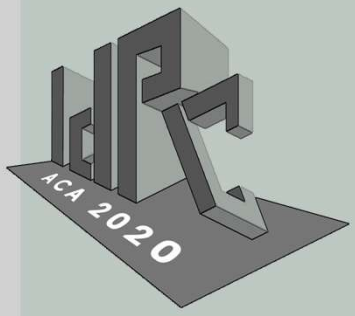
*The inaugural IDRC conference intends to cover an array of topics that enables Students, Academicians and Practitioners to voice their notions, hypotheses and ideologies evolved and devised through research and practice. It will entail eminent speakers who will showcase their work and share their knowledge on the subject*

***THEME:***

***ARCHITECTURE THOUGH REPURPOSE – A Purposeful Approach Towards Built Environments.***

***SUB-THEMES***

- ***Innovative Material and Alternative Techniques for Built Environment***
- ***Upgradation of Built Environment through cost effective material, methods and techniques***
- ***Project management strategies considering Recycle and repurpose on onsite debris with innovative building material approach***
- ***Energy efficient design process, techniques and methodology through recycling of waste during built form or built environment renewal projects***
- ***Urban planning strategies and Urban design policies on Repurposing Built form or Environment***
- ***Management of Resources – Embodied Energy cycle – Carbon footprints of Built form or Environment through Repurpose***
- ***Proposal of Modules or prototypes or Typology of Sustainable Built form or Environment through Repurpose.***




# ABOUT IDRC

# Message From Founder Trustee

**Shri Harishchandra Mishra**
Founder Trustee & Chairman

*A Leader is one who shows great perseverance, integrity, determination. They are the ones with the ability to guide and encourage others to achieve their goal. However, it is the traits of mental strength, high moral character, authority, and ability to find new solutions that forces others to look up to them.*

*Aditya College of Architecture (ACA) is fortunate to have such a leader. Our chairman, Shri Harishchandra Mishra, a leader who is proactive and driven by his passion for education. One that effectively takes his team along with him to scale the heights of success*

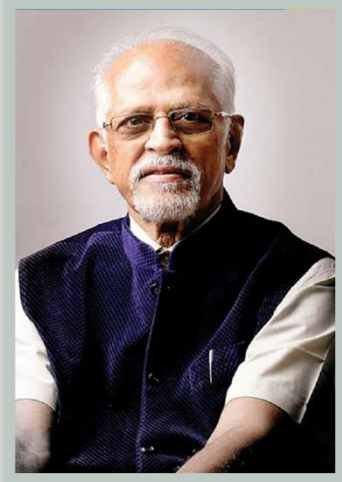
*It gives me immense pleasure to see the Aditya College of Architecture flourish with its abundant academic knowledge, immense industry exposure, and their innovative strategies in the field of education and research.*

*I congratulate Aditya College of Architecture for organizing the 1st International Design and Research Conference 2020 (IDRC) on the theme ''Architecture through Re-purpose.'' IDRC aims to create awareness about the need to reuse and recycle waste material. This would decrease the burden on the environment and contribute towards ecological sustainability.*

*We hope that IDRC will educate and nourish everyone with valuable message and insight. I wish all the prosperity and fortune to the institution and to the students who will take the baton ahead, to illuminate the world with their spark.*

*On behalf of Aditya College of Architecture, I wish International Design & Research Conference 2020 a grand success. May our team succeed in truly transferring knowledge without any limitations.*

# Message From Mentor



**Ar. Gurunath Dalvi**
Mentor & Advisor

*As a Mentor of Aditya Collage of Architecture for last 8 years, I take great pride to keep on record that the college, after successfully organizing International Design Competition consecutively for last 6 years, is majestically organizing 1st International Design & Research Conference on 11th-12th December2020.*

*The management, faculty and students deserve all praises and compliments for spending their enormous time and putting their efforts for the success of conference, in-spite of calamity of pandemic.*

*ACA is known for its vision and has been nurturing its students making them think out of the box. Various themes for last all IDCs proves the truth. The theme chosen for the 1st IDRC... "Architecture through Repurpose" is the record very apt for current global situation.*

*Understanding the need of the time, ACA came forward and shouldered the responsibility to bring all concerned together to deliberate on the burning issues mentioned under sub theme.*

*I hope that conference will prove to be useful and come with solutions to solve the problem of depletion of resources which can be put before the various authorities in State and Central government.*

*I wish the Conference a grand success.*

# Message From Principal

**Ar. Rita Nayak**
Principal

*"I only feel angry when I see waste. When I see people throwing away things we could use."*

—

*Mother Teresa*

*On a planet that has been ravaged by consumerism of the last few decades, there has been millions of tons of material generated that we call 'waste'. To me this waste is just another form of matter that we have not yet understood what to do with.*

*This brings us to our theme of 1st International Design and Research Conference on the Architecture of "Repurpose" which aims to promote the re-use of waste material by recycling and re-moulding. The intend of any development should be to meet the demand of the present, without compromising the needs of future - making it imperative to create buildings that are zero discharge and manifest carbon negativity to achieve ecological balance.*

*This year the IDRC 2020 platform reached out to students, Academicians and professionals who are sensitive towards the environment and have researched around recycling and re-using the waste material. Whether it is plastic waste to create bricks or paving material or cement design mix with demolition debris as aggregate, or even broken pieces of glass to create a new wall cladding, almost 90% of the waste material generated can be reused in innovative ways. The abstracts presented in the compendium, touches upon the various issues that plague the industry and showcase technologies and design strategies that can be employed to reduce the burden on our limited natural resources.*

*On behave of ACA I take immense pleasure in welcoming all to the annual IDRC event and hope it will spread awareness to the cause of "Architecture through Repurpose "*

# Message From IDRC Coordinators

*We here at ACA are proud of launching the 1st International Design and Research Conference 2020, a vision of our trustee's since the continued success of our International Design Competition. It is indeed an honor to be a part of this venture and lead an enthusiastic team of colleagues. For this maiden Conference, we strived to select a very relevant and meaningful theme – Architecture through Repurpose.*

*This Conference truly has an international reach; Eminent Architects, from India and abroad were invited after meticulous research. We are very proud of our association with such Industry stalwarts, whose work largely addresses our theme through their design.*

*Since its initial launch, IDRC has garnished tremendous response from the architectural community with over 130 abstract submissions for the Research Paper. We are thankful to all the participants and to the esteemed Review committee for their commitment. The varied topics chosen by the researchers based on the sub-themes of the conference showcase the urgency and sensitivity felt by the fraternity with regard to this issue. It strengthens our resolve to nurture this in ourselves and as mentors, in the next generation.*

**Ar. Rasika Chodankar**
Associate Professor

*It has been a pleasure to curate the 1st International Design and Research Conference 2020 on the theme of REPURPOSE THROUGH ARCHITECTURE wherein various enquiries from micro to macro level were generated through 130 plus abstracts received on subthemes of the Conference which gave us all an opportunity to look at the building materials, technology as well as waste management ; giving a very different lens of thought with REPURPOSE as tool to Sustainable and Energy Efficient Approaches under Architecture, City planning as well as Resource management.*

*The idea of Research Conference was conceptualized to have a meaningful Exchange of thoughts, which may be a primitive idea but having a capacity to trigger a sequence which ignites the research attitude in us. This Conference working has been an immense journey of learning for me, for the opportunity it gave me to reach out to faculty and researchers internationally as well as the collaborations that it prompted with Government and Private agencies who are actively involved in the planning and implementation process and somewhere there has given me a hope of inserting this seed of research at the start point of these planning processes.*

**Ar. Trupti Biswas**
Associate Professor

## Message From Publication Head

*Creation and demolition are two facades of Architecture. Every building has limited life span, which may vary depending upon its constructure type. In vernacular architecture, construction material being eco-friendly, either it was reused or got degraded naturally without any environmental concern. However, with the use of modern construction material, need was felt to reuse the construction waste as it is posing huge challenge for its eco-friendly disposal. True sustainability can only be achieved during creation stage which not only uses construction waste but also defines its reuse and adaptation after its demolition.*

*The theme for the conference 'Repurpose through Architecture' is to investigate innovative design strategies without overlooking the local concerns that will promote environmental sustainability with hindering creativity.*

**Ar. Aparna Parate**
Associate Professor

## About Our Reviewers

*Dr. Vasudha Ashutosh Gokhale: Professor, Dr. Bhanuben Nanavati College of Architecture, Pune; Ph. D. from Indian Institute of Technology Roorkee, India. 2 0 0 2; M. Arch from University of Roorkee, Roorkee, India. 1991 First Class Hons; B.Arch from Maulana Azad College of Technology, University of Bhopal, India 1989 First Class Hons. She is awarded with University of Pune -Best Teacher Award for contribution in academics 2009-10; "Best Teacher Award for Excellent Contribution in Architectural Education 2008. by Maharashtrra Association of Schools of Architecture and Council of Architecture, India; Best Teacher Award for contribution in academics by Indian Institute of Architects, Pune Chapter 2009; Maharshi Karve Award for Excellence 2010.*

*She has conducted multiple workshops/lectures for the students of architecture with reference to "Earthquake Resistant Architecture" & "Architectural Research". She is active member of Society of Architectural Historians; Indian Institute of Architects; Council of Architecture, India. CA/93/16256; Indian Institute of Interior Designers. She has also written a book chapter "A tiny whole world: Sustainable Design Lessons from the Architecture of Under Privileged Class",Chapter 7, "Reading the Architecture of Under Privileged Class, Ashgate Publishing Ltd, Burligton US, 2014.*

**Dr. Vasudha Ashutosh Gokhale**
Professor, Dr. Bhanuben Nanavati College of Architecture, Pune

## About Our Reviewers

*Dr. Ujwala Shirish Chakradeo: Professor and Principal of Smt. Manoramabai Mundle College of Architecture, Nagpur. Lecturer in Department of House & Interior Design of L. A. D. College for Women, Nagpur from Nov. 1985 to Dec. 1996 – 11 years. Associate Professor at Smt. Manoramabai Mundle Department of Architecture, . L. A. D. College for Women, Nagpur from 1997-2003. Approved Professor of RTM Nagpur University, Nagpur at Smt. Manoramabai Mundle Department of Architecture, L. A. D. College for Women, Nagpur from 2003.*

*PROFESSIONAL EXPERIENCE: Interior Design of Govt. and Private Sector Offices. Interior Design of Residences, Shops etc. Residential and Institutions buildings. Landscaping work of Japanese Garden through Design Cell of the College Design of School Building for Women's Education Society through Design Cell of The College. Various Projects under Design Cell of the College. For RTM Nagpur University and Govt. Departments.*

**Dr. Ujwala Shirish Chakradeo**
Professor and Principal of Smt. Manoramabai Mundle College of Architecture, Nagpur

*Dr. Roshni Udyavar Yehuda: Dr. Roshni Udyavar Yehuda is an Architect, Academician and Environment Consultant whose core competency lies in energy and environmental design of buildings – Building Energy Simulation; Green Building Certification; Building Physics and Solar Passive Architecture. She is Director, Roshni Udyavar and Associates; President, Institute of Environmental Architecture and Research (IEAR), Mumbai; served as Head – Operations, for the project on 'Promoting Clean and Energy Efficient Cold-Chain in India' for MP Ensystems Advisory Pvt. Ltd. in collaboration with Shakti Sustainable Energy Foundation, New Delhi and University of Birmingham, UK (March 2019), Vice President, Sustainability, ICMQ Certification India Pvt. Ltd. (till July2018).*

*As a writer and a professional, she has numerous articles and writings to her credit in various journals and books. At the 34th international conference on Passive and Low Energy Architecture – PLEA 2018, December 2018, Hong Kong, she received the 'Best Paper Award' for the paper co-authored with Dr. Archana Bhatnagar entitled 'Assessment of ThermODrain System on Thermal Comfort – study of a office building in Nashik, India'. She co-authored the book, 'Survival at Stake: An Anthology of Essays by Rashmi Mayur' in 2012.*

**Dr. Roshini Udyawar**
Director, Roshini Udyawar & Associates;
President, Institute of Environmental Architecture & Research (IEAR)

# IDRC TEAM

**Ar. Rita Nayak**
Principal

**Ar. Rasika Chodankar**
IDRC Coordinator

**Ar. Aparna Parate**
Publication Head

**Ar. Trupti Biswas**
IDRC Coordinator

**Ar. Varsha Swar**

**Ar. Akanksha Katare**

**Ar. Manali Rane**

**Ar. Ajay GeeVarghese**

**Ar. Pranita Daware**

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# REVAMPING OF FLOOD DEPOSITS INTO CONSTRUCTION BLOCKS: AN EXPERIMENT TO PROVE ITS EFFICIENCY

**Sibin Sabu[1] Indugeetha[2], Student[1] Associate Professor[2]**
**Marian College of Architecture and Planning Trivandrum, sibin.sabu@gmail.com**

**Abstract:** Soil is used as a building material in different parts of the world. With the least demand for resources, it is economically the most efficient means for house construction in developing countries. The 2018 flood in Kerala resulted in a huge loss of lives, many lost their homes, some houses were partially destructed and the overall effect was devastating. Post-flood Kerala saw huge deposits of waste and clayey soil accumulated in lands which need to be cleared somehow. Why can't we use these deposits as raw material for construction? To study this possibility, deposited soil from areas of Periyar, Kerala were collected and several tests were conducted on it to check its efficiency. Different types of blocks were prepared from this soil with and without adding stabilizers. Tests such as compressive strength and total water absorption were conducted on it to evaluate their strength and durability. Finally, the values and properties of prepared blocks were compared and its efficiency to be used as a construction material is proved. This paper is a review of the creation of such clay blocks from flood deposits and the scope of using them in building walling system.

***Keywords:*** *Kerala flood 2018, Flood deposits, Construction block, Efficiency, Affordable housing*

## 1.1 INTRODUCTION

The 2018 flood in Kerala has left behind huge deposits of waste and clayey soil in lands and even inside the buildings. The accumulated sediments consist of rich organic matter and debris. This flood waste has to be cleared and disposed to bring life back to normal. Considering the composition of the deposits, there is a possibility of it to be used as a construction material. Mud bricks have several advantages over other conventional building materials. These advantages include; a very minimal manufacturing process, availability from natural resources, inexpensive and mud structures can perform satisfactorily under hot environmental conditions.

Adequate shelter is one of the most important basic human needs. Currently, the majority of developing countries are faced with the problem of providing adequate and affordable housing in sufficient numbers. In the last few decades, shelter conditions have been worsening; resources have remained scarce, housing demand has risen and the urgency to provide immediate practical solutions has become more sensitive. Conversion of flood deposits into construction blocks could introduce a new low-cost construction block into the market which can act as an efficient solution for the provision of affordable housing. In this research, the possibility of revamping of the accumulated flood-waste into construction block is identified and its efficiency is tested through various laboratory experiments.

## 1.2 AIM

To find a suitable method for the effective clearance of flood deposits and experimenting the practicability of conversion of the deposits into construction block.

## 1.3 OBJECTIVE

- To constructively reuse accumulated flood deposits.
- To make construction blocks using these deposits and prove its efficiency using lab tests.

## 1.4 NEED OF THE STUDY

- Considering the sustainability aspects, the study finally finds a solution for flood-waste disposal by reusing the same as a construction material.

## 1.5 SCOPE OF STUDY

- Finding an appropriate solution for the clearance of flood-waste deposits.
- Introducing a low-cost construction block to the market.
- The double benefit of disposal of waste and creation of a new construction block.

## 1.6 METHODOLOGY

- Collecting samples of waste materials accumulated in the land during the flood in the Periyar region.
- Studying its contents and properties.
- Conversion of it into a block and experimenting it.
- Proving its efficiency as a construction block.

### 1.6.1 Methodology Chart:

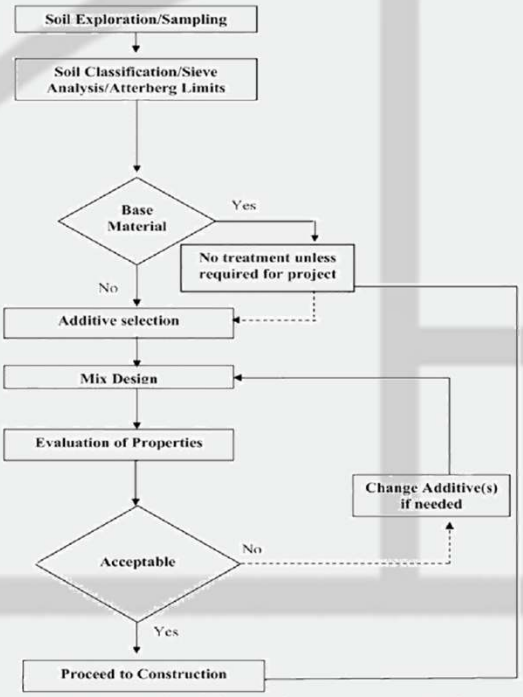


*Figure 1: Methodology Chart; Source: Author*

## 2 LIVE CASE STUDY

### 2.1 Introduction:

To learn about the possibilities of making construction blocks using mud, a live case study was done at the brick manufacturing cooperative society located at Amaravila, Neyyatinkara, Trivandrum and the brick making process was studied. The bricks produced there were tested and these values were later used to compare with the block produced using flood deposits.

*Figure 2: Soil from Plavilamoola used in Amaravila Cooperative Society; Source: Author*

### 2.2 Soil:

The society uses the soil from Plavilamoola riverine edge for the construction of brick blocks, clay tiles etc. The soil contains a high amount of clay and less organic matter. The soil was exposed to natural weather for 20 years before using for construction which leads to its reduced organic content.

*Table 1: Sieve Analysis; Source: Author*

| Component | Percentage |
|---|---|
| Gravel | 12% |

| | |
|---|---|
| Sand | 6% |
| Silt and Clay | 82% |

**2.3 Procedure:**

The process of brick manufacturing was explained and demonstrated by experts and workers in society.

**2.4 Tests on soil:**

- Dry Compressive Strength Test
- Water Absorption Test

*Table 2: Test Results- Block using Soil from Plavilamoola; Source: Author*

| Unconfined Compressive Strength | Shear Strength | Dry Compressive Strength | Water Absorption |
|---|---|---|---|
| 1.23 kg/cm$^2$ (Stiff strength category- IS Standards) | 0.615 kg/cm$^2$ | 11.29 N/mm$^2$ | 18.50% |

*Table 3: Test Results- Normal Burnt Brick Blocks (For Comparison); Source: Author*

| Dry Compressive Strength | Water Absorption |
|---|---|
| 3.26 N/mm$^2$ | 6.19% |

**2.5 Inference:**

It was found that bricks made from soil exposed to natural weather for longer periods show more strength comparing to normal burnt bricks.

**3 LITERATURE CASE STUDY**

Studies on stabilized mud block were conducted to learn about the possibilities of reinforcement to increase the block`s strength in case of failure of the construction block.

**3.1 Introduction:**

This study aims to prove the efficiency of locally available soil to be converted into earth blocks with the use of proper stabilizers.

The main objectives of this project are:

- To investigate locally available soils to identify their suitability in stabilized earth block production.
- To study experimentally the effect of altering the content of the stabilizers such as cement, lime, straw fibre, coir, plastic fibre on the properties and performance of stabilized earth blocks.
- To meet the economic requirements of the local situation by reducing dependence on outside sources and ensuring low-cost alternatives.
- To determine the most effective stabilizer for the chosen soil and its percentage.

**3.2 Experimental Setup:**

Different soil samples were collected from Koothattukulam, Neriamangalam, Nellikuzhy, and Cheladu of Ernakulam district. All the samples were properly dried. Sieve analysis was done on the samples to get different fractions of gravel, sand, silt and clay. (A good soil sample for mud block construction should have 10- 15% gravel, 50-75% sand, and 15-30% silt & clay.)

**3.3 Sieve Analysis Observations:**

*Table 4: Sieve Analysis; Source: ijirae*

| Component | Percentage |
|---|---|
| Gravel | 6.6% |
| Sand | 89.6% |
| Silt and Clay | 3.8% |

**3.4 Proportions of Stabilizers used:**

*Table 5: Stabilizer Proportions; Source: ijirae*

| Mix | Proportions |
|---|---|

| S | Soil only |
|---|---|
| L5 | 5% Lime |
| C5 | 5% Cement |
| L10 | 10% Lime |
| C10 | 10% Cement |
| C5C | 5% Cement, 3% Coir |
| C5P | 5% Cement, 3% Plastic Fibre |
| C5S | 5% Cement, 3% Straw Fibre |
| C10P | 10% Cement, 3% Plastic Fibre |
| C10S | 10% Cement, 3% Straw Fibre |
| C10C | 10% Cement, 3% Coir |

**3.5 Tests Conducted:**

- Compression test
- Water absorption test

**3.6 Conclusion:**

- Compressive strength increased with an increase in cement content. However, an increase in lime content showed very little increase in strength.
- Compressive strength increased by 43.39% for 10% cement content (C10).
- Compressive strength increased by 201.88% for 10% cement content and 3% coir (C10C).
- Compressive strength increased by 169.81% for 10% cement and 3% plastic (C10P).
- The average water absorption for blocks C10, C10 and C10P was less than 15%, satisfying the IS recommendation.

**3.7 Inference:**

The mix of 10% cement and 3% coir (C10C) shows good compressive strength and low water absorption characteristics and satisfies the IS recommendations and the mix with 5% cement and 3% (C5C) coir also shows a slight increase in strength. Hence, we could conclude that both cement and coir are good reinforcements for mud brick construction which aids in increasing the durability of the block.

**3.8 Findings:**

- The value of compressive strength of brick block for construction varies between 2.75 – 3.25 N/mm$^2$.
- The per cent of water absorption of the constructed brick block should fall below 20% (IS Standards).
- Fibres are added to bind the soil together with greater strength.
- If the soil is very rich in clay, stabilizers may not be required to improve the strength.
- Artificial fibres like cement are having good stabilizing properties than natural fibres like coir and jute.
- Using the soil as such is suitable and economical, stabilizers are needed only if the soil is of poor quality.
- Fibre-reinforced brick blocks cannot be burnt or baked to achieve strength since the fibre would also get burnt and create voids in moulded brick, therefore, it can only be sundried.
- The burnt brick will have more strength and durability than sun-dried bricks, but the burning process should be gradual as sudden heat could make cracks in bricks.

**4 INTERVIEWS AND TELEPHONE CONVERSATIONS**

- Telephone conversations with Ar. Vinu Daniel, Ar. Guruprasad Rane, and Ar. Ganga.
- Meeting with Civil Engineers, Geology specialists, Brick workers and other experts in the field.

**4.1 Inference:**

Identified the process of collecting and storing the soil samples after talking with experts in the field. First, the top layer of about 60-100 cm shall be removed from the deposits to avoid humus and the soil underneath shall be collected for the experiment. The soil should be stored in airtight bags. During the process of making the bricks, it should only be sun-dried since fibre and organic matter burns when the brick is burned in a kiln.

**5 FLOOD DEPOSITS STUDY**

**5.1 Experiment:**

The flood-waste deposit from Periyar was collected as suggested by the experts. The collected samples of flood deposited soil were very carefully examined and tested using the various field and lab tests.

*Figure 3: The Flood-Waste Dump in the Periyar River Edge; Source: Author*

**5.2 Field Tests:**

*Table 6: Field Tests Conducted; Source: Author*

| | |
|---|---|
| Visual Examination | Drying Time |
| Ribbon Test | Work and Time from Liquid Limit (LL) to Plastic Limit (PL) |
| Odour Test | Shine Test |
| Touch Test | Toughness at Plastic Limit |
| Wash Test | Shake Test |

**5.3 Lab Tests:**

*Table 7: Lab Test Results; Source: Author*

| **Tests Conducted** | | **Obtained Value** |
|---|---|---|
| Natural Water Content | Water Content Present | 62 % |
| Specific Gravity | Density Bottle Method | 2.53 |
| Hydrometer Analysis | Per cent of Clay-Size Particles | 66 % |
| | Per cent of Slit-Size Particles | 34 % |
| Atterberg Limits | Liquid Limit (%) | 70 % |
| | Plastic Limit (%) | 28 % |
| | Plasticity Index (%) | 42 % |
| Compaction Test | Optimum Moisture Content | 23.2% |
| | Maximum Dry Density | 1.49 |
| Unconfined Compressive Strength | UCC Value | 0.632 kg/cm$^2$ |
| | | Medium Strength (IS Standards) |
| | Shear Strength | 0.316 kg/cm$^2$ |

**5.4 Inference:**

The collected soil contains high plastic clay content and its composition per cent is highly different from what observed in live case studies. But it can still be used for making construction blocks with proper stabilization of fibres, and the soil itself is categorized in the medium strength category as specified in IS standards.

**6 BRICK FROM FLOOD DEPOSITS**

**6.1 Introduction:**

Since the collected soil contains a good amount of clay, it could be moulded directly (inferred from live case study). Therefore, the general procedure of kiln burning is done for making the bricks. The mould was prepared in 2 different ways:

I. The soil as such (soil collected from Periyar).

II. The soil mixed with a certain amount of soil which was left exposed to natural weather for 20 years (soil collected from Plavilamoola).

*Figure 4: Periyar Soil + Water Mix; Source: Author*

*Figure 4: Periyar Soil + Clay Soil + Water; Source: Author*

*Figure 6: Burnt bricks inside the chamber (Kiln); Source: Author*

**6.2 Procedures:**

The process of brick manufacturing was explained and demonstrated by experts and workers in society.

**6.3 Tests Conducted:**

- Dry Compressive Strength Test

*Figure 5: Machine for Testing the Strength of Brick; Source: Author*

- Water Absorption Test

*Figure 6: Water Absorption Test; Source: Author*

*Table 8: Tests Conducted on the Block from Flood Deposits; Source: Author*

| Block | Dry Compressive Strength Test | | Water Absorption Test | | |
|---|---|---|---|---|---|
| | Load Applied (kN) | Dry Compressive Strength (N/mm²) | Dry Weight of Moulded Brick in kg | Wet Weight of Moulded Brick in kg | Water Absorption (%) |
| | (Average value noted out of three experiments in each case) | | | | |
| Block using soil from Periyar alone (Burnt brick) | 24.80 | **1.37** | 1.58 | 1.98 | **25.01** |
| Block using collected soil (Periyar) + a certain amount of clay from the site of the live case study | 65.50 | **2.71** | 1.92 | 2.31 | **20.07** |
| Block using soil from Plavilamoola (live case study) | 285.00 | **11.29** | 2.59 | 3.07 | **18.50** |

**6.4 Inference:**

- The mud block burnt in the kiln (as done in the case of live study) doesn't get enough strength as expected due to the percentage increase in organic matter content.
- The organic matter got burnt inside and created voids in the prepared mud block which resulted in its lack of required strength.
- The mud block made using both Periyar soil and Plavilamoola soil shows a slight increase in strength as compared to mud block made only with Periyar soil.

**6.5 Failure results:**

- The block with Periyar soil alone shows a decrease in the adequate strength as compared to the normal burnt brick block where the values were 1.37 $N/mm^2$ and 3.26 $N/mm^2$ respectively.
- The block with Periyar soil plus a certain amount of pure clay shows decrease in strength as compared to the normal burnt brick block where the values were 2.71 $N/mm^2$ and 3.26 $N/mm^2$ respectively.
- The block with Periyar soil alone shows % increase in water absorption when compared with the normal brick block where the values were 25.01% and 6.19% respectively.
- The block with Periyar soil plus a certain amount of clay shows % increase in water absorption when compared to normal burnt brick where the values were 20.07% and 6.19% respectively.

**7 POSSIBILITIES OF REINFORCING WITH NATURAL AND ARTIFICIAL ADDITIVES**

Since the prepared block didn't show the required strength, the soil sample collected from the flood deposits is mixed with different natural and artificial additives to study the effect on the strength of the mud block to be made. Cement is used as an artificial additive, jute and coir are used as natural additives.

*Figure 7: Cement; Source: Author*

**7.1 Selection of Fibres:**

Due to the ease in availability of natural materials like jute and coir, it was used for reinforcement of the soil and both have very low moisture content. 5 strands of each fibre were picked and the average diameter of each was found out. The diameter of the jute was 0.1mm and that of coir was 0.2 mm. Jute has very thin strands and it breaks off easily as compared to coir fibre.

*Figure 8: Jute Fibre; Source: Author*

*Figure 9: Coir Fibre; Source: Author*

**7.2 Preparation and cutting of Fibres:**

Fibres have to be mixed with the soil in definite proportion for its maximum strength. They are cut into uniform pieces (stapled form) in a defined ratio depending on the diameter of the strands. The l/d (length/breadth) ratio for coir fibre is 80 and jute fibre is 45. Jute and coir fibres were cut into 5cm and 1.6cm respectively to satisfy the l/d ratio of these fibres.

*Figure 10: Jute Fibres Cut into an Equal Length of 4.5cm; Source: Author*

*Figure 11: Coir Fibres Cut into an Equal Length of 1.6cm; Source: Author*

**7.3 Compaction Tests:**

*Table 9: Compaction Test for Mud-Coir Mix; Source: Author*

| Per cent of Coir | Maximum Dry Density (g/cc) | Optimum Moisture Content % |
|---|---|---|
| 0.0 % | 23.2 | 1.49 |
| 0.5 % | 22.1 | 1.56 |
| 1.0 % | 20.1 | 1.63 |
| 1.5 % | 22.8 | 1.53 |

*Table 10: Compaction Test for Mud- Jute Mix; Source: Author*

| Per cent of Jute | Maximum Dry Density(g/cc) | Optimum Moisture Content % |
|---|---|---|
| 0.0 % | 23.2 | 1.49 |
| 0.5 % | 21.8 | 1.53 |
| 1.0 % | 19.2 | 1.68 |
| 1.5 % | 18.1 | 1.73 |
| 2.0 % | 20.3 | 1.50 |

*Figure 12: UCC Test; Source: Author*

**7.4 Unconfined compressive strength ($kg/cm^2$):**

*Table 11: Unconfined Compressive Strength ($kg/cm^2$); Source: Author*

| Soil Type/Mix | Unconfined Compressive Strength ($kg/cm^2$) |
|---|---|
| The soil as such | 0.632 |
| Soil with 1.0 % coir | 0.934 |
| Soil with 1.5 % jute | 0.989 |

**7.5 Inference:**

- With the addition of fibres, the soil shows an increase in strength properties from its unreinforced state.
- In the case of soil mixed with coir, the strength of mix is maximum with the addition of 1% of coir.
- In the case of soil mixed with jute, the strength of mix is maximum with an addition of 1.5% of jute.

## 8 CONSTRUCTION OF FIBRE REINFORCED MUD BLOCKS FROM FLOOD DEPOSITS

### 8.1 Procedures:

1. The soil is grinded to very fine particles manually.
2. Mixing of and coir, jute or cement in the soil in definite proportions.

*Figure 13: Manual Grinding of Soil; Source: Author*

*Figure 14: Mixing of Stabilizers; Source: Author*

3. The prepared mix is placed in metallic moulds having the volume of the brick.

*Figure 15: Metallic Mould; Source: Author*

*Figure 16: Prepared Mix in the Mould; Source: Author*

4. The block is then taken out of the mould and sundried for two days. The process is done to prepare itself for getting compressed under the machine, as a certain amount of the moisture content should be removed to do that.

*Figure 17: Moulded Bricks Sundried to Reduce Moisture Content; Source: Author*

5. The block is now compressed using the compressive machine and the perfect shape of brick is achieved. The process is done to ensure proper bonding of soil particles.

*Figure 18: Pressing of Prepared Mud Blocks to get Shape and Strength; Source: Author*

6. It is again let to dry in sun for 3 to 4 days. This is done for the complete removal of moisture present in the prepared block. It is then taken for various tests to analyse its strength and durability.

*Figure 19: Mud Blocks after being Sundried for the Second Time; Source: Author*

**8.2 Tests Conducted:**

*Table 12: Tests Conducted on Fibre Reinforced Block from Flood Deposits; Source: Author*

| Block | Dry Compressive Strength Test | | Water Absorption Test | | |
|---|---|---|---|---|---|
| | Load Applied (N) | Dry Compressive Strength (N/mm²) | Dry Weight of Moulded Brick in kg | Wet Weight of Moulded Brick in kg | Water Absorption (%) |
| | (Average value noted out of three experiments in each case) | | | | |
| Block using soil from Periyar + 1 % coir | 80.50 | **3.15** | 1.45 | 1.84 | **27.03** |
| Block using soil from (Periyar) + 1.5% jute | 100.33 | **4.34** | 1.52 | 1.82 | **19.69** |
| Block using soil from (Periyar) + 5% cement | 155.33 | **6.00** | 1.96 | 2.32 | **18.17** |

**8.3 Limitations:**

- Fibre-reinforced brick blocks cannot be burnt or baked to achieve strength since the fibre would also get burnt and create voids in moulded brick which increases the chance of getting cracks. So, it can only be sun-dried.
- Sundry takes a longer time than burning bricks in the kiln.
- The normal durability of a fibre reinforced brick is just 3 years, or else the fibres should be properly coated with solvents like bitumen, turpan, polish or varnish which is very time consuming and are difficult processes.
- In case of a wall with fibre reinforced brick, it becomes necessary to plaster the outer layer, whereas burnt brick could be used directly without any plasters. Pests and hermits may attack the fibre reinforced brick as the fibres in the most situation are exposed.
- There is a possibility for cement reinforced block to get exploded when burned in the kiln, so it can also be sundried only.

**8.4 Inference:**

- The strength and durability of block increase with optimum addition of fibre content.
- The use of these fibres could fix the pores in the moulded brick efficiently and hence water absorption will be low as compared to other mixes.

**8.5 Success results:**

- The blocks with cement (5%), jute (1.5%), coir (1%) respectively shows adequate strength for construction when compared to normal burnt brick.
- The block with cement (5%) as stabilizer shows increase in strength when compared to jute (1.5%) and coir (1%) where the values were 6.008N/mm², 4.34N/mm² and 3.15N/mm² respectively.
- Water absorption is least in case of cement (5%) as a stabilizer when compared to jute (1.5%) and coir (1%) where the values were 18.17%, 19.69% and 27.03% respectively.
- The soil collected during live case study (soil from Plavilamoola- which is being weathered for more than 20 years) is found to be the best in terms of both strength and durability.
- **Therefore, the blocks reinforced with 5% cement, 1.5% jute, 1% coir respectively shows good strength and durability and could be used for construction.**

**9 CONCLUSIONS**

- The study shows a positive use of flood-deposited mud in an efficient way and the possibilities to be developed as a construction block which has enough strength to be used for construction.

- Since the major raw material is flood-waste, there is no additional cost in the procurement of raw materials which in turn helps the construction block to be made lost-cost.
- Fibre-reinforced brick blocks cannot be burnt or baked to achieve required strength since the fibre would also get burnt and create voids in moulded brick which increases the chance of getting cracks. So, it can only be sun-dried.
- The quality (in terms of use for construction) of a clay-rich soil depends on the organic matter present in it. Lesser the organic matter more will be the quality and strength and greater the percentage of organic matter, lesser will be the quality and strength of the soil.
- In cases of deposits with high organic content, the accumulated flood-waste can be added with any natural or artificial stabilizers on the process of making the blocks, the addition of fibre in their respective optimum value has increased the unconfined compressive strength of the construction block.
- Hence, the possibility to reuse the flood-deposits in construction is proved irrespective of its organic content.


*Figure 20: Different Blocks Constructed; Source: Author*

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# DO THE SURROUNDING CONDITIONS OF JOGGING TRACKS AFFECT TO THE ATTENTION? A CASE STUDY ON JOGGING TRACKS IN SUBURBAN COLOMBO

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**Abstract:** Urbanization has brought half of the world's population into urban areas while transforming the way people live, work, travel and building network. Similarly, the urbanization made a significant impact on lifestyles in urban and sub-urban Sri Lanka. Jogging is found as one of the favourite physical activities among people in these areas. Unfortunately, the absence of proper design elements and surroundings of dedicated jogging tracks in Sri Lanka resulted in distracting joggers while jogging. Therefore, this study examines such design elements and surrounding factors and their impact on the attention of joggers in Sri Lanka. We select two jogging tracks in the capital of Sri Lanka, as our case studies. Further, we use online surveys and face to face interviews with joggers as data collection methods while triangulating data with experts' opinions from park managers and landscape architects in government authorities. Moreover, we gathered photographic data while observing tracks physically and using satellite images from online sources. The collected data is examined in both qualitative and quantitative methods to identify our results in which six factors emerged as most affecting factors to the level of attention of joggers. These six factors are increasing temperature, seeing amphibians in the surrounding, excessive traffic noise, vehicle smoke, dust particles in the atmosphere and level differences of the jogging track. Finally, we propose a set of recommendations for maintaining, restructuring, and developing jogging tracks in Sri Lanka in order to minimize the distractions of joggers.

***Keywords:*** *Urban health, Leisure activities, jogging tracks, Surrounding conditions, Attention, Sri Lanka.*

## INTRODUCTION / BACKGROUND

People do activities such as Jogging, cycling, walking, running, and outdoor gym exercising to either maintain or improve their physical and mental health. People who live in cities and suburban areas are tend to do these activities more as a part of the daily routine. Jogging is found as one of the everyday activities among Sri Lankans who live in urban and suburban areas. Sri Lanka has developed several dedicated places to facilitate these people. However, the poor conditions and the surroundings of theses jogging tracks might raise issues as they badly affect the physical and mental health of joggers. This research focuses on the part of the mental health, in particular,- the level of attention of joggers. Further, the research studies on two main factors that affect the level of attention of joggers, namely, (a) surrounding factors of the jogging tracks, (b) jogging track conditions/facilities. Jogging tracks (two tracks) situated in the capital of the country are selected as case study areas. The results reveal key factors that affect the level of attention of joggers. Finally, the author provides a set of recommendations to improve the surroundings and conditions of jogging tracks in Sri Lanka while making them to minimize the distractions of their users.

## LITERATURE REVIEW

### THEORETICAL BACKGROUND

The world health organization defines health as "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" (WHO, 1948). Further, they elaborate health as a combination of physical, mental, and social well-being. When considering mental health, Proulx (2017) explains mental health as "the condition of your mind and your ability to balance your emotions".

Kaplan and Kaplan, 1989 explains the "Attention Restoration Theory" (ART) is the focuses on how natural environments can engage involuntary attention, and thus allow recovery of a fatigued directed attention system and also, ART states that the benefits of interaction with nature are largely due to cognitive benefits and "soft," effortless fascination (Kaplan and Kaplan, 1989). The theory identifies four qualities that contribute to a restorative experience. Fascination implies

that there is something in the surroundings that captures one's attention in a non-depleting, replenishing way (Kaplan and Kaplan, 1989). Extent assumes that the environment should have coherent scope such that one feels like being in a whole other world and Being away means being mentally detached from everyday worries and concerns (Kaplan and Kaplan, 1989). Finally, Kaplan explains the environment should match one's current needs to support the restoration, thus, compatibility is important. These four qualities explain the human and environment interaction.


**Fig. 1:** Theoretical Framework
Source: Author

## RELATED WORKS

There is a limited amount of research has carried out on jogging tracks and their users in Sri Lanka. Hettiarachchi and de Silva (2016) explains human behaviour is defined as a result of human perception and cognition which change from person to person and situation to situation according to their needs, preferences and attitude. Moreover, they discussed urban recreational landscape designs are created with the intention that the users would obtain the maximum benefit out of them. Hettiarachchi and de Silva (2016) identifies design weaknesses like less convertibility, lack of safety, uncomfortable scale, isolation and less permeability may lead to an attention and unwell mindset of people who live among those places.

The study adopted a mixed method which is twofold, namely a literature survey and a case study. A literature survey was carried out to identify theories and arguments related to the subject area. The factors which contribute to effective urban public spaces recommended by different scholars which apply to urban recreational landscape designs were analysed to identify the significantly common factors to investigate further. Our research study employees a similar methodology to investigate the natural and designing factors of jogging tracks which affect the attention of joggers. Kalansooriya (2015) explains structural constraints that affect joggers in Sri Lanka such as accessibility, natural environment, safety & maintain, characteristic of places, aesthetic and scenery, location of area and cleanliness and lighting condition. The methodology of this research involved qualitative data analysis of 30 interviews from randomly selected joggers. However, to better inform the results, the author used observations and secondary data sources.

## THEORETICAL AND CONCEPTUAL FRAMEWORK

After a careful study of urban health, mental health, ART, and urban leisure literature, we created a theoretical framework (See, Fig. 1) and its application as a conceptual frame (See, Fig. 2).

The main research objective of this research is to identify the factors that affect the attention of joggers in sub-urban Sri Lanka. To achieve this outcome, two hypotheses were designed aligning with the theories consulted.

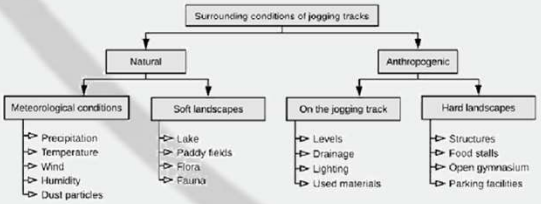


**Fig. 2:** Conceptual Framework

**H1:** There is a relationship between jogging track surrounding and the level of attention of users.

**H2:** There is a relationship between jogging track conditions and the level of attention of users.

These hypotheses were transformed into two main research questions to be answered in this research.

**RQ1:** What are the surrounding factors that affect the attention of joggers?

**RQ2:** What are the jogging track conditions that affect the attention of joggers?

**Table 1**: Considered factors for each research question
Source: Author

| | | |
|---|---|---|
| Attention | Surrounding factors | (a) Meteorological conditions |
| | | (b) Flora, fauna and wetlands |
| | | (c) Situational surrounding |
| | Track conditions | (a) Construction elements |
| | | (b) Facilities of the premises |

The following methodology section explains the steps we followed to answer RQ1 and RQ2

Aligning with the literature (Kalansooriya, 2015), these factors were derived from two main categories (See, Fig. 2). The initial list of factors is decided based on the related studies and further refined based on several visits to the selected case study area. We further discuss this process in the methodology section.

## METHODOLOGY

This research investigates the impact of surrounding conditions of jogging tracks on the attention of joggers. Further, the surroundings of the jogging tracks are investigated under two main parts, namely, track conditions and track surrounding. Interviews and a survey were used as the primary data collection techniques. We further interviewed experts to triangulate the data we gathered. Both quantitative and qualitative analysis were used to derive the results. Figure 3 depicts the methodology as an overview and important steps of the methodology is further discussed in the following subsections.

## CASE STUDY SELECTION PROCEDURE

First, the author did the pilot visit to six jogging tracks which are well known in urban and suburban Colombo to observe the surroundings, joggers, and observation data gathering for the research. Most of them were under-occupied due to the prevailing COVID 19 pandemic restrictions at the time of this writing. Out of these sites, we selected Diyawanna lake jogging track and the Kimbulawela jogging tracks as our case study areas. This decision was motivated by the fact that these were comparatively more occupied during the visit times. Further, these two tracks situated next to each other on the sides of the main access road. Moreover, both tracks had several different surrounding factors which made them good representative of other tracks we visited

## CASE STUDY AREAS

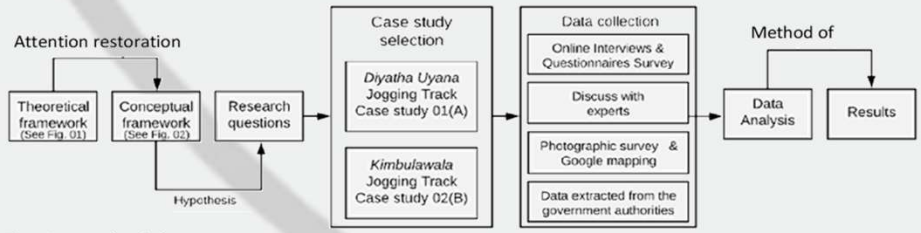


**Fig. 3:** Methodology
Source: Author

The selected jogging tracks are situated in the capital of Sri Lanka, Sri Jayewardenepura Kotte (60°52'46" N, 79°55'35" E). The Diyawanna jogging track (See, Fig. 4 - A) is a line track of approximately 1.8 km length which situated along the Diyawanna lake. It is faced with the Diyawanna water body. On the other hand, the Kimbulawela jogging track (See, Fig. 4 - B) is a circular track of approximately 3.5km length around Kimbulawela paddy fields.


**Fig. 4:** Selected case study jogging tracks, a google image bird view (A –Diyawanna lake jogging track; B –Kimbulawela jogging track) *Source: Google Earth(https://www.google.com/earth/)*

## RESULTS AND DISCUSSION

This section presents the results of this study based on the 40 responses received for the survey distributed. The observations and other collected data inform the discussion around these results. The survey received 40 responses representing age 15 to 70. Out of the 40 participants, 18 were male, and 17 were female, while 5 of the participants preferred not to reveal their gender.

### ANSWERING RQ1: MAIN SURROUNDING FACTORS THAT AFFECT THE ATTENTION OF JOGGERS

In this sub-section, we discuss the surrounding (natural) factors that affect the attention of joggers. This sub-section focuses on three main surrounding categories, namely, (a) meteorological conditions, (b) flora, fauna and wetlands, and (c) situational surrounding (such as vehicle smoke and dust).

#### (a) Meteorological conditions

We examined four meteorological conditions (rainfall, temperature, wind and humidity) against the attention of joggers. Among these conditions, normal rainfall is found as the main meteorological factor that increases the attention of the joggers. This is generally supported by 62.5% [25 out of 40] of the participants. Out of these 25 participants, 3 participants strongly agreed that normal rainfall change their attention (See, Chart 1). Three interesting responds strongly disagree with this opinion.

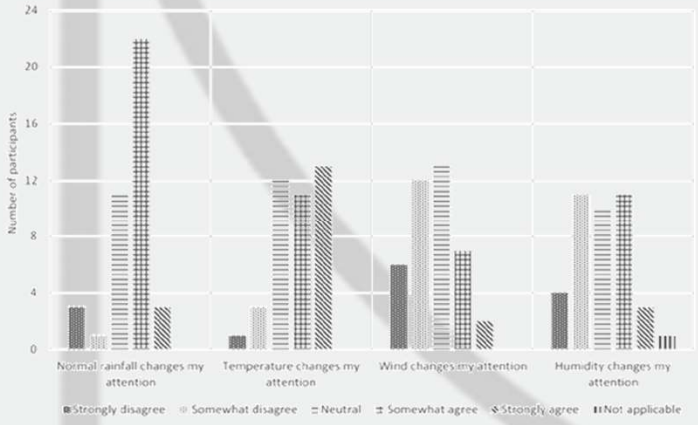


**Chart 1:** The way meteorological conditions affect the joggers' attention
Source: author

Increasing temperature is identified as the second most affecting factor to the attention of joggers. Twenty-four participants (60%) agreed with this opinion; however, twelve (30%) participants remained neutral to this statement. A micro-level analysis showed that this particular participant uses the Diyawanna jogging track and the Kimbulawela jogging track mostly between 5 – 7 a.m. and 5 – 7 p.m.

The author learns that this was because the increasing humidity causes the sweating, which creates discomfort to the joggers. On the flipped

side, comparatively, Wind and Humidity do not increase joggers' attention level as 77.5%, and 62.5% of the participant respectively responded either neutral or disagreed to the idea of changing the attention against wind and humidity.

**(b) Flora, fauna and wetlands**

The flora, fauna and wetlands that are in the surrounding area can affect the joggers' attention when they are jogging. Seven factors were examined under this category as seeing crocodiles living in Diyawanna lake (adjourn to the jogging tracks), birds and their noise, seeing four-limbed animals (e.g., dogs), location of trees and creepers, shade from trees, the aroma of flowers and seeing the paddy fields around Diyawanna lake (adjourn to the jogging tracks)

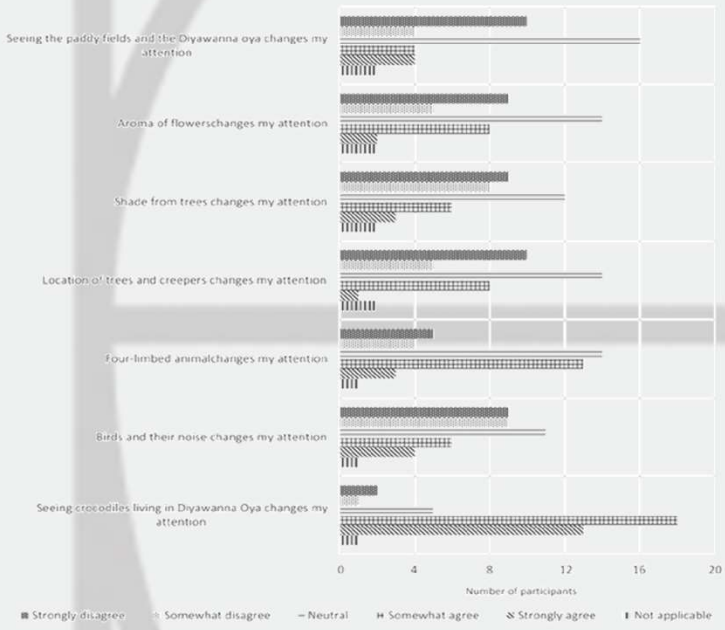


**Chart 2:** The way flora, fauna and wetlands affect the joggers' attention
Source: author

We found that seeing crocodiles living in Diyawanna lake is the main factor that increases the attention of joggers. This was supported by 31 participants (77.5%), and 5 remained neutral (See, Chart 2). Four-limbed animals (e.g., dogs) is identified as the second most affecting factor to the attention of joggers. Sixteen participants (40%) agreed with this opinion; however, fourteen (35%) participants remained neutral to this statement. The author learns that this was because the four-limbed animals cause the sniffing and licking the joggers, which change the attention of them.

In contrast, according to our results, birds and their noise, shade from trees, the aroma of flowers and seeing the paddy fields supposed to concerntrate to jogging.

We further observed several protection steps taken for the safety of the joggers of the tracks. There was notice board saying "beware of the crocodiles" and stretch the wire mesh (See, Fig. 5) along the Diyawanna lake for the safety of the joggers. These developments might have affected the opinion of the joggers as they felt safe from any potential threats of crocodiles.

**(c) Situational surrounding**

In the third sub-category, we investigated the surrounding situational factors that change the attention of joggers. These jogging tracks are close to junctions which has heavy traffic during peak times. Hourly traffic flow shows 7 a.m. to 8.30 a.m. and 4 p.m. to 6.00 p.m. as the busiest traffic times in this area. Therefore, we considered three parameters as traffic


**Fig 5:** Notice board and wire mesh
Source: Author

noise, vehicle smoke and dust particles in the air. Our results suggest all three elements are changing attention of joggers in general.

There was a strong agreement 85% [34 out of 40] of the participants for vehicle smoke as the leading cause of attention. This was followed by 85% [34 out of 40] of the participants and 77.5% [31 out of 40] of the participants strong agreements for noise and dust particles, respectively as change attention for joggers (See, Chart 3).

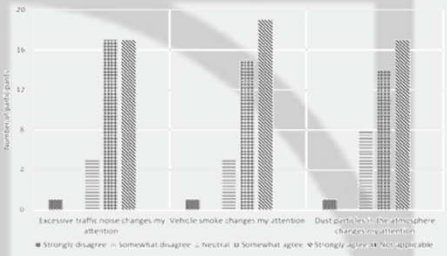

**Chart 3:** The way excessive traffic noise, vehicle smoke and dust particles affect joggers' attention
Source: author

During our field visits, we observed that less soundproofing barriers in heavy traffic areas as an issue in these tracks. Further, we identify the smoke and dust particles may create some discomforts such as coughing, sneezing or runny nose, which affects their attention.

## ANSWERING RQ2: MAIN TRACK CONDITIONS THAT AFFECT THE ATTENTION OF JOGGERS

In this sub-section, we discuss the track conditions (anthropogenic) affects the attention of joggers. This sub-section focuses on two main surrounding categories, namely, (a) jogging track construction elements and (b) facilities of the premises.

### (a) Construction elements

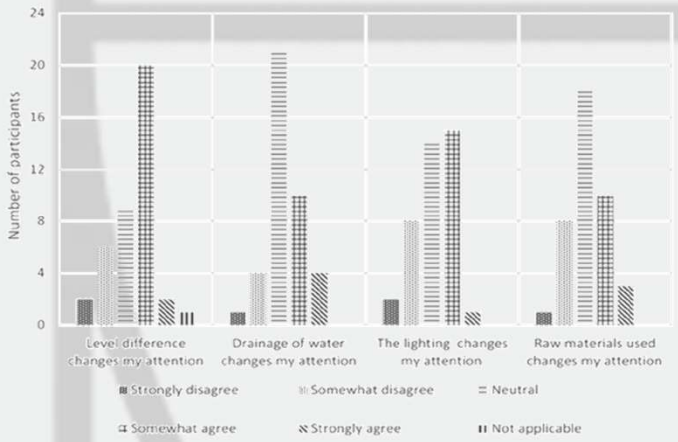


**Chart 4:** The way level differences in the steps, drainage of water, the lighting and raw material used in the tracks affect the joggers' attention
Source: author

In this category, we examined four factors and their effect on the attention of the joggers. The factors we considered are level differences in the steps, drainage of water, the lighting and material used in the tracks.

According to our findings, there was a strong agreement 55% [22 out of 40] of the participants for level difference as the leading cause of attention. The landscape lighting is identified as the second most affecting factor to the attention of joggers. Sixteen participants (40%) agreed with this opinion; however, fourteen (35%) participants remained neutral to this statement. The maximum number of participants acted neutral to other two factors (See, Chart 5). However, in comparison, it is revealed that drainage of water (35% of participants) and raw material used (32.5% of participants) comparatively, less contribute to change the attention of the joggers. Joggers were less concern about the material (red-yellow podzolic and humus mixed soil) that has been used in these tracks (See, Chart 4).

The author collected important observations during the field visits, which are aligning with these outcomes. With regards to lighting conditions, Diyawanna lake jogging track and Kimbulawela jogging track has an average lighting condition. All lamp posts are operating through the solar power and two luminaires fixed to each lamp post to get a better lighting condition and most of them are illuminating in the day light colour. But some of luminaires illuminating in the warm light colour. jogging track has a cylinder shape (See, Fig. 7). while Diyawanna Oya has a cube shape (See, Fig. 6).

With regards to step levels of the tracks, in the Kimbulawela jogging track, the author identified some places had a few steps as the track crosses an access road towards a highly residential area from two places. During our interviews, Joggers

found crossing a road as inconvenient as it brings steps on both sides (See, Fig. 8) of the crossings as well as busy roads often interrupt the rhythm. This changes the attention of the joggers.

**(b) Facilities of the premises**

In this category, we examined four factors, namely, and their effect on the attention of the joggers. The factors we considered are mobile food outlets, the seating arrangements, the parking lot and outdoor gymnasium (See, Chart 5).

**Fig 6:** *Landscape lighting, location, mounting method and the use*
*Diyawanna oya Jogging track*
Source: author



**Fig 8:** Kimbulawela jogging track fragmented by the access road (Left) Steps and ramps constructed across the jogging track (Right)
Source: author

Out of the four factors we considered, mobile food outlets have average impact on the attention of joggers as 15% of participants strongly agree with the opinion that food outlets change their attention. In contrary, interview participants revealed that foods smell, advertising methods and also street food lovers hanging around food stalls affect joggers' attention.

## LIMITATION

This study inherits the limitations of the case study approach, such as less generalizability. We only examined two jogging tracks in Colombo. Therefore, we do not see these factors as the ultimate list that affect the attention of joggers in Sri Lanka. We acknowledge that there might be several other factors which are not mentioned in this study. We only had 40 responses and ten interviews to inform our results, while more face-to-face interviews could have brought more validity to this study. We faced several situation incidents such as COVID-19 restrictions during this study which affected the timeline of this study. We use data triangulation techniques with interviews and expert opinions to verify our results from the survey as a strategy to decrease the threat of data manipulations. The author of this research observed and studied the case study areas, and some of the observations mentioned in this research are based on the best of author's knowledge. In order to minimize the author bias, we discussed these observations with experts (landscape architects) at Urban Development Authority to verify them as correct.

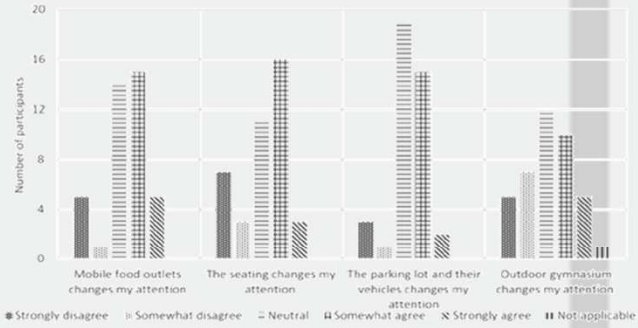


**Chart 6:** The way mobile food outlets, seating arrangements, parking lot and outdoor gymnasium affect the joggers' attention
Source: author

## SUMMARY AND RECOMMENDATIONS

This research identifies surrounding and track condition factors that affect the attention of joggers in Sri Lanka. The results are derived through a survey and other data sources such as face-face interviews with joggers and expert opinions. Our results identify six main factors that affect the attention of joggers, namely, increased temperature, seeing amphibians in the surrounding, excessive traffic noise, vehicle smoke, dust particles in the atmosphere and level differences of the jogging track. After a careful analysis of these factors and other field visit observations, the author proposes a set of recommendation for maintaining, restructuring and developing of jogging tracks in Sri Lanka. We divide these recommendations into two categories as short-term and long-term recommendations based on the easiness to implement the recommendation. To note, these are suggestions which are not ordered as we understand the prioritization of such suggestions need more in-depth study about the other parameters such as cost and benefit.

| | |
|---|---|
| • Spray the water vapours to the jogging track to reduce the heat waves from the jogging tracks. | Temperature |
| • Build a sound-absorbing wall near the highly noisy areas such as near the junctions. | Excessive traffic noise |
| • Add dust proofing nets where necessary. | Dust particles |
| • Rebuilt the step to reduce the height of the existing steps in Kimbulawela jogging tracks aligning with the anthropometrics designs.<br>• Increase the slope and width of the ramps for easy access.<br>• Display the signboards on the access roads which crosses the tracks to reduce vehicle speed. | Level differences |

**Table 2:** List of short-term recommendations
Source: author

| | |
|---|---|
| • Propose more spreading canopy, medium height trees such as "Karanda trees" for the shady in the parking space.<br>• Plant medium-height trees in the bays of the jogging tracks to reduce the surrounding temperature.<br>• Add cellular pavers for the parking space to reduce the urban heat island effect. | Temperature |
| • Add sound-absorbing plants and shrubs along the roads next to the tracks. | Excessive traffic noise |
| • Plant air purifying plants for the jogging tracks and the parking area. | Vehicle smoke |
| • Develop natural green curtain wall near to the junction area to reduce the sound, smoke and dust in the atmosphere.<br>• Develop broad leaves canopy trees either sides of the jogging track to reduce the dust in the atmosphere. | Dust particles |
| • Design the track where possible in a way that they avoid any access roads<br>• Construct a vehicles speed limit table to reduce the vehicle speed while both table and jogging track have the same level. | Level differences |

**Table 3:** List of long-term recommendations
Source: author

## CONCLUSION AND FUTURE WORK

The objective of this study was to identify the surrounding conditions of jogging tracks that affect the attention of the joggers. Also, this research Investigated the jogging track conditions that affect the attention of joggers. We identify six of these main factors, followed by several other factors. To minimize the impact of the identified factor, we presented a set of recommendation which can be considered during maintaining, designing or developing jogging tracks in Sri Lanka. The future work of this research includes (a) verification study of this research using different jogging tracks, (b) conduct an in-depth analysis of the factors to identify recommendations further and finally, (c) prioritize the set of recommendation considering other parameters such as cost and benefits.

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# IMPACT OF GREEN SPACES ON MENTAL HEALTH AND WELL-BEING - A STUDY ON EMPLOYEES AT SOFTWARE COMPANIES

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**Abstract:** Workplace pressure can cause depression and anxiety of workers affecting their productivity. It was hypothetically assumed that exposure to mother Nature can psychologically induce workplace satisfaction leading to less stress due to the restorative effects. The regular touch with nature has been identified as an essential activity to reduce workplace stress while maintaining good mental health through the literature. The exposure to greenspaces and its impact on maintaining balanced mental health at the workplace was tested by this preliminary field investigation with reference to software companies(n=3) in Sri Lanka. The cases (C1, C2, C3) were selected based on the existing levels of greenery, with high density, moderate density, and low density of greenery, respectively. An online questionnaire survey was conducted among three volunteer groups of employees (n=20 per case) for the final field investigation. Aligning with literature, the study concluded a direct interaction between the quantity of greenspaces vs workplace satisfaction and workplace stress of the employees as the main parameters of mental health at the workplace. The perceptions of respondents clearly expressed that green spaces help to maintain a balanced mental health at the workplace while reducing stress and enhancing the job satisfaction.

***Keywords:*** *mental health, workplace stress, green spaces, job satisfaction.*

## INTRODUCTION

This exploration has examined the impact of green spaces on mental health of employees at corporate companies with special reference to the software industry as having an artificial working environment compared to other corporate companies. The current exploration signifies the potential of incorporating nature, green elements, and landscape interventions as a tool to reduce workplace stress and maintain a balanced mental health of employees at companies in the software industry as an alternative solution.

### 1.1 Research problem

A considerable increase of employees with poor mental health in the corporate sector has been identified as an alarming prevalence. Various studies stated that there are mental disorders in employees of corporate companies frequently software program engineers involving substantial costs to the employers including adverse impacts on creativity, innovation, efficiency, and productivity as the stress is found to be high in software professions because of their nature of work, target, achievements, night shift and excessive workload. As several researchers have stated, a higher number of employees in the software industry are prone to develop a range of health problems due to continuous mental stress including tension, headache, hypertension and etc. (Padma et al, 2015). Thomée, Härenstam and Hagberg (2012) stated, the aspects of ICT use can contain risk factors for mental health and wellbeing among young adults. Accordingly, maintaining a balanced mental health becomes a vital necessity in the software industry to enhance job satisfaction, worker productivity and performance.

### 1.2 Significance of the study

Plants can reduce stress, make employees happier, increase worker productivity, make an office look better, improve the air quality, and provide comfort as the benefits of adding green spaces at the workplace (Brown P. D. (03 Jun 2017). The current study signifies the potentials of implementing greenery at the workplace as a productivity boostable method in the workforce in Sri Lanka by increasing the efficiency of workers while maintaining a good mental health.

### 1.3 Research objectives

(1). Explore the relationship between green spaces and mental health.

(2). Assess the benefits of green spaces at the workplace through the literature.
(3). Inquiring the impact of green spaces on job satisfaction and workplace stress of the employees; with special reference to Sri Lankan software industry

## LITERATURE REVIEW

### 2.1 Mental health and workplace stress

Mental health issues in the working environment which contributes to employee physical and mental health have serious reverberations not only for the individual employee, but also for the productivity and outcome of the employer. Several aspects such as unbearable workload, limited time periods to complete tasks, exceeded working hours, lack of training & etc. have been identified as the reasons for the mental stress of employees at the workplace as it occurs in a wide range (Dravigne, Waliczek, Lineberger & Zajicek, 2008; Han & Hyun, 2018; Largo-Wight et al., 2011; Lottrup, Stigsdotter, Meilby & Claudi, 2015.

"Workplace stress" has been identified as the main reason for overall job-related stress by most of the researchers. Exposure to sick working environments with unpleasant conditions may occur for the workplace stress of employees. The employees at healthier workplaces with pleasant conditions take less leave days (Largo-Wight et al., 2011). Rahman and Zanzi (1995) argued that less organic orientation relates to lower stress in the workplace.

### 2.2 Effects of workplace stress during working hours

The Canadian Centre for Occupational Health & Safety (CCOHS, 2020) stated; lower productivity due to less efficiency, inability to complete tasks during the given period due to the waste of working hours for non-billable activities, reduction in output, poor decision-making, lack of ability to pay attention to work and to strained relationships with other employees, increase in error rates,... and etc. as the main consequences of workplace stress of employees on the enterprise.

### 2.3 Benefits of reducing workplace stress of employees

There are several benefits of reducing workplace stress of employees such as; higher efficiency of employees, improvements of communication skills with co-workers, physical capabilities of employees, increasing the productivity of the organization, improved daily functioning of individuals, increasing the job performance of individuals and etc. A healthy, happy workforce is a vital component for the employees to boost up the productivity of the workplace [World Green Building Council (WGBC)].

### 2.4 Less nature-contact as a reason for workplace stress

The literature establishes with a strong frame of evidence that "less nature-contact" is the most effective reason for workplace stress as the regular touch with nature is required to maintain a balanced mental health. (Dravigne, Waliczek, Lineberger & Zajicek, 2008; Han & Hyun, 2018; Largo-Wight et al., 2011; Lottrup et al., 2015).

Less number of individuals have been reported as less mental distressed as the purposeful use of the nature-contact helps to reduce workplace stress (Largo-Wight et al., 2011).

Scholars have discussed that the human contact with nature boosts mental health and well-being by the process of visual perception. The exposure to greenery was found to reduce anxiety and stress as the colour green has been found to be soothing, refreshing, relaxing and elicits feelings of happiness (Mahnke, 1996).

#### 2.4.1 Nature-contact at software companies

Comparatively, a higher amount of employees are prone to develop a lot of health problems which are induced by stress in IT industry as the working environment being highly detached from softscape elements of nature and highly characterized with more hardscape elements namely laptops, desktop computers, screens, servers, electrical and network wiring/cables, artificial lighting, air conditioners... etc is critical in this regard (Padma et al., 2015)

Dravigne et.al, (2008) have shown that the people who work on computer rooms with the presence of plants are less stressed than the people who work on computer rooms where there are no plants.

### 2.5 Exposure to green spaces

Hassen (2016), concluded the main aspects of green spaces into three parameters: quantity, access, and quality.

**Quantity:** The area of spaces dedicated to greenery/ the amount of green spaces defined as the quantity of green spaces. This refers to the amount or the number of green spaces, or the perception of the quantity (Houlden et al.,2018 and Colley, Brown and Montarzino, 2018).

**Access:** The mobility to green spaces which can be measured either objectively or subjectively refers to the access to green space which has the ability to encourage individuals to engage in physical activities that hypothesized to boost mental health benefits such as walking and cycling in comparison to staying indoors with less nature-contact (Rugel, 2015). An outdoor nature view through a window is the easiest strategy of approaching outdoor greenery during the work hours. Walking is generally limited to leisure times during the workplace as a comparison to physical access methods (Lottrup et al., 2015).

**Quality:** Quality of green space may vary in different conditions such as cultural context, community need, aesthetics ... etc. Also, it includes the presence of water features, noise levels, and biodiversity/species richness (Rugel, 2015).

### 2.6 Impact of exposure to green spaces at the workplace

Largo-Wight et al. (2011), states applicable three main Nature-contact types at the workplace as the outdoor nature-contact, indoor nature-contact and indirect nature-contact.

**Outdoor Nature-contact:** The exposure to the outdoor green spaces refers to the outdoor nature-contact. The use of outdoor greenery for work breaks rather than using indoor break rooms or lobby areas is a straightforward way to promote mental health while reducing mental stress (Largo-Wight et al., 2011)

**Indoor Nature-contact:** The exposure to indoor green spaces refers to the indoor nature-contact. A small green intervention could help to boost employee happiness in the office (Seppälä & Berlin, 2017). Lottrup et. al. (2015) mentioned (as cited in Dravigne et al, 1996), the employees, who work with indoor plants are more satisfied with their job and they are more productive than the employees who work in plant less office environments

**Direct nature-contact vs indirect nature-contact:** Outdoor nature-contacts and indoor-nature-contacts refers to direct nature-contacts. The outdoor nature-contact is the most direct nature-contact has the powerful interrelation with stress reduction while indirect nature-contact is the least form of nature-contact which can be defined as the subjection to conceptualized or symbolized representations of nature such as landscape sceneries, photographs, experience recorded nature sounds etc. (Largo-Wight et al., 2011).

### 2.7 Theoretical framework

Visual perception theory, stress reduction theory and attention restoration theory have been combined by considering the visual, psychological, and social aspects, respectively to find out “how to use green spaces as a tool to reduce stress”. Prospect and refuge theory come under the combination of the aforementioned aspects.

#### 2.7.1 Visual perception theory - Gibson (1966)

According to Gibson's visual perception theory, the parameters which affect employees’ visual identity are connected to the psychological reality. Perception of the green spots at workspaces have a direct visual effect on employees during the working hours (Brogaard & Gatzia, 2016).

### 2.7.2 Stress reduction theory - Roger Ulrich (1991)

Ulrich's stress reduction theory (SRT) express the emotional and physiological reactions in the presence of natural elements. The exposure to natural environments in working environments helps to maintain relaxed attention positively and effectively while employees experience a decrease in stress.

### 2.7.3 Attention restoration theory - Stephen Kaplan (1980)

The employees' attention plays a critical role during the working hours as the attention fatigue is a domain issue in the human mind. According to Rachel & Kaplan's attention restoration theory (ART), exposure to green spaces helps to improve the focus and ability to concentrate due to the restorative effect of Nature (Ohly et al., 2016).

### 2.7.4 Prospect and refuge theory - Jay Appleton (1975)

Appleton's prospect and refuge theory concluded that people tend to be in the most acceptable place which gives great opportunities [prospect] including safety [refuge]. People gravitate to edge conditions as they wish to have the refuge than expansive spaces preserving the prospect to observe the remainder of the outdoor space. In addition, the employees gravitate to the edge workstations rather than working in a centre being observed.

## METHODOLOGY

The software companies which composed of more hardscape elements such as computers, screens, laptops, desktops etc. rather than softscape elements have been chosen for the field investigation. The endorsement of the theoretical framework has been accomplished through the pilot study which was conducted as an online questionnaire survey among 50 employees (n=10 per case) of five major software companies in Colombo, Sri Lanka.

The three cases for the final study (case1, case 2, case 3) were selected considering the existing level of greenery (C1,C2,C3 composed of indoor and outdoor greenery in the decreasing order); from the pilot study. An online questionnaire survey was conducted among 60 employees (n=20 per case) as a method of self-report measures to assess the impact of exposure to nature at the workplace on mental health and well-being of employees.

Limm et.al.,(2010), have identified self-perceived stress as an appropriate indicator of identifying employees who experience psychosocial problems at the workplace. Accordingly, the current investigation incorporated testing perceived stress levels of employees. The questions for the final questionnaire were derived from standard attested questionnaires as an extraction of the below mentioned questionnaires.

- Perceived Stress Questionnaire (PSQ) - to measure the stress level.
- Nature-contact Questionnaire (NCQ) - to measure the Nature-contact.

The collected data from the field investigation were visualized and analysed in tabular, graphical form using Microsoft excel spreadsheets. The collected data were first coded into the numbering format with values to generate graphs for the visualization. Bar charts and scatter plots were derived to accommodate easier data comparison.

## RESULTS

Most respondents at case one (C1) which composed of high density of greenery, are taking 5 or more outdoor meal breaks per week as they are well-experiencing the existing green areas within their working environment. 50% of respondents at case two (C2) which composed of moderate density of greenspaces, are taking 3 outdoor morning/evening meal breaks per week. Comparatively a less amount of outdoor meal breaks has been recorded from case three (C3) which composed of minimal density of green spaces, as they are experiencing the lack of outdoor green spaces at the workplace (50% and 40% for 0 outdoor meal breaks during the morning/evening and lunch breaks respectively).

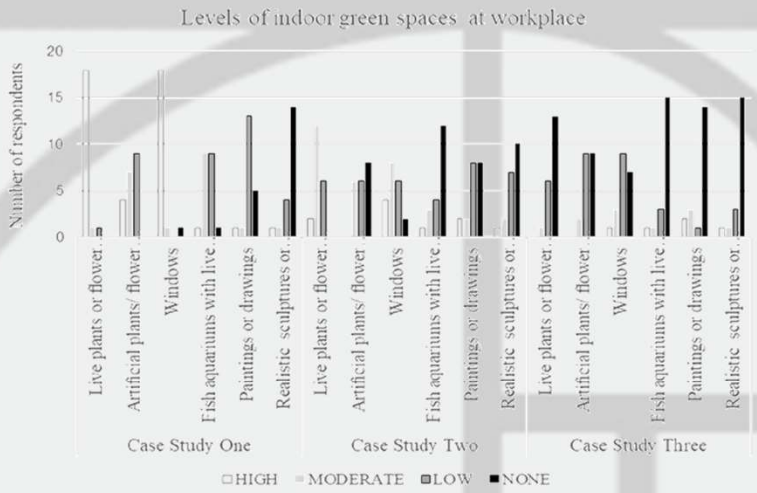


**Figure 1.** Levels of greenery at primary workspace and its surrounding

Source: Compiled by author

Among all the 60 participants of the study, the majority have recorded that the green spaces help to increase working efficiency by maintaining a balanced mental health. 90%-strongly agreed, 27%-agreed, 5%-neutral and 1%-disagreed to the statement.

**Table 1. Perceives Stress Questionnaire (PSQ) assessment**

| Category | Sub Questions | C1 | C2 | C3 |
|---|---|---|---|---|
| Questions to measure the workplace satisfaction | a. You feel rested | 2.65 | 0.95 | 1 |
| | d. You feel you are doing things you really like | 2.1 | 1.2 | 2.5 |
| | g. You feel calm | 2.4 | 1.05 | 1.55 |
| | j. You feel tense | 2.35 | 1.1 | 1.2 |
| | p. You enjoy yourself | 1.75 | 1.35 | 1.45 |
| | b. You feel lonely or isolated | 0.55 | 1 | 1.15 |
| | c. You find yourself in situations of conflict | 1.05 | 1.5 | 1.6 |
| | e. You feel tired | 0.9 | 1.95 | 2 |

| | | | | |
|---|---|---|---|---|
| Questions to measure the workplace stress | f. You fear you may not manage to attain your goals | 1.05 | 1.45 | 1.7 |
| | h. You feel frustrated | 0.75 | 1.55 | 1.6 |
| | j. You feel tense | 0.85 | 1.65 | 1.75 |
| | k. Your problems seem to be piling up | 0.7 | 1.4 | 1.75 |
| | l. You feel you are in a hurry | 0.65 | 1.8 | 1.8 |
| | m. You have many worries | 0.5 | 1.7 | 1.75 |
| | n. You are under pressure from other people | 0.3 | 1.55 | 1.55 |
| | o. You feel discouraged | 0.25 | 1.25 | 1.45 |
| | q. You feel mentally exhausted | 0.55 | 1.45 | 1.65 |
| | r. You have trouble relaxing | 0.6 | 1.2 | 1.4 |
| | s. You feel criticized or judged | 0.5 | 1.15 | 1.5 |
| | t. You feel under pressure from deadlines | 0.7 | 1.7 | 2 |

**0 = None 1 = Sometimes 2 = Often 3 = Usually**


**Figure 2**. Variations of job satisfaction of employees at three case studies
Source: Compiled by author

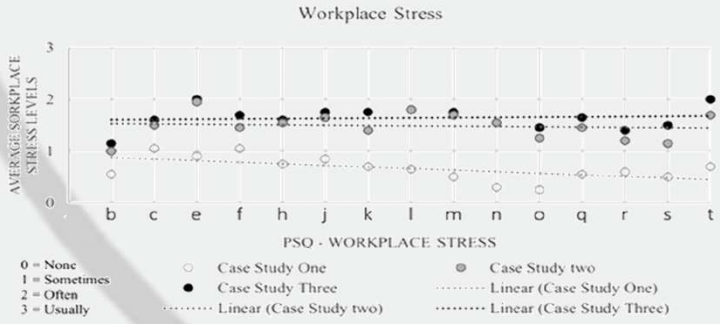


**Figure 3.** Variations of stress levels of employees at three case studies
Source: Compiled by author

According to the findings, the employees in case one which was composed of high density of greenspaces are more satisfied (80%) compared to other 2 companies. The employees at case three which includes minimal density of greenspaces are less satisfied (71%) compared to other 2 companies.

The employees in case three which was composed of minimal density of greenspaces are more stressed (857%) compared to other 2 companies. The employees at case one which includes a high density of greenspaces are less stressed (88%) compared to other 2 companies.

## CONCLUSION

Workplace stress of employees is a critical issue that causes the lack of concentration to work, unhealthy relationships among employees and degraded productivity of an organization. These issues can be minimized using a well formulated health initiative at the workplace. This will also reduce the workforce retention rate as satisfied and healthy employees are much more likely to stay longer with the organization. Multiple previous studies have emphasized the importance of nature-contact to maintain good mental health. The current study discusses the psychophysiological parameters of mental health, theories, up-to-date practices of exposing the workforce to nature and its impact to the increment of worker productivity because of good mental health. The findings of the current study highlight the significant effect of exposure to green spaces on mental health and well-being. It was evident that the regular exposure to greenery was instrumental in reducing the workplace stress of employees which leads to increased worker productivity. Although this study was mainly conducted focusing on three companies in the software industry of Sri Lanka, it can be extended to study corporate companies apart from the software industry as well. The study recommends extending the investigation to evaluate the impact of green spaces on worker productivity and efficiency of employees of corporate companies in Sri Lanka.

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# IMPACT OF LANDSCAPE ENVIRONMENT ON ELDERS MENTAL HEALTH AND WELLBEING: A STUDY ON LANDSCAPE INTERVENTIONS IN ELDERS HOMES OF BADULLA, SRI LANKA.

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**Abstract:** Senior citizens are the most rewarded community group in the society, yet who are particularly vulnerable, neglected, and less considered. Accordingly, their declines in mental and physical health cannot be helped only by medicine. The increment of the senior population emphasizes the need for well-designed health care facilities, elders' homes incorporated with geriatric landscape in the urban context. Incorporating a liveable landscape environment which care and give solutions to mental health issues and wellbeing of senior citizens who are living in elders' homes is vital in this regard. The current investigation aims at determining the preferable elements of domestic landscape environments which may contribute in enhancing mental wellbeing in order to provide a quality and healthy life for adults in Sri Lankan urban context.

The study tested the perceptions regarding of landscape interventions by elderly through a comparative investigation between three elders' homes located in Badulla, Sri Lanka (C1, C2, C3) (N= 15 per case study) based on the availability of outdoor landscape attributes C1 (57%) < C2 (64%) < C3. Semi-structured interviews, questionnaire surveys and behaviour analysis were used to find out elders preferred landscape with reference to their mental health which was assessed and analysed by adopting the WHO world mental health & wellbeing scale and The Warwick-Edinburgh Mental Well-being Scale (WEMWBS).

The findings demonstrated that the frequent exposure to well-designed landscape interventions in elders' homes cause high levels of mental satisfaction and wellbeing of adults. C3 witnessed to have high scores in terms of mental and wellbeing over C1 and C2. The study identified the importance of well-designed landscapes that motivate elders to experience, expose, participate and interact with the landscape in achieving mental wellbeing.

***Keywords:*** *Geriatric Landscape, Elderhood, Mental health and wellbeing, therapeutic and healing Landscape*

## Introduction

As defined by the world Health Organization, a person who has completed 60+ years is refer to the older or elderly person. Elderhood being the last stage of human life, is characterized with biological and psychological declining. Accordingly, in the process of aging of humans, the elders become like children once again in life. Biological alterations happening in their body cause changes in their needs and perceptions. This emerges the need for someone to care and protect them. Taking care of senior citizens could be identified as one of the greatest responsibilities of any society worldwide.

According to Jayawardena (2016) as cited in Rathnayakka (2018) clarifies that Sri Lankas had a custom of protecting elders as a duty and responsibility of children brought up by them. Elders role was advising juniors and caring and guiding their grandchildren. However, family composition varied from extended family backgrounds into nuclear families as a result of social and economic deviations. Isolation of the aging population emerged as critical with this context in Sri Lanka. The contemporary younger generations in this backdrop having tough work schedules have compelled to select an institution to provide care for their parents. Such socio-cultural transformations occurring with time has resulted elders to become helpless being send for elder caring canters/homes. With this background, elders' homes/care centers should provide friendly, conducive and interactive living environments for seniors being the place where they spent most of their last stages till death.

The conditions of living environment of elderly are connected to their physical health, mental health and wellbeing. Thus, elderly centered design strategies should be considered in creating safe, sound and comfortable environments for seniors. Incorporating contemplative and healing landscape designs can be an effective approach for mental wellness of

elderly. However, proper integration of landscape Architectural solutions to elder's homes is not considered well in Sri Lankan context.

### Increment of elderly population

Kuroda (1993) identifies this 21'st century as, the "era of population aging". The researchers have identified the increment of the population as well as the geriatric population worldwide aligned with global social-economic changes. Declining fertility, as well as mortality rates and increasing out-migration have become major causative factors for the increase of the elderly population. Siddhisena (2004) as cited in Gunasekara (2006) identifies an increasing trend of the ratio of older to young (index of aging) from 1981-2031. They could identify a shift of age structure from younger to older with a higher proportion resulted in a transformation of the shape of the age pyramid of the country from a broad-based to barrel-shaped, thus confirming aging at the apex (Gunasekara ,2006).

When considering about the modern global situation, we can identify the accretion of the old population. As per predictions of UNFPA and PASL cited in Siddhisena (2004), this value will increase at an alarming rate during the next two decades leading to an immense issue to be faced as a nation. It is anticipated that in 2030 the population of the elderly (above 60 years) in Sri Lanka will be 22%. To be precise, 1 out of every 5 people will be an elderly person (Siddhisena and DeGraff, 2009).

This dominant group's health status can make a huge impact on the sustainable development of the country. The society/government has a huge responsibility to provide quality and healthy living for seniors who are more or less a neglected. Development cannot be achieved excluding any group within a community. The need for this research aroused with the increment of the neglected elderly population in Sri Lanka and their decreasing health conditions. Further, the fact that the projected image of the elder's home environments in Sri Lanka at the moment being not satisfactory in providing a pleasing environment for users was another factor to be looked at.

### Concept of aging

Aging is a biological process which happens in an individual, that starts from the date of insemination and end from the demise. It occurs due to alterations in physical, psychological and functional arenas in human beings. It is an irreversible, unavoidable, global phenomena. The only moderation which can be done is altering the quality of aging through diverting socio-cultural, economic and environmental factors that are highly associated with this process.

Biological aging is the chronic condition related to accumulated damage to cells, weakening the immune system, and decline of the capacity of the body to repair itself over time. Being elderly is characterised by the arise of the risk of the body to be the host of various disease (Steves et al., 2012). Amidst this situation of the decline of body and quality recovery, achieving fulfilled wellness is a difficult task. Normally every elder suffers from chronological pain with physical changes and a decline of functions of organs.

### Elderly and elderly care context.

The World health organization develops concepts, action plans, and stereotypes referring, elder's needs and services to provide healthy and quality aging. Countries and region experiencing significant crisis and need strategies to enhance the elders' quality of life has been identified. European countries have proposed the means of developing comfortable life elderly namely, providing schools/institutes for retired, homecare services for professional programs, programs for intergenerational engagement, housing, assisted living facilities and urban design spaces, etc.

- Nursing home concept: Nursing homes have an institutional and homely environment. It provides 24-hour health services, support day-to-day activities for elders with help of professional caregivers. They followed the medical somatic model of care to supply their service (Rathnayake, 2018).
- Urban-aging concept: Designing public spaces/parks specially catering to elders with relevant facilities.
- Elders homes: The concept of the elder's homes in Sri Lanka raised in 1948 with the establishment of the social services Department. Western province was identified to have a high accumulation of elder's homes. It was predicted that 242 homes with about 8000 inmates is needed to meet the requirement (Rathnayake, 2018).

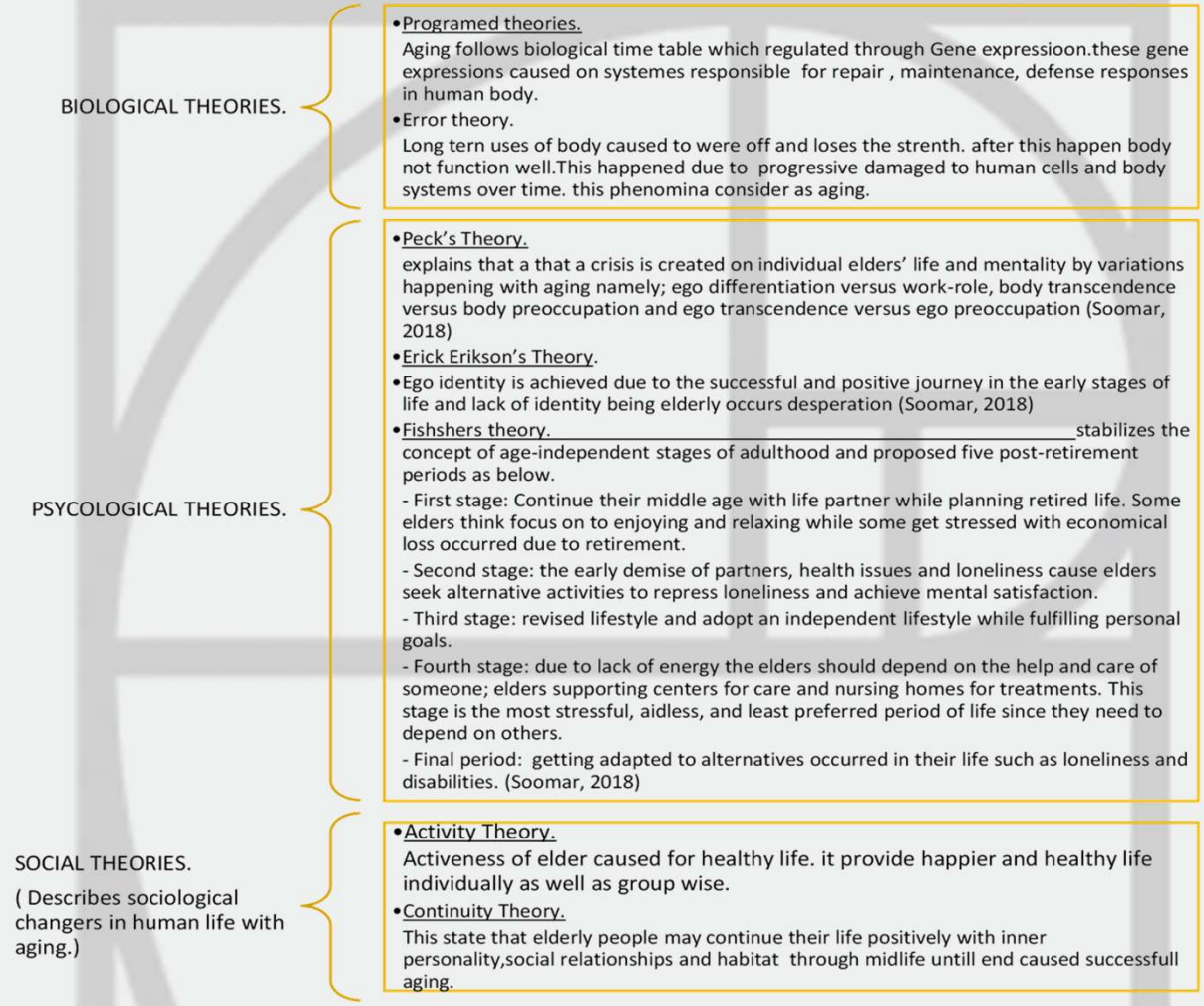


*Figure 1: Theories of Aging*

The previous studies have identified that even if the most seniors prefer to spend their last days with their children, some practical circumstances like not having enough economic strength to carry on their cost and care, not having families, issues arise when living with their children, or not interest to live with them or other personal values have made them to select elders' homes. (Lamichhane, 2017).

- Elders day centers: Carter (1981) as cited in (Gunasekara, 2006) defines that day services are offered as caregiving services with or without payment, outside the elder's own home. They can return to their own homes after getting services on the same day. Above approaches help elders to revenge from loneliness and spend an active and effective life.

**Health and living environment**

"Whether people are healthy or not, is determined by their circumstances and environment. To a large extent, factors such as where people live, the state of the environment, genetics, level of income and education level, relationships with friends and family all have considerable impacts on health ..." (WHO)

DeMello (2016) stated that, one's particular living spaces have tremendous impacts on his/her feelings and reactions. Designers have identified new concepts of answering some of the physical, psychological and emotional problems, especially those increasingly present as we age, through environmental modification. (DeMello, 2016).

Accordingly, it is important to create spaces that allow an individual to physically, psychologically, and emotionally flourish. All three must be nurtured because one area cannot be present for overall good health if the other two are not (DeMello, 2016).Studies predict that elders highly seek physical and psychological sensory comfort through their living environment (Feng et al. 2018). Both type of living environments; built and landscape environments need to compensate with the geriatric related physical, social and mental changers.

Outdoor spaces can be considered as a dilemma for elders which offer great opportunities to be active, relax and meet people. It is vital to provide many activities associated with moving around and enjoying the outdoors. These activities require a certain level of strength, agility and stamina that many older people are in the process of losing as aging advances (Sugiyama & Thompson, 2007) .

A study done with picturesque views of the natural environment and urban environment by Ulrich (1979) revealed that exposer to nature sceneries increase positive mental situations such as feeling of affection, friendliness, playfulness, elation while reducing arousal of fear in stressed individuals.

## Study Background.

People mostly consider the physical wellbeing of man which can easily appear and identified. Even though mental wellness is a hidden and overruled factor which can impact on physical health. Being healthy needs to achieve both. The living landscape environment impact on both statuses.

When people reach old age, they mentally worry and regret the changes that occurred in their lives. Health problems, changes in physical appearance, feeling of lack of energy, failing to do their own works, separation from a spouse, relatives, family members and etc., fear of death, death of their same age people are some of the feeling which overrule their minds. This cause low self-satisfaction, stress and regret. Social changes, diversions in economic status and changes in physical living environment may add additional threat to elderly people's wellbeing (WHO, 2017). Though situation is more or less common to all senior citizens, elders who live in elders' homes, are highly worried about above issues compared to others.

Mental stress is the most common issue in almost all elders who are living in elderly homes which can cause physical inactiveness and some of the physical illness. The quality of their living environment is significant parameter related to mental stress of elderly. In Sri Lanka, old houses being renovated in to elders' homes. Appearance and lack of well-arranged landscape spaces and well-designed elder friendly places in such renovations effect on the mental wellbeing of elders. This backdrop has not built a sense of livelihood or pleasant feeling about the living environment. Accordingly, most elders stuck to their beds with basic needs provide by these homes which are not satisfactory. The living environment, being highly contributing towards elder's mental health should be designed focusing on elderly centric spaces and landscape designs.

## Significance of study

Sri Lanka, as a developing country, must resolve the issues pertaining to the economic implications of the aging population. Previous studies done in Sri Lanka revealed the need-of sustainable and most reliable policy options, approaches, and programs to address economic and social challenges to encompass these demographic changes in the elderly population (Parasnath n.d.). Actions are being taken by the Government to enhance senior's quality of life and health by additional financial allocations. Further to above, the improvement of medical treatments and facilities are considered. Elderly design can consider as an alternative approach that resolve most of the issues in a sustainable manner.

Designing a living environment that help seniors maintain their independence for as long as possible is key for maintaining a high quality of life (DeMello, 2016, p.25). RIBA (2014) identifies the necessity to address elders physical and social alterations occurred with aging process as a burning issue to be resolved via designing elder's homes or care

service environments. There are more discussions, approaches, inventions and awareness going around to address geriatric issues worldwide.

However, within the Sri Lankan background, elderly centric design, geriatric landscape Architectural approaches not been much discussed in resolving aforementioned issues. Even in the existing elder's home the consideration on architectural services and elderly centric designs aspect in construction are less. Even if past empirical studies done in local context have assessed the impact of landscape on elder's physical health, the impact on mental health and wellbeing and approaches for most conducive landscape design interventions are less considered. To understand the concept of elderly centric Landscape design in the Sri Lankan context an in-depth background study on senior's perception of landscapes attributes will be needed.

## Aim / purpose

Study aimed to investigate the landscape architectural approaches in remedying geriatric issues arises in Sri Lankan context as a south Asian country. The main intension of the study was to identify preferable domestic landscape attributes in providing a comfortable, satisfiable, mentally healing environment for senior people while identifying the connection between the elder's domestic landscape and mental wellbeing.

## Problem statement.

Research issue emerge with the increasing demand for finding solutions in sustaining the lifestyle of elderly and enhancing elderly care services in Sri Lanka. With the modern situation, it is required to investigate alternative ways to sustain their mental and physical health beyond medical treatment. Accordingly, the current investigation looks in to the qualities and attributes of a domestic living landscape which can positively impact on elder's health and mental wellbeing.

## Research methodology

This was carried out as a cross-sectional study using a mixed method. Data were collected under three key areas mentioned below.

- Environmental quality of landscape: Available percentage, condition and features of the outdoor landscape. (qualitative and quantitative analysis)
- Elders mental health and wellbeing: Measured through sleep analysis and questionnaire survey adopting the WHO mental health & wellbeing scale and Warwick-Edinburgh Mental Well-being Scale (WEMWBS).
- Connectivity with the outdoor landscape: frequency and usability of spaces, personal ideas and perception, behavioral observation, semi-structured interviews and questionnaire surveys were implemented to study the participants connection and preference to the landscape.

In accomplishing the aforementioned aims and objectives the study conducted a comparative evidenced-based analysis between the three selected elders' homes.

**Selection of case studies.**

Selection of three case studies were done (C1, C2 and C3) studies were done based on the degree of the availability of environmental conditions as mentioned below,

- Percentage of open area
- Percentage of built area
- Percentage of green cover / garden area
- Availability and quality of landscape environment/landscape features.

**Selection of samples.**

As per the research design it was attempted to select an equal number of participants (N≥15 per case). However, due to certain unavoidable conditions caused due to COVID-19 pandemic scenario the number of participants varied from the targeted numbers in between homes. Accordingly, a sample of 47 who volunteered (age between 65 years 88years) were tested using the afore mentioned data collection tools with the assistance of the staff members. All the procedures were carried out with less disturbance to their daily schedule. The age and gender of the participant were not considered as a

variable. The elders were requested to freely express their preferences through their responses to interviews and questionnaire surveys.

## Findings/ analysis & inferences.

### Conditions of outdoor landscape environments across cases.

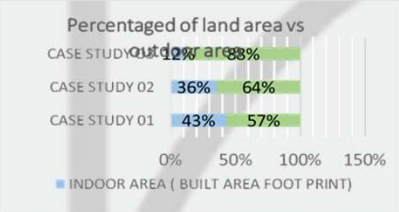


Figure 2: Extent of indoors vs outdoors comparison

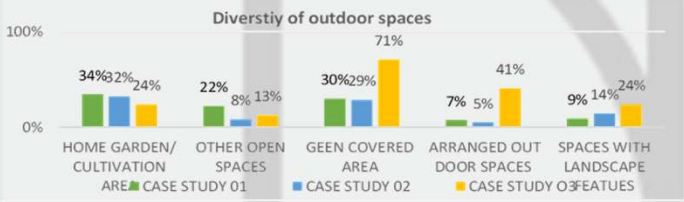


Figure 3: Diversity of landscape elements in outdoor environment. (Percentages of variety outdoors among all land area across cases).

The percentage of outdoor landscape area was identified to increase from C1 (57%) < C2 (64%) < C3 (88%). According to figure no 2 and 3, C3 was found to consist 7 types of varieties in outdoor spaces among the 88% landscaped area out of total land extent. C2 had less varieties in the outdoor landscape within 64% of outdoor landscaped area. C1, while having area of 57% out door landscape was found to comprise with more variety in spaces than C2 but less than C3.

### Usable and preference of outdoor environment

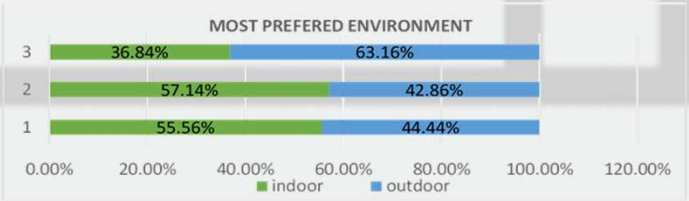


Figure4: Percentages preference – Indoor vs outdoor

63% participants in C3 preferred to be in outdoors presumably due to the variance of the availability of outdoor landscape elements/spaces. The percentage of elders in other two homes who preferred outdoors were less than 50%. Instead, they were found to prefer indoors and intermediate area of their homes. The factors contributing to the condition of the outdoor areas summarized below based on the responses of adults may have resulted the above selection.

Climatic comfort and visual comfort were identified as positive aspects for the preference of outdoor. The reasons behind not preferring the outdoor were noted as lack of sense of safety, not designed catering to elder's needs/preference, lack of maintenance, behavioural traits of some adults to stay indoors and low activeness/mobility. To get rid of the lockdown mindset (during pandemic situation), to interact and communicate with other inmates, experiencing new encounters, relaxing the mind, get an active feeling and means of recalling past memories were highlighters as the significant reasons of using/being outdoors.

As a general finding most of the participants across all the cases studied preferred areas with natural attributes namely areas where soft and hard landscape are combined with natural attributes having nature related materials, shade and visual comfort. Without any hesitation most of elders preferred intermediate areas such as verandas and corridors due to sense of safety, refuge and comfort enhanced by the facilities and seating arrangements provided.


Figure 5: Time of usage of outdoor environment.

Participant of C3 was found to be in outdoor for long hours compared to C1 and C2.

### Factors effecting elder's connectivity with outdoor landscape.

Availability of preferable landscape qualities of outdoors motivated elders to get exposed, experience, interact and use out doors for active aging. Parallel to the finding of Zupancic (2014) study on elderly housing design of case Ljubljana, the current study identified that the availability of natural elements in the adjoining spaces or borrowed landscapes (water features, trees and plant elements natural sceneries and landscape elements) with reference to the three cases have contributed towards preference of landscape by elders. Arrangement of space, level of comfort, safety and refuge, cleanliness, memories related to similar spaces, use of materials, percentages of hard landscape vs soft landscape, condition of outdoor spaces, landscape arrangement and individual preference were identified as the factors which enhance the senior citizen's connectivity with outdoor landscape.

**Attributes of landscape preferred by elders across cases.**

a. Combination of soft landscape and hard landscape elements with use of high rates of natural materials.
b. Natural features/elements adjoining spaces or borrowed landscapes
c. Gardening and home agricultural activities.
d. Outdoor Spaces/attributes which provide comfort; shade, seating, climatic comfort, easy access to the home garden.
e. Seating areas as elements which relate to past experiences
f. Spaces with privacy
g. Communal spaces and welcoming spaces; specially kids, their sons and daughters, monks
f. Safe and secured places; Secure from human threats and environment hazards, being non-slippery, supportive structures providing safety/ feeling of safety, Protective fence, shade, wide openings
g. Calm quiet and clean spaces
h. Availability of spaces for to activities relate to daily routine of elders; sun bathing, resting, reading, worshiping, physical exercise...etc.
f. More green areas with resting, aesthetic and utilitarian value.
g. Spaces for social interaction; visitors welcoming areas, communal spaces, social interconnection with others enhance through aesthetic and spiritual landscapes.
h. Age friendly design; humanistic spaces which are related to culture, perceiving sense of home, easy and comfortable access to services.

### Usability of Landscape

Mostly used spaces identified across the case studies were found to have one or more factors identified above. Qualities of Landscape environment such as, sense of safety and, communal support, healing, climatic comfort, areas related to sense of home and areas where they don't feel about their disabilities and regrets were found to positively impact to select and use outdoors leading to mental wellness. Furthermore, landscape spaces with nature related elements, (forms of nature, water, soil, rock ...) and materials (clay, soil, timber, glass, rubber) were found to be preferred by elders.

### Mental health and wellbeing

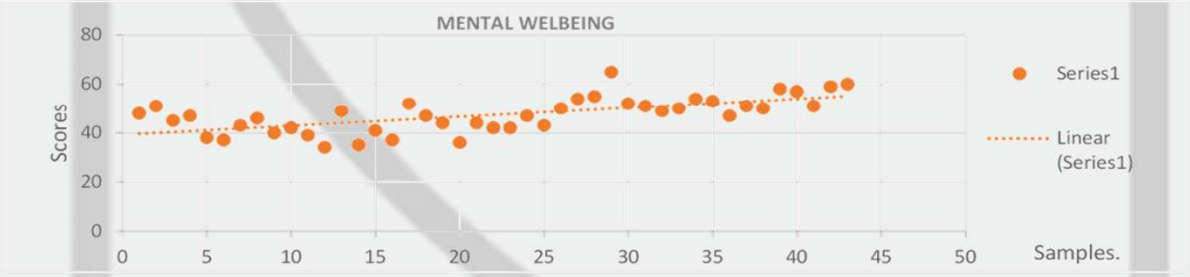


*Figure 6: Metal Well-being of elders tested through a questionnaire survey [ adopting the WHO mental health & wellbeing scale and Warwick-Edinburgh Mental Well-being Scale (WEMWBS)].*

Aligned with the attention recovery theory of Ulrich (1991) usability of preferred landscape environment and qualities of landscape spaces were found to associate with reduction of stress levels leading to mental health and wellbeing of adults. As per the above table mental health and well-being scores were found to increase from C1 to C3 (C1< C2< C3). The responses related to sleeping behaviour of adults of C3 was found to result higher scores and signified low stress levels which was validated through the medical team compared to other two studies. Study evidenced that lack of outdoor activity and resting environment have led adults to sleep-in day time which is their most preferred activity.
Specific elders who demonstrated higher scores for mental wellbeing and healthy sleeping behaviours in C1 and C2 were found to have frequent interaction with landscape considering over others members in their respective homes.

## Conclusion

The current investigation revealed that the elder's preference and usability of landscape depend on the presence of conducive characteristics such as availability of ample visual stimulation, sensory comfort, sense of safety and security, sense of belonginess, sense of spirituality and harmony, healing and therapeutic aspect, sense of care and conducive elder friendly special arrangements facilitating social connections. The study clearly evidenced that having frequent contact with outdoor landscape with above conducive attributes have shown to bring out positive impacts on mental health and wellbeing of senior citizens in Sri Lanka. Accordingly, design of conducive outdoors can be identified as an approach to provide active aging and mental satisfaction while catalyzing medical treatments for a healthy life. However, a minor percentage of elder's were found not to obtain the benefits of outdoor as their individual preference and identical habitual behaviours led them to stay indoors.

## Suggestions for future.

Being dominantly characterised by an alarming increment of elderly population, Sri Lanka needs to go forward in designing geriatric landscape stating from elder's homes to other building and cites as a whole.
The findings of this investigation can be effectively incorporated in designing geriatric landscape in elders' homes significantly in a context where the designing of elders' homes to the most part is reusing old homes.
It is recommended to continue this investigation forward as a longitudinal study focusing on specific health issues of elder's and deviations in preference of elders based on regional diversity within the country.

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# HABITABLE TRANSITION SHELTERS: IMPROVISING TRANSITION HOUSING IN DISASTER REHABILITATION

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**Abstract:** Natural disasters affect an estimated number of 160 million people each year. Children, women, the elderly, and the differently abled are the most vulnerable during disasters. Facilities for proper sanitation, personal and menstrual hygiene, supporting pregnant and lactating mothers, medical and psychological support are often neglected during the initial recovery phase. Transition shelters have been incorporated in rehabilitation programs worldwide, to successfully aid in post-disaster recovery. The paper systematically analyses vulnerable sections and their needs, the current guidelines and practices adopted, and the habitability of shelters provided in Kerala after the 2018 floods, and similar national and international initiatives. Also, the potential and need for transition shelters in improving the living conditions of the refugees are examined. Gaps in implemented projects and planning for identified vulnerable communities are studied. Results indicate that planning, and proper execution of the shelters, using locally available resources, and reusable materials, results in faster and better recovery by providing the victims with a base to start their lives afresh. Habitable transition shelters can ensure the safety and privacy of the victims and effectively ease the process of rehabilitation.

***Keywords:*** Transition shelters, Refugee needs, Vulnerabilities, Habitability, Inclusive shelters.

## INTRODUCTION

In 2018, 28 million people were displaced across the globe due to conflict and disasters. Weather-related hazards accounted for most of the displacement associated with disasters, triggering 17.2 million displacements (IDMC, 2019). This is an alarming number of refugees that need to be sheltered and provided for. This study focuses on displacements caused by natural disasters and weather conditions. Children, women, the elderly, and the differently abled are the most vulnerable during crises. Refugees are usually forced to live under unsafe and unhygienic living conditions which aggravates their already desperate situation. Shelters broadly refer to protection from bad weather, danger, or attack, which incorporates the principle of environmental protection, and security. It also influences the psychological, physical, and social welfare and acts as a catalyst in re-establishing livelihoods after a disaster. Transitional shelters, therefore, are habitable covered living spaces, with a secure, healthy living environment ensuring privacy and dignity to those within it (Da Silva, 2007). Transition shelters play a vital role in large-scale disasters and disaster response and recovery. They provide privacy and security for people who have left or lost their households due to disaster. It not only provides immediate and short-term shelter for the victims of a disaster, but also help them to recover from the trauma, and provides a base to start the process of rehabilitation (Bashawri et al., 2014). The study reflects on the basic guidelines and design principles to follow while designing transitional shelters. The habitability and performance of selected shelter programs are studied and compared. The study analyses how sensitively designed transitional shelters can benefit the community and aid in positive recovery.

## AIM

The study intends to analyse how sensitively designed transitional shelters can aid in disaster recovery and enhance the conditions of the refugees, by focusing on the habitability aspects of the shelters. The refugee crisis is a critical issue which needs urgent studying and planning to help the victims overcome and start rebuilding their lives. Efficient and flexible transitional shelters can aid in this process. To design shelter programmes that efficiently aid the user group, studies are undertaken to identify the needs and characteristics of the user group. Many vulnerable groups are prone to negative implications even after the actual disaster. Refugees only from natural disasters are included in the study. The

need for inclusive and flexible shelters are studied, and basic guiding principles for the same are studied in this paper. The post disaster shelter management after the 2018 Kerala floods, gaps in the program and the need for inclusive and habitable shelter programs in the state are also questioned.

## RESEARCH METHODOLOGY

Available data on the subject are thematically segregated and studied. Background study include identifying the necessity of improving refugee living conditions, most vulnerable population, and basic refugee needs. Background study involves understanding Design Principles and Guidelines and literature study of selected shelter programs. A set of shelter objectives and habitability factors essential for optimal living conditions are identified through the study and selected examples are studied based on these factors. Examples of shelters provided in Kerala after 2018 floods are examined based on these factors and possible solutions discussed.

## LITERATURE REVIEW

### 1. Identifying vulnerable population and basic refugee needs

There are sections of the population more vulnerable during the post crises situation. This is often because they hold less power in society, are more dependent on others for survival, are less visible to relief workers, or are otherwise marginalized. They are deprived from resources, face discrimination and at most time's violence in refugee camps/shelters**. Women, children, elderly population, differently abled population, LGBTQ community** (sexual minorities), **migrant labourers** are among the most marginalised post disasters. A study of these sections and the basic needs of refugees is essential for providing shelters that are habitable and benefit them. Their safety and well-being must be ensured while planning shelter programs.

- In Pakistan following the 2011 floods, 52 per people reported that the privacy and safety of women and girls was compromised, and several women and girls were facing aggravated domestic violence, forced, early, and exchange marriages (IASC, Global Protection Cluster, 2015).
- One third of the women with disabilities interviewed in post-conflict Northern Uganda reported experiencing Gender Based Violence and several had children after rape (IASC, Global Protection Cluster, 2015).

The instances cited above indicates the need of considering vulnerable populations in shelter design. Health based risks are also a concern after disasters. Risk of outbreaks is determined by the size, health status and living conditions of the population displaced by the natural disaster. Conditions such as crowding, inadequate water and sanitation, and poor access to health services, that are characteristic to post disaster situations, increase the risk of communicable disease transmission (WHO, 2006). Water borne diseases, diseases associated with crowding like measles and meningitis, vector borne diseases like Malaria and Dengue, and other diseases like caused due to improper management of dead bodies are common after disasters. Prevention of diseases following natural disasters include safe water, sanitation, and site planning, providing primary health-care services, Immunization etc.(WHO, 2006). Therefore, proper understanding before site and shelter planning is necessary in preventing such risks.
Basic needs of the refugees can be classified into physical and psychological–social. Physical needs are examined as spatial, thermal comfort, acoustical, optical, hygiene, and security needs (Ammoun and Uzunoğlu, 2020), as listed below in table 1.

*Table 1: User requirements* (Ammoun and Uzunoğlu, 2020)

| | |
|---|---|
| Spatial Needs | The dimensions (static, dynamic and anthropometric), activities and related behaviours of people. |
| Thermal Comfort Needs | Suitable, temperature, humidity, and air movement in a space. |
| Acoustical Needs | Sound intensity, transmission, and reflection properties of the space. |

| | |
|---|---|
| Optical Needs | Suitable light intensity and illumination level in a space. |
| Hygienic Needs | Clean water, garbage and disposals, protection from germs and harmful organisms. |
| Security Needs | Stability, protection against natural disasters, thieves and accidents. |
| Psychological | Privacy, behavioural, aesthetic, and social needs. |
| Privacy Needs | Acoustical, visual, personal, and social privacy. |
| Behavioural Needs | Personal (45-120 cm), social (120-360cm), public (360-cm) spaces |
| Aesthetic Needs | Formal, textural and colour features. |
| Social Needs | Social relations, activities, and related needs in a space. |

**2. Design Principles and Guidelines**

Designing transitional shelters requires understanding the user group and their needs, their culture and ethnic beliefs, and a thorough study of the standard guidelines and principles. Physical, cultural, and social needs of the people should be solved by focusing on the spatial organization of the shelters, users' behavioural patterns and interactions adapting to the environment and the requirements of different user profiles such as disabled and elderly (Hasgül et al., 2017). The Sphere standards, The UNCHR Handbook for Emergencies are widely adopted standard guides. National and regional context and requirements should be studied. The objective of transitional shelter can be summarised as:

- To provide adequate protection against the environment.
- To contribute to personal safety and security, dignity, health, and wellbeing.
- To enable normal household duties and livelihood activities.
- To bridge the gap until durable housing is available.

Shelter in a humanitarian context is increasingly being seen not as discrete product, but as an integral part of a settlement which includes the physical and social infrastructure needed to support communities, including water, education, health, and employment (Da Silva, 2007). Shelter design should therefore focus on the end user – the community, and its vulnerable sections. To enable the site for safe and secure rehabilitation, specific attention to basic services is essential for overall well-being of the community. Design of individual shelters should be based on considerations like hazard resistance, functionality, durability, and owner driven reconstruction. The community and people should be included in aspects of decision making, like deciding spatial requirements, selection of materials, construction technology, and execution of shelter construction (NDMA, 2019).

**3. Habitability factors**

Quality of the lives of the inhabitants should be the prime concern while designing shelters. Refugees should not be considered as hopeless victims incapable of recovering from their trauma, and should be treated with dignity, including them in the rehabilitation process. They should feel at home, safe and welcome in their new habitat. The shelters provided should satisfy a minimum set of conditions to be habitable and inclusive. A study by (Da Silva, 2007) have used a set of transitional shelter objectives to analyse the feasibility of different transitional settlements. They are Environmental protection, Comfort Dignity, Household, Health and Safety. These parameters are used to study different selected examples of transitional shelters across the globe. Two additional parameters are added – Inclusivity, which considers the shelters' capacity to provide for and ease the daily lives of the vulnerable groups, especially the differently abled. Flexibility of the shelters is studied to show its ability to perform different tasks and adjust according to the residents' requirements. The transitional shelter objectives identified for the study are Environmental, protection, Comfort, Dignity, Household, Health, Safety, Inclusivity and Flexibility. Habitability qualities like **temperature, ventilation, light, privacy, space, cooking, water and sanitation, vector control, safety, security, structural stability, disabled friendly design, flexibility, cultural appropriateness** etc. are studied under these shelter objectives.

**4. Overview of the studied transitional shelter responses:**

A) Philippines, 2011: Over 39,000 houses were damaged and over 400,000 people were displaced following tropical storm Wash in December 2011. Catholic Relief Services' transitional settlement response in Cagayan de Oro City is studied. A transitional settlement program to house affected people in a safe and dignified living environment was launched, providing more than 1,300 shelters. Shelters were designed to suit the local climate and inspired by traditional architecture, and materials used could be moved and or used for future interventions. Advanced WASH facilities and sensitive design focusing on vulnerable groups made the shelter response successful (Hirano, 2012).

B) India:

1. Muzaffarpur, Bihar 2007: An estimated 10 million people were affected after the severe flooding that hit the state of Bihar in August 2007. Around 29,000 houses were destroyed and 44,000 were severely damaged, and 10,000 people displaced. CARE India's shelter response in the district Muzaffarpur is studied here. The program built 145 transitional houses incorporating brick plinths and frames, tiled bamboo roof, bamboo matting walls, a small veranda, and an attached toilet. Surveys showed that inhabitants felt the shelters were resilient to disasters even 8 years after construction. Periodic maintenance was needed since the structure was meant to be only temporary. The houses have met or exceeded people's expectations and satisfaction with the programme is high (CARE, 2016).
2. Ganjam, Odisha 2013: Cyclone Phailin caused widespread destruction in the state of Odisha in October 2013. 8,000,000 people were affected, and 419,000 houses destroyed. Mud houses with thatched roofs suffered the worst, affecting the coastal districts, especially the district of Ganjam. The shelter program, Ganjam Aashray Yojana, headed by SEEDS India, addressed shelters, water, sanitation, and hygiene (WASH) and livelihood aspect. SEEDS constructed more than 250 disaster resilient shelters. Intermediate shelters were addressed as a foundation towards permanent housing. Shelters were designed accordingly for the elderly and differently abled residents where needed. (SEEDS, 2014).

A comparative analysis of the above shelters based on habitability qualities are listed in table 2.

**3. Transition shelters in Kerala**

- Project Vision (Wayanad): 328 temporary shelters of 150 sq.ft area made of Trafford GI sheet for roofing supported by steel pipes were built. The sides of the shelters were covered with bamboo and can be built in a day. Each shelter approximately cost Rs 20,000 (The Times of India, 2018).
- Project Vision (Alappuzha): Prefabricated shelters constructed of trafford sheets, steel pipes and plywood sheets, that can be assembled in three hours (Manorama, 2018).
- SEEDS (Wayanad): The shelters are 260 sq. ft in area and costs approximately 75,000/- Rs. They are made of wooden walls along with galvanised sheet roofing. Locally available timber is used for walls to cut costs and to minimize heat. The shelters have a lifespan of 1 year (The Times of India, 2018).
- Oxfam India (Idukki and Wayanad): Provided with clean water, hygiene, emergency food security and temporary shelter support. Major interventions included repairing existing toilets and building new temporary toilets, village cleaning drives, debris removal, raising awareness on the importance of cleanliness, prioritizing personal hygiene of women and girls and large-scale distribution of 'dignity kits' in the most underserved areas (Oxfam, 2018).

**ANALYSIS &INFERENCE**

**Habitability assessment:** The shelter examples from Philippines, Odisha and Bihar are analyzed Based on the shelter objectives and habitability factors listed earlier to estimate the qualitative habitable environment. An analysis of the different methods through which the habitability factors have been achieved in the physical design of the shelter is listed below in table 2.

*Table 2: Comparative analysis based on habitability qualities of the shelter*

| Habitability Qualities | CASE STUDIES | | |
|---|---|---|---|
| | **Philippines** | **Bihar, India** | **Odisha, India** |
| Weather proof | • Built on stilts to protect from flooding<br>• CGI sheets for the roofs provide protection from external/climatic factors. | • Raised plinths<br>• Durable frame strong enough to survive flooding and high winds<br>• Resilient structure even after 8 years of construction | • Raised plinths<br>• Simple building shape to reduce wind pressure<br>• Tin-can concrete footing for stability and cyclone resistance<br>• roof angle of 30˚ to 45˚ to protect from winds<br>• four-way slope works aerodynamically against rain or wind |
| Thermal comfort | • Off the ground shelter gives excellent ventilation to the interior | • Durable and maintainable roof maintains acceptable internal environment | • trees and bushes planted as wind breaks |
| Privacy | • Lack of private spaces for individuals | • Lack of private spaces for individuals | • Window and door leaves that can shut properly |
| Space | No private space provided | No private space provided | No private space provided |
| Cooking | • Water supply provided<br>• Kitchen inside the shelter | • Kitchen inside the shelter | • Kitchen inside the shelter |
| Water and sanitation (WASH) | • For every 10 households a WASH area was provided.<br>• Two latrines, two showers, laundry space and 1,250 litres of water storage.<br>• Drainage for rainwater, wastewater, and solid waste disposal.<br>• A single uPVC septic tank of 1sqm for 2 toilets | • 1 tube well shared between 5-7 families.<br>• Toilets were built attached to the homes, against the wish of the residents.<br>• Toilets did not have adequate drainage and waste disposal measures<br>• Toilets were left unused; people went back to open defaecation. | • WASH facilities were provided separately |
| Vector control | • Being built on stilts provides vector control | • Raised plinth provides vector control | • Raised plinth provides vector control |
| Safety | • The residents felt safe. | • The residents felt safe. | • The residents felt safe. |
| Security | • The residents felt secure inside the shelter. | • Kitchen located inside, and a hand pump and toilet nearby ensured safety for women and girls and addressed their daily needs | • The residents felt secure inside the shelter. |

| | | | |
|---|---|---|---|
| Structure | • Walls - bamboo<br>• Frame - coco lumber<br>• Roof - CGI sheets<br>• Floor - plywood boards | • Plinths – bricks<br>• Roof - tiled bamboo<br>• Walls - matted bamboo<br>• Columns - concrete | • Footing - tin-can concrete<br>• Bamboo frames and bracing<br>• Split bamboo wall<br>• CGI sheet roof |
| Disabled friendly design | • Differently abled, single headed household and the elderly given preference during selection.<br>• Retrofitting of WASH facilities.<br>• Disabled friendly toilets per every 4 clusters | No special features for disabled population. | • Shaded area outside the shelter<br>• Extra steps from the plinth level for easy movement<br>• Brick stack inside the house for resting |
| Flexibility | • Shelter is easily dismantled & erected and relocated<br>• Can be upgraded to permanent shelter<br>• Can be constructed in 2 days | • Materials used were flexible, and according to users' availability.<br>• Temporary walling that could be maintained or replaced.<br>• Few residents replaced bamboo walls with bricks; designated space was made for religious activities. | • Shared walls between shelters to reduce material usage and cost<br>• Locally available resources like bamboo, mud, cow dung, stones, and red soil were used. |
| Cultural appropriateness | • Usage of local building materials & techniques | • Indigenous materials & building techniques used<br>• Toilet provided inside the homes was against their culture, and hence not used | • Usage of local building materials & techniques |

(Table 2: continuation)

**Findings:**

- Shelter program in Philippines have given priority to comfort, dignity, health, safety, and environmental protection in designing the shelter. Meticulous planning of WASH facilities, incorporating local materials and techniques and flexible design made the shelters popular within the inhabitants.
- The shelters provided in Bihar mainly focused on safety and security aspects by providing toilets within the shelters. Environmental protection and durability of the shelters are notable since they have been in usage for more than 8 years. The major drawback noted is the attached toilets being unused due to cultural preferences. Provisions for the differently abled were not identified.
- Safety, security, environmental protection, thermal comfort aspects were addressed efficiently in the design of shelters in Odisha. Provisions for the differently abled residents were also provided where required.
- An absence of personal space was identified in all three studies.

**CONCLUSION**

The study shows an absence of large-scale planning and consideration of habitability factors in the design of transitional shelters in Kerala, mainly due to lack of experience handling disasters and rehabilitative shelter programs until 2018. Over ten thousand relief camps were set up, accommodating over 1.5 million people during the initial recovery phase

(Mathrubhumi, 2018). Most of the camps were housed in institutions and public buildings, which were evacuated later, rendering many victims homeless. Even though reconstruction and housing projects are underway, it will take time to complete. Meantime, many people live in unsafe and unhygienic conditions. In the wake of frequent natural calamities witnessed by the state, there is an urgent need for effective shelter programs in the future. Identifying and developing potential locations for relief shelters and planning relevant temporary and permanent rehabilitation solutions is necessary (Mathrubhumi, 2018).The state government has identified and examined 26 sites for Multi-Purpose Cyclone Shelters (MPCS) across 9 districts (KSDMA, 2018).

The studies show sensitive and habitable shelters can positively impact the affected population. Research on shelter designs considering aspects such as climate, local materials and techniques, culture, behavior, and the livelihoods of its population can benefit rehabilitative shelter programs in the future. Further studies focusing on the habitability factors influencing the population of Kerala are required for designing efficient and livable shelters. Shelter design should primarily focus on protecting and empowering the affected community. It will ensure the prevention of epidemics and instances of violence that are common during crises and aid in the physical and psycho-social wellbeing of the victims. Planning beforehand can multiply the effectiveness of shelter response for disasters. Transition shelters also become relevant in the event of pandemics, where a need for temporary housing solutions arises. Studies on sustainable materials and technology are necessary for building eco-friendly and re-usable shelters.

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# ELECTRO(RE)FORMING: AN ADDITIVE APPROACH TO METAL PRODUCTION

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**Abstract:** A 19th century dormant technique of manufacturing, Electroforming, is scrutinized against the demands of the 21st century architectural fabrication. In an attempt to harness its capabilities of additively forming metallic objects.

The research aims to aid in the manufacturing of free form complex surfaces and structural members, and their perpetual requirement of mass-customization. Consequently, questioning the monopoly of subtractive manufacturing methods at customization, their high costs, their wastage inefficiencies, and their unsustainability.

Literary explorations are undertaken to understand the discovery of the process, its induction into the industry, its additive phenomenon, its manufactured structure and properties, its opportunities and limitations, its base set-up and its diverse applications in the field. The accumulated knowledge is applied to construct prototypes supporting the hypothesis.

The research develops a hybrid method of involving advance designing using Computer Aided Manufacturing, rapid prototyping using 3D printing and manual assembly by hand. A Craftier, hands-on, analogue approach is attempted to involve the maker in the complete manufacturing process. Using this method, flexible and impermanent formwork such as stretched latex membranes and interlaced networks of fibrous threads are turned into delicate and complex metallic entities. All materials utilised are either recycled or reused.

***Keywords:*** *Metal-manufacturing, Mass-Customization, free-form surfaces, flexible form-work, Electro-forming*

## INTRODUCTION

Now at the culmination of two decades into the 21st century, architecture is finally relishing its liberation from the dogma of orthography. Free-form, a defiance to the order of the modern formality, was once restricted to unbuilt graphical visions, literature and models. But it now finds a much more amenable ground, sown at the end of the 20th century, with seeds of digital revolution which have come of age. Computer-aided-design (CAD) and Computer-aided-manufacturing (CAM) have become more or less survival tools in architectural offices, helping to realise such free-forms.

Although as liberating as they sound, Free-forms are inherently complex to design, and then later to translate into buildable information. Complex surfaces are designed as assemblies constituent of sets of flat, singly curved, doubly curved and unique surfaces. Each set of them requiring a specific and distinct manufacturing technology for their production, i.e., it necessitates mass-customization. (Eigensatz, et al., 2010) Manufacturing industry, has come a long way, to facilitate mass-customization of components, where it still lacks is in the efficiency of their production. For instance, CNC operates on hefty stock material subtracting off what is not required, consequentially producing excessive waste. Similarly, when shaping a bespoke mould for each component it produces non re-usable formwork. CNC also struggles in achieving undercuts and steeper profiles. Mass-customization hence upsurges the cost per panel making production unfeasible. It also slows down mass-production, which is most efficient when standardization is at play. Optimization of form bridges the gap between mass-customization and mass production, by minimizing the number of bespoke components, at the same time 'pixelating' the otherwise smoother definition of form.

How does one stop the pixilation of form and ensure feasibility of mass-customization particularly of metallic components? Perhaps a step-back and a change in nature of process of formation is required. Technological stride towards metallic 3D printing attempted a fresh approach towards additively manufacturing complex components, an aberration from omnipresent subtraction. But this did not lower the costs, it surged them further.

**Deviation:**

Metals have a fair opinion of their own shape: solid, dense and glossy. Although, seldom found as described here. Instead, they are found in rocky, brittle ores, chemically corrupted by other minerals, from which they have to be extracted. The first ever use of metals can be traced back far beyond the recorded history. And till date, alike our ancestors, we fundamentally use coercion to shape metals into useful objects with forceful methods such as smelting, casting, forging, alloying, boring, milling, lathe, and extrusion etc. (Browning, 1977) (Winchester, 2018) These coercive methods have become so ubiquitous, owing to the remarkable control and precision they offer, that thinking beyond them has become rather ludicrous. And therefore, the only perception we have about metals is that they are solid, dense and glossy.

The ensuing question, thus, formulates if not coercion than what? The answer to which was discovered about two centuries before in Russia. Much unrelated to the advances in the field of metalworks of the era, the method uses coaxing and not coercion to grow metal, and not form it. Growth is a very natural term, against man-made compulsion it sounds alien. (Miodownik, 2013) Metals are made of microscopic opaque crystals, and under certain influences, they tend to aggregate and thus grow. This process of coaxing metal to grow is what we now termed as electroforming.

**Research question:**

Can Electro-forming, on flexible and light-weight mandrels, simplify and economise the production and mass customisation of complex metallic surfaces and structural members?

## ELECTROFORMING:

Electroforming began with a very different name, Galvanoplasty, and later Electrotyping. Various records attribute its discovery to professor Moritz von Jacobi at The Academy of Science in St. Peterborough, in 1838, roughly nine years after the invention of electric batteries. (Bart, 1962) Understandably, immediate applications were to produce replicas of sculptural objects, each further age provided its own impetus, such as military equipment (submarine shells, antenna's, 60-inch reflectors etc.) for the upcoming wars, medical equipment (linear accelerator), space-race (space equipment's) and so on. (ASTM, 1962)

**Process:**

Amidst the slugfest to tap onto the potential of electricity, the method was built upon preceding simple experiments of *Electrolysis*. When a pair of nodes (in the case copper anode and any conductive cathode) were partly-submerged in an electrolyte solution (in the case copper sulphate, mild sulphuric acid and distilled water) and connected to respective ends of a power supply, in those days a Voltaic cell, element deposition was observed on the cathode.

What ensued was an effective swapping of elements, with copper being extracted at the positive (a)node and been deposited on the negative(cathode). What professor Jacobi did next was just to substitute the negative node with a conductive mould (mandrel), onto which he got a compact and solid copper deposition. (Walker, 1848) (Browning, 1977)

**The set-up and economics:**

To elucidate, four main components constitute the electroforming setup. The first being a power source to supply electricity to the circuit, along with a pair of black and red banana-to-alligator cables, red one is plugged in the positive terminal and the black one in the negative. Alligator clips are then connected using copper extensions to the respective nodes.

The next two components are the nodes, one made of pure copper and connected to the positive terminal termed as anode, and the other to which the mould (mandrel) is attached, termed the cathode. All the experiments in the project have utilised recycled copper, shaped as wires, pipes and plates as per requirement.

The last component is the medium for transfer of elements, in which both the nodes are submerged, it is termed as the electrolyte. A tub made of polypropylene 5, a very durable and chemically inert plastic, is used to contain the electrolyte. For copper electroforming, the electrolyte is made up of copper sulphate, sulphuric acid, distilled water, and additional brightening agents. This electrolyte is the simplest, most inexpensive, highly conductive and the least unsustainable of all the electroforming processes.

Most of the commercially viable metals, such as gold, silver, tin, lead, zinc, cadmium, chromium, nickel and platinum, can be electroformed. Although, each metal requires a tailored set of electrolyte and nodes. More components beyond these can be employed whenever the set-up requires sophistication to improve results such as Filtration unit, tank heater, Agitator etc. (ASTM, 1962) (Browning, 1977) (Dini, 1993)

In India, Initial costs would be starting at around rupees 5000-7000, surging to 10000 professionally. To relate, To CNC mill a single unit of 100cm x 100cm, with modest complexity it costs 15,000-20,000 rupees. To metal- 3D print such a unit would add another 20,000-25,000 pounds above that. Prices upsurge even more when customization is desired from each component. Appropriate set-up conditions and reading values are veiled under confidentiality by associated industry. Much of the crafty world trails on thumb rules. Following are some of such thumb rules and chemical composition provided by the set-up supplier (Gateros Plating Ltd, 2019) and confirmed by the literature (ASTM, 1962):

**PROTOTYPE 1,2,3: TWISTED CUBOID, WAX MANDREL, CNC WAX MANDREL:**

The objective of the first three prototypes was to get introduced to the process. The first prototype attempted to do the same on slightly complex twisted cuboidal shape. The next prototype, attempted to extract the electroformed deposit off the mandrel. For this wax was chosen, which could be easily melted off. The third prototype attempted to test the precision of the process. For this machinable wax was CNC milled to precision and electroformed over. A highly accurate replication of the complex surface was achieved. But since the research aims to not use CNC, a new method of manufacturing was sought.

**FORM FINDING, FORM FREEZING (RESEARCH HYPOTHESIS):**

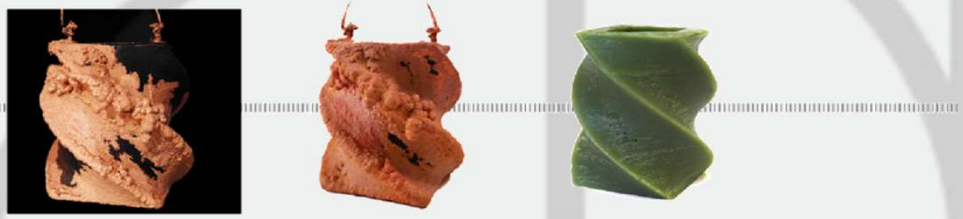
Frei Otto form finding experiments are pretty well known. He called them “optimised path systems”. These “machines” were devised in a way such that the various elements interacted with each other, under fixed boundary conditions, but otherwise free by themselves to “find a form” based on natural forces at play and complex material behaviour. Most of these systems were vector based, which tried to economises, optimise, minimalize, paths by merging or bifurcating, in the process generating a minimal form. (Songel, 2010)

All these systems were ‘soft’ in nature, made of agile, wet and delicate material on a small laboratory scale. The forms they took, on being wet or stretched, were presumed to portray the obscured process of stabilization of form by nature itself. These forms were to be replicated on a much larger scale using stiff, dry and strong building materials. Although being delicate, these systems did not last long enough, and so the found-forms had to be measured in-situ or photographed, and then their proportions were scaled and resolved to the proposed architectural visions.

When we now look back at electroforming, it is a process that share this small scale of manufacturing with these ‘soft’ systems. But interestingly, it has never employed them as mandrels to coat on. As a process, fundamentally, conductivity is the only essential prerequisite required of a surface. It does not discriminate based on the physical nature of the mandrel itself. The mandrel can therefore be both stiff or flexible, it can be a single unit or a network of units. The only constant being that the deposit itself is always a stiff replica of the ‘parent’ surface.

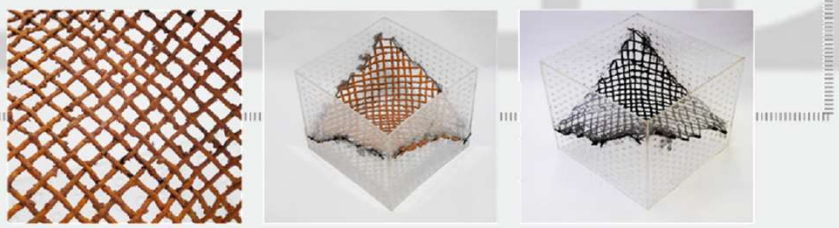
**The essential hypothesis this conveys is that these soft systems of stretchable membranes, threads, sponges and such fragile form-work can become substrate for growing metals on, in the case copper. The ease with which such systems can be shaped and deformed allows highly twisted, doubly curved and thus complex but delicate forms to be solidified into rigid metallic components. The following protypes were constructed to test this hypothesis.**

**Prototype 2:** Electro-forming on wax to later extract deposition by melting



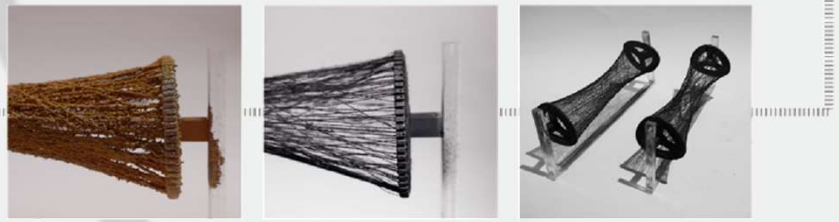
**Prototype 3:** Electro-forming on Machinable wax to produce precise complex surface

**Prototype 4:** Electro-forming on a hyperbolic paraboloid network of strings



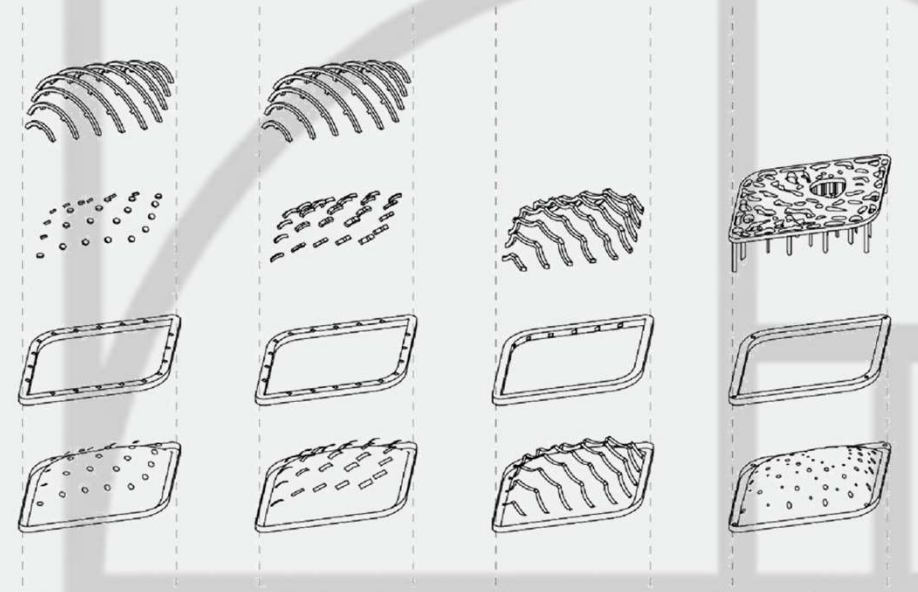
**Prototype 5:** Electro-forming on a hyperbolic paraboloid shaped stretched latex.

**Prototype 6:** Electro-forming on interlaced strings producing structural member



**Prototype 7:** Electro-forming on a pin- 'animated' stretched latex to add on complexity

## PROTOTYPE 8: GENERATING COMPLEX CUSTOMISED METALLIC SURFACES, THROUGH FLEXIBLE BASE.



Parametrically designed frame-work is virtually dissembled and then 3D printed.

The 3D printed components are assembled and glued in place to form the base.

Latex is glued to the out perimeter first. Then gently pushed inwards and glued to the "ribs"

The inner surface of the stretched latex is then spray painted with graphite to make it conductive >>

One of the panels half-way through the process of deposition of electroforming.

Copper deposition filling up intermediate gaps, initiating at the wire contact points.

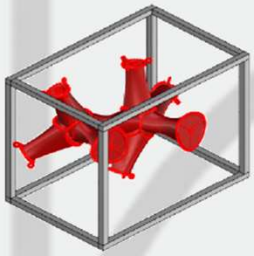
Post-electro-forming, a Dremel cutter is used to give each panel a neater edge.

The Base frame-work is gently heated with a heat-gun and pealed off leaving behind the deposit.

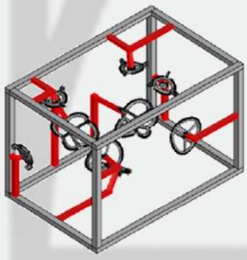
Built full scale model of network of panels supported by 3D printed base frame work held by a wooden base. Mimicking facade systems, which can be made more sophisticated.

Connections using magnets, which can be swapped with nuts and bolts professionally. The outer surface is darked by graphite, while the inner surface boasts a very organic finish.

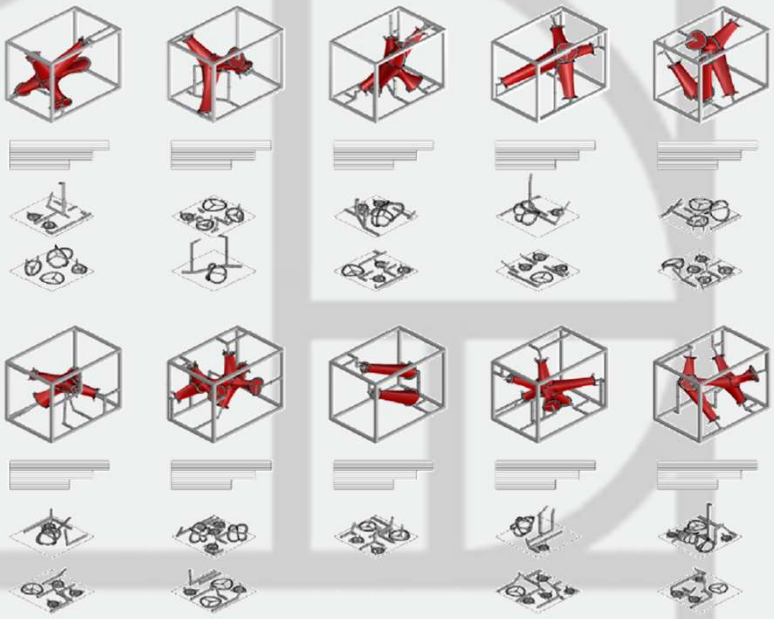
## PROTOTYPE 9: GENERATING COMPLEX STRUCTURAL METALLIC GEOMETRY, THROUGH FLEXIBLE BASE.

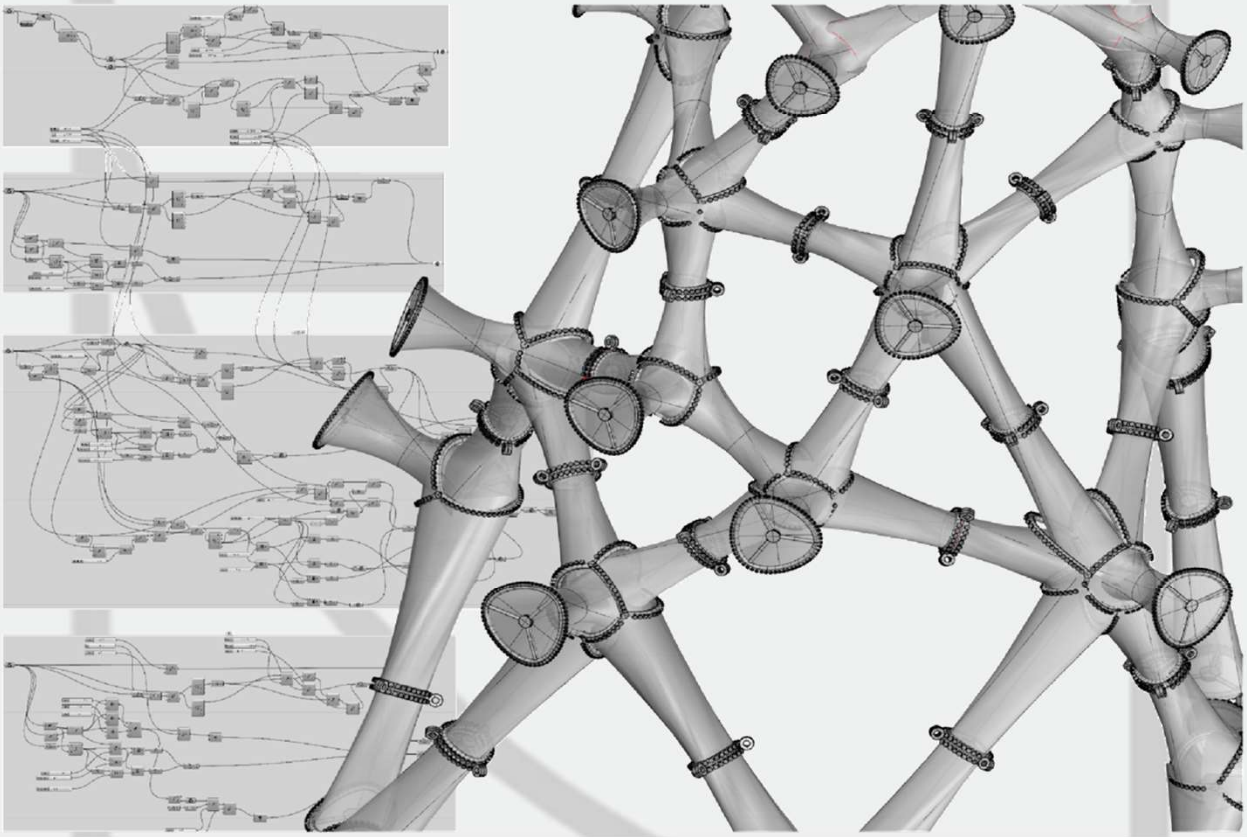


A Complete manufacturing grid is created with acrylic box



3D printed locator units and anchor points over which threads are inter wind.





The 3D printed locater elements and anchor units are stuck in place, referenced using the acrylic box. Polyester strings are inter wind over these anchoring units, creating the complex geometry through its network. A complete assembly of manufacturing boxes is put in place, all electro formed simultaneously. Post-electroforming the solidified metallic geometry is snapped off and assembled using nuts and bolts.

**CONCLUSION:**

Standardised industrial markets often create susceptible cul-de-sacs for themselves, when they avoid customisation, halting there manufacturing progress. In such scenarios, deviations of approach (such as 3D printing) or rejuvenations of obscured (such as of electroforming) are required. Additive manufacturing being the stimulus for both the approaches.

Where they lie juxtaposed, though, is in their methodology. 3D printing being an extensively controlled industrial process while electroforming a crafty hand-held flexible process. Which also makes it economically approachable and playable. What the research demonstrates through its prototypes was a playful re-tweaking of two centuries old electroforming into contemporary manufacturing methodologies such as of rapid-prototyping, and to use that to manufacture complex elements. **Therefore, we loop back to address the question asked at the introduction of the research: Can Electro-forming economise the production and mass customisation of complex metallic surfaces and structural members?**

The aspect of lowering economics is dealt both at set-up level and component level. As elaborated in the related section beforehand, the whole ensemble is assembled in cost equivalent to that of manufacturing a single component by CNC milling. Constituents of mandrel are affordable materials such as latex sheet, PLA filament, synthetic strings and recycled copper. Producing a single component or a hundred takes the same time just bigger baths, all of which can be customised by selective 'animation' of latex or changing patterns of threads. This effectively ensures mass production and mass customisation going hand-in-hand. Finally, complexity, of double curvature, patterns and undercuts, is effectively provided by the agile nature of its constituent elements: latex and threads, and their infinite forming possibilities. So, to answer, yes, electroforming can provide an alternative prudent path of achieving customisation yet maintaining affordability.

Beyond that, each prototype celebrates the eccentric aesthetic characteristics of the process: rugged surface, nuanced patina and colour, metallic temperature, glitter. It's a rich sensory experience unique to each object. Prototypes strive to be both a piece of art and yet be utilitarian, consciously distancing from excessive of either. The self-forming events such as dendrites, nodules, patina etc. lend in organic detailing to the surface, which interestingly goes with ideolog of modernism: the only ornamentation being the manufacturing history rendered on the surface of a material. Since each protype takes a few days to grow, its growth attaches certain significance of effort to its meaning, and thereby preciousness, as used to be attached to artefacts made by hand in prior ages. The modern-day manufacturing is a swift process: what can be built fast, can also be discarded fast. Importantly, an electro-former, is a craftsman religiously engaged in small scale studio fabrication, prototype dependent, running on an economy-of-means approach. (Pallasmaa, 2009) (West, 2016) The following two quote are both in and out-of-context:
*"To work with a minimal amount of materials using a minimum of energy, this can lead to a new architecture of lightness." – (Frei Otto)*

*"One must not forget that all these promising developments are made possible by the progressive liberation of reinforced concrete from the fetters of wooden forms. Until these bonds are totally removed, the architecture of concrete structures is bound to be… an architecture of wooden planks" - (Nervi 1956).*

Achieving Sustainability was paramount. The project does utilise chemicals, but in comparison to other electroforming baths it's the least damaging to the environment. The same set-up can be kept in circulation for many months if not years and with constant filtration system it would last even more. The project also attempts to break the cradle-to-grave linear progression of objects described by McDonough and Braungart in Cradle to Cradle, where they go from production, to use, to grave. Instead, all materials utilised are either recycled or reused. (McDonough & Braungart, 2008)

At conclusion, Ursula Franklin, in her book *The Real World of Technology,* observed that technology is not an assembly of tools and gadgets, but instead "a way of doing something". (Franklin, 1999) This distilled gist of the thought, liberates the 'way' from just what has been established, thereby opening imaginative ways 'of doing something'. Electroforming on flexible mandrels presents one such experimental novel pursuit of achieving free-forms. Certainly, it

does not match the speed of industrial production, and yes, it has not been scientifically perfected, nevertheless, the latent opportunities it offers are quite real.

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# PROCESSING IRREGULARITY - ENGAGING THE DIGITAL WITH MATRIAL CULTURES

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**Abstract:**

This paper focuses on an approach to re-imagine the way we use basic building 'materials' that are available in the form of debris or construction waste. Within the context of this project, 'materials' refer to articles which are considered unusable by the construction industry in their natural state, due their irregularity[1].

This paper investigates an approach at the intersection of designing with irregular materials and computational processes. The project introduces a 'digital fabrication' workflow to create a complex non-standard assembly. The assemblies are fabricated with the 'as found' materials and is fully reversible. An approach that aims to be sustainable, economical and contextually engaging. This paper offers

- An approach to develop connections from appropriate scanned data of the raw material.
- Results of the initial physical experiments and review of their performance.
- Insight into using augmented reality to assist the construction of such non-standard structures.

Overall, the paper outlines the end to end development and prototyping of a new language in stone upcycling, which can be potentially adapted for various materials.

***Keywords:*** *Digital fabrication; Workflow; Scan; Sequential Assembly; stone; Augmented Reality'; Reversible;*

## INTRODUCTION / BACKGROUND

### Motivation

Naturally occurring stone and their irregular counterparts - offcut[i] pieces of stones, are one of the most found articles, particularly in construction and demolition sites. Often regarded as an innocuous material that embodies contextual information, geological time and human history. In recent times, the inherent value of these 'as found' materials are disregarded, as they are relegated to a solely superficial purpose such as decoration or is processed into fine material that is homogenized with other materials, which is a rather resource intensive approach (Tam,2009). From a different perspective, within the construction industry, the natural inclination for working with irregular stones is through two common approaches. First, is to dry stack, a technique that emerged from ancient stone-fitting techniques or a second approach, which is a more permanent method of setting them in mortar. Both methods can also be characterized as limitations, as it can only achieve certain kind of construction structures and works fittingly with regular[ii] geometries of stone within a construction system. This limits the overall *'buildability'* of such material. The statistical significance of these materials in landfills, particularly in UK and Europe make this more evident (service, 2018).

Every year there are tons of construction debris and irregular offcuts, especially concrete and rock rubble, which are discarded to landfills around the world (Puskas, et al., 2014). However, there has been considerable amount of recovery operations through the past decade that looks at recycling, upcycling and reusing these materials. There has been significant improvements in the various methods and processes of working with construction and demolition waste, where its inherent value is cannibalized to produce new materials that can be used, especially in construction. e.g.: cement aggregates (Tam, 2009). However, these processes are highly energy intensive and discards a possibility for a new style of construction.

Aim & Objectives :

The aim of the project is to explore the possibilities in working with these natural cutoff or irregular material. It attempts to explore and conceive a different approach of construction with said material, within the framework of fabrication technology combined with procedural form finding, structural optimization and digital augmentation. The main research investigation addressed in this paper is to

*'Develop techniques to use computational design tools to create non-standard geometric interfaces between as-found materials that allow the assembly for complex aggregate structures.'*

This research is implemented in conjunction with a specific interest to *'Generate a workflow that can determine the extent to which the process can be computationally solved in order to optimize resource efficiency.'* Here, the term *'resource'* refers specifically to machining time, overhead costs, material usage and fabrication labor.

The research is developed with a focus on one type of material i.e. irregular stone in order to solve the various inquiries in the process and understanding the correct aspects to work with in order to systematize this approach.

With the modern computational tools and digital technologies, it is feasible to control, manipulate and work with the complexities of irregular geometries and thereby, subsequent complex construction, in their full three dimensionality. The intention is to harness these tools to increase the buildability of these 'as-found' materials. The system-based understanding of these tools in relevance with the materials, also provoke our awareness of standardization and contextual concerns. The constantly changing requirements in the architectural design industry urges us to not limit to a fixation with 'objects', but to take into consideration the 'performative' and 'performance-oriented' aspects as a crucial part of the concepts behind how to work with these irregular geometries. Some basic enquiries were if these materials can incorporate various requirements, such as structural, environmental, perhaps cultural aspects into a responsive system.

*"Performance in this sense is not an inherent property of a material, product or a system, but a value that related to a specific context. Instead of a merely technical optimization of the performance of a building part, these design approaches conceive architectural production as an active agency which creates a direct and dynamic relationship between human needs, spatial and material organization and the environment."* ***Invalid source specified.***

In order to develop a structurally stable assembly, computational methods are used to generate a robust workflow of mutually symbiotic relationships; between the physical aspects of the stone and technical aspects of manufacturing. This workflow attempts to offer a new approach for designing as a material practice.

Some of the key questions addressed in this project are:

*Is it possible to generate reliable 'interlocking' of the interfaces with the stone to make stable structural assemblies using available manufacturing methods? Can such structures be designed according to a certain performance criterion? Further, can the scanned data from the raw material be sufficiently exploited to produce engineered connections that allow for zero processing on the as found material, but reflect a highly efficient fabrication workflow? How can the differences in the features or individuality[iii] of the material play a vital role in defining its role within an overall structure? How can these various processes be complied into a straightforward end to end process that can be adapted to other similar materials?*

*Fig 1: Sample pile of irregular rubble material that the project's workflow targets to work with.*

Investigations into these questions provide an indication for the nature of the joint components or connections. The connections prove successful if their interlock-ability would be robust enough to hold the overall structure in place, whilst not being permanent[iv] on the stone. The interlocking refers to the physical method of joining individual parts (stone and the connecting element), which is informed by computationally solving various parameters as part of the digital fabrication process. Addressing these questions help the project to progress a step closer to reinventing how to work with one of the oldest building materials available. Striving towards this could potentially have a real impact on 'reversible' modern construction methods with stone.

## RESEARCH METHODOLOGY

The main targets of the thesis were addressed through a series of studies which were investigated and revisited repeatedly as the project developed. The initial studies were developed in the following order:

- Understanding the existing methods of working with stone in comparison with other aggregate structures.
- Investigation into joinery methods, joint component elements and their performance.

- Investigation into methods of fabrication and machining for mass customization.
- Integration of a design and the role of a designer within a procedural form finding workflow.
- Overall performance of such complex *'modulated aggregate'* structures.
- Role of augmented reality as a guidance for a sequential assembly construction system.

The following chapters elaborate on four key elements of this thesis. Chapter two elaborates on methods and projects in the realm of this project, currently in the industry. It ends with considerations that is carried forward into chapter three for the workflow development. The fourth and fifth chapters elaborates on the fabrication processes in developing the joint components and the subsequent overall assembly.

## LITERATURE

### Context

One of the earliest construction methods with stone is drystone walls. They are extremely durable structures, due to their intrinsic ductility, permeability and material strength. Their stability is largely owed to their composition into a cohesive structure, appropriate placement and friction (Adcock, 2012).

*Fig 2: Cyclopean masonry - Inka Roca, Cusco Peru c. 350 CE.*

In terms of understanding the process of working with recovered rock, the concept of cyclopean masonry provides a stimulating insight (Clifford, et al., 2018). This paper investigates how an age-old knowledge of stone cutting can help combat construction waste and fuses it with advanced digital techniques. The theory of the paper revolves around the concept of ingestion of waste material to generate new structures. Ancient stone fitting techniques, as exhibited in the Inca stone works (Fig 2) is considered and are adapted by advanced fabrication technology to test this hypothesis. Further, the paper breaks down the working of stone fitting techniques such as bed joints, Utah details etc. Using this bank of knowledge on construction techniques, computational approaches are taken to find trends in shape grammars that help design the 'recipe' of a prototypical wall. The approach employed aligns with the approach of this paper in several ways. The initial procedural steps; where demolition debris is gathered, scanned, data is processed with a computational algorithm, is akin to the process employed in this project. While the preliminary intentions are comparable, the treatment employed to the debris and therefore, the outcome differ a great deal. The ancient methods have been replaced with the latest fabrication technology thereby making the process more efficient, however, this results in structures that are like the structures formed by ancient cyclopean masonry. This is foreseeable because the material is 'treated' in a similar manner. The prominent use of this building 'block' through generations of design, has in many ways developed and conditioned our tools, techniques and minds to treat stone in a certain tectonic language.

In terms of developing a new tectonic language, with an alternative take on aesthetic and structural morphologies, which are load bearing, jammed architectural structures are relevant.

Jammed and unjammed architectural configurations in many ways offer a contemporary take on the method of dry stacking. Their stability is largely controlled by friction and load. It was an initial consideration to treat the stones as pure aggregate material. It has been previously proven that granular aggregates can be designed to meet target properties. Further, they can be made into resilient assemblies as well as be manipulated to exhibit properties such as high porosity with high strength. However, the major limitation with these stochastic configurations are that, they are constrained in terms of design complexity and can only work successfully with certain aggregate shapes (Dierichs & Menges, 2016) a and sizes (Keller & M. Jaeger, 2016).

In the paradigm of aggregate architecture, there are two different approaches to aggregate structures – Engineered aggregates and not engineered aggregates (may include additional supporting[v] components).

(CASE 1) NON-ENGINEERED AGGREGATES

The focus of these structures shifts from precise assembly of known parts to controlled aggregation of granular parts such as gravel or rocks (Aejmelaeus-Lindström, et al., 2016). The research describes a new granular construction method that is *"(1) efficient in terms of capacity (formal and functional), (2) reversible without additional formwork or other means of manual construction, and (3) aggregated from local or recycled materials into complex geometries."* Comparable to this approach in jammed structures, a type of construction that is not dependent on costly materials and/or component prefabrication as well as transportation and material waste can be evolved. However, this research was limited to a certain size of aggregates (graded aggregates of 5-15mm grain size with sharp edges and high frictional resistance), and consequently relies on robotic fabrication for its assembly and mechanical interlocking. Some of the other key drawbacks of jammed structures as described in the paper are *boundary fragility*[vi] and *material deformation*. To address the fragility of the edge, a reinforcement such as a low-grade string was introduced (Fig 3), to strengthen the system, which can handle the edge condition and redirect the forces as the structure builds up. This line of research leads to interesting method called 'rock printing' (Fig 4). Rock printing creates a niche in aggregates through randomly packed, fully reversible and reusable, jammed structures that form non-standard assemblies. The structure holds together with the help of wires that give it the friction and tension required to strengthen the boundary conditions.

*Fig 3: Rock printing using the string to combat boundary fragility..*

*Fig 4: Rock printed structure that is held together using aggregate friction and string.*

*Fig 5: Shapes of gabion units that demonstrate the boundary geometry.* ***Invalid source specified.***

Another well-established form of aggregate structures are 'gabions'[vii]. Gabions are essentially a frame filled with rocks, stone, concrete or even earth using the conventional stack-and-pair configuration (Fig 5). From a broad perspective, they are like the previous research in the method of using a 'boundary condition' to hold the aggregates in place, while exploiting the virtue of the mass and interlocking. While these frames or boundary conditions can be of various shapes, they ultimately substantiate that there is a fundamental link between the unit shape and the structural integrity (Ramli, et al., 2013). This limits shapes of the overall structures; complex shapes with branching or specific geometric performance become increasing difficult to achieve because they work against the principle of these configurations.

(CASE 2) ENGINEERED AGGREGATES

Alternatively, advanced computational capabilities have made it possible to create highly customized building elements with the intention of increasing structurally active interlocking. The idea is to create these 'tumbling units' or aggregates which can be self-confined and will hold down the geometry of the overall structure when forces act on it, all owing to the shape of each aggregate unit (Dierichs & Menges, 2016). The project is elaborated on the concept that,

*"Methodologically aggregate systems challenge conventional architectural design principles: whereas an architect generally precisely defines local and global geometry of a structure, in a designed granular system he can only calibrate the particle geometry in order to tune the overall behaviour of the aggregate formation."*

This concept could be extrapolated further and applied in the form of calibrating a secondary element[viii] that affects the behaviour of the aggregate formation. By this method, the elaborate process of generating many 'aggregate unit' is avoided and precise specific components can help use the available materials (stones) as aggregates to achieve the target results.

The above-mentioned projects serve to verify the theoretical applicability of the concepts introduced in this research. Stochastic configurations of granular material as well as aggregate engineering, provide key insights. The crux of this project truly lies at the intersection between these aggregate configurations and precise component engineering. It is through 'engineered elements', that value is added in the form of control over form, function and performance of these materials. This taps into the qualities of these stones, such as their size, texture, weight, strength etc. and provide an opportunity to use them.

## WORKFLOW

Developing a workflow that aids in a systematic approach to working with these irregular materials is central to the project. The essential feature of this system is the unique integration of a variety of materials with this digital fabrication workflow, so their overall capabilities and limitations can be identified and appropriately manipulated to suit the target performance (Fig 6).

Fundamental to the workflow are four processes: ***Data gathering, Designing, Fabrication*** and ***Assembly***. Each stage of the workflow is crucial in informing the next stage of the workflow.

Phase 1 – Data gathering

The initial phase of the workflow went into studying the existing conditions of these materials. Once salvaged, recovered or gathered, it goes into a readily available material pallet. It then becomes crucial to understand the materials and create a database with the information regarding its origin, structural integrity, texture, size etc. To gain and store this data, a digital library of the pallet can be created using either photogrammetry or hand scanning. The 'Creaform handyscan[ix]' is used to scan the rocks. The hand scanner provides high resolution scans and proved to be a significantly faster process to gather information in comparison to photogrammetry (

).

Post scanning and tagging the rocks with the appropriate information, the materials in the pallet can now be categorized into the different groups based on size, texture, shape etc.

Adding a layer of complexity, a second set of data is gathered from the stones. This is the information regarding the surface features. Extracting the ridges, valleys and vertices on the surface would allow the further establishment of the roughness and high friction zones on the stone(s). This is the critical data that gives us the rudimentary knowledge of what the 'grip-able' parts could be, which acts as the seed data for the next stage of the workflow.

Given that there is a point of intersection, the next task was to define 'HOW'. We set up a process through which we could make sense of these materials and give us provocations about a form with practical applications for it.

*Phase 2 – designing*

The conceptual design thinking while designing for such a hybrid system needs to shift from the conventional notion of a finite pre-conceived structure, informed by artistic intentions, towards a realm based in information processing.

This involved a basic design intent and understanding for which stones suit what purpose better. As typical of aggregates, these irregular stones work best in compression. In order to harness their compressive forces, the direction of forces need to be aligned to work with the design intent. This involves a twofold process, explained through an experiment. Firstly, a simple compression structure is designed, a three-legged arch structure (Fig 8). A basic frame of this design is

developed with the required inputs of the number of stones, which act as 'nodes' and the connections between them act as supports.

*A basic frame of this design is developed with the required inputs of the number of stones, which act as 'nodes' and the connections between them act as supports. This base frame is fed into a physics engine with an algorithm. This genetic algorithm[x] processes the various possible combinations of stones within this base frame and places them appropriately based on the input parameters. The algorithm employs a multi-objective function that finds the most viable results that satisfy the various fitness values such as overall structural stability through finite element analysis, maximum assembly height and minimal distance between the nodes etc. Here, it is important to note that the above analysis is done considering the nodes of the frame structure as point loads of weight of the stones and does not consider the volume and shape of the stone. This leads to the second part of the twofold process. The individual stones along with their data about grip able parts is analysed with reference to a target parameter. In this instance, it is to find the longest line that connects two grip-able zones on the surface of the rock through the 'centroid zone[xi]' of the stone (Fig 7). This ensures that forces are correctly distributed to the subsequently developed connection joint at the grip-able joint. A second algorithm runs the permutations to check the results for this logic and provides a number of possible options.*

Herein, our hand as designers play a role in creating the logic for this generative environment. While the designer plays a final role in selection of a result that is suitable, he does not play a direct role in determining the exact positioning of the stones. A significance of this kind of an iterative process is that it allows for multiple forms to be generated rapidly from large quantities of data. In many ways, this detaches the role of the designer as a 'master builder' with a single solution and allows for multiple possibilities within an established set of parameters.

Phase 3 – fabrication

Post designing and finalizing the structure of the design, the joint components can be fabricated.

Since reversibility and disassembly were key, multiple forms of connections were explored.

The connection element is treated much the same way as the aggregates in the programmable matter project (Dierichs & Menges, 2016), where the shape and placement is defined not to achieve a certain geometry but rather to calibrate a certain material behaviour in combination with the stone to promote target behaviour for overall assembly. The

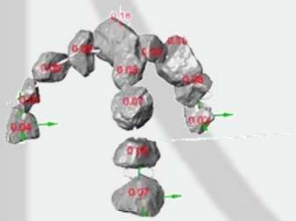

*Fig 8: Digital simulation of the three-legged arch experiment to test the workflow.*

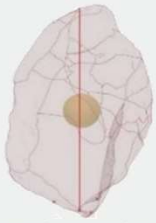

*Fig 7: Finding the orientation and connection point through algorithm based on constraint to find longest line through the centroid zone.*

*Fig 6: Basic preliminary workflow overview for the development of the project.*

connection morphology has two aspects, both the geometry as well as the material composition and their cumulative effect on behaviour of the stone. In terms of fabrication methods, the main goals were to fall in line with the overall

sustainability motive of the project. It was critical to explore suitable manufacturing techniques that uses little manual and machining labor as possible, as well as to reduce material usage and wastage.

The joint components in theory could be manufactured from a variety of materials. However, every material brought with it, its pros and cons, therefore it was crucial to experiment the working of these materials through trial and error.

While it is noteworthy to establish that more than one manufacturing method shows promise, the later stages of this project exclusively employed additive manufacturing. Detailed investigations in fabrication has been elaborated in the next chapter.

Phase 4 – Assembly

And lastly, a significant strand of research this project is based in assembling these natural and engineered parts together and making this a straightforward process. The construction process entails instructions for sequential assembly and formwork.

A common problem that has been addressed repeated by this generation of designers is visualization. *"The ability to conceptualize, visualize and communicate 3-dimensional ideas to both oneself and non-architecturally educated audience has long been a challenge for architects"* ***Invalid source specified.***

Drawing techniques, renderings, blueprints etc. have helped addressed this. However, as the construction gets more 3-dimensionally 'customized' to the very 'building block' which is the stone here, the assembly instructions and visualizations needs to evolve with the design philosophy. It gets quite tedious and complicated to communicate the directions effectively between the various professionals involved in executing such a project, from the stage of conceptualizing to the deployment on site. In this sense, traditional analogue assembly instructions seem to be a setback. It is herein, that AR proves itself as an effective, significant tool at the designer's disposal for assembly instructions to anyone engaged in the process.

## DISCUSSION

### Results and Failures

This paper is at the intersection of aggregate architecture and a component-based building system. As a novel field, it challenges many concepts of architectural design. The relevance of working with these stones as a granular aggregates is that , on one hand it can it be functionally graded within the collection of aggregates and on the other hand, it allows for rapid reconfiguration, with the added advantage of not destroying but recycling the connections. This allows for the frequent re-configurations according to requirements or aesthetics, which abandons the conventional architectural notion of permanence and eventual destruction. The forces lines are established based on parameters that affect the stability of the overall design. This is derived through the workflow developed in the project. While the resultant work-in-progress prototypes displayed evidence of success for the force line distribution (Fig 11), the overall success of the workflow is yet to be tested after a suitable scaffolding system is in place.

*Fig 11: Work in progress of structure's development during the assembly.*

The fabrication experiments have shown unprecedented strength in gripping. This strength was however, displayed only by the connections developed on the gripping zones that used the algorithm to find the zones with the highest surface variations. The connections developed prior to that, using other methods, specifically using the aluminium connections showed slippage and less strength. As for the joint components developed through additive manufacturing, we are combining a pre-existing material with 3D printed biodegradable components, the environmental implications in terms of wastage is negative. Moreover, these systems become highly interesting in an architectural context as the target behaviours can be pre-programmed into the connection elements that affect the aggregates. It also widens the possibility of multiple functions being integrated into the component by accommodating functions such as channels/grooves for wiring
or other structural performance

*Fig 12: Work in progress and projected structure for this project.*

**CONCLUSION**

The research developed in this paper aims to develop a procedure through which the designer can use 'as found' materials as a building medium. The project aims to extrapolate information from materials that are abundantly found but otherwise discarded and manipulate this information into data that can guide fabrication. The possibilities of designing with such materials are numerous, but with an end to end workflow, it can equip the designer with a powerful tool to methodically deal with the data. This provides the knowledge and control which can manipulate, analyse, and identify areas of flexibility and areas that require high amounts of precision in the design.

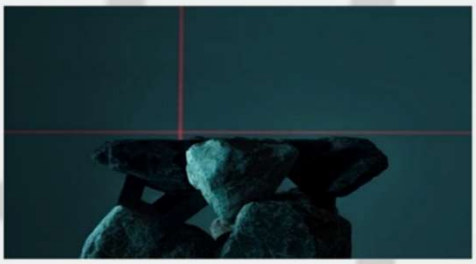

*Fig 9: Photograph of Project prototype exploring datum precision*

To develop this thesis, a wide variety of subjects have to be considered in terms of practical, methodological and theoretical implications. The study begins with the basic understanding of lifecycles of abundant but irregularly shaped waste material and the role of workflows within manufacturing environments. A coherent understanding of precision data, manufacturing tolerances and their role within the project influences the reversibility and sequential assembly of the components. The hands-on experimentation and manufacturing have given key insights into tactical and strategic decisions, to make mass customization of the joint components a more efficient process.

*Fig 10: Photograp spaces and connec*

Assembly sequence planning is a crucial technology that facilitates design realizations. It deals with component related factors such as form, feature, orientation, size and weight, but also fabrication techniques like handling, gripping and scaffolding. While a logical conclusion would be to create precedence relations for joint components, this does not necessarily express the complexity of the assembly relations. This provides an avenue for investigation that could simplify greatly the complications of developing a scaffolding system.

These initial physical experimentations open opportunities for further research into the architectural implications of these kind of a material driven digital design and fabrication process. Within this context, the work presented here is a step in the direction of systemizing the process of considering any bulk amount of irregular material as aggregates and test their applications and implications by initial design experiments and simulations.

*Fig 11:: Final structure built using the methodology explored in this research. Structure exhibited at Bartlett*

Further research & Scope:

As structures that are less dependent on transportation and with almost zero material wastage, a variety of rapid load bearing construction types can evolve. Going forward, this system can help architects design structures that meet specific criteria with the most complex geometries of material. The combination of various types of connection materials within the same assembly widens the scope of possible and useful assembly behaviours, in terms of passive engagement through perforations, lighting, haptic experiences of locally available material etc. However, this has only been marginally explored.

As a workflow, it is flexible enough to adapt with a variety of design scenarios. Apart from exhibiting a different approach, these design scenarios could entail remote locations with limited resource access and heritage sites that needs minimally invasive structures. To further widen the ambit of this research, this could potentially allow designers to remotely experience a structure that is proposed for a location that is difficult to access. Enabling for an informed decision making in design, based on how the space is perceived. Further steps can include considerations of immersivity, interpreting the visualization and creating a feedback loop that can inform the design. While the current development does not reach as far as interaction with the visualization, the power of the tool is promising enough to encourage investigation.

When linked with an adaptable formwork system and digital guidance system, this workflow will satisfy requirements for a system that is economic, customizable, precisely controlled with minimal wastage and fast construction.

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[i] Unevenly shaped rubble as a result of demolition, explosion, quarrying or breaking off from original evenly shaped material.
[ii] Geometrical shapes in stone, with a certain tolerance for symmetry or flat surfaces that can be aligned against one another.
[iii] Each stone has its unique characteristics and features in the form of color, rides, valleys, grain, texture etc.
[iv] The connecting joint component is a reversible fixture that can be assembled and disassembled from the stone.
v Refers to the wires used in the rock print project and the boundary geometries provided in the form of containers in gabions.
[vi] Boundary fragilities and material deformation play a key role in determining the overall structure's stability.
[vii] They are gravity structures that provide structural fixity in fortifying structures.
[viii] In this specific project, the element would pertain to connections or joint components between the stones.
[ix] It is a handheld portable metrology grade 3D scanner. It provides a resolution of 0.100 mm.
[x] Genetic algorithm solves optimization problems with or without constraints. It is based on natural selection.
[xi] This is a tolerant centroid region provided in order to establish stability of the center of gravity of stone in the structure.

# AN INVESTIGATION ON CONSECUTIVE PATTERN OF THE BANGLADESHI TRIPURA COMMUNITY, FOR DETECTION OF A DUAL ACTIVITY, "MODULAR FRAMEWORK" - PROTOTYPE DESIGN FOR SUSTAINABLE BUILT ENVIRONMENT

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**CUET, Chattogram-4349[1] , CUET, Chattogram-4349[2] , CUET, Chattogram-4349[2]**

**Abstract:** "Indigenous People," or "Ethnic Minorities," are termed to identify few social castes whom carries harmonic social-cultural individuality which distinct from the dominant stratum. The majority among 11 tribes, "Tripuris" are larger, living at CHT (Chittagong Hill Tracts) region in Bangladesh whom are the aborigines of North-East India & Bangladesh. Anteriorly, for living Tripuris depends upon Shifting Cultivation and animal-husbandary but environmental damage, severely effects on their economies & frequent discriminating actions due to ethnicity are gradually vanishing their tangible living pattern. For restoring the tangible pattern & economic progression, Bangladesh Government includes them in a development project titled "Ekti Bari Ekti Khamar", that's basically a farm cum shelter for every rural individual. The objective of this study is identification of their culture & living pattern from various tribes, which will certainly help in perceiving their settlement evolution with livelihood pattern. The discussion focuses on detecting of a **modular framework** from sustainable local materials, incorporating their living, & working/farming zone in a frame with a mixture of consecutive & modern technics. For limitations in standard verses, data were collected from historical backgrounds, survey, case studies & interviews, aiming at to build a module to recourse their dual activity zone_ living & livelihood.

***Keywords:*** Consecutive living Pattern, Culture, Sustainable Materials, Settlement Evolution, Dual Activity Zone, Modular Framework.

## INTRODUCTION

*"Indigenous peoples have rich and ancient cultures and view their social, economic, environmental, and spiritual systems as an independent."* - (International Fund for Agricultural Development (IFAD), 2011)

Amidst 45 different ethnic groups living in Bangladesh, Tripuris are one of the prominent age-old tribal communities, colonized in the Chittagong Hill Tracts (CHT) region which consist of three hilly districts namely Rangamati, Khagrachari and Bandarban, located in the south-eastern part of the Chittagong division [1]. Tripuris are also living as inhabitants in Noakhali, Cumilla, Sylhet and some far northern areas of Bangladesh [2]. Being a non-dominant aboriginal community, self-identification through unique culture and festivals, social organizations, housing forms, and settlement patterns have become their focused fundamental criterion. Geographically living in remote and inaccessible areas, these ethnic minorities remain caged in poverty traps with the inadequacy of their economic, social, political, and structural developments. Additionally, lack of education and employment facilities have left them with no choice except agriculture and cultivation. For years, the traditional cultivation called "Jum"- clearing forest lands through slash and burn, producing varieties of crops using a hoe and stick, and raising livestock, remained the principal source of their existence [3]. Recently the "Adivasis" are shifting their settlement to plain lands and changing their fully agro-based lifestyle because of environmental and ecological impacts over hilly forest regions due to cultivation.

The livelihood activities for both hilly and plain land dwellers, ascertained by perceptions of people interviewed, presented in Figure 1-

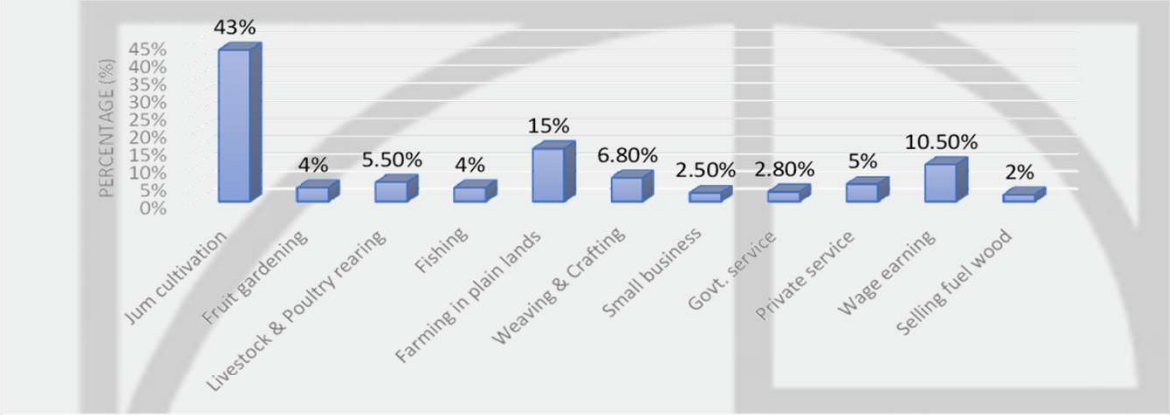



*fig 1: Major livelihood activities of Tripuris in the CHT region*

Figure 1 above indicates that, besides Jum cultivation on hilly lands, Tripuris living in plain lands have taken gardening, poultry rearing, weaving, selling fuel woods, and wage earnings as their primary source of revenue. [4]

Deforestation, landslips, infertile lands, and scarcity of farming lands are not the prime reasons for these ethnic people to migrate to plain lands. Land dispossession is the most common complexity of Tripuris living in Bangladesh. “Land is the main problem" - as noted by a prominent local during field surveys. In most cases, Adivasis have been systematically dispossessed of their lands either by force or by law in the name of development, like creating reserved-forests, building development projects, national-parks, eco-parks, or establishing military base camps [5].

Bangladesh is a developing country where most of the tribal population lives under the poverty line here. The Government has launched the “Ekti Bari, Ekti Khamar" project as a rural development program to influence the rural economy and total GDP. It is a process that comprehends the whole key of social, economic, technical, and political developments, increasing the well-being of rural citizens. Under this project, every house is a production house where every efficient individual becomes part of production activity [6].

A survey has been conducted on the beneficiary group of "Ekti Bari Ekti Khamar" project comparing the monthly income of a group of people who depends on agriculture. Figure 2 shows that people are benefited from the “living cum farming” project- making more profits and improving their economic conditions.

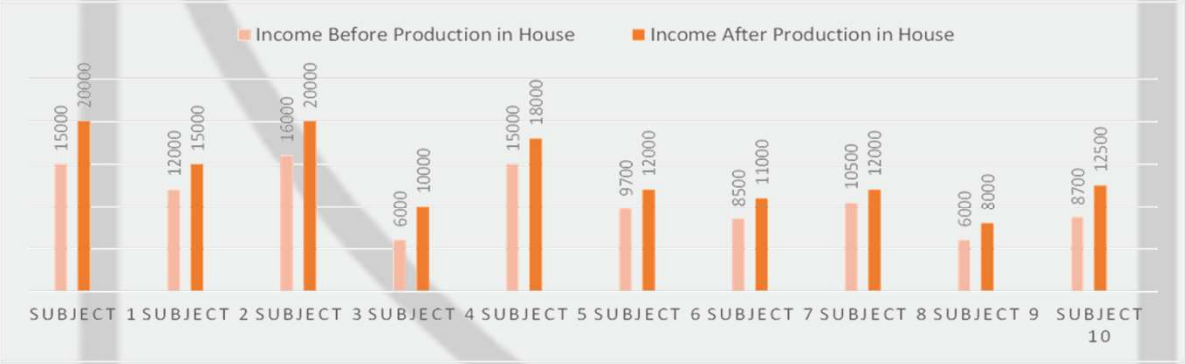



*fig 2: Income comparison of villagers who depend on agriculture under the "Ekti Bari Ekti Khamar" project*

This paper aims to identify a modular framework for the Tripura community to incorporate the “living & farming - dual activity zone” under a single roof, using sustainable local materials through modern technics to stabilize the benefiting "One house one farm" project for these underprivileged indigenous people.

**BACKGROUND**

The name "Tripura" or "Tipra" originated from the word "Top" means "river" and "Pra" means "confluence", together they indicate "the people who used to live in the confluence of rivers."[7] Tripuris are the native people of the "Indian state of Tripura" who are highly enriched with their unique culture, and history. Through the "Manikya dynasty", the Tripuri people ruled the whole "Kingdom of Tripura" over 2000 years. In 1512, Tripuris were at the peak of their reign as they defeated the Mughals at that time. They were able to expand their dominance as far as Chittagong, Sylhet, Cumilla & Noakhali. After several years of glorious supremacy, in the 18th century, the community got divided, and plain Tripuris became a colony of Britain where the hill Tripuris remained independent [7].

Tripuri community mainly follows Vaishnava Hinduism and are deeply influenced by natural spirits and highly believed in their priests. Previously, they had faith in “Animism” as they believed that all substances have life. They have worshipped various deities and used to sacrifice creatures to satisfy the deities. They had no visual symbol of god, but they make an abstract symbol of structure like a Christian cross using bamboo poles to satisfy the natural deities [8]. Nowadays some of their small numbers became Christians and Muslims, but all their rituals are based on Hinduism [2]. Their native language is Kokborok which is also the second official language of Tripura [7]. But most of the Tripuris, living in Bangladesh, know Bengali, for communication [2].

The Tripura culture has its own uniqueness. Their distinctive culture strongly reflects on their festivals, community affairs, and food habits [7]. Garia, Kharchi & Ker are their major festivals, celebrated with folk songs, dance, & sports. Buisuk is one of their primitive traditional festivals. It is celebrated during the occasions of harvesting in mid-April [9]. Their society is patriarchal so, all the property of father is automatically inherited by the oldest son of the family that’s why most Trpuris retained the joint family culture [2]. The village administrative body is called “Panchayet” & the chief addressed either “Sarder” or “Rai”. All the minor manageable issues handled by him [10].

**AIM of This Study**

- Identification of consecutive pattern & architectural characteristics of Tripuris by analysing the features of both inward & outward portion of built environment.
- Evolution of their tangible pattern according to environment & employment availability.
- Architectural solution to recourse their living & earning facilities under a single roof to accumulate the maximal in affordable way from a national initiative.
- An idea of a modular framework with sustainable materials & modern technics through evolution analysis.

**RESEARCH METHODOLOGY**

From many years, ‘the lives and the rights’ of ethnic community has remained one of the most debatable topic among researchers. Climatic disadvantages effects there economy which gradually fading the consecutive architectural pattern of Tripuris. But hardly there is any research on the survival of architectural heritage that is indeed not only for ethnic minorities but also for our pride. Eventually “Ekti Bari Ekti Khamar” is an appreciable national initiative for their survival which may enhance their economy as well as conserve the tangible architecture.

**Data Collection**

This study focused on the architectural transition of Tripuris of entire CHT (Chittagong Hill Tracts) region. Whole survey context divided into 6 zones of three hilly districts Kawkhali & Langadu of Rangamati, Beltoli Khamar para, Shiv Mandir & Gachban of Khagrachai, Tarasha Para of Bandarban which contains the major percentage of Tripura community. Data have been collected to identify the extinct architecture of Tripuris.

Secondary data was collected from the archival study where for primary data collection a questionnaire with bunch of questions regarding on daily schedule, family structure, economical condition, demographic data, cultural & social

aspects, geographical advantages & disadvantages, available local materials & admired construction technics etc. were surveyed & community personals were interviewed. To verify the existing layout features & climatic situation_ field observation & photo documentation of the target area also aided the data collection steps. Data analysis & the entire research process were synthesized with a mixed-methodological approach.

**Research Framework**

The comparative analysis of evolution of Tripuri architecture based on environmental impacts that effects employment amenities are basically qualitative data which were analysed by co-ordinating responses from the target community.

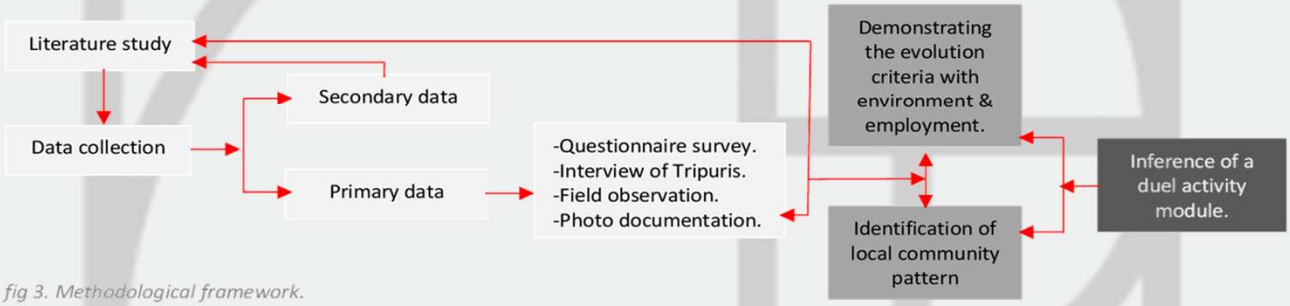



*fig 3. Methodological framework.*

**Demonstration of Settlement Pattern Evolution:**

Anteriorly Tripuris of the CHT region lived at the top of the hill tracts. They had another recognition known as the "Jumma People" since from fig. it can be determined that 43% ethnic minorities depend on agriculture for their solvency. Swidden/ Slash & Burn cultivation is the main form of it which is locally known as " Jum Cash" [1]. For survival they built their house form at the top of hill tracts or near to any water source. Hilly construction forms were developed too closely to one another with a road front linear pattern at relatively milder terrains to avoid climatic hazards as much as possible. The hilly Tripuris had a vernacular consecutive pattern of those built structure with 5-6 feet raised platform from ground & a ladder to enter from outward access [2]. The "Stilt House" on hill slope made of wood bamboo & thatch as prime construction materials also named as "Tong Ghar". However the indigenous people living in the CHT region are regarded as "One of the most vulnerable" because of the deprivation they face on basic needs & suffers a lot with geographical, economical, social along with political crisis are the reason of their evolution or else extinction of their consecutive architecture. Land dispossession is social as well as political crux for them where discrimination & violations from Bangalee settlers & armed force also aided the complications. Cutting & burning the trees from hills for cultivation, damages the ecology forcefully, lands becoming infertile & that's why Landslides, erosion, siltation on water source & floods are occurring frequently [1].

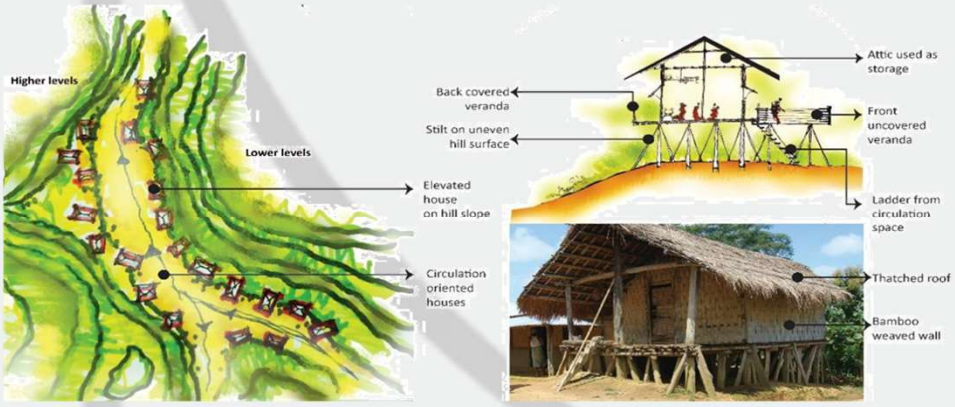



*fig 4. Early settlement pattern & house typology of Tripuris at CHT.*

All this reason constrained them to figure out alternatives & migrate toward plain land that actually initiated the extinction of the tangible pattern & their battle for survival. In the transformed pattern on plain still there are lots of similarities found such as water front & pathway oriented settlement. Mud and bamboo are the primary construction materials for houses on flat land, roof materials are mainly corrugated sheet or thatch. Exceptions who are wealthier enough can afford the houses with roof tile. Internal spaces are directly connected. They use bamboo strip as blinds. A small cattle house/ Khamar attached with the main built forms. It's made with bamboo and 3'/4' heightened from ground. A small space (like verandah) added in front of the house. Most of the time it is used for waste loom. Either front yard or back yard sometimes both has been added to their transformed pattern.

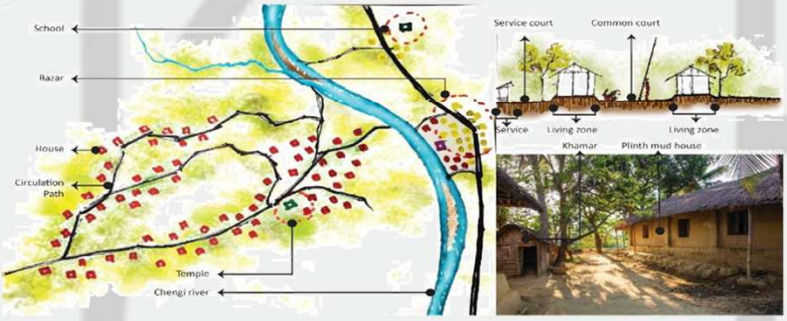


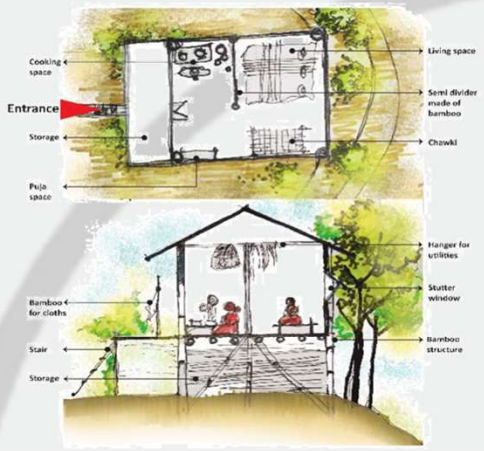
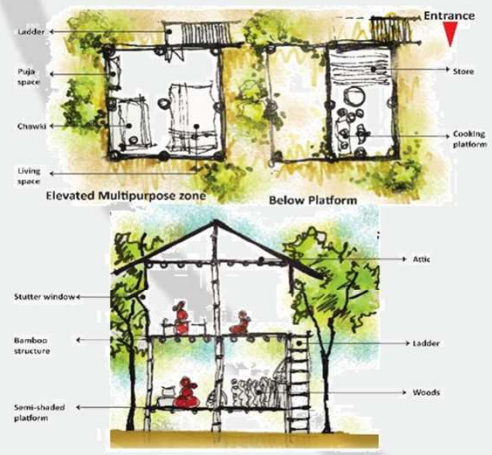

*fig 5. Existing settlement pattern & House typology of Tripuris at CHT region.*

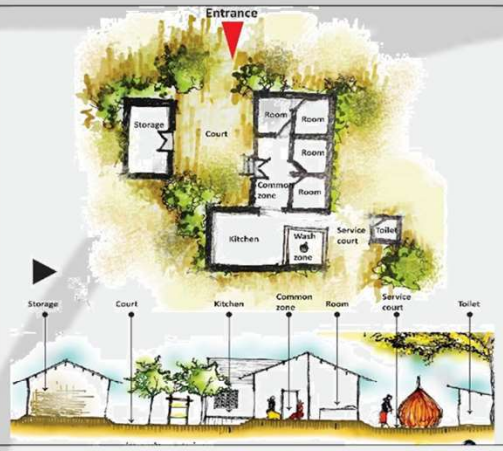
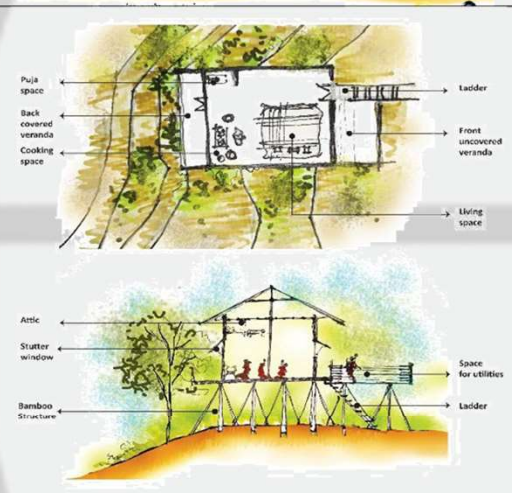
**Comparison of local pattern to identify the pre-eminent features:**

Economic crisis, wilderness of nature & so called dominant stratums forced them to transform their cultural uniqueness which bring their consecutive architecture on the verge of extinction. Evolution of their living pattern solely gives an overview of the tangible character, but the 6 different study areas of CHT region gives furthermore in depth architectural features of Tripuris. Still several survived & few converted characteristics have been observed from the physical survey of selected zones in their construction techniques, materials, circulation etc. The comparison of these house typologies will certainly help to conceptualize an ideal module for Tripuris to accumulate the utmost feedback of "Ekti Bari Ekti Khamar" project. A table showing the comparison of individual habitat layout of specific zones with its advantages & drawbacks are given below –

**Table 1: Analysis of Existing Architectural pattern at selected zones of CHT region -**

| Survey Zone | Plan & Section Layout | House Typology | Family Structure | Advantages & Drawbacks |
|---|---|---|---|---|
| **House no. 1 At Kawkhali, Rangamati** |   | Converted Courtyard Mud Plinth house Pattern | Extended Family | **Advantages** 1. Orientation conscious for ventilation. 2. A central courtyard. 3. Road oriented built form. 4. Living space divider. 5.Use of local sustainable materials. **Drawbacks** 1. No specific zone for puja (Worship). 2. Completely converted from their consecutive architecture. 3. Incompatible organization of spaces. 4. Flood prone zone. |

| | | | | |
|---|---|---|---|---|
| | | | | 5. Damping of construction. |
| **House no. 2 At Langadu, Rangamati** |  | Continued Machan House pattern (Living in elevated platform) of bamboo & water front (Myinee river) settlement | Extended Family | **Advantages**<br>1. Built form orientation according to hill gradient.<br>2. Road frontal house form.<br>3. Elevated space below living, used as storage.<br>**Drawbacks**<br>1. Lack of durable to standstill at time of natural disaster.<br>2. Absence of proper service facilities.<br>3. Deficiency of space for an extended family. |
| **House no. 3 At Beltoli Khamar para, Khagrachari** |  | Converted Courtyard Mud Plinth house pattern & Water front (Chengi river) settlement | Extended & comparatively Affluent than other families ("Rai" house-Village Chief) | **Advantages**<br>1. Comparatively bigger space.<br>2. Additional crafting zone.<br>3. Road oriented court access.<br>**Drawbacks**<br>1. Unworthy space organization sequence.<br>2. Blind type windows, incapable to control changing weather.<br>3. No specific puja space.<br>4. Flood prone.<br>5. Lack of damp proofing. |
| **House no. 4 At Shiv mandir, Khagrachari** |  | Mixed pattern Of early era with additional Concept, Machan House pattern (Living in elevated platform) of bamboo. | Extended family | **Advantages**<br>1. Below platform of Machan used as store as well as cooking zone.<br>2. Stutter type widow.<br>3. Attic for temperature control.<br>**Drawbacks**<br>1. Lack of living space privacy.<br>2. Untreated bamboo used for structure.<br>3. Hygiene issue on open space cooking.<br>4. No specific orientation consideration. |

| | | | | |
|---|---|---|---|---|
| **House no. 5 At Gachban, Khagrachari** |  | Converted Courtyard Mud Plinth house Pattern & Water front (Chengi river) settlement | Single family | **Advantages**<br>1. Road oriented access to courtyard.<br>2. Indoor privacy.<br>**Drawbacks**<br>1. Flood & Damp prone.<br>2. Separate storage shade, waste of space.<br>3. No frontal veranda in front of entrance.<br>4. Lack of natural lighting for insufficient window. |
| **House no. 6 At Tarasha para, Bandarban** |  | Continued Machan House pattern (Living in elevated platform) of bamboo & water front (Sangu river) settlement | Single family | **Advantages**<br>1. Consecutive architecture of Tripuris.<br>2. Orientation depends on hill gradient.<br>3. Road front access.<br>4. Attic for temperature control & utilities.<br>5. Front & back uncovered, covered verandas.<br>**Drawbacks**<br>1. Weaker structure when confronted to natural disaster.<br>3. Cooking space is on the forward portion of indoor zone.<br>4. Lack of privacy. |

**FINDINGS & INFERENCE**

There are lots of peerless features in social, cultural, life & livelihood pattern of Tripuris that is distinctive by analysing their settlement pattern from the ancient period till now. Use of renewable materials, climatic responsive ideas such as attic to control temperature, bamboo weaved blind windows for lighting & ventilation, Machan house to prevent natural calamities like flooding etc. are notable in their architecture. Unworthy evolution of their living pattern due to climatic change. Lack of modern technics, scattered use of comfortable features, deficiency of precise employment facilities are responsible of their pitiful situation. To accommodate sustainable & comfortable architecture into their dual activity module, conceptual frames are given below-

The total plot of individual families for living is divided into three zones_ living, connectivity, working area. There working area is categorized from fig.1 employment types. On the module various Khamar characters are shown according to the criteria of that specific work type such as too much height isn't allowable for livestock or poultry farming that's the reason for a floating design idea similarly to control moisture & avoid flood risk the cultures or the crafting shelters are elevated from ground with strong concrete post & the granary proposals are with a solid plinth as it need to be strong enough to held comparatively louder weight. The living mass is divided into two spaces living & service zone where the living space is elevated & the below platform is used for service. To avoid flooding, dampness, erosion & rain water flow the two storied structure is built high from the earth surface. Toilet & kitchen space have level difference to keep their religious sentiment.

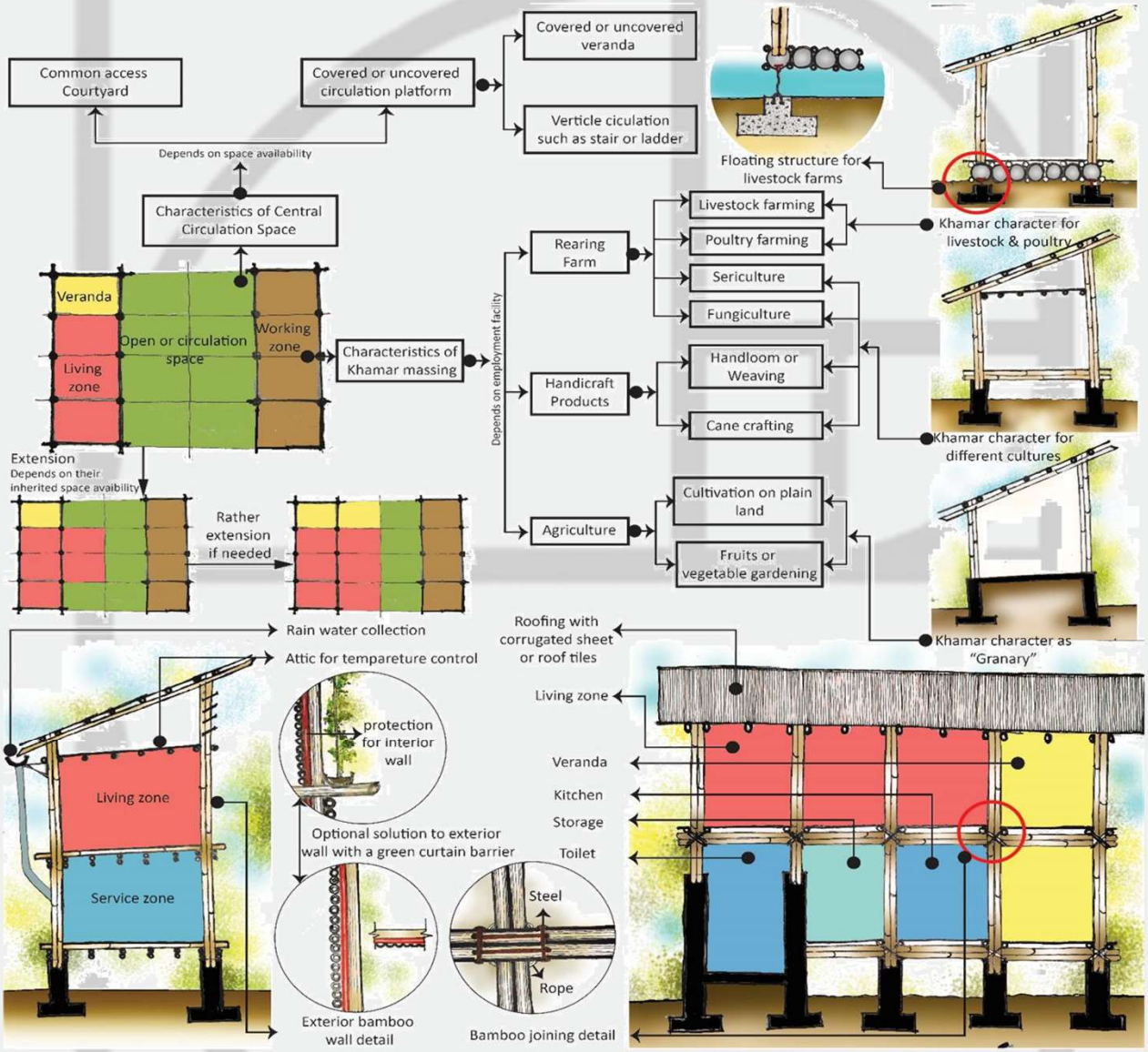



*fig 6. Conceptual details of Duel Activity Modular Framework For "Tripuris".*

On their consecutive pattern they use sustainable renewable materials as construction components which is also fruitful for the environment. To protect the structure from any kind of calamities a strong concrete footing can be used along with bamboo. Two layers of bamboo wall is needed to extend the durability of the module with an internal protection layer with low cost plastic such as Nylon sheet or Polycarbonate sheet. The exterior bamboo wall can be protected by building a green curtain bamboo weaved frame to catch the rain water. Rain water collection facility is foremost criteria in such sustainable living module.

**CONCLUSION**

Enormous plan & policies were created but nothing can turn out as a saviour for indigenous communities of CHT. Ensuring the economic subsistence of these people is also a tough challenge. "Ekti Bari Ekti Khamar" is a project which

will not only revive their entire situation it will also enhance the national economy by different worthy production. Tripura community has distinctive characters where their tangible living pattern is supreme. Passing time & changing climate is vanishing their vernacular architecture. To conserve this age old architecture, an affordable solution for their living pattern isn't enough, a stabilized earning is also needed. The affordable modular framework concept from renewable local material can change their lot & solution from the theme **"Architecture Through Repurpose"** can be the best way to improve their survival condition.

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**Questionnaire Pattern**

1. What is your family type? / How many members are in the family?
2. How many members of a family are associated with production activity? / Does woman participate in production activity?
3. In what time of your day do you start working? / How many hours do you work?
4. How much is your monthly income? / Are you satisfied with your earnings?
5. Do your family associated with this production activity traditionally? / Since when did your family start this production activity?
6. What space in your house can serve the living & working environment simultaneously? / Are you satisfied with your living space & condition? / Are you satisfied with your work environment?
7. What kinds of materials do you use to build your house? / Did your past generations use the same materials traditionally?
8. Have you hear about the Govt. project of "Ekti Bari, Ekti Khamar"? / What do you know about this project?
9. Do you believe "living & working" under a single roof can improve your condition economically?

# FINDING WORKABLE SOLUTIONS TO THE ISSUES ADVERSELY AFFECTING THE CONSERVATION LED REHABILITATION OF BUILT CULTURAL HERITAGE IN INDIA

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**Abstract:** The primary postulation of this paper is to examine existing urban planning and design strategies and policies in relation to conservation and rehabilitation of residential and commercial built heritage by critical examination of existing case studies in India. An analysis of three case studies – Nizamuddin Basti - Urban Renewal Project led by AKTC, Shekhawati and Pune's historic core, will help achieve the objective of how social, economic, and political conditions affect the state of built fabric and the resident communities living in the vicinity. To validate a case study a "success," certain criteria for evaluation need to be introduced. Based on three case studies, the evaluation criteria will be composed of certain common themes, which are important indicators of positive change, with a few germane variations, which may or may not have an inadvertent effect on the outcome. This paper will carry out detailed comparative analysis of current Indian government policies against successful urban planning, design strategies and policies adopted globally, highlighting the parameters of successful policies such as tax incentives and the means to successfully implement them in residential and commercial built heritage conservation in India. Traditionally, in the Indian context, conservation, and rehabilitation of major built heritage in India has been approached from an antiquarian and archaeological point of view whereas residential and commercial built heritage remains neglected. This built heritage stock has a huge capacity to generate financial benefits to the owners while already contributing to the social identity of the place. Finally, the paper shall also highlight the negative ramifications of demolition of such built heritage to make way for new buildings both environmentally as well as from a socio-economic standpoint.

***Keywords:*** *Conservation, Rehabilitation, Residential and Commercial Built Heritage, Social identity, Socio-economic benefits, Tax incentives, Shekhawati, Nizamuddin Basti Urban Renewal, Pune's historic core*

## AN OVERVIEW

When we think about conservation from an Indian lens the most common postulation that comes to our minds is a historic monument like the Humayun's Tomb, the Red Fort, or the Taj Mahal, and rightly so because of how rich the palimpsest of India's history is. The other extreme in this conservation and adaptive re-use rhetoric is heritage hotels – wherein palaces and forts have been converted into hotels. While both examples are correct, they do not actually address the bulk of structures that do indeed meet the criteria deeming them to be historic but are seemingly often ignored or forgotten to the point that they suffer what can be termed as demolition by neglect. It is also important to note in terms of revenue streams – the target audience for most heritage hotels belong to a financially affluent background, meaning in the process of conservation and adaptive re-use of such structures, it is effectively turning its back to more than 2/3$^{rd}$ of the country.

In terms of existing urban planning and design strategies and policies that already exist, there is a lack of attention being paid to this existing building stock, with conservation related information more often than not finding its place towards the end of visioning documents such as Development Plans (if at all), and laws pertaining to conservation related matters being fairly antiquated and still based on their pre-independence roots. Such scenarios then make historic building stock vulnerable to what is known as the builder lobby, who are then able to find loopholes in the law, acquire lands that are unprotected since they fall through the cracks between the tussle of state and central machinery, and develop these lands into modern townships or commercial office complexes that have no connect to the history or social fabric of the place, thereby permanently gentrifying the existing historic fabric. It is therefore pertinent to acknowledge the otherwise neglected residential and commercial built heritage stock and effectively conserve and/or adaptively re-use the structures before it reaches a stage where they become unsalvageable.

**AIM / PURPOSE**

The primary postulation of this paper is to examine existing urban planning and design strategies and policies in relation to conservation and rehabilitation of residential and commercial built heritage by critical examination of existing case studies in India. An analysis of three case studies – Nizamuddin Basti - Urban Renewal Project led by AKTC, Shekhawati and Pune's historic core, will help achieve the objective of how social, economic, and political conditions affect the state of built fabric and the resident communities living in the vicinity. To validate a case study a "success," certain criteria for evaluation need to be introduced. Based on three case studies, the evaluation criteria will be composed of certain common themes, which are important indicators of positive change, with a few germane variations, which may or may not have an inadvertent effect on the outcome.

**CASE STUDY 1: NIZAMUDDIN BASTI URBAN RENEWAL LED BY AKTC INDIA**

Nizamuddin Basti, located in the city of New Delhi, is a compact, self-contained urban settlement with high count of landmark structures dating from the 14$^{th}$ to 17$^{th}$ centuries. Due to severe developmental pressures, inadequate social and physical infrastructure has led to the serious decay of the built environment, with heritage structures being impacted in a major way. As a result, the historic settlement is constantly undergoing socioeconomic, political, and spatial changes.

Located in the heart of New Delhi, adjacent to World Heritage Site of the Humayun Tombs, Hazrat Nizamuddin Basti is named after the revered Sufi saint Hazrat Nizamuddin Auliya, who lived here in the early 14th century. This settlement developed during the saint's lifetime and it has been continuously inhabited ever since. Hazrat Nizamuddin Basti is the densest ensemble of medieval Islamic buildings in India, occupied by a vibrant local community with 700 years of living heritage.

This case study like many other historic cities in India represents a concentration of a large number of abject poor in urban environments. Due to these circumstances, it is not just a case of socioeconomic issues that has to be addressed as these people, owing to their poor conditions, further aggravate the problem faced by historic cities in India and other parts of the developing world. This project relates to other case studies in terms of the community's aspirations for development, a raised quality of life, and the process that has been undertaken by the Aga Khan Trust for Culture to address the issue.

Nizamuddin Basti is dotted with several monuments of significant historic value. Years of neglect and uncontrolled urban growth around the monuments have taken their toll on these structures and their settings. The project area was chosen for the high density of historically significant buildings and for the potential of conservation initiatives to be coupled with a socioeconomic-development program that would benefit the resident population, the unique 'living culture' exemplifying religious tolerance within a prominent location in the capital, as well as for the development of an ecological zone of significance to the city.

The Nizamuddin Basti has a resident population of approximately 20,000. It has one of the highest densities of populated areas in the city of New Delhi. Apart from the resident population, there is also a floating pilgrimage population, which resides there for shorter periods. The pilgrimage population runs into the millions.

The Aga Khan Trust for Culture is the principal implementation body and facilitates between the various partner agencies. The public partners in this project are the Archaeological Survey of India, Municipal Corporation of Delhi, and Delhi Development Authority. The institutional purview focuses on interventions in health, education, and sanitation in order to address the most immediate needs of the women, children, disabled and the elderly. Simultaneously, renovation of open spaces and landscaping of parks, coupled with community mobilization and making these spaces safe for the women and children to access, are high on the priority list. Rapid physical densification and uncontrolled population growth have put enormous strain on Hazrat Nizamuddin Basti, especially in terms of environmental sanitation, waste

management and infrastructure. In addition, there are grave threats to some of the historic monuments located in the Hazrat Nizamuddin Basti. Baoli.

The primary objectives of the project are to integrate heritage conservation, socioeconomic development, and improvement of urban environment in consultation with the people and key stakeholders.80 The intent is to improve the quality of life for the residents by strengthening basic services through interventions in the field of health, education, environmental sanitation, and engaging community through regular interactions and cultural activities.

The immediate priorities of a depressed historic area like Nizamuddin Basti are first and foremost social and economic. The other major concern is to connect people with existing employment opportunities instead of creating new jobs to foster employment. The Nizamuddin Basti area is now one of the most congested, underdeveloped, poorly served ghettos in this otherwise prosperous part of the capital. Like most communities occupying historic spaces, the people of the Basti Nizamuddin area were initially wary of any deviation from a time-honoured way of life. Because of their disenchantment with elected representatives to provide even basic amenities, such as schools, dispensaries, parks, libraries, night shelters and livelihood options, the local population was initially sceptical, to say the least. But their scepticism faded when the people realized that AKTC was not in the business of throwing away money; it simply wanted to combine conservation, urban improvements, and socioeconomic-development initiatives to achieve the United Nation's MDGs.

The hope behind this urban-revitalization project is that the series of small, grassroots changes will eventually turn into a meaningful, sustainable model over the course of time. Moreover, it will become a model for similar projects in dilapidated historic areas, where the resident communities' exhibit signs of desperation and cynicism, when faced with an opportunity to turn things around for a better future.

The approach taken by the Aga Khan Trust for Culture becomes important, because it attempts to acknowledge the presence of inherited tangible and intangible culture in framing the development and conservation proposals and policies for the urban revitalization of Hazrat Nizamuddin Basti.

In Hazrat Nizamuddin Basti's case, financial resources, technical capabilities coupled with administrative and political have permitted Aga Khan Trust for Culture to immediately address the issues adversely affecting the social aspects, as well as the built heritage. The quality of life has improved as a direct result of the socioeconomic interventions. Thus, this initiative fulfils both the utilitarian evaluation goals and neglected aspects of socioeconomic development.

**Case Study 2: Shekhawati**

Nestled in the desert area of Rajasthan, the Shekhawati region is renowned across the world for its frescos that adorn the surfaces of innumerable traditional buildings. Shekhawati is claimed to have the highest concentration of painted structures anywhere in India, spread over the three districts of Jhunjhunu, Sikar and Churu. Fresco-painted havelis (mansions) are a distinct feature of towns in the Shekhawati region, constituting the bulk of its heritage. Mostly built in the period between the 1850s until the 1930s, Shekhawati's havelis have withstood adverse conditions. The havelis (mansions) are the remnants of the vast riches controlled by the business community. Though the Marwari merchant personally never stayed in these for long, the haveli came to represent the scale of his prosperity. The more prosperous had bigger mansions, replete with the best frescoes, painted by the best artisans.

However, in the absence of patrons, havelis are now in a derelict state. Many these structures are privately owned and do not come under ambit of heritage regulations for the protection of built-cultural heritage. The typology of these buildings has outlived its usage. With changing socioeconomic and political conditions, and preferences for a contemporary lifestyle, these buildings have fallen into disrepair. Lack of periodic monitoring and regular maintenance has led to the theft of historic wooden and stone architectural elements that are being sold in the antique markets. Simultaneously, unplanned development, inappropriate additions and alterations have accelerated the deterioration. Many havelis are deliberately being neglected, so that they can be declared unsafe and demolished to make land

available for new construction. The reclaimed land is being used to construct buildings that are non-contextual, visual eyesores, erasing an important link with the past. The surge in tourism activity is negatively affecting this heritage as well.

This case study relates to the broader issues of Indian heritage. Literally, every district and *taluka* of this country is bestowed with several heritage buildings, which instead of being properly cared for, are languishing in disrepair due to lack of attention and funds. Moreover, due to growing developmental pressures and insufficient knowledge about appropriate restoration with traditional construction technology, inappropriate alterations and use of cement cause much damage.

To combat these conditions, the Shekhawati Virasat Abhiyan's (literally meaning Shekhawati Heritage Initiative) Haveli Owners Awareness Program was initiated by conservation architect, Urvashi Srivastava, with the support of Department of Science and Technology, Government of India, and the New Delhi Office of UNESCO. The project area is endowed with many culturally significant buildings and was chosen for its potential for a conservation effort to be coupled with an awareness-raising program, training of traditional craftsman, and better management of historic resources. The project exposes haveli owners, caretakers, tenants and craftsman with the concepts, methodology and issues surrounding the conservation, repair, and maintenance of havelis.

Under this initiative, all the four stakeholders were brought together onto a common dais. A contributory strategy including management of historic resources and preventive conservation was intended to augment in safeguarding of built cultural heritage, including havelis and other structures in Shekhawati. In order to make a significant addition to preservation in Shekhawati, individual stakeholders were made aware of their individual obligations and part in the process.

The single biggest contribution of the Shekhawati Virasat Abhiyan has been to create awareness amongst the stakeholders and public at large about the immediate issues facing the built heritage. More importantly, it brought the various stakeholders together through discussions for the very first time. Through participatory workshops, appropriate and scientifically correct training with traditional materials and technologies is imparted to the craftsmen to both prepare and repair the murals. This is a cost-effective method of successfully safeguarding the murals and aids in the continuity of traditional building and artistic skills.

One critique of the initiative is that no major restorations or adaptive reuse projects have been conceptualized or executed. Thus, there is no immediate impact on the quality of life of the community. Due to extremely limited funding resources and negligible government support, it would not have been prudent to aim for major conservation or urban rejuvenation.

**Case Study 3: Pune's Historic Core – The Vanishing Wadas of Pune**

Pune today is known as Oxford of the East and a technological hub, but it traces back its origins to the 13$^{th}$ Century. Pune's historical point of origination is Kasba Peth, from where the city organically grew. And it is in this organically growing city that a young Chhatrapati Shivaji Maharaj along with his mother settled and laid the foundations of what is today known as the Maratha Empire.

Traditionally, after the reign of Chhatrapati Shivaji Maharaj, Pune was the stronghold and seat of the Peshwas, who were the ministers of the Maratha Empire, and it is under their reign that the Shaniwar Wada was built. Subsequently the settlements that we now call the Historic Core of Pune, developed around this Shaniwar Wada, growing in an almost organic yet concentric manner along the 17 original Peths or streets of the historic core, eventually developing into independent neighbourhoods delineated by profession, and each centred around one principal nobleman's house or Wada. A Wada can be thus compared to the Rajasthani Haveli or the Bengali Bari, is a form of the courtyard housing typology and usually belonged to either noblemen from the Peshwa's court or affluent merchants and was a homestead for a large joint family.

During their heyday, these Wadas were highly ornamental with carved wooden beams, archways, columns, and screens, and usually contained at least one courtyard and had dedicated and segregated public and private spaces. The larger the Wada, the more affluent or prominent its owner. Today however, most of these Wadas are a shadow of their former glory. They have been divided into tenement housing and leased out, have had many ad-hoc structural changes made, thereby destroying the original characteristics and unlike their Rajasthani or Gujarati counterparts, most of these Wadas have multiple owners – both descendants of the original owners as well as tenants that have lived for over 20+ years further adding to their current dilapidated state. Since most of these are privately owned, and money is tight owing to both rent control and lack of finances, many Wadas have suffered a fate of demolition by neglect. Not all suffer this fate however and some (although very few in comparison to the privately owned ones) that are under state or central government control, have been restored and in some cases adaptively reused (Vishrambaug Wada is used as both a museum as well as a post office).

With an ever-increasing population, need for modern amenities and an ambitious builder lobby, most of these private (and albeit non-litigated) Wadas shall eventually make way for modern buildings and the historic character, the social/community fabric and essence of Pune's otherwise hustling and bustling historic core shall be lost forever. Others that face litigation currently shall suffer demolition by neglect and endless court battles but shall also eventually make way for modern buildings. Unfortunately, owing to the lack of clear heritage and design control guidelines, lack of political will, funding for conservation and restoration work or other government subsidiaries such as tax incentives, not much can be done as of this moment, and other than the monitoring and control of the on-ground situation under the supervision of the Pune Municipal Corporation by INTACH Pune Chapter and local conservation architects not much seems to have been done. It is however interesting to note that the Pune Municipal Corporation acknowledges the importance of this historic core and does indeed have plans for the same in the Development Plan for Pune. Now it remains to be seen as to whether these plans are carried out in actual practice per the visioning document, or it remains forever on paper alone.

**CREATING AN EVALUATION CRITERIA TO ESTABLISH A BASELINE FOR BEST PRACTICES**

For the scope of this thesis, the larger issues that affect the built-cultural heritage in India, and probable mechanisms to cope with them can be funnelled into the following questions:

- How do we define a successful preservation initiative and is success an intermediate goal, whose importance is contingent on what it finally contributes to human life?

- Is the link or disconnect between heritage conservation and people, fundamental or perceived?

Based on these questions, and to create a baseline for best practices an in-depth analysis of the above case studies was carried out. The current status of built heritage in Shekhawati is ambiguous. Efforts of various stakeholders are not coordinated, and there is a lack of a coherent vision. It will be impossible to make any progress in the direction of heritage conservation if there is no coordination and consensus amongst the stakeholders. Only successful partnerships between owners, the local community, tourism industry, visitors and government can help preserve the cultural legacy.

Due to the emotional value attached to the historic sites, conservation activities can acquire broad support in local communities, especially when undertaken on community assets. Adaptive reuse of historic sites in semi-urban India is a developmental service catering to the people, just as heritage tourism does.

Local communities need to understand the potential benefits arising out of conservation of monuments, which in turn will lead to emotional and pragmatic attachment to heritage sites and ensure long-term preservation of the same.

The process of urban conservation should involve reactivating people's abilities to take care of themselves and their surroundings. These can be initiated by linking their lives to the creation of jobs, apprentice opportunities, and making resources available to motivated residents.

Decentralization and people's participation can lead people to become active drivers of good management and development of urban services, rather than merely passive recipients. People's engagement ensures access to basic services, especially for the weak and marginalized sections of society.

The intangible aspect of the human and cultural dimension made the creation of historic cities possible. This dimension needs to be re-appropriated, to regain a sense of community for stakeholders, and the links to the tradition and culture that are embodied in these special places. Indeed, historic cities are the repositories of these values, memories, roots, and traditions.

The overall conservation-based strategies, coupled with incentives, facilitate (both financial and non-financial) appropriate development. Incentives, such as an upgraded physical infrastructure, help mitigate the inefficiency and apathy of the local administration, thus gaining the trust of the people.

Another important ingredient is the application of traditional-construction methods in the upkeep of historic buildings. This aids in continuity of skill by training both craftsmen and apprentices in traditional construction and conservation.

Based on the inferences drawn, the following criteria was identified to establish a baseline for Best Practices:

- There is a need for stricter urban design guidelines, more central government schemes such as HRIDAY and AMRUT (that take care of upgradation of the surrounding infrastructure along/around/within the historic precinct and/or have revenue generation models that make the project financially viable and sustainable) and stronger laws to protect existing built heritage
- It is pertinent to test run pilot projects for SMART Cities scheme within the historic core/traditional settlements – it is easy to bring in SMART City initiatives into an already modern environment to upgrade the standard of living, it is more challenging and beneficial to do so in traditional/historic settlements.
- Monetary incentives such as tax credits or tax breaks need to be introduced to the general population to further encourage them to avoid demolishing and building anew.
- Financial assistance and/or additional/compensatory TDR/FAR needs to be given to the general population who cannot afford to restore/re-use their historic property.
- A list of locally available industry experts such as architects and contractors need to be made easily accessible to ensure that appropriate materials are used when restoration works are carried out.
- Community engagement workshops need to be held to encourage community pride while explaining the benefits of having/restoring existing built heritage and the negative ramifications that come with demolition both deliberate as well as through neglect. These include disturbing the existing balanced eco-system (because new construction doesn't only affect humans but all living creatures), monetary problems (tall/modern buildings also increase expenditure since modern building infrastructure maintenance cost is higher in comparison to traditional/historic structures), material costs and building energy (larger and newer the buildings the more it costs to build and the less it is energy efficient since most modern building materials are not climate sensitive).
- Faster and just/sound grievance redressal needs to be made accessible so as to reduce legal costs while ensuring that every person involved has a fair stake/claim or adequate compensation (this is applicable to both landlords as well as tenants – just because your tenement comes under rent control doesn't mean you get to take advantage and bleed the landlord dry; conversely just because you're a landlord stuck with rent controlled tenants you cannot make the premise unhabitable thereby forcing either gentrification or demolition by neglect).
- An agency/organisation needs to be established that is both independent of the local, state and central government (as may the case be) but answerable to the local population, that shall be responsible for implementation, monitoring and control of updated government norms without any for profit motive, governmental/political interference.

- A list of companies as well as various CSR initiatives that can be mutually beneficial to both parties involved (companies as well as the local population; initiatives such as adopt a street/road/highway, community amenity beautification projects, creation/maintenance of local community civic infrastructure such as community/public toilets, schools, parks, gardens, health clinics etc, vocational training as well career counselling workshops/facilities to the local youth).

Finally, to both inspire as well as prove that with a few changes, such adaptive re-use projects (both residential and commercial) can be made successful as well as be beneficial to the community as whole, we have identified a list of projects that have successfully managed to blend the old with the new, while giving a new life to a historic building/structure, and they are as follows:

- The Ferry Building, San Francisco – office space and market
- Zeitz MOCAA, Cape Town – Silos converted into an Art Museum
- The Warehouse Hotel, Singapore – A spice warehouse/godown has been converted into a boutique hotel
- The Cinnamon Boutique, Bengaluru
- The House of MG, Ahmedabad – boutique heritage hotel and homestay
- Vishrambaug Wada, Pune – as a post office and museum (semi-successful since it is not commercially popular)
- Thakur Bari House Museum – as a part of the Rabindra Bharati University, Kolkata
- Sassoon Dock Art Project by St+art India Foundation – Temporary Art Exhibit housed within the 140+ year old Dockyard Complex highlighting the fishing and maritime history especially of the Koli Community using Modern Art as a tool of expression

**KEY TAKEAWAYS**

In the cases of both Shekhawati and Hazrat Nizamuddin Basti, poor civic infrastructure, inconsistent new development, dilapidation of historic buildings, and government apathy accompanied by lack of funds and intent, apart from affecting the life of people on a daily basis, also act as a hurdle in the packaging and upgrading of these two sites as international-tourist destinations. In the case of Pune's historic core demonstrates much altered condition of authenticity and significant urban transformation. Its geographical and economic propinquity has exposed it to the ill effects of urbanization and, in a sense, further degraded the integrity of its monuments for posterity.

In the end, it is pertinent to remember that heritage conservation, restoration and adaptive re-use is not just about the pretty picture – about the physical restoration of the structure, it is also about giving a new yet purposeful life to the structure, it is about community development and engagement – creating a sense of community pride and enhancing the historic identity of the space while seamlessly blending with modern times. And none of this is possible by having a unilateral focus, be it political, social, economic, or ecological. All these aspects along with the physical building itself are intrinsically interlinked. It is also pertinent to create more awareness about the positive impact of such large-scale community development and conservation efforts and pushing for reform in the development plans and laws, and creation of appropriate urban design guidelines. Because at the end of the day, the beneficiaries of such urban development reforms are the people inhabiting the urban/peri-urban spaces itself, and demolition whether deliberately or by neglect benefits no one, and what we end up creating is a cold, clinical, unsustainable built environment, or sprawl with none of the community engagement character and climate and material sensitive built form that historic cores or traditional settlements had.

For the creation of community assets, one of the institutional models that should be adopted is the multi-sectoral linkages and coupling of preservation goals with existing central-governmental schemes at the national-policy level, like the National Rural Employment Generation Guarantee Act (NREGA) and Barefoot Innovators initiated by the National Innovative Foundation, Department of Science and Technology, Government of India. With over $33 billion spent between 2007-2013, NREGA164 is the world's largest poverty-alleviation scheme providing 100 days of employment,

which includes activities with a 60:40 ratio of an unskilled manual-labour component to the material component. Conservation of historic buildings could be coupled with NREGA, as conservation typically has a much higher labour component.

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# INFUSING NEW PURPOSES WITH AN UNDERGROUND WATER RESERVOIR (UWR) PROTOTYPE AS A SUSTAINABLE DESIGN STRATEGY FOR HILLY AREA - A CASE STUDY IN BANDARBAN, BANGLADESH

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**Abstract:** The water supply system in hilly areas of Chittagong Hill Tracts (CHT) is mostly dependent on surface water. People use water from surface water bodies, such as freshwater streams, reservoirs, rivers, etc. with or without treatment, during the rainy season (June to September). But during the dry period, these sources become limited and scarce creating an acute water crisis in the recent past. Presently different NGOs and governmental bodies are promoting technical supports for adopting new technology including the construction of underground water reservoirs (UWR) for storing water in the rainy seasons. In most cases, these prototype underground water reservoirs serve as merely mono-functional service utility in spite of the huge construction cost and resource-investment involved. The study investigates a case study to show how the infusion of new functions with these UWRs can validate the investment of resources to ensure sustainable operation, maintenance and prolonged service life. The study area, an orphanage called Megher Bari, in Naikhongchori, Bandarban, had a similar case of a water crisis with a proposal of UWR design intervention. In order to find out the possibilities of the new functions, analysis of the surrounding context, compilation of meteorological data and focus group discussion were carried out during the pre-design research. The study thoroughly revealed some possible functions based on which design decisions were made to infuse new purposes; in the UWR prototype for the hilly areas ensuring its easy operation and maintenance throughout the year.

***Keywords:*** *Prototype Design, Water Crisis, Underground Water Reservoir, Multipurpose*

**INTRODUCTION:** The Chittagong Hill Tracts (CHT) is located in the south-eastern part of Bangladesh comprising three hill districts of Bandarban, Rangamati, and Khagrachari. The total area of CHT covers an almost one tenth land area of the country (MOCHTA, 2018). It is characterized by hilly and rugged terrain covered by tropical evergreen and semi-evergreen and well known for its biodiversity and ethno linguistic complexity. It has a subtropical climate with an average annual rainfall of 2500mm (Stephan Mantel, February 2006). The region is the home of thirteen tribes of indigenous communities who largely depends on the forest resources to meet their basic needs and earn their livelihood (Rasul, 2007). Also, they rely on numerous creeks flowing through these forests for the source of water to sustain life and community.

However, it is reported that in the last few decades, most of the natural forest has been significantly damaged due to the increased population pressure, commercial plantation, and short-rotation shifting cultivation causing the loss of the rich biodiversity of this region, aggravating soil erosion and landslides (Gain, 2000). As a result water streams are drying out at an alarming rate, creating a water crisis during the dry season and affecting the indigenous community. Hill people depending on these streams for safe water are now traveling longer distances to collect safe water (Mong, 2004). The problem is becoming acute day by day and some communities are forced to find new solutions.

Previously, hill communities have been practicing a number of indigenous methods of water harvesting. Jhurjhuri, for example, an excavated pit at the base of hill slope to collect water through seepage and natural filtration which also served as a convenient meeting place for the community (M. R. Kabir, 2000). Though these methods are deeply rooted in the tradition and culture of the tribal people, these practices are threatened by growing water demand of the increased population, large scale deforestation, dried out creeks and springs and relocation of the hill people.

Being in a region with a significant rainfall rate in the monsoon, harvesting rainwater locally in community-scale and storing it in a water reservoir for the dry season can be a potential alternative. Presently, different national and international NGOs are working for upland water management and promoting rainwater harvesting systems in the hills, however, there is a demand for the development of the technology (Md. Shirajum Monir, 2016) . In some communities, the practice has already brought some benefits with some essential challenges. Change in traditional methods and contact with non-indigenous people from plane land has resulted in a pattern of cultural and architectural changes in CHT (Rashid, 2016). The inevitable non-native infrastructural intervention in the CHT needs to be contextualized with the spatial and cultural traditions of the community. Moreover, an underground water reservoir (UWR) used for harvesting rain has no other function than providing utility service in the dry season. Although previous researches discuss the conventional method of collecting rain water using roof plane, yet the cultural and spatial integration of this utility design in the context of CHT is rarely explored. The study explores how infusing new purposes to rainwater harvesting utility in this region can elongate its service life and ensure sustainable maintenance throughout the year.

**AIM / PURPOSE:** This study considers a Marma community in Naikhongchori, Bandarban in the CHT as site context. The project, taken as a case study, is designed by the authors; hence the documented data of the predesign and the post design phases are used as a part of this study. The research aim is to understand how infusing new purposes with a water harvesting utility can ensure its sustainable usage throughout the year with easy maintenance and elongate its service life. The aim complies with three objectives, which are:

1. Study of the predesign phase: Describing the site context and the study on the user group and finding out the possible functions to be incorporated.
2. Study of the design phase: Understanding the participatory design approach with possible functions and describing the design with the relevant considerations.
3. Study of the Post design phase: This phase describes the observations about the performance of the design and documents the responses from the user end. This helps to understand the design performance in terms of its operation and maintenance by the users.

**RESEARCH METHODOLOGY:**To understand the context in the predesign phase extensive literature study was done. The homestead patterns, multipurpose spaces, local materials, and skills were understood from the field study. The primary data has been collected through structured and semi-structured activities with the children and focused group discussion with the community people. After analysing the findings different options for the new functions are suggested.

These suggested functions are then elaborated in the design phase to find out what option suited best for the particular site. Besides, informal discussions with the community craftsmen and the user groups were held to document their responses and further develop the design.

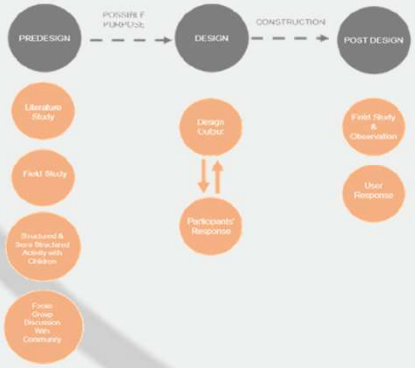


**Figure 1: Diagram of the Methodology**

In the post design phase, the authors conducted field study to understand how the design responded to the users need along with serving as a utility. Based on these observations and the user's response the author explains how the infrastructure can be a sustainable model that can serve the community even after its service life.

**STUDY AREA:**

**Geographical Location:** The study area is located in Sonaichori village (21°23'00.8"N 92°09'34.7"E) of Naikhongchari Upazila (21.4167°N 92.1833°E), Bandarban in Bangladesh. Naikhongchari Upazila is surrounded by the Arakan state of Myanmar in the East, Ukhia, Ramu, and Chakaria Upazila in the West. Lama Upazila on the North, Arakan state of Myanmar on the South. Being a part of the broader hilly terrain, the area offers pristine natural beauty along with a distant view of the hamlet of the ethnic groups. Indigenous communities such as Chakma, Marma, Murang, Tabjhong belong to this Upazila. People from the plain land (known as Bengali) has possessed an important portion of the total population in recent years due to migration and resource extraction which made the fact of cultural amalgamation and invasion of non-native intervention in the built environment inevitable.


**Figure 2: Project location (Source: Google Map)**

**Project Brief:**The project "Bamboo Hydro Pod for Harvesting Rain Water" is situated in an orphanage named 'Megher Bari' situated in Sonaichori village in Naikhongchari Upazila, Bandarban in Bangladesh. The orphanage is run by 'Bidyanondo Foundation', a non-profitable organisation, where orphan children from various part of the Chittagong hill tracts are given proper shelter, education, and training. The selected site, situated on the ridge of a hill, lacks proper communication, infrastructure, and electricity. One of the biggest challenges of the site was the lack of safe drinking water. Water is collected from the nearest stream by a solar-operated pump machine. The water is collected on a daily basis and stored in recycled plastic drums. However, the situation gets worse in late summer and early winter when the stream water level goes down. The only source of upstream dries out and finding no other way the orphanage authority made a dam to hold the downstream water for a while and pump it several times in a whole day cycle.

**Figure 3: Built dam to hold the downstream water in winter**

The project was conceived as a large water reservoir that can reserve rainwater for the whole dry season accompanied with rain catchers to collect rain water in the rainy season. The project also aimed to be the icon of the orphanage and exhibit the foundation's philosophy of environmental awareness.

**ANALYSIS &INFERENCE:**

**Predesign Phase:**

1. **Contextual study:** To trace back the Cultural linkage with their perception and formation of spaces, empirical methods had been adopted. The field study of the surrounding households & prevailing infrastructures eventually resulted in some interesting observations about the spatial organisation, placement, and pattern of the very community; findings on prevailing trends of the Indigenous construction technique; and how it is being infused with the surge of non-native materials and methods.

**Figure 4: Study of Homestead pattern, Local materials and spatial configurations**

2. **Workshop:** A Daylong interactive workshop was conducted participated by the resident children of the Child home, for the purpose of mind mapping of the primary user group of the design and speculating an overview of how they perceive and interpret the idea of mono & multifunctional space.

**Figure 5: Interactive workshop with the user group to map the possible functions**

**Figure 6: Outcome of the workshop showing some spectulation of the new functions**

Followed by a lively ice-breaking session, 87 students, grouped according to ages, were given interactive tasks of drawing their favourite spaces. Then there was a one to one discussion session, while the kids described, in their own words, what they expect if they had the scope to design their favourite spaces.

**Design Phase:**

1. **Meet up/ Session with the Artisans & Craftsmen:** The design process intentionally adopted the policy of avoiding the typical top-down method of design, transforming it rather into a participatory one. It acknowledged the prevailing "Design and Make" practice of the indigenous community. There were some long informal sharing sessions with the artisans and craftsmen of the community. To overcome the linguistic limitation the session included preliminary model making to express and harmonize the extract of the shared knowledge with the technicalities and design decisions.


**Figure 7: Participation of the Local Craftmen in the process of design decision**

2. **Design component:**

i. **The Reservoir:**

The location of the reservoir was chosen on the slope of the top ridge of the site considering the easy distribution of the water by the gravitational force. As flat land is rare in this context, the reservoir is designed with several compartments

to reserve rainwater as well as provide retention support to the soil from erosion. In order to conform to the site contour, the chamber tops are arranged at various heights according to the soil level. The chambers were interconnected through a built-in ducting system so that water from one chamber can flow to the next one depending on the level of the harvested rainwater.

The reservoir is supported by four intermediate columns which give the whole structure a strong foothold and also act as anchor points for the designed Bamboo rain catcher. Provision was kept in the concrete columns to insert the bamboos and tie them with the anchor rods ensuring a firm foundation for any bamboo superstructure. Hence, the reservoir can work as underground footing for any future structure above the ground ensuring its elongated service life.

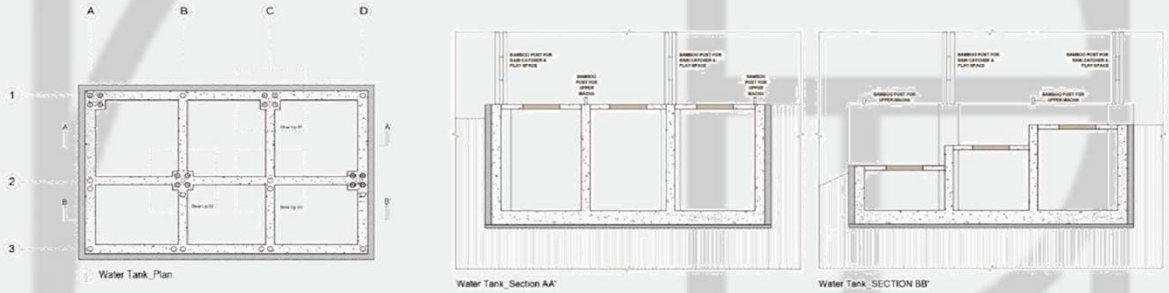


**Figure 8: Plan and Section of the underground water reservoir**

ii. **The Rain Catcher:** The rain catcher is designed as a collection of four upturned pyramidal funnels which are supported by bamboo columns. This is the most visible part of the project above the ground level. Mostly made out of bamboo, a locally available resource, the rain catcher creates a sense of roof plane over the reservoir tank. The inner faces of the upturned pyramidal funnel are covered with polycarbonate sheet to ensure the leakage proof collection of the rainwater. A custom-made iron funnel acts as a connector between the polycarbonate sheet and the water collector PVC pipe. The collection pipe runs through the hollow space of each vertical bamboo columns and directly connects with the reservoir tank. In order to create lateral support the structure includes diagonal bracings and horizontal connections which gives the superstructure a visual unity.

**The Platform:** Taking the advantage of the diagonal bracing, several horizontal platforms are accommodated in different levels. The flat surfaces of the top planes of the reservoirs are also covered by bamboo platforms creating a play space of varied levels for the children of the orphanage. The platform acts as a very familiar component, popularly known as 'Mancha', a well-practiced architectural element in the hill community of Bandarban. These connected terraces of bamboo can also be used an open air space for learning, eating, and relaxation for the children.

**Figure 9: Three dimensional model of the final design.**

**Post-Design Phase:** After the completion of the project, the children of the orphanage made the "bamboo playscape" their daily activity hub. Being part of a rugged terrain, the orphanage could offer little flat space for the children. The platforms of varied level gave them a space where they can play common games. As the children are very familiar with the traditional mancha space, they found the designed space very user friendly. During the field study, the authors identified the following activities (shown in the diagram) associated with bamboo structure.


**Figure 10:Repurpose- Accomodating multipurose activities and uses.**

Beneath the bamboo playscape the UWR stores the collected rain water from the rain catcher and the roof of the nearby office block in the rainy season. Moreover provision is made to store stream water by using solar pump, when necessary. The inclusion of the playscape with this utility service gave it a distinct character in comparison to the other utility services in the community. The children user group keeps the surrounding of the playscape clean and active and thus the water reservoir is not used as merely a utility anymore ensuring its sustainable service life. It may reserve water for the dry season but, at the same time, offers different services to its user group throughout the year. In a group discussion, the community people responded that they would be able to reshape the mancha /platform easily according to their need using local skills and materials. Even if the water reservoir gets abandoned, the provision for bamboo column will help the underground concrete construction to be used as footing for any bamboo superstructure. Hence the investment of the UWR will serve long after its own service life reducing the chance of being discarded as utility infrastructure.

**Figure 11: Documented Activity of the Children**

**CONCLUSION:**

"Hydropod-Playscape", at its completed phase, has endeavoured to bridge the gap between the inevitable non-native infrastructural intervention in the CHT and the very essence of contextual sensitivity so far missed in the typical practice of communal utility design, especially in the immaculate tenderness of the remote hills. The Utility, even before the inception of its full-fledged operation, managed to attain positive response among the primary user group i.e. the children of "Megher Bari Child Home" and the surrounding community as well. Children found it engaging and dynamic, while for the community it has exemplified a replicable contextual amalgamation of communal space and public utility. With a new yet native appearance and experience, it provided the children with the scope of playful multiplicity, myriads of interactive activities, rather than acting merely as service utility. Bamboo, as the prominent local resources, has been promoted in this project as fairly feasible enough for structural competency of Community Scale -infrastructure Utilities. Without sacrificing the aesthetic attributes of a drab Utility-skeleton, infusing new purposes ensured the sustainable operation, maintenance and prolonged service life of the project, while enabling local craftsmen to accommodate changes in the future .The operative performance & the efficiency of the harvesting and reserving system are still to be precisely evaluated until the onset of the first rainy season when the utility is expected to be in full swing. Yet the way it has already been accepted by the children and the community consequently pose a greater prospect of future replication, within the locality itself and expanding it beyond the immediate context with greater potentials of adaptability in non-identical situations.

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# FUSING NEW METHODS WITH TRADITIONAL MATERIAL - RETHINKING INTERVENTIONS IN CHILD PLAY SPACE IN BANGLADESH

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**Abstract:** In 1991, Under the program of UNESCO and the Asian Development Bank, the Bangladesh government initiated the Development Plan "Education for ALL'' to improve access to education, which results in the enrolment of 32.3 million children from pre-primary to secondary levels till 2018. But the focus is now on the quality of education through play-based development which is indispensable to develop children socially, emotionally, and physically that is neglected throughout the country. Despite having national guidelines, it is observed that playgrounds of primary schools are merely occupied with apparatus made of stainless steel in the name of play facilities. This relies on a shift of mentality towards reusing or adapting to traditional or local materials, which is sustainable construction without new materials instead of those limited resources. By adopting a multi-methodological approach where the primary study will show the comparison between native and foreign playground design practices through case study analysis and other study will be conducted by a representative participatory approach, giving a lead to children and community people to make guidelines. Within this article, child, play and playground concepts will be examined and this will offer a guide so that it can give a promising solution for repurposing architecture.

***Keywords:*** *Child-friendly Built Environment, Sustainability, Local material, Traditional Play, Children's Wellbeing*

## INTRODUCTION

*"We can't go home again to the times when virtually every child worked and played in the natural playgrounds of creeks and hills, mudholes, junkyards, overgrown lots, and fields and barnyards, but we can show the world how to bring little pieces of such rich, nurturing places to our schoolyards, neighbourhoods, and cities. If historical and research evidence for children's play, playgrounds, and recess were taken seriously by adults, threats to their existence would soon be over. History and a century of scholarly research say that play is essential for healthy development. We must save playgrounds, free outdoor play, and recess, because they matter—for children's health, for their development, and for their future."*

-Joe Frost(PLAY, 2008)

The predominance of play is recorded as the most important element for intellectual, social, emotional and spiritual well-being of children since the beginning of time. As play is the foundation of human development, so understanding what play can and what is its benefit towards children and society is indispensable (Aaron and Winawer, 1965). Since school is the basic form of development for any children, a well-designed playground makes it more sustainable for other mandatory growth mentioned above while a child is acquiring institutional knowledge. But in developing nations like Bangladesh, this dominant feature became less observed and hardly designed without having any consideration of children-psychology or desire or demand. Basic education needs to include play as a part of the whole development process. Despite of having curriculum based guidelines, the basic layout and structure of this school playgrounds where the same steel apparatus set in concrete have remained unchanged since early 2000s. So these tendencies are making gaps with the potentialities of play and development or growth of children. The deficiencies are numerous in number in terms of its potential for providing desirable interactive play space for children.

In Bangladesh, especially in urban and peri-urban contexts, we see that the scope of outdoor and free play experience for children is decreasing day by day. Although our habitats and lifestyles have changed compared to the life 30 years ago in the when there was simply more space, better safety in the neighbourhoods and a simpler life with less technology and a less structured formal education system- which gave more opportunity to the children for unbounded play, we believe we can still create the impact of play if we could collectively realize that play is a critical component to growth (Baidya and Zannat, 2020). Playgrounds we see in schools and in neighbourhood open spaces with steel swings, high slides, and heavy and often rusty seesaws are expensive, not age specific and often dangerous, especially for younger children. Typical practice is to provide education environment which is important for gaining skills used in the workforce.

But other aspects get neglected that involves development of evocative relationships and cohesive nature of children. With the development of life skills, a child needs those intangible space to develop through his stages of growth. This relies a shift on mentality towards rethinking play spaces in education with architectural intervention. So there lies a question-to what extent can different approach in playgrounds or adventure playgrounds contribute more effectively to play-based learning and the development of school-going juveniles than the sterile Bangladeshi school play spaces?

## Aim

To align with the UNESCO's purpose to develop the education system, we need to introduce sustainable ways like play induced learning for socio-emotional or cognitive development. So the main aim is to propose the sustainable technic for transforming typical education environment into more lively, vibrant leaning environment where students, toddlers, children will stumble, play, get dirty, communicate, interact with each other and will develop a cohesive positive society. While questioning contemporary practices mostly in developing nations like Bangladesh, we will evaluate the other perspectives of playground designs from different areas. This analysis shows the diverse characters of contrasting approaches practiced worldwide and also suggests how alternative thinking in play spaces can augment the play environment by accommodating traditional material and play.

## Purpose of the Study

The primary purpose of the study is to explore the existing condition of play spaces of schools in Bangladesh. Secondly, we will determine the gaps between the design guidelines and practices. The study will investigate the comparison between contemporary practices of other countries with the existing situation of Bangladesh. Lastly, the purpose of the study is to recommend some interventions with using local native materials. The aim of this study is to explore the consequences of play structures in children's development and to bring a new perception in playground environment and equipment design concepts. On the other hand, inadequate aspects of outdoor play structures in Bangladesh are underlined where scopes, potentialities and viabilities of traditional approaches will be highlighted through this research.

## LITERATURE REVIEW

According to Mathews (1985), as a result of, industrial revolution and urbanization, American playgrounds have been converted from unbounded rural landscapes to fenced playgrounds with equipment made with concrete and steel. Sorensen observed that children play with more enjoyment in a junkyard filled with scrapped materials discarded from construction sites than they do while playing in the traditional playgrounds with limited space, fixed playgrounds, and steel fences all around. He also explored the idea of a play leader who will only facilitate and observe children's play, not restrict, direct or strictly supervise. In an interview (2008), Joe Frost, an expert on play and playgrounds said that the practice of play in America has changed drastically in the past decades and now it's in a really bad shape. Play makes them better prepared to adapt to culture and society and through play they can learn to negotiate and solve problems. Narratives from Frost suggests that play is one of the basic driving force and evidence shows that children who are detached from play may have 20% to 30% lesser intellects than normal range as per age. Researches also say that children cope and behave better as adults when they play well as children. In Bringing multiple intelligences outdoors (2006), McFarland and Adhikary depict how the design and management of playgrounds can help enhance different kinds of development as analysed in the theory of multiple intelligence by Howard Gardner. An open-air music corner in which pieces of bamboo or recycled pans are used as drums for children to play with can help build their musical senses and learning about rhythm, sound, frequency, etc. They also advise creating storage systems and transitional activities which can help children clean up after the play has been done

## RESEARCH METHODOLOGY

### Overview of Methodology

During study with children, one must need to collect data only by observation and measure them through scientific analysis. As children are more complex in nature, so there's a difficulty in extracting exact data, so observing them without interruption gives more authentic information. When this type of approach is done properly, the data collected from this study provides a good portion of information for research progression. Out of two ways of observational approach those are naturalistic and observation with intervention. Naturalistic observation approach is conducted to gather information about children's perception about play and surrounding environment. Primarily children are observed in natural setting by involving them in some activities like drawing, playing etc. then the parents were interviewed to know about their thought on differences between their childhood and their children's childhood. In the next stage those data were put on respectively with their prospective variables.

### Participatory Approach: Observing Children

While observing child without intervention, the researcher doesn't need to give any effort as subject is being scrutinized without letting him know. this is the advantage of this type of observation where you'll get information in unstructured way. For field study, we had selected a pilot playground and observed the children while noting down their activities on a sheet. Throughout the study, children's mental development was also evaluated with the investigation of their physical growth on the basis of play spaces equipment design. We thoroughly observe the interaction between child and their surrounding outdoor play space, how a child communicates with other things.

### Profile of Study Participants

5 school going kids from the Banasree area of Dhaka were selected randomly from the age of 8 to 14 years old. Participating in analysis with children could be a comparatively new approach to capturing children's voices to not marginalize their position in society. Viewing youngsters as "objects," with a spotlight on developmental psychology and universal stages of development and socialization, has dominated the manner children are perceived. The study seeks to know the development of by inquiring into the meanings of a child's expertise as they will propose their thoughts into it by taking the lead where participatory observers will act as an unprofessional. The participatory methods like those within the Mosaic Approach (Clark, 2008) offer the chance to "empower youngsters in decision-making processes that affect them. For limitation of social distancing, observation proceeds with5 kids. For functions of this study, children were asked to draw an image of their "favourite space" within the playground. Participants were instructed to think about why it was their favourite place—whether it is reminded them of another place that they had felt sensible in, or however, it created them feel—and to then draw symbols showing what the play meant to them. Every participant was told they might embrace stories with the icons if they wanted and to feel free to use different colours to represent different moods in their drawings.

### Playground Design Practices Through Case Study Analysis

Firstly, we analyse the existing design practices of the playground in primary and elementary Govt. schools of different areas of Bangladesh. The scenario seems to be somehow the same as they are managed through the central education system. Then we will study the international case of Anji and Caukin Studio to compare the gaps in the practices of three different countries of contemporary time.

## FINDINGS/ ANALYSIS &INFERENCE

### Methodological Reflections

**Findings from Observation:**

During the study we saw that children were enjoying their tasks of drawing and they enthusiastically completed their tasks on time. As children mind are reflection of their environment, we got to know much qualitative nature of their surroundings and its impact on their normal stages of growth. This confirms Cele's (2006) suggestion that drawings are influenced by previous experiences and context. They emphasize on things they think that are important to them.

*Figure 1 Drawings of Children*

According to Cele's recommendation of conducting interview with minimum three children, they talk about their drawing and demonstrated their thought on favourite play space. The interaction was more informal as children were likely to get nervous by the intense situation. Through our study we somehow feel that there's a gap between our childhood and today's young generation. We try to learn from parents their childhood memories of play and where parents mentioned about pretend play, traditional play like ekka dokka, iching biching and many more, At the same time children try to draw their favourite thing, play or spaces whatever they like. This shared journey is an impactful way to slowly change the culture of play and outdoor play. All these things suggest that something is missing in present time which is making those playgrounds into abandoned backyards.

**Existing Situation of play grounds of primary or elementary schools in Bangladesh**

From a study in 2007 where researcher of the Robert Wood Johnson Foundation, experimented at more than 1000 plus schools, found that whatever happens in playground is as important as what happens in the classroom. This finding directly relate to the issues like mental health, obesity, depression, bullying, violence etc. In Bangladesh, the practice of designing this important learning based play element is very much neglected as the design work is limited by installing only a steel seesaw, a steel swing or sometimes a steel slider. About 32.3 million school going children are studying currently in primary and elementary schools. But this huge population are paying an invisible loss as they don't have that much opportunities to learn from play. To look at the situation of existing play models from different schools in different

*Figure 2 Existing Play spaces*

areas of Bangladesh, we can see this steel material is itself not child-friendly. When using these tools, their only concern is to provide a play toy not to design the whole play environment which will support the socio-emotional, cognitive, physical development of children. In some playgrounds, we observed some dismantling or broken steel apparatus while some of them are rusty. All these situations are very risk-prone if any child goes to play carelessly, they can hurt themselves. Some play spaces are newly designed but composed of plastic materials which are harmful to children's skin-related issues as well as not that environment friendly in the manner.

**International Case Study- Anji Play**

Anji is an internationally recognized profile for play based learning. It is a service running almost in 140 centres where it has facilitated more than 14000 children of 3-6 years old at Anji in China. The main philosophy of this this playground is to provide children a free space to explore his imagination with trial and error. This place is designed with loose materials, re-used, recycled materials to ensure sustainability towards nature. The five principles which makes Anji unique from other play spaces are love, joy, engagement, risk and reflection. Anji play is a response to an observation that false play gives false joy. False play is where play is structures, strictly supervised by adults and defined by strictly defined

*Figure 3 Anji Play spaces*

developmental goals. Anji play is a fruitful outcome of sensitive thinking for future generation, having trust on their children's capability. This is a result of combined true intention of related authorities and parents of those children who had faith on their children and let them play in risk without any hesitation. There are some important characteristics of Anji to be noted down-

- Flexible Play- Play equipment made as flexible as possible so that children can use their imagination in building shapes, structures and stories while using those. Simple objects as tires, wooden planks, wooden blocks, ladders are used.

- Exhibiting Children's Creations- Careful presentation of art and craft work by children is a way of documenting their development process. Exhibiting children's creations allows children to visually experience their own process of development. Children feel ownership to the spaces.
- Materials- Local low-cost materials were introduced to promote native products. In some places, they also used wooden logs available near sites as seats or as balancing beams. They further recycled tires for climbing apparatuses and to frame the sand and water corner.
- Community participation- The Anji Play is a successful concept and is accepted worldwide for accepting children as they want to be. They also try to involve parents in their play design and reflection session to evaluate their work how it is working in development of children.

**International Case Study- Playdium-Bali, Playscape- Koh Rong Island (Caukin Studio)**

*Figure 4 Works of Caukin Studio*

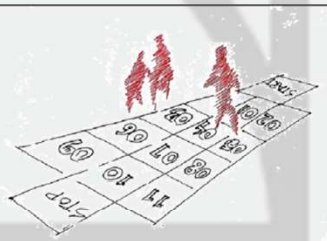
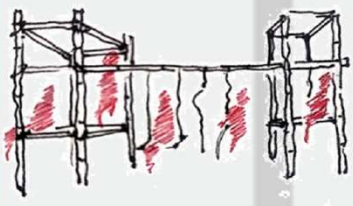
At CAUKIN their mission is simple: bring fun, innovative & creative designs to communities around the world. PLAYDIUM-Bali & PLAYSCAPE- Koh Rong Island are the projects of Caukin studio. Their motto is to design play spaces or play-scape more creatively and providing learning space, when previous study shows the scattered movable elements for play, these type of project is more concentrates on composite play element accommodating relaxing, reading and activity zones in a singular space. They try to achieve sustainable development goals in their design by using local technic people, material and also contextual diversity. There are key elements of their design which are analysed for sustainable repurpose playground design.

- A creative play and learning space
- Low/positive environmental impact on the surroundings.
- Wider impact on local design and construction techniques.
- Collaboration of Local community and international participants increased employability.

**Recommendations**

Anji Play models are designed to give children the opportunity of development through age specific, context and culture appropriate learning through play. From the case study, we can also say that culturally symbolic elements, flexible settings can make play accessible and contribute in preserving culture and improve the whole culture of play. We can repurpose our elements from native and traditional zones to accommodate these play spaces and can design an inclusive child-friendly space which is sustainable at the same time works as healing and learning element for future generation. Here we are incorporating our own pilot project under BRAC IED. The project shows that Children take great pride and

joy and decorating walls of their schools and play spaces with vibrant colours. This help in growing a sense of ownership in them. Here are some recommended points which is suggested after the comprehensive study-

| Strategies for Rethinking Playground Design | References with Image |
|---|---|
| •Promote culturally evolved play<br>•Promoting culture through the use of local material.<br>•Incorporating traditional games into play space design. |   |
| •Low-cost design<br>•Usage of sustainable material, re-use material, local material to design a cost-effective playground.<br>•Vernacular material<br>•Low-cost design is easily replicable. |   |
| •Environment friendly material<br>•Eco-friendly materials to create stability in the environment<br>•Using indigenous technique to build.<br>•Use of Bio-degradable materials.<br>•Re-use materials<br>•Utilization of Local available materials. |   |
| •Context –friendly design<br>•Considering site surroundings<br>•Having clear understanding of size, shape of school premises<br>•Design based on existing tree location<br>•Site orientation |   |

| | |
|---|---|
| •Constructing playground with local labour to engage the community<br>•Re-use Materials<br>•Used tires<br>•Used plastic bottles |  |

## CONCLUSION

Through our study we somehow feel that there's a gap between our childhood and today's young generation. With the development of civilization, we are getting more bounded, limited eventually children are being neglected in this process. We are imposing our intentions also on children specific spaces, this bounded nature is supressing children's psychological, mental, physical, cognitive growth and development. Views, perceptions, perspectives of children need to be highlighted to make spaces child-oriented. All these things suggest that something is missing in present time which is making those playgrounds into abandoned backyards. Parents aspiration and children's curiosity gave us the hint that play is more about adventure, risk, enjoyment. The purpose of this study has been to compare existing playgrounds with adventure playgrounds in meeting the play needs of children. The research clearly shows that creative, alternative playgrounds provide a wider range of play experiences and capitalize on children's natural learning processes. Public school playgrounds can enhance play experiences and provide a learning resource centre if they are converted into an adventure playground using sustainable local materials and adapting new approach or technique of advanced play based learning. Using local materials and local crafts gives an opportunity to build the play grounds in low cost and also is a way to preserve local construction techniques and crafts. When children and communities join in the construction process, they tend to take care of their playgrounds with enthusiasm; it becomes a place of pride and dignity for them. So we can conclude with some highlighting strategies to change the priests of play spaces and adapting new architectural responses, those are to promote culturally evolved PLAY, to introduce eco-friendly materials to create stability in the environment, to make context –friendly design, to construct playground with local labour to engage the community, to utilize the local available materials, recycled & re-use Materials for architectural repurpose.

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# ADAPTIVE FACADES AS A PASSIVE DESIGN APPROACH FOR THE BUILDINGS IN UAE.

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**Abstract:** The availability of an affordable and heavily subsidized energy by the government of UAE increased its consumption leading to endangering the environment in the past decades. Thus, the supply of adequate and reliable energy was felt like a necessity securing the environment in a sustainable and benign manner. To address this, the UAE government took some strong initiatives along with ESTIDAMA committing itself to adopt strategically the designing and installing adaptive facades aesthetically and for improving the building's energy performance utilizing various energy, material, and land resources. It improved the thermal comfort reducing the dependence on active cooling systems for indoors. This paper presents the results of the "Energy – Building" relationship as sustainable development and the methodologies as to how the Energy conservation in a building is achieved, incorporating the Passive Design. The research will analyse two buildings as examples using adaptive facades with automated control systems vis-a-vis its effect on the building environment as a vital aspect of Passive Design evaluation of its performance and occupant behaviour. The assessment mainly focuses on pre- and post-construction phases of adaptive facades. It includes the design-assist phase, which cites the durability test, visual mock-up, onsite mashrabiya mounting, and the weather stripping. Then the commissioning phase focussing on the field verification and performance testing followed by the analysis and the corresponding assessments during the monitoring stage at last. The outcome of this study will identify the quantifiable performance of optimal adaptive facades as a progressive approach in the building design.

***Keywords:*** *Adaptive façade, Responsive envelopes, Passive design, Intelligent skins, Sustainable materials.*

## INTRODUCTION

With the growing demand of the energy efficiency in the new and existing buildings in recent decades has led the design research to experiment within smart and adaptive envelopes. A new generation of vertical closure systems aimed at zero reduction of net energy consumption in the buildings integrated, with its design. The aim is to improve occupant comfort while dealing with technological and ecological aspects of sustainable building skins. Over the years, the building envelope systems has seen a shift from passive technical solutions to active systems. The new envelopes are well equipped to produce energy from renewable sources. Still, they have evolved in terms of their spatial and behavioural configurations to be an amalgamation of dynamic and adaptive systems that help improve indoor comfort conditions as well. The building envelopes or the external skin having smart materials and automated systems can thus be compared to a living organism since all its components react to the external and internal stimuli, in turn, adapting to its surroundings while regulating and optimizing its overall energy balance which is required for its functioning.

Banham in 1969 identified three typologies of building envelopes which are conservative, selective, and regenerative; over the time a fourth typology has been added, which is the smart or adaptive envelope. Adaptive facades are building envelopes that can adjust to changing climatic conditions on every hour, day, season, or yearly basis. By adaptive, we mean the capacity to react or profit by external climatic conditions to meet productively and more essential successfully inhabitants' comfort and well-being necessities (Labile, 2014). Adaptive building envelopes can interact with the environment and the user by reacting to external output and adapting their behaviour and functionality accordingly: the building envelope insulates only when necessary, it produces energy when possible, and it shades or ventilates when the indoor comfort so demands (Ailene, Brzeski, Knaack, Labile, Perino, & Wellers off, 2015). Adaptive façades consist of multifunctional, highly adaptive systems, in which the physical separator between the interior and exterior space can change its functions, features, or behaviour over time. This character of change is in response to transient performance requirements and boundary conditions, intending to improve the overall building performances (Loosen et al. 2015).

Several different types of adaptive envelope concepts have already been developed like light control dynamic façade. Furthermore, these types of façades allow energy to be saved while adapting to prevailing weather conditions supporting comfort levels by immediately responding to occupants' needs and preferences (Loosen, Track, Cassola, & Hansen, 2013). Consequently, adaptability can be understood as the ability of a system to deliver intended functionality, considering multiple criteria under variable conditions, through the design variables changing their physical values over time (Ferguson et al., 2007).

## BACKGROUND

In UAE rising energy consumption causing environmental imbalance led to an urgent need of technical innovations in building design and research. The sustainable development based on intelligent and environmentally friendly building designs received an overwhelming support from the government of UAE. In recent years, the technical research has investigated new experimentation frontiers capable of reaffirming the osmotic quality of a process of exchange concerning energy flows that have been passed and exchanged right through the envelope (Altomonte, 2008). The building facades equipped with systems are designed to ensure a dynamism, allowing them to control the flow of energy like a biological organism. The new frontiers of experimentation with facades, as discussed in the case studies presented in this paper proposes the latest models of living in which the building organism would be able to ensure the comfort of its users. Adopting innovative sustainable and smart building design to enhance the efficient use of energy material and land resources was initiated as a new regulation.

## AIM / PURPOSE

Energy is central to improved socio-economic well-being, indispensable to most industrial and commercial production and is vital in improving human welfare and thereby raising living standards. This paper presents the results of research arising from "Energy – Building" relationship in terms of sustainable development. The study emphasizes why and how energy conservation in building operation is achieved through "Passive Cooling Systems" or Passive Design Approach" using architectural design.

### Adaptive building façade - Connecting element between inside and outside

Building envelopes usually are defined as its skin, an enclosure that acts as a separator between the outdoor environment and the indoor environment. It provides functions like control, support system and building finish, which adds to its aesthetic value. In addition to this, it also acts as an environmental moderator. The way architects and designers have perceived the building envelopes have changed drastically over the time. From being introduced as minimal environmental solutions in the form of a tent and a campfire as representations of a building capable of dynamically modifying its boundaries and thermal properties in response to the environment by Banham in 1969.

## RESEARCH METHODOLOGY

The paper addresses that Passive Design Approach used in the buildings to minimize energy consumption and improve thermal comfort. This can bring the reduction in the use of active systems for indoor climate control and therefore contribute to mitigating greenhouse gas emission and addressing Global Warming (Confirming to LEED standards and guidelines). Suitable measures in planning, disposition, orientation, building form and material selection are adopted to optimize interaction with the local microclimate. An adaptive facade of the building in this respect presents the performance evaluation of facade elements, systems, and overall building performance coupled with occupant behaviour and occupant satisfaction and therefore, passive architecture. This paper presents a case study of an adaptive sunscreen facade and evaluation of its performance and occupant behaviour.

### Adaptive façade systems – Design parameters

- The building façade systems are characterized as Adaptive façade systems, if there is a presence of one or more of the following technological features in them:

- High-performance innovative materials and systems for absorbing and storing solar energy (e.g., smart, biomimetic, or bio-inspired façades, etc.).
- Devices for managing natural ventilation in combination with mechanical ventilation systems (e.g., adaptable, advanced, responsive façades, etc.).
- Movable screens for controlling solar radiation (e.g., smart, adaptable, responsive, and switchable façades, etc.).
- Technological solutions designed to increase and/or control comfort inside the building (e.g., adaptable, active, kinetic, intelligent, interactive, and switchable façades, etc.).
- Building automation systems for the management of plants and elements of the building skin (e.g., intelligent, responsive façades, etc.).

The adaptive façade systems efficiently contribute to the energy balance of the building in turn limiting the use air conditioning devices, with a consequent reduction in energy consumption. In many cases, intrinsic dynamic façade systems are used, which delegate the adaptive capacity to the use of smart materials (e.g., PCM, TIM, ETFE, BIPV, etc.) of which they are composed. The adaptivity of some façade systems is based on the capacity to move all or some of its parts. These are known as kinetic façade systems (Fox & Yeh, 1995; Wang et al. 2012). These can change by moving in space and taking on different structures and configurations over time. The long-term changes are achieved through reversible and unique conversions in the context of a flexible structure, while short-term reversible adaptations can be brought about through mechanical solutions. The Light control dynamic façade systems are automated daylight control and shading systems which are integrated and operated based on the external climatic conditions and are suitable for all climatic zones.

**Adaptive façade – Applications**

The application of adaptive façade is done to satisfy functions like improving thermal comfort, energy performance of the building, improve the indoor air quality, visual comfort and in some cases improve its acoustic performance as well. Depending on the design, the components which acts as an adaptive facade vary from being integrated with the solar systems and developed as a glazing or a shading device in the skin of the building. Based on the spatial scale, the response time of each of the design varied. A comprehensive table below explains the different applications of the adaptive facades and other factors associated with it.

| Purpose | Thermal Comfort | Energy Performance | IAQ | Visual comfort | Acoustic Performance | |
|---|---|---|---|---|---|---|
| Components/materials | Shading | Insulation | Switchable Glazing | Integrated solar system | | |
| Response time | Seconds | Minutes | Hours | Day | Season | Year |
| Spatial scale | Building material | Façade elements | Wall | Window | Roof | Whole building |
| Visibility | No | | Low | | High | |
| Degree of Adaptability | On/Off | | | Gradual | | |

*Table 1: Characteristics of Adaptive façade design*

There are various external factors that influence the human comfort described as below:

- Solar radiation: The amount of sunlight needs to be balanced continuously between adequately addressing the thermal comfort and visual comfort needs.
- Outdoor temperature and Humidity: These parameters vary throughout the day and throughout the year and are one of the most important factors in passive heating and cooling design. The fluctuations of outdoor temperature and humidity are related to heat and moisture transfer at the level of the envelope.

- Wind and Precipitation: These outdoor environment characteristics are also likely to affect the human comfort and need to be considered in façade design. In this respect, it is known that wind can provide natural ventilation and passively increase occupant comfort, in addition of assisting the precipitation in migrating through the building envelope (wind driven precipitation).
- Noise: Buildings are often subjected to outdoor noise (environmental noise) caused mostly by traffic, which is characterized by strong temporal variability. Sound design and noise control implementation at the level of façades can play a fundamental role in obtaining the adequate acoustic comfort inside the rooms.

| HUMAN COMFORT / EXTERNAL FACTORS | Thermal comfort | Energy performance | IAQ | Acoustic performance | Visual Performance | Duribility |
|---|---|---|---|---|---|---|
| Solar Radiation | ■ | ■ | | | ■ | ■ |
| Outdoor Temperature | ■ | ■ | | | | |
| Wind | ■ | | ■ | ■ | | |
| Humidity | ■ | | ■ | | | ■ |
| Precipitation | | | | | | ■ |
| Noise | | | | ■ | | |

*Table 2: Matrix showing the relationship between external factors and human comfort.*

**FINDINGS/ ANALYSIS & INFERENCE**

**The case study of Al Bahr Towers (Abu Dhabi, United Arab Emirates) - Light Control Dynamic Façade**

In 2008, the Abu Dhabi Investment Council an investment arm of the government of Abu Dhabi launched an international competition for its new headquarter located on the north shore of Abu Dhabi Island, overlooking the Eastern Mangroves and towards Sadiyaat island and the Persian Gulf beyond. Therefore, the project name is Al Bahr which means the sea in Arabic. Abu Dhabi has a hot, humid climate, too sunny with temperature and humidity reaching 49°C and 100% respectively during summer. Aiming to design two symbolic towers, on the area of 56,000 square meters primary for office use (Al Hilal Bank) architect Abulmajid Karanouh (AHR/Aedas) offers two 150 meters high (25 stories) circular towers with a kinetic shading system curtain wall reflecting the region's architectural heritage.

**Concept**

The project concept is inspired by traditional Islamic object the 'Mashrabiya' to stand out with two circular towers covered by honeycomb-inspired structure and its automated dynamic solar screen. The design of the dynamic "Mashrabiya" adopted a similar concept by Nouveal to create a responsive façade. The 'Mashrabiya' is a wooden lattice screen with a service life of 20 years is used for achieving privacy and environmental control, including natural ventilation, and operate as a series of camera lenses, shrinking and widening in response to sensors to control the penetration of sunlight into the building. In total each tower has 1049 Mashrabiya shading devices, each weighing about 1.5 tonnes. The shape of the building in plan and elevation led to 22 different variations in the Mashrabiya geometries, which created

a challenge for managing their manufacture and assembly (Figure 1a). The tower floor is open plan office spaces with service core.

*Figure 1: (a) Northern facade and (b) south facade of Al Bahr Towers, with some opened and closed shading devices according to the sun movement (photo courtesy: Terry Boak)*

(a) (b)

**The Envelope**

The two circular towers are clad with a weather-tight glass curtain wall that comprised of unitized panels with a floor-to-floor height of 4200 mm and a variable width of 900 mm to 120 mm. From floor to ceiling the vision area of the curtainwall spans 3100 mm. The curtain wall is separated from the kinetic shading system through a substructure through movement joints (cantilever struts) at different levels to allow them to behave independently from the substructure. The dynamic shading system is a screen comprised of triangulating units like origami umbrellas (Figure 2) acting as individual shading devices that unfold to various angles in response to the sun movement to obstruct the direct solar radiation. The mashrabiya panel cantilevered 2.8m from the primary structure. The shading device system has stainless steel supporting frames, dynamic aluminium frames, and fibreglass mesh infill. Each shading device comprises a series of stretched polytetrafluoroethylene (PTFE) panels. When the shading device is closed, occupants can still see through from inside to the outside (Figure 3).

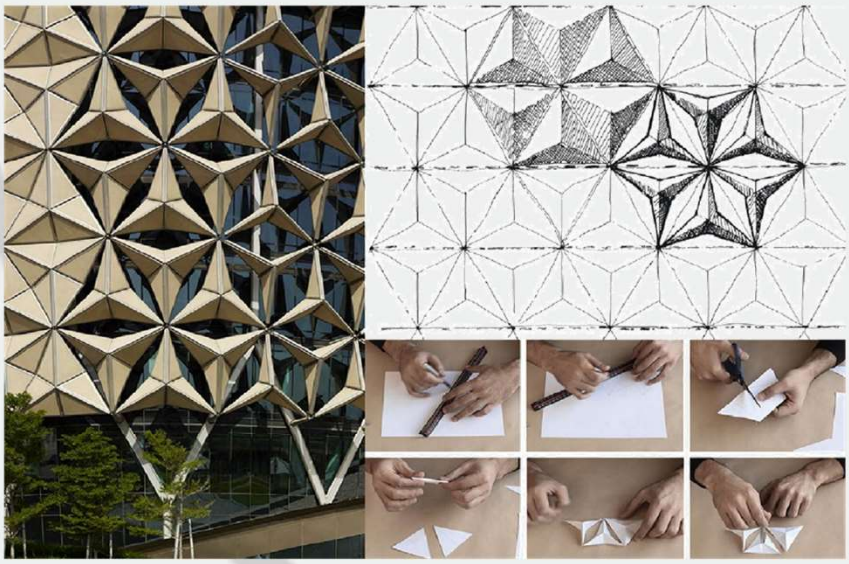


*Figure 2: Triangulating units like origami umbrellas (photo courtesy: Terry Boake).*

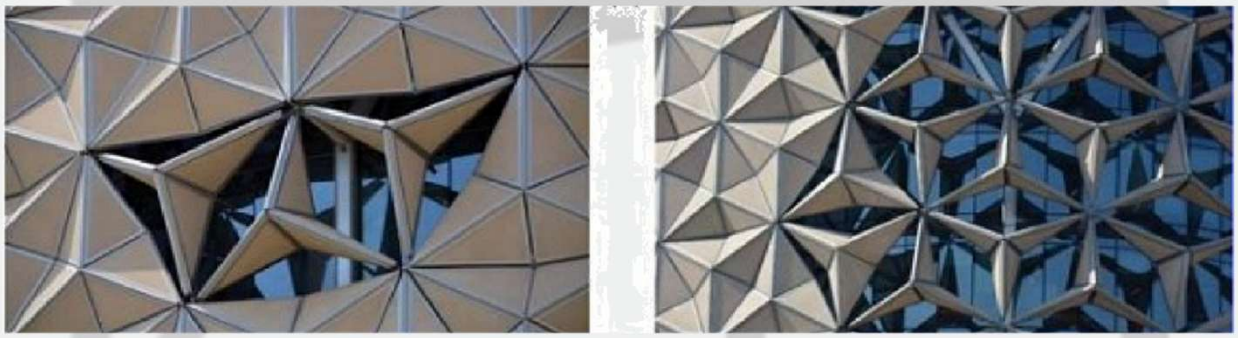
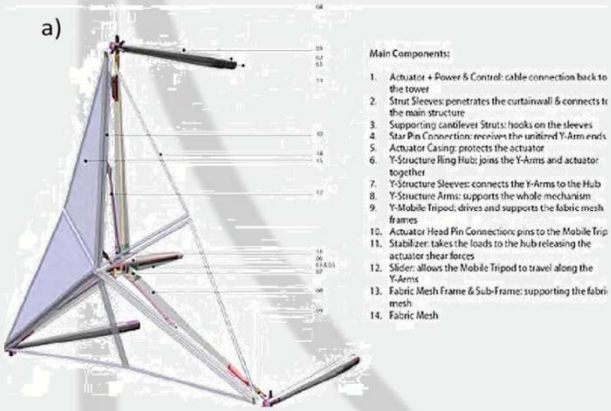


*Figure 3: (left)Three fully opened shading devices allowing an open view during non-solar periods and (right) A group of fully opened shading devices (photo courtesy: Terry Boake).*

**Automation and Adaptations**

The shading screen is computer-controlled to respond to optimal solar and light conditions. The mashrabiya shading devices are grouped in sectors and operate through sun-tracking software that controls the folding and unfolding sequence according to sun angle. Each shading device comprises a series of stretched polytetrafluoroethylene PTFE panels and is driven by a linear actuator having a service life of 15years. In the case of overcast conditions or high winds, a series of sensors integrated on the building envelope will send its logged signals to the control unit to open all units. (Figure 4) shows a detailed 3D model of an individual shading device with the actuator, sleeves, arms, and fabric mesh. The mashrabiyas are controlled through a central Building Management System (BMS) that can control each unit individually or in groups. The system is run with Siemens technology in an automated present control following the sun's path through the year. The system is updated every 15 minutes using a light meter and an anemometer on the roof. In the case of weather events, the automated program gets overridden. Power and data transmission are enabled through the strut sleeves, as shown in Figure 5.

a)




b)

*Figure 4: a) Detailed 3D model of an individual shading device, b) Image showing the individual shading umbrella (photo courtesy: Wood15)*

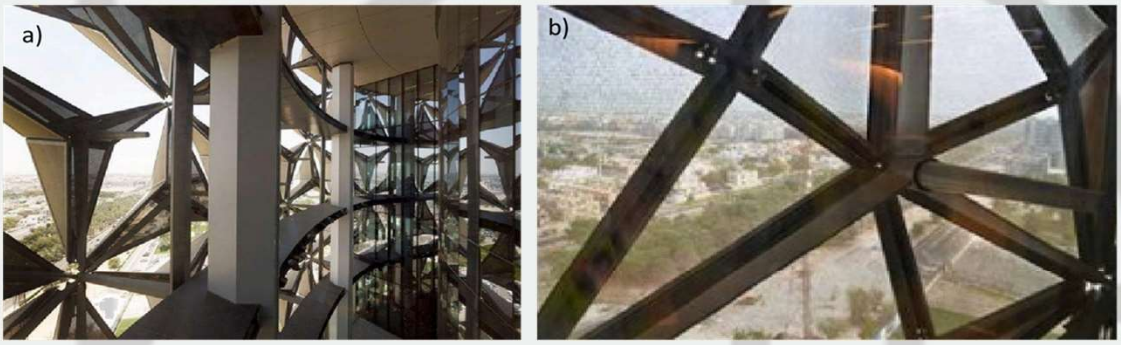



*Figure 5: a) An Interior view of the mashrabiya and curtain wall where the strut sleeves penetrate the curtain wall and connect to the main structure and (b) a view when the Mashrabiya is open (Source: Google images).*

Below is the table for performance analysis.

| Al bahr Tower | | | | |
|---|---|---|---|---|
| Purpose/Goal<br>Parameters for Adaptive Façade | Thermal comfort | Energy Performance | Acoustic performance | Visual Performance |
| Innovative materials | - | Yes | Yes | Yes (40% vision light transmission) |
| Natural +Mechanical ventilation | - | - | - | - |
| Movable screen | Yes | Yes | - | yes |
| Building Automation system | Yes | Yes | - | Yes |
| | | | | |

*Table 3: Table of performance analysis*

**Results and analysis:**

- **Façade design process description**

  The Al Bahr towers delivery process was frequentative with the experimental validation approach. There were twelve stages of the delivery process-

  1. Competition with the dynamic Mashrabiya concept.
  2. Setting the design team, (AEDAS þ Arup);
  3. Submission of the project (July 2007);
  4. Winning the competition (Nov 2007);
  5. Assembling a design team (70 architects and 150 engineers (structure, MEP, Fire, etc.))
  6. Design development and construction documentation.
  7. Tendering and contractor selection.
  8. Mock-ups.
  9. Benchmark.
  10. Construction.

11. Occupation.
12. Commissioning.
13. Soft landing.

The frequentative approach allowed a holistic integration, for example, the glass was selected during the material identification workshop supporting glass box concept for nearly zero energy targets much before the mechanical, thermal and visual performance criteria of the glass was assessed. Thus, the selection of the façade glazing was purely aesthetical during the schematic design phase. The glass façade comprised of three layers the primary (internal) curtain wall, the steel structure, and the automated glass sunshades. The most critical layer of the façade was the third layer with external automated sunshades. This layer had multi-functional and multi-criteria performance requirements, including glass transparency, colour, weight, size, solar energy transmittance (g-value or SHGC) and movability. However, the project delivery process forced the architect to select the louvres based on their transparency and colour neutrality. Later, the energy and building physics consultant had to optimize the glass louvres to avoid glare and overheat when the louvres set to block the sun. The energy and building physics consultant had to conduct several simulations models and experiment with a climate chamber and testbed in the Netherlands, to maximize the g-value. Finally, a printed glass with tempered mesh was finally proposed to address the performance criteria. To ensure proper coordination between the various building components, a digital model fulfilled the criteria ensuring integration between the concrete core, the structural steel frame, and the Mashrabiya.

- **Façade Assessment Process Description**

  Most of the façade testing was conducted offsite. The design team relied on simulation tools and CFD analysis. Then static and the mechanical mock-ups were put on hold. It was felt essential to set up a visual and kinematic mock-up before the static and mechanical mock-ups. Also, a series of wind-tunnel test was conducted at various scales. The façade contractor was responsible for three mock-ups:

1. Onsite mock-up for fabric testing.
2. The shading devices tested to operate with high reliability and robustness. A series of prototype test on the PTFE panel were conducted at both ambient laboratory and elevated temperatures to check the required durability and life of actuators, bearings, and mechanism overall.
3. Mock-up for lighting: A benchmark for this was set up onsite. The façade assessment and commissioning were mainly on the hand of façade subcontractor. The building was opened in 2012, and the commissioning phase ended with the beginning of the soft-landing phase in 2015. Occupant behaviour of building users was identified, and the deficiencies encountered during the summer and winter cycles were highlighted.

- **Survey results**

  The survey results concerning thermal comfort recorded 86% were comfortable, and the rest 14% included the ladies who reasoned the discomfort due to overcooling.

- **Discussion and Conclusion**

1. The project embeds a series of innovations and is a fruit of successful collaboration between the client, design team and builder. The mashrabiya concept and its implementation are ground-breaking, and the towers succeeded as an iconic landmark.
2. Another success of the design was the performance requirements for the adaptive façade setting new standards for the façade design and construction quality. It also set up the specification of the façade performance with a focus on structural, mechanical and durability of the facades.
3. The use of BIM and parametric geometrical modelling was a crucial tool for the concept development and team collaboration. The advanced computation design capacity of the design team (AEDAS + Gehry Technologies) allowed the building envelope development and the rationalization of the complex façade geometry including

the curtain wall glass panels in a uniform and coherent manner. The use of Rhino Script to calculate the deflection limits of glass panels based on established algorithms rules was to refine and optimize geometry. Moreover, the advanced paramedic modelling was the critical methodology to control the mashrabiya folding limits. The coordination of work among various contractors, manufactures and suppliers in a seamless way with minimal class detection was BIM cause success.

**Masdar Institute for Science and Technology (Abu Dhabi, United Arab Emirates)**

Masdar Institute for Science and Technology is in Masdar City under the supervision of the Masdar Initiative. It is designed by Foster + Partners (Figure 6). Abu Dhabi's climate with temperatures that vary from warm in winter months to hot in summer with sunny blue skies prevail throughout the year and rainfall is infrequent which affect the building architecture design to fulfil the environmental and climatic conditions. Sustainability as criteria of design explores the use of a diverse range of materials such as terracotta tiles, aluminium, and recycled steel as well as GRC screens to create buildings that have good thermal insulation properties. The geometrically perforated mashrabiya act as an architectural expression and reflection of a modern city that is re-shaping its identity with sustainability as an underlining theme.


*Figure 6: Masdar Institute for Science and Technology (Abu Dhabi-U.A. E) (Source: Google Images)*

Following criteria were considered while the design strategies for adaptive façade for MIST were evolved:

- **Sun control**

The Institute has self-shading facades and is orientated to provide maximum shade as well as sheltering adjacent buildings and the pedestrian streets below. Windows that are not already shaded by adjacent buildings have louvres vertical to block morning and afternoon and horizontal to block mid-day sunset to prevent direct sunlight from shining into the building.

- **Natural ventilation**

There is a contemporary modern version of the traditional Arabian (burjeel) wind tower which brings cooling breezes to the courtyard. Rising 45 meters above the podium, this modern interpretation is the landmark for Masdar city. Sensors at the top of the steel structure operate high-level louvres to open in the direction of the prevailing winds and to close in other directions to divert wind down the tower. The tower will incorporate solar-powered LED screens that will flash green, pink or red lights to give those on campus an idea of how much energy they are consuming. A PTFE (non-stick brand Teflon) membrane carry the wind downward while mist generators at the top add additional cooling to the air. Combinations of evaporative cooling and air movement techniques help to moderate perceived air temperatures, thereby improving users' comfort (Figure 7).

- **Moisture control**

Behind the foil is a highly insulating and highly sealed panel. Aside from the rest of the façade, are highly packed, insulated and wrapped 90% windows, recycled aluminium sheeting and rose-red colour.


*Figure 7: Masdar's colossal wind tower is touted as a symbol of the Institute's zero-energy concept. (Source: Google images)*

- **Material**

Facades at Masdar city incorporate a variety of technologies and materials to address sustainable building. Laboratory buildings are characterized by air-filled ETFE cushions (30 cm thick) that ensure almost no solar gain on the structure and limit the heat re-radiated to the street. A reflective foil-clad inner layer behind the cushions send light to the pedestrian street below.

- **Energy generation**

There are over 5,000 square meter roof dynamic photovoltaic panels (Figure 8) which provide power and further protection from the direct sun. The photovoltaic array above the building helps to provide 30% of the electrical load of the city. Masdar utilizes the three most commercially viable types of solar panels to convert the sun's energy into electricity. These photovoltaic (PV) technologies include monocrystalline silicon panels, polycrystalline silicon panels, and thin-film panels. The community is powered by a solar field consisting of 88,000 solar panels. Within the properties, lights and water taps turn on and off by motion sensors. This significantly reduces consumption and reduces the cost of living in Masdar City.


*Figure 8: Masdar institute with solar energy in Masdar City. (Source: Google images)*

**Discussion and Conclusion**

In Abu Dhabi, new applications of regional and traditional designs create new venues for sustainable design that goes beyond the social perception of environmental design. The use of the contemporary geometries reinterpreting mashrabiya screens represents an inevitable necessity to adhere to global changes in the realm of architecture to produce new forms that are iconic and aesthetically pleasing. The visibility of such geometries on a large scale in the way of building skins. They also highlight the available technologies and materials for building skins to reduce

glare and create more comfortable and sustainable indoor environments. Masdar Institute represents a modern interpretation of ideologies explored by the pioneers of architecture such as Le Corbusier, Mies Van der Rohe and Hasan Fathy that addressed the production of environmentally oriented urbanism beyond the norms of Classical architecture. The materiality and design of the buildings in Masdar City offer an opportunity to create numerous scenarios of sustainable design that is culturally and environmentally oriented.

**CONCLUSION**

The provision of adequate and reliable energy services at affordable costs in a secure and environmentally benign manner, and in conformity with social and economic development needs, is an essential element of sustainable development. Understanding of adaptive façades shows that the architectural research on dynamic envelopes is moving towards innovative solutions. By exploiting the possibility of integrating IT systems, mechanical actuators, and innovative materials, these technological solutions can transform the envelope from a static element into a dynamic element capable of rapidly and efficiently changing shape in relation to specific functional, static, and physical requirements. The advanced screen, eco-efficient, and sustainable envelope interacts and regulates energy flows and, in some cases, becomes a plant system, by itself, capable of producing energy, heat, or electricity, and of distributing it at a building or even at an urban scale.

Adaptive architectures can therefore be considered as the last goal of contemporary architectural and technological research and there is always a continuous effort which is ongoing and striving to propose new dynamic envelope models. These technological solutions can control energy flows by regulating fixed devices that can be characterised by the presence of smart materials, variable structures (e.g., sunshades, opening/closing of windows, ventilation outlets, among others), manual or automatic control, or regulation in relation to the type of user and complexity of the building. This envelope typology is marked by dynamic anisotropy that is the capacity to offer different solutions for the different exposures of the building. The change within the structure modulates the various environmental flows according to the climatic conditions of the place, including external climatic-environmental conditions. Hence it shows that the components with the capacity to change the structure regulate the thermal, light, and sound energy flow that passes through it thereby improving the occupant comfort making environmentally more efficient and sustainable.

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# REPROCESSING LEFTOVER SPACES INTO CAMPUS ASSET: A PROPOSAL TOWARDS FUNCTIONAL REGENERATION OF THE BUILDING COURTYARDS OF SUST

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**Abstract:** In recent decades, responsive reuse of waste materials became a growing practice in architectural space-making as a part of environmental consciousness. However, the wastage of space, particularly in non-historical public buildings, remains mostly unnoticed in the general practice of reuse. The academic buildings of Shahjalal University of Science and Technology (SUST) contain open to sky courtyards at the centre and enclosed by single-loaded corridors on all sides. Those courts remain unused maximum time of a year. Although designed with positive intention and have significant potentiality to contribute in the learning environment, generally count as leftovers in reality. This research is a primary attempt to find and investigate the shortcomings of these designed courtyards and propose space modification options to make those valuable places more integrated and usable. The research method adopted a combined approach consists of intensive literature study, morphological analysis and planning considerations, microclimatic analysis, participatory questioner surveys among the stakeholders, interviewing the experts and selective national and international case studies. Finally, a specific affordable space modification solution has been proposed by considering the conflicting issues that the research has identified to make those courtyards active in a new way.

***Keywords:*** Learning environment, Building courtyard, Leftover space, Functional regeneration, Affordable solution.

## 1. INTRODUCTION

As one of the oldest architecture footprint courtyard is found in both private and public buildings which provide meeting pockets on activating community engagement (Reynolds, 2002). A courtyard often defined as the enclosed open to sky area that surrounded by walls or buildings, have been designed and enhanced by the integration of social, cultural and environmental factors (Almhafdy et al., 2013). The word *court* or *yard* sometimes used singly to indicate an enclosed space. In some countries, university courtyards are known as *quadrangles* too. Built form around a courtyard is very familiar in Bangladesh, from rural to urban and vernacular to contemporary architectural works, found almost every region of the country. Ancient educational institutes such as *Shalvan Vihara* and *Somapura Mahavihara* till bear the traces of inner courtyards. Many educational and institutional building has been designed with inner courtyard mainly for climatic and social advantages. Shahjalal University of Science and Technology (SUST), established in 1986, have notable number of courtyard buildings use for academic, residential and recreation purposes. With a chronological development over time, all five academic buildings of the campus have a central courtyard surrounded by single loaded corridor followed by classrooms which created a unique internal educational environment. With limited use and maintenance, these courts remain neglected maximum time of the year. Having enormous use potential, this wastage of space unfortunately stay unnoticed to the authority and maximum part of the stakeholders.

***Figure-01:*** *SUST campus top view (left) and Academic buildings with enclosed courtyards (right) Source: Google earth satellite view 2019.*

## 2. LITERATURE REVIEW

Courtyards were frequently used for various activities as working, playing, gardening, cooking, sleeping or keeping domestic animal to be mark as a prominent community meeting area (Edwards et al., 2006). Courtyard modify microclimate to improves comfort conditions of the internal spaces in a building (Almhafdy et al. 2013), inducing both physiological and mental sensation of its users (Antonio & Carvalho, 2015). Large buildings with bigger courtyard with a great number of users often act as an important place for socialization by providing different functional usages (Becki et al., 2013). As an open and cluster space, courtyard fulfills various aspects as functions, social perspectives, leisure or microclimatic and acoustic protection. Thermal comfort largely depends on courtyard geometry and material makeup (Meir, 2000). Almost all ancient civilizations of the world including Indus valley, Mesopotamia, Egypt, China along with Greek-roman classical period used courtyard in their built forms as prominent design feature (Das, 2006). Courtyard performance depends upon its orientation, exposure, configuration, boundary conditions, aspect ratio and type of surroundings. The application of courtyard that disregards its basic design characteristics and placement would affect its potentials (Reynolds, 2002). Adopting courtyard from other climatic zones neglecting indigenous socio-cultural and climatic community properties may lead to much thermal affliction in buildings (Berkovic *et al.,* 2012). Passive design strategies and courtyard orientation can improve natural cooling with a minimum energy requirement (Akande, 2010). Higher rate of ventilation results lower rate of indoor temperature in the adjacent spaces of a courtyard. It has been seen the central courtyard creates a negative pressure zone within which improves the natural ventilation performance where accelerated airflow evacuates the heat upward (Aldawoud, 2014). Safarzadeh & Bahadori (2005) stated that installing natural creatures in a courtyard would result impressive environmental profit and the thermal comfort. Large number of plants lowers the temperature by evapotranspiration and Photosynthesis activities as vapour is released to reduce the temperature of the surrounding (Zango, et al. 2017). In a hot-humid region, continuous ventilation is very essential to remove humidity and heat to achieving comfort inside (Koch-Nielsen, 2002). Although proven successful in past, many of the traditional courtyards around the world have undergone modifications, even being completely closed off or air-conditioning unit has been installed (Lobo, 1989). Affection towards centralism and religious tradition brought out the general courtyard character for institutional buildings in Iran where Central courtyard regarded as a symbol of sanity and perfection (Mahdavinejad, et al., 2013). Although traditional residential courtyards begun to diminish by the 20th century second half in Cyprus due to technological advancement, changing lifestyles and socio-economic status, but use of courtyards in educational buildings begun to rise at a remarkable rate for its multidimensional perspectives(Kolozali & Kolozali, 2016). In Hong Kong University campus healing properties has been promoted on building courtyards as social support promoted through designing gardens, where sense of privacy and control for academic atmosphere was maintained through meditation garden (Lau & Yang, 2009). Extreme weather or functional need can create diverse ideas as design of greenhouses in the interior courtyards where water features and targeted species could result a pleasing microclimate and add significant value (Anghel et al., 2016). Gangwar (2016) stated that the design of courtyard due to its versatility could be very creative solution to meet the present need of people. Most of the previous studies regarding building courtyards were focused on climatic performance and design considerations also limited to residential and traditional buildings in maximum cases. Except few historical conservation or revitalization, study on courtyard reuse or modification is very rare in the field of research.

## 3. RESEARCH METHODOLOGY

A combined approach was adapted to understand the scenario from multidimensional perspectives. Along with the physical observation research attempted to understand specific experience from different stakeholders to identify the factors behind the current scenario and also count the suggestions to improvement.

**3.1 Physical survey:** Physical survey was conducted separately for each academic building to collect information on courtyard enclosure, aspect ratio, building material, surface and vegetation, drainage etc. to construct proper physical

overview. The survey also included socio-cultural dimensions to understand the user behavioural pattern and expectation on indoor learning environment. For climatic aspects, computer aided model with proper geo location for each building were created for climatic analysis. Both physical and computer based data were compared for different time periods and seasons.

**3.2 Questionnaire Survey:** A survey was conducted among the students of the university from January 01, 2020 to March 01, 2020 asking their opinion toward usage of the courtyards in their academic buildings. The survey included randomly chosen 50 students from each of the five academic building. The questionnaire included a set of six questions, four of those were focused on the necessity of courtyard, use consistency and view towards repurpose, later correspond to Likeart scale format and create an unambiguous scale to use in satisfaction analysis. The sample size was determined by the formula: n = N/1 + N (e)2, where 'n' is the size of sample, 'N' as population and 'e' represent the level of precision which is ±20%. The other two questions covered the ideas, needs and suggestions on specific courtyard.

**3.3 Expert Interview:** Two experts from relevant study field were interviewed about the present condition, shortcomings and possibilities, affordable and sustainable rethinking suggestions on the existing academic courtyards. Both of the experts are active faculty member of the University, has more than 12 years of experience in academy and nearly 20 years in architecture profession.

**3.4 Case Study:** Selected national and international successful projects were studied and analysed. For national selection climatic and socio cultural context were emphasised. In case of selecting international case studies, sustainable and innovative examples were considered.

## 4. ANALYSIS & DISCUSSION

Academic Building A has only soil covered courtyard in the campus where other four has plastered ground. None of the courtyards has any define activity or guideline. All of the courtyards discourage physical accessibility due to solid brick railing. Lack of maintenance often force those use as dumping debris by the users. Academic Building D has the largest courtyard and has notable seasonal activities as cultural program, exhibition, mini concerts, indoor sports etc. Rainwater runoff system works quite well in almost all the courtyards.

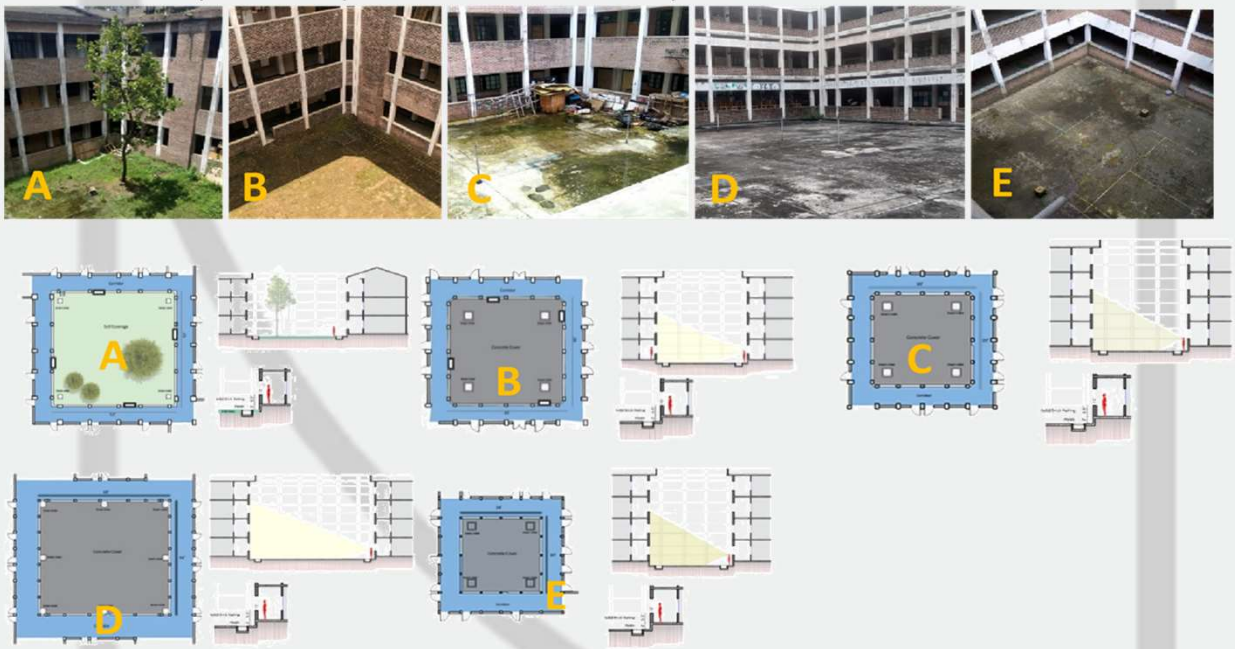


***Figure-02:*** *present scenario, Plan and sectional views of the courts inside Academic building A, B, C, D and E*

From Table-01 there is a prominent indication of less permeability of courtyard where only building 'A' courtyard has some vegetation but not in any clear planned way. The drainage system lacks a proper maintenance. The aspect ratio is square but the size differs from one another without defined reason. A clear lack of ownership was observed during the survey. Often users dump their debris on the courtyard and remain there for a long period of time.

| Topics | Buildings | | | | |
|---|---|---|---|---|---|
| | A | B | C | D | E |
| Aspect Ratio | Square | Square | Square | Square | Square |
| Dimension(Sq.ft.) | 46X46 | 42X42 | 44X44 | 66X66 | 40X40 |
| Enclosure Material | Exposed Red Brick Wall, Painted Concrete columns | | | | |
| Surface Material | Soil | Concrete | Concrete | Concrete | Concrete |
| Permeable Surface | 100% | 0% | 0% | 0% | 0% |
| Vegetation | Wild grass, Medium height plantation around edge, One Large Plant around the center | No Vegetation, Algae grow during Rainy season | No Vegetation, Algae grow during Rainy season | No Vegetation, Algae grow during Rainy season | No Vegetation, Algae grow during Rainy season |
| Drainage | Disconnected Inlet | Disconnected Inlet | Connected Inlet | Connected Inlet | Connected Inlet |

***Table-01:*** *Overview on comparative physical analysis of different courtyards*

Annual weather report shows Sylhet has high precipitation (177.9mm) and humidity (77%) consolidates the need of direct airflow to ensure user comfort. During summers, higher precipitation along with higher temperature causes discomfort. Shadow analysis help to determine the courtyards exposure to direct sunlight, shape the use frequency, placement of any function, vegetation and so on. Using 3ds max geo-location on three different daytime data of 16th of May & 1st December was generated for each courtyard to overview the major difference between summer and winter. From the figure 3, during winter the whole daytime can be utilized for use. On contrast in summer exposure is greater resulting in direct use to a smaller extent.

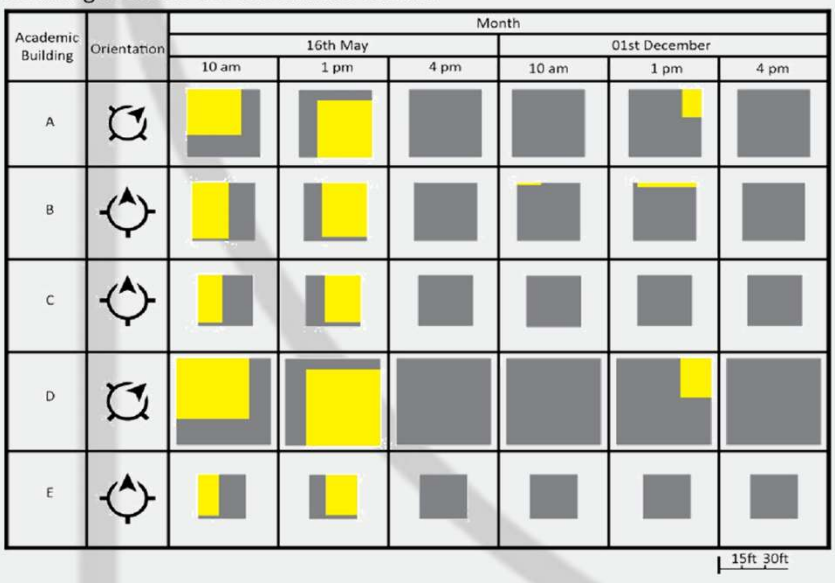


***Figure-03:*** *Shadow Analysis of Courtyard Illustrated*

From the questioner survey, 210 questionnaires returned maintaining 84% of response rate. The result of students' response regarding the courtyard usage survey is showed in Table-02, where majority of the respondents agreed on the necessity of a courtyard in their academic buildings. 43% of the respondents feel the extreme necessity of courtyards, 31% of them felt courtyards are very necessary. Only 21% of them thought that the use of courtyard is fairly moderate and a majority of 53% of them responded the present usage of courtyard as 'poor'. In the following question they were asked about the idea of repurposing the courtyards, 57% of them responded 'very likely' about repurpose, 28% of them thought the idea was 'likely', 2% of the respondents thought the idea as 'waste of resource'. Then the students respond over six functional ideas, they choose according to their needs specified to the courtyard they occupy.

| Questions | -2 | -1 | 0 | 1 | 2 |
|---|---|---|---|---|---|
| Necessity of Courtyard? | 9% | 5% | 12% | 31% | 43% |
| Usage of courtyard? | 15% | 53% | 21% | 7% | 4% |
| Regarding repurpose? | 2% | 9% | 28% | 57% | 4% |

***Table-02:*** *The result of student response on courtyard survey using Likert scale*

Figure-04 demonstrates the count of response on several functions for different courtyards where some basic functions like waiting zone, food zone, and cultural activity zone were much anticipated by the responders. Then occasional sports and large cultural activities were popular in the larger size courtyards. Outdoor classroom as a co-curricular function varied with the activity type of different departments occupying different building courtyard.

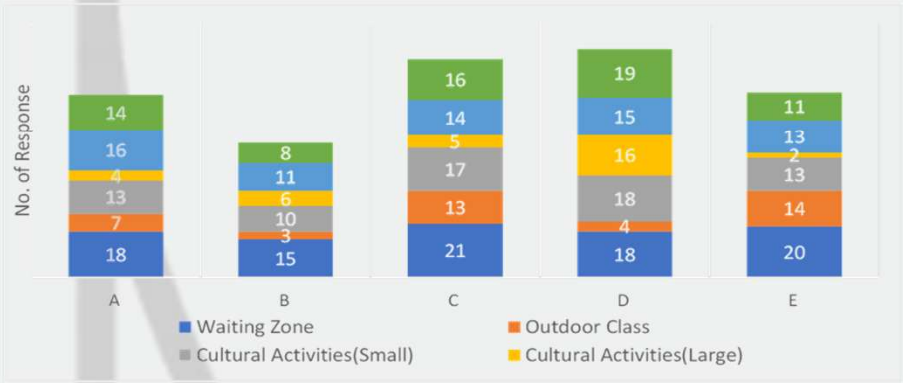


***Figure-04:*** *Response on different types of reuse proposal according to different building courtyards*

As an expert Mohammad Shamsul Arefin, Assistant Professor and landscape specialist in Department of Architecture stated that landscape modification can easily make these courtyards more active and valuable with innovative and separate modification ideas for each courtyard with different seasonal appearance to break the chain of monotony and create a unique identity for each academic building. Modification should not include any water bodies as those are hard to maintain and may lead to increase mosquitoes in campus. Removal of plaster ground and replacing the solid railing with transparent option including hanging creepers, shaded trees or multilevel plantations on different floors can provide a volumetric green escape zone for the users. As a part of rich in biodiversity, courtyards with seasonal flowers, fruits and leafs will attract various species of birds and insects that will offer natural stability and healthy learning environment. Kawshik Saha, Associate professor in the same Department, stated that, socio-cultural significance was not considered on designing the courtyards in SUST. Student behaviour pattern should be analysed for sustainable modification as they occasionally use some of those spaces as badminton court, mini concert, religious

ritual as Swaraswati puja and fresher reception program. Alternation should be minimum, limited to the maintenance capacity, he also added.

Designed by famous American Architect Paul Rudolph, Bangladesh Agricultural University has several prototype courtyards for different faculty connected through shaded corridors. Unique ambience, accessibility and connectivity made the learning environment admirable. In Acharya Jagadish Chandra Bose Building in Khulna University inner courtyard designed with several seating options into green ground. Architect Paulo Zimbres showed significant natural and structural mingle on his courtyard design in University of Brasilia, Brazil where semi shaded frame used with creeper like vegetation created a pleasant atmosphere.

## 5. RECOMMENDATION AND CONCLUSION

For affordable and sustainable reuse of the existing courtyards inside the academic buildings of SUST, this research came out with the following recommendations to be considered:

-Solid ground surface should be replace with semi paved solution
-Solid railing should be replaced with more transparent option for better accessibility
-Multilevel plantation should be installed could add under expert supervision
-Multipurpose use option during different time of the year
-Thematic case specific solution for different courtyards to create own identity
-Create sense of ownership to ensure better maintenance
-Enhancing the existing rich biodiversity of the campus through design
-Ensure better learning environment to encourage and inspire the users

***Figure-05:*** *illustrated idea of a case specific design for different courts to create own identity*

This research is a primary attempt to stand for reusing leftover spaces. In the field of architectural reprocess, reusing unused space can easily contribute on creating new resources with less attempt and money even with economic regeneration. In case of Bangladesh, courtyards in public buildings such as hospital, government offices, college and universities often remain leftover due to poor maintenance; sometimes become a place of negligence and waste dumping even crime. Considering this repurpose issue on the larger public building courtyards has huge potentiality to add a significant change on the people's perception of built environment.

## 6. ACKNOWLEDGEMENT

Thanks goes to the students of 2015-16 session of Architecture Department, SUST for the field survey on the existing building courtyards of SUST campus.

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# CHALLENGES OF A CITY WITH A HERITAGE CORE CASE STUDY: PUNE

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**ABSTRACT:** Indian cities for over centuries have had a great history, a rich legacy of cultural and architectural heritage. These cities have stood the testimony of time, stayed true to their ethos in their historic cores. Pune is one such city with a recorded history of over 1000 years and plethora of Maratha architecture, culture and tradition, but in conflux of conserving the past and keeping pace with urbanization. With the advent of time, uncontrolled and insensitive developments, government negligence, conflicting land uses, encroachment by commercial establishments, non-contextual architecture, traffic and parking problems, the historic core of Pune seems as a fractured entity today.

This paper thus aims at understanding the current scenario and the emerging concerns in the historic core of Pune city. Using survey techniques and analysis, the paper proposes a management framework that could help *re-purpose* the architecture in the city core. The objective of this paper is to identify areas of concern in the historic core of Pune (Tulsibaug area) and propose solutions for decongestions and explicate the character and the image of the historic core. This study could further also form a basis of creating management frameworks for several such cities across the country having rich built and cultural heritage.

***Key Words:*** *heritage, public awareness and participation, context, management*

## 1. INTRODUCTION:

*"The heritage is the seed of past, that brings forth the harvest of the future"-Wendell Philips*

The heritage core of the city sustains a number of ever evolving activities, distinctive characters and patterns of growth. Pune is no exception and the architecture and urban patterns are a reflection of social, cultural, political and economic situations of the past. However, the expansion has been so fast and enormous that the original character and face has been lost and marginalized in the process. Tulsibaug is one such part of the city that has witnessed this change and shift from being a place of spiritual significance to that of a commercial street. This shift has brought change in its identity, streetscapes, patterns and life. Unorganized and dominating developments, uncontrolled and haphazard growth and neglect by authorities, communities and individuals has led to severe decline in its character. To reduce the further decline of areas, individual and community's active participation is essential.

With changing times, the perceptions and life of people in the historic core has witnessed a shift, with citizens getting accustomed to the changing environment and growth patterns and gradually becoming less aware of it. Familiarity breeds contempt. Though part of the fabric and determinant of the community life, the heritage buildings are often neglected, resulting in consequent deterioration. In the present culture and systems, it seems that progress is associated with the rejection of past (Debashish Nayak, Development and Community heritage, 2005). Heritage is considered stagnant, with a myth that it cannot adapt to changes and accommodate modern facilities. But at the same time we cannot ignore the fact that there is too much to conserve and there are too little financial resources available. However, undeniably Heritage conservation and heritage repurposing is the need of the hour (Debashish Nayak, Development and Community heritage, 2005).

## 2. AIM:

This paper thus aims at understanding the current scenario and the emerging concerns in the historic core of Pune city. To understand the scenario, on-ground survey is conducted, using mapping techniques and understand the current state of built and un-built fabric of the city core. Further the paper also proposes a management framework that could help re-purpose the architecture in the city core.

**3. OBJECTIVES:**

a. To study the current scenario of Heritage in Tulsibaug and changes in the urban fabric over the years by preparation of base maps, identification of elements that make this fabric.
b. To investigate factors responsible for deteriorating heritage in Tulsibaug.
c. To understand the role of community and an individual to safeguard the heritage.
d. To propose a solution for better management of heritage and *re-purpose* the same.

**4. SCOPE:**

The city of Pune has a rich history, a history witnessed by these heritage buildings, the fabric of old city. Each wada, a building, the meandering lanes, the chowks, and peths have stories to tell, if paid an attention to. Tulsibaug is one such part of the city, which gives a glimpse of the rich urban fabric once the old city was about. Thus, the research intends to study this fabric, its elements and understand the growth patterns, associations of communities with their heritage and co-relation between awareness about heritage and its conservation and management.

**5. LIMITATIONS:**

The study of heritage buildings and precincts, their condition, understanding community's and individuals opinion about their heritage, due to limited time frame was restricted to a part of Pune city's historic core i.e. Tulsibaug. Thus the research and surveys are area specific. The research methodology could be applied to a larger area, scaled as per scope of research and time available.

**6. PROBLEM STATEMENT:**

Heritage conservation movements are far strong today, than they were decades ago. Non- government organizations like ASI, ICOMOS, INTACH, are striving hard to create awareness amongst communities for conservation of their heritage and boost their participation levels. Though considerable efforts are made and several conservation projects are implemented, but are at a very low scale. Scaling up such initiatives is essential. However, it cannot just happen by a group of organizations or authorities, but a collective effort by different sections of the society is essential.

To generate awareness one has to understand and propagate that heritage does not oppose development but falls prey at the hands of insensitive growth. Heritage apart from imparting knowledge of the past has a lot more to offer and has much wider power to inspire people and move them towards development and progress of their community (Dr. Meera Dass, Heritage Concerns and Cultural Ethos of a Town, 2005). Heritage provides landmarks, gives a sense of belonging and identity and carries connotation of pride, tradition, identity and quality (Debashish Nayak, Development and Community heritage, 2005). Thus, an effective approach towards conservation of heritage can only be brought with change in the attitude and understanding by different constituents of the society towards their heritage. Further, the need to repurpose the architecture cannot be neglected. Like in the west, heritage is celebrated as a "living" Heritage, it's important to look at reusing, restoring and repurposing our built heritage.

Tulsibaug, a dear place not just to a *Punekar* but an attraction for many, today is all about markets and street shopping. Little does anyone know of the treasures it hides in its interwoven and dense fabric? But with changing times and perceptions, these treasures lie under the constant threat of uncontrolled developments. Thus what we see today is buildings and facades sandwiched in between old buildings. With absence of vision and lack a proper direction, the day would not be far away when Ram Mandir would be overshadowed by vertical developments. Thus, without proper supervision and maintenance of these historic buildings, the city will eventually lose its historic townscape that portrays its uniqueness. In order to achieve this balance between respecting the past and welcoming the future, only government bodies and authorities cannot be blamed or held responsible but a holistic approach by communities and public participation is essential to safeguard these treasures and regenerate the quality of these areas and buildings from their present declining state.

*Fig 01:* Heritage buildings, wadas in dilapidated conditions and overshadowed by insensitive developments (Source: Authors)

*Fig 02:* Wada's sandwiched in between new developments (Source: Authors)

**7. LITERATURE REVIEW:**

Most contemporary societies are very keen on the preservation and conservation of their heritage (Greffe, 2004), as heritage satisfies a variety of needs. Heritage conservation not only is a concern in India or the East, but also the Western countries. Every city or state in the world is behind inventing new methods, possible solutions and ways for justifying heritage precincts and buildings and balancing between the old and new developments.

Nik Farhanah Nik Azhari and Embong Mohamed, in the paper "Public Perception: Heritage Building Conservation in Kuala Lumpur" published in 2012, attempts to review Malaysian public's perception on heritage building conservation. The authors investigate about condition of heritage buildings and public participation and awareness about the heritage through surveys and interviews. Since the results show lack of awareness amongst people in Kuala Lumpur regarding their heritage, the authors feel promoting of heritage through mass media like newspapers, news, television, radio, social media and internet is essential. To make people aware and create sense of responsibility regarding the heritage, Heritage management and its importance should be a part of education system, where right from the school days, these values are imbibed. Participation from both government and non-government organizations is essential to protect, conserve and respect heritage.

Marlijn Baarveld and Marnix Smit, in the paper "Cultural Heritage in urban redevelopment projects :A framework to analyze collaborative strategies" published by " University of Twente- Department of Construction management and engineering, Netherlands" states about benefits of collaborative of the government, developers, financers, users and the society for a holistic re-development without loss of heritage and drastic alteration in the environment. This is because in re-development or new development interventions mutual dependency is the driving force which either would ease the task or make it more complex. Since this mutual dependency is mainly because of finances and raising funds the authors state that '*Balancing of costs and benefits is the only option to preserve cultural heritage'*. The statement is justified by presenting detailed analysis based on five urban re-development projects with built cultural heritage and the difficulties the stakeholders and investors face in planning process right from the start. It concludes with the fact that along with all aspects mentioned above, time is also an important criteria determining success of such projects and that it is hard to measure performance in case of urban re-development projects.

**8. METHODOLOGY:** For this research, three fold methodologies were used, which included:

8.1 Survey - Physical Mapping (of the selected city core area)
8.2 Semi structured interviews (to understand the resident, user perspective)
8.3 Passive observation (made at various times of the day and on various days)

*8.1 Survey- Physical Mapping:*

Base maps were prepared for existing structures, their land-uses, their age to gain a broad perspective about the character of Tulsibaug and understand the present scenario.

*8.2 a) Questionnaire Design:*

A semi structured questionnaire was used for survey to gather the primary data. It included 7 sections with series of both open and closed ended questions. This paper however will focus only on 4 sections to fulfill the objective of paper.

*8.2 b) Questionnaire Distribution:*

The interviews were held randomly is Tulsibaug, and were distributed randomly by 'Convenience survey'. Before questions were asked, the respondents were briefed on the objectives and the purpose of the survey. Due to manpower and time constraints, the subjects for this study included only 50 individuals. They were selected based on non-probability convenience sampling.

*8.3 Passive Observation:*

It was used as a tool to understand behavior of people in heritage premises, visual character of the place, cultural understanding etc. The way these heritage precincts are used, looked at or neglected, can clearly be understood by observing the users / visitors of the place.

## 9. DISCUSSIONS AND RESULTS:

### *9.1 Tulsibaug: Transformation and present state*

Tulsibaug has a rich history and has witnessed and sustained number of ever evolving activities. Tulsibaug, Once a place of spiritual significance, today is a shopper's paradise. The architecture and urban patterns are a reflection of social, cultural, political and economic conditions prevalent then. But over the years, these determinants of the urban fabric have transformed, altering the fabric and skyline. What could not alter with this transformation are few of the heritage buildings and precincts, today marginalized and which stay in a deteriorating condition.

Tulsibaug today is a typical Indian market with uncontrolled and haphazard developments, traffic snarls and sprawling activities. Once a garden known for its Tulsi/ basil plantations, because of which Tulsibaug derived its name, at present has new and insensitive developments planted around. Such was the shift in its character and the heritage associations it carried.

Physical mapping exercise was carried out to get a broad perspective about the present state, land use and character of Tulsibaug. Fig 03 shows the mapping of built and unbuilt, to understand the present urban fabric and morphology. The built masses have no visual character and harmony amongst each other along with no respect for the heritage precincts. Such blocks have come up in Tulsibaug altering its skyline. The developments around heritage buildings or old wada's have no regulated setbacks, thus overshadowing these treasures. The second map from fig 03 depicts mapping of buildings from different periods. This presents us the amount of development that has happened post 1900 AD. Taking no cognizance of the past and future, these buildings have come up in the most haphazard manner.

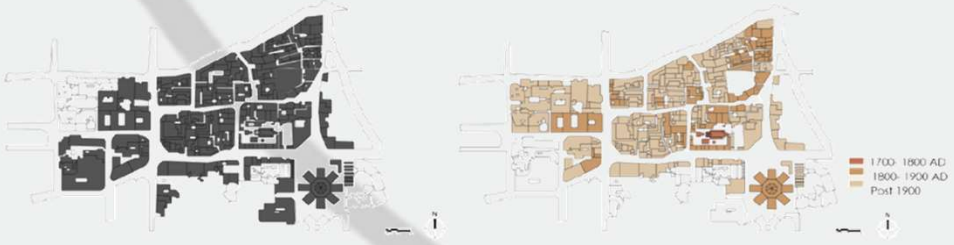


Fig 03: Mapping the built and un-built fabric and buildings according to eras (Source: Authors)

Fig 04 shows mapping of building typologies and the listed heritage buildings in Tulsibaug. The first map depicts maximum area covered under mix-used typology. This is because, many of the property owners have rented out the ground floor spaces to shops and for other commercial activities as a source of income generation. The growth of commercial areas is increasing with each passing year. Tulsibaug, earlier a place of leisure and then a residential zone now has only a little of residences left. These too are either wada's or newly developed residential buildings. The second map from the fig 05 depicts heritage buildings and precincts listed by INTACH or state archeological department. Few of the total 11 buildings are in good state and are been conserved. But these too includes only the main heritage buildings like Vishrambaug Wada, Ram Mandir or Belbaug, while other treasures are neglected since the people or government are not aware of it and are not taken cognizance of.

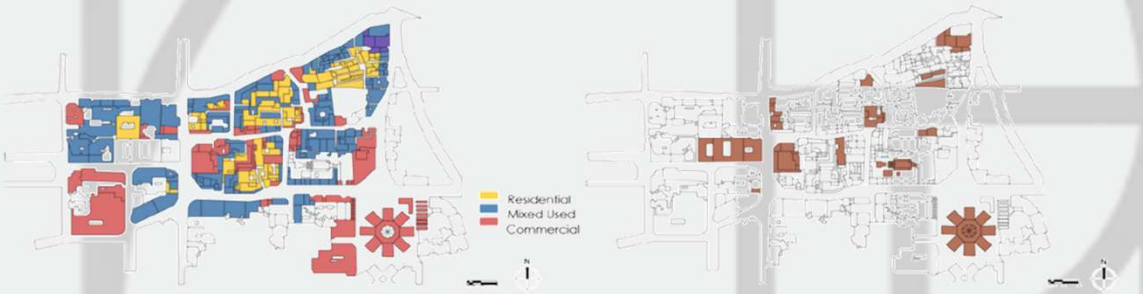


Fig 04: Mapping the building typology and listed heritage buildings (Source: Authors, INTACH, Pune)

*9.2 Results through questionnaire survey:*

i. The first section of the questionnaire was used to understand perception of people towards the heritage in Tulsibaug. Respondents were asked to select any one option out of 4 choices given. Fig 05 shows their opinions on why is it important to conserve heritage?

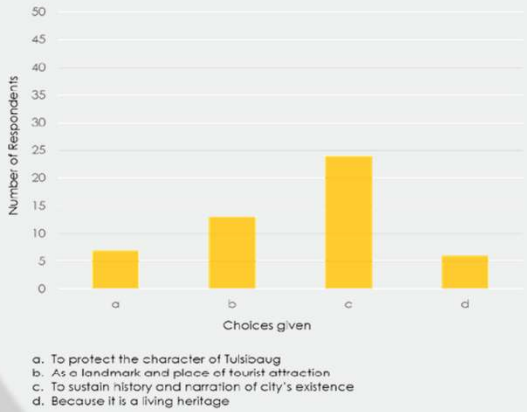


Fig 05: Bar graph depicting the opinions of respondents (Source: Authors)

During the survey, other reasons for why is it important to conserve heritage were received from public when asked this particular question. Most of the respondents i.e. 24 out of 50 (48%) people considered that conserving heritage is important to sustain history and narration of Tulsibaug's existence. Without the heritage character of Tulsibaug will be altered and diminished was their opinion. 7 out of 50 (14%) people felt it is essential to conserve heritage as a landmark and a place of tourist attraction, since this activity can result in revenue generation and then aid or funds by government can be allotted for heritage conservation.

This section of the survey was important to understand the definitions or ideas of people about conservation of heritage in Tulsibaug.

ii. The second section of the questionnaire was used to understand awareness of heritage buildings or precincts in Tulsibaug amongst the people. Respondents were asked to select any one of the 4 choices and list down the names of heritage buildings they knew in Tulsibaug. Fig shows the results.

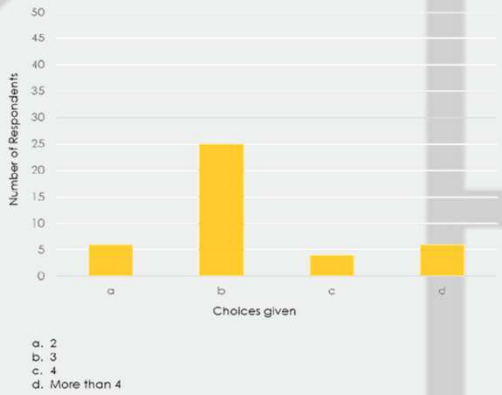


Fig 06: Bar graph depicting the opinions of respondents (Source: Authors)

The results show that most of the people i.e. 35 out of 50 (70%) knew about 3 heritage buildings in Tulsibaug, which included Vishrambaug Wada, Belbaug Mandir and Ram Mandir. Whereas 6 out of 50 (12%) knew only about Vishrambaug Wada and Ram Mandir. There were very less respondents who knew about other heritage buildings like Bhide Wada, Gandhi Nivas and Limbaraj Maharaj Mandir, etc. These were people who knew the area since they were a residing in Tulsibaug for a long period or had been a part of Heritage walks conducted by INTACH. The results thus present that there is lack of awareness amongst people about the rich heritage of Tulsibaug.

iii. The third section was to understand public reactions and perceptions about which section of the society plays an important role in protecting and conserving the heritage. Like the above two sections, people were asked to choose any of the 4 options.

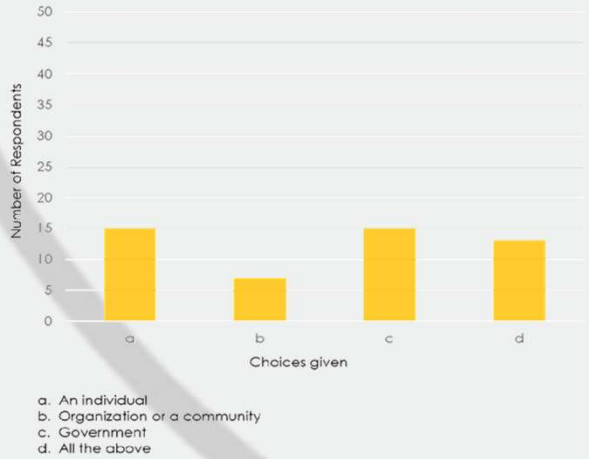


Fig 07: Bar graph depicting the opinions of respondents (Source: Authors)

The results show that 15 out of 50 (30%) people thought conserving heritage was individuals (property owner's) responsibility, while the rest of 30% respondents felt that it was government's responsibility to conserve the heritage. 13 out of 50 (26%) of the respondents thought that all the options were valid and it was responsibility of all sections of the society to conserve and protect the heritage.

iv. The fourth section of the survey aimed at knowing public perception about the deteriorating heritage. Respondents were given 4 choices and were asked to select any one. The results are shown in fig

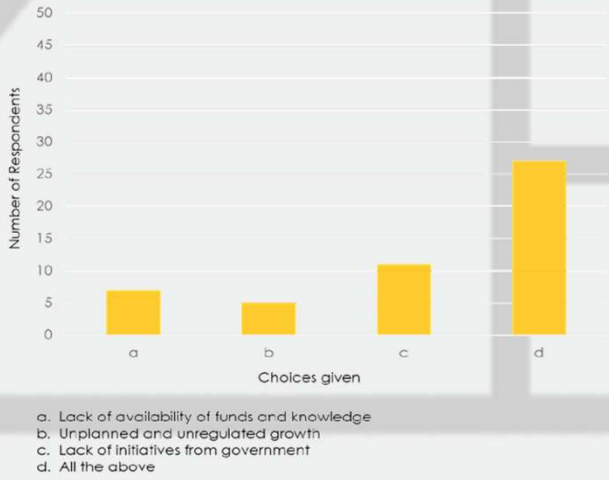


Fig 08: Bar graph depicting the opinions of respondents (Source: Authors)

The results show 27 out of 50 (54%) of the respondents felt deterioration and neglect of the heritage was due to all the listed reasons which included lack of availability of funds and knowledge for conservation of their heritage, unplanned and unregulated growth happening around the heritage buildings and precincts in Tulsibaug and lack of initiatives by government.

Thus, through this survey it was observed that majority of the people lack awareness about the heritage buildings in Tulsibaug along with lack of knowledge and guidance about conservation and management of their heritage. Thus, because of absence of knowledge or help, people who own heritage properties in Tulsibaug are either restoring it in a wrong manner, altering its character or are giving them away to developers in hope of better living conditions. Along with efforts to increase public participation and awareness, it is essential to find sources that would guide, fund and help people to restore and conserve their heritage. With the increase in availability of financial resources, one can witness change in the scenario with more people interested in conserving their heritage rather than demolishing it.

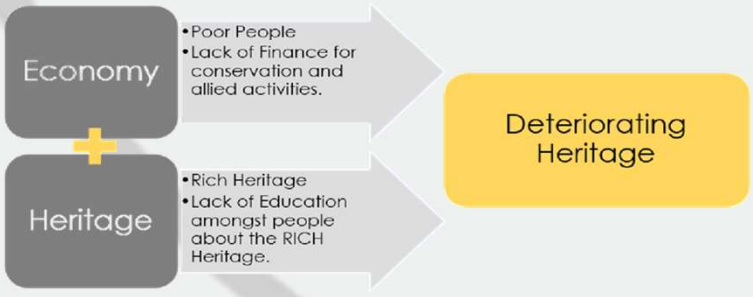


Fig 09: Relation between economy and heritage (Source: Authors)

*9.3 Passive Observation: Results*

The passive observations aimed at understanding the associations, concerns and perceptions of people, about the heritage in Tulsibaug. With lack of awareness amongst people, we find the facades of these treasures altered because of the commercial activities around. Amongst the stalls, lights, hawkers and the crowd it becomes next to impossible to identify the heritage buildings.

Old wada's like Patwardhan wada, Bhide wada, Pakhankhar wada are overshadowed because of these activities. Stalls are set in front of these buildings and their walls are used for display. Though been identified they still are not. Such is the sad state of heritage. Engrossed in shopping, people fail to notice these treasures. Modifications of the shops and insensitive and convenient use of its facades in Ram Mandir precinct has disturbed the visual harmony.

We exist in a constantly changing world and our cities and its people have adopted and adapted to changes, giving a little attention to these entities of past. (Debashish Nayak, Development and Community heritage, 2005) With no specific rules and laws on conservation of heritage precincts, apart from listed heritage structures other remain under the constant threat of developments. With the increase in undirected growth of urban patterns, the day may not be far away when Tulsibaug and such historic areas may be invaded by office tower and shopping blocks altering the existing skyline of the area.

A chain is only as strong as its weakest link. India being a democratic country, with freedom to express opinions, each individual in Tulsibaug, has its own say and take whether to or not to conserve and protect heritage. But the sad fact is, even though we believe in this freedom of opinion institution, we are experts at blindly following others. This scenario can be well observed in Tulsibaug, with wada owners giving away their properties to developers. As an exception, when an individual feels to respect this heritage, he is either restricted because of finance or pressure from the wealthy.

With such diversity of thoughts and ideas, rules and regulations and conditions it is essential to address the following concerns for better conservation of heritage and management in Tulsibaug:

a. Contextual addressing of issues and site specific understanding.
b. Defined role of agencies like INTACH, ASI, State archeology departments.
c. Active involvement of people and an urge to associate with the living heritage.
d. Holistic management of the heritage.
e. Awareness about heritage within people of Tulsibaug


Fig 10. Shops in the Ram Mandir precinct (Source- Authors)

## 10. CONCLUSIONS:

The studies and surveys of Tulsibaug, present that people have a little awareness about their heritage in terms of its existence, condition and importance. The heritage which has marvelous tales of the past are overheard in this commotion of insensitive development. Known as the wealth and prosperous spine of Pune, it is essential to answer, in what ways exactly have we become prosperous? And at what cost has this prosperity come? It is high time that we realize where exactly are we heading? And are we lost in this vast ocean of modernism that we have left our roots far behind?

Undeniably it essential to preserve and conserve these treasures of past, who have given us identity and shaped up the image of our city.

A journey of thousand miles begins with a small step. Thus, in order to conserve heritage and create awareness about it, it is essential for different sections of the society to put a foot forward and work collectively. Efforts from an individual and a society are necessary to develop a holistic approach, where we respect the past and welcome the future (the repurposed development).

## 11. RECOMMENDATIONS: *The "5 P" approach*

Management of heritage buildings in Tulsibaug cannot happen just by formulating rules and guidelines, just by creating awareness and sense of belonging in individuals or just by availability of funds or financial resources. We have to understand that these factors are interdependent and initiatives taken at all these levels and amalgamation of these factors can help us in conserving, protecting and respecting the heritage.

*What is the "5 P" approach about?*

a. **Political Will**: Change in the attitude towards development, and repurposing heritage
b. **Preparing Master Plan**: To become more comprehensive taking into account conservation and restoration in equilibrium with development
c. **Public Participation**: Getting community involved and making them more responsible
d. **Proper Monitoring**: Making local authorities accountable for monitoring and follow up
e. **Proper Law Enforcement**: There are existing laws which need to be implemented at every level


Fig 11. The "5 P" approach (Source- Authors)

*A problem shared, is a problem halved*. If all these elements think and work collectively, taking cognizance of each other, with realization of their roles and duties, heritage conservation and management will not be a concern, but a responsibility.

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vi. Inclusive India- Re: Pune, Action plan for a Proposed Urban conservation for Pune Historic city core (2011)

**ANNEXURE I: *Survey Questionnaire***

Name: _____

Age: _____

1. For how long have you been living / own a shop in Tulsibaug?

   a. 5-10 years b. 10-15 years c. 15-20 years d. more than 20 years

2. What do you associate Tulsibaug with?

   a. Ram Mandir/ Heritage precinct b. shopping destination c. Market

3. According to you what should be Tulsibaug known for?

   a. Its heritage buildings and precincts
   b. Markets and street shopping

4. How many heritage buildings do you know which are in Tulsibaug? List

   a. 2 b. 3 c. 4 d. more than 4

   Names: _____

5. What is the condition of heritage buildings in Tulsibaug?

   a. Good b. Bad c. Maintained d. Dilapidated

6. According to you should these heritage buildings be conserved?

   a. Yes b. No c. Other opinion : _____

7. Why is it important to conserve heritage?

   a. To protect the character of Tulsibaug
   b. As a landmark and place of Tourist attraction
   c. To sustain history and narration of city's existence
   d. Because it is a living heritage

8. According to you whose responsibility is it to conserve and protect heritage?

   a. Individual b. Organizations c. Government d. Others

9. According to you what is majorly responsible for deteriorating heritage?
   a. Lack of availability of funds and knowledge
   b. Unplanned and unregulated growth
   c. Lack of initiatives from Government
   d. All the above

# MATERIAL AND ADVANCED TECHNIQUES TRANSFORMING RECOVERED POLYMERS INTO BESPOKE BUILDING COMPONENTS: HARVESTING LOCAL PLASTIC WASTE FOR BUILDING MATERIAL

**Architect Chris Thurlbourne**
**Aarhus School of Architecture, Aarhus, Denmark**

**Abstract:**

The paper will present how a partnership with Aarhus School of Architecture, Denmark, and Udaipur Municipality - under the Smart City programs, has produced a plenum of knowledge for:

a. Identification of waste plastic types and sources, together with experiments into processing the material for preparation

b. Development of new building component types using plastic waste, and knowledge transfer for local production

c. Establishment of a knowledge 'incubator' and live testing in both India and Denmark to address specific brief requirements

d. How new technology in digital fabrication techniques can be combined to craft specific building parts from recovered plastic waste into architecturally refined building components

e. Demonstration of how sustainable tectonics of waste material can solve complex urban regeneration challenges

The paper will describe how, through project and material development, complex challenges to improving the urban landscape can serve as catalysts for processing and reusing locally discarded plastic wastes and open up new business opportunities and job creation in the construction industry.

***Keywords:*** *Circular resource efficiency; Architectural and urban sustainable design; Sustainable tectonics; Recovered Plastics*

## INTRODUCTION / BACKGROUND

### Why Plastic?

Imagine a world without plastic? Maybe environmentalists dream of such a scenario, but a world without plastic as a material is almost unrealistic simply because the ductility and strength has, and is, contributing considerably to the advancement of our modern environment. Like it or not. Just taking medical implants as one example, plastics are used in hip-joint replacements, pacemakers and new lenses for cataract patients. The list can be considered almost endless. There is however considerable concerns in respect to the long term effects of plastic circulating in our society and environment. More significantly there are concerns microplastics[1] are harmful to humans.

Because plastic is such a persistent material, the ecological, economic and eco-toxicological effects of plastic pollution are all long-term. These include:

Physical impact on marine life: entanglement, ingestion, starvation

Chemical impact: the build-up of persistent organic pollutants like PCBs and DDT

Transport of invasive species and pollutants from polluted rivers to remote areas in the ocean

Economic impact: damage to fisheries, shipping, and tourism

In recent years, the amount of attention focused on very small plastic particles, i.e. plastic fragments resulting from the breakdown of larger plastic debris at land and sea.[2]

[1] https://en.wikipedia.org/wiki/Microplastics
[2] https://theoceancleanup.com/faq/what-are-the-long-term-effects-of-plastic-pollution-in-the-oceans/

But do the disadvantages and effects of using plastics out way the advantages. And more importantly however, what is the substitute? It is important to acknowledge that it is impossible to make something out of nothing. Simple reasoning. This also points naturally towards the art and/or science of alchemy that could serve as a good historical reference. The alchemist's first law of Equivalent Exchange is:

> Humankind can not gain anything, without first giving something in return. To obtain, something of equal value must be lost.[3]

This is the paradox society has been met with in respect to extinguishing plastics from further production. To adopt the opinion that plastics will not go away, simply because it is here, has proved its worth - and substitute materials have so far little traction to compete with the advantages of plastics – is potentially a more productive mindset than attempting to eliminate plastic from our environment. According to Deutsche Welle, there is 83 billion tons of plastic in the world[4]. 83 billion tons will not just go away. My research interest however is not concerning study into alternatives to plastic, but to give value and reason to reprocessing what today is considered waste, and reintroduce it into production to reduce production of virgin polymers. Through case studies described in this paper, I discuss an approach to thinking of already produced plastics as a potential resource, rather than a burden. My main focus of interest is recovered plastics for new architectural building components and focus on establishing an approach that is embedded in studies that go beyond practical, pragmatic mindset, but is an attempt to bring recovered plastic materials into a palate of quality materials to promote and facilitate good design aesthetics.

**Palingenesis**

Palingenesis is the concept of rebirth or re-creation that has been used in various contexts in philosophy, theology, politics, biology and other humanities. Its meaning stems from the Greek words palin, meaning 'again', and genesis, meaning 'birth'[5] . It's concept in short is the belief one can bring things back to life by burning them. The English physician-philosopher Sir Thomas Browne in his Religio Medici (1643) declared a belief in palingenesis when stating:

> A plant or vegetable consumed to ashes, to a contemplative and school Philosopher seems utterly destroyed, and the form to have taken his leave for ever: But to a sensible Artist the forms are not perished, but withdrawn into their incombustible part, where they lie secure from the action of that devouring element. This is made good by experience, which can from the ashes of a plant revive the plant, and from its cinders recall it into its stalk and leaves again[6]

The mindset of a belief one can bring things back to life by extinguishing them – or rather the mindset that one can bring existing plastic products back to life by burning them – could bring traction into understanding existing plastic products more as a resource. Incinerating however is to deny the material the possibility for reinvention. Collecting, cleaning, shredding, melting however can provide raw material for further future use and could claim to be a modern translation of Palingenesis, the concept of rebirth or re-creation. But we need to avoid repeating the same mistakes of the past, where production is

[3] https://www.urbandictionary.com/define.php?term=equivalent%20exchange
[4] https://www.dw.com/en/there-are-83-billion-tons-of-plastic-in-the-world/a-39765670
[5] https://en.wikipedia.org/wiki/Palingenesis
[6] Browne, Thomas. *The Major Works*. Patrides, C. A. (ed.). Penguin, 1977, R.M.1:48.

determined by demand alone. To fully grasp and appreciate the inherent value of existing plastics as a resource one needs to in effect go back to the study of plastics to help redefine how this material, although recycled, could provide new ways of application and appreciation, and in this way I attempt to introduce a value through understanding the inherent tectonics of the material – not necessary the assembly and composition of materials to resolve the challenges of gravitational pull and building assembly, but the composition of the material in question. To explore, metaphorically speaking, the materials inherent DNA as a means to achieving a high level of architectural design articulation and detail.

**On the origin of species**

During the Victorian era (1837-1901) it was normal, or fashionable, for aristocracy to own a billiard table. Billiard balls were crafted from ivory. Hunters had however reduced elephant herds so dramatically that ivory was becoming scarce and expensive. By 1863 the shortage of ivory had become such that a billiard ball manufacturer from New York, Michael Phelan[7], offered a 10.000USD prize to the person that could provide an adequate and economical substitute. The declared winners were John Wesley Hyatt and his brother Isaiah[8]. They apparently never received the prize money, but they invented a material that formed the foundation for modern plastics, Celluloid. With a mix of cellulose nitrate and camphor The Hyatt's developed a technique of heating the chemicals so they became soft and malleable, but at normal temperatures were hard, strong and permanent. It was thus a plastic that could be created by modifying natural materials in specific ways. This technique 40 years later was developed by the Belgian chemist Leo Baekeland in 1907, who is seen today as the inventor of modern plastics.

Leo Baekeland, in 1907, developed the first synthetic polymer that he named Bakelite. Baekeland was a successful chemist. He developed a chemically coated light sensitive photographic paper called Velox, later selling the rights to Kodak for 1M US dollars in 1899. This formed a safe financial cushion for further experimentations, and in 1907, combining phenol, a bleach, with formaldehyde, invented Bakelite. 11th July of that year he wrote:

"Unless I am very much mistaken, this invention will prove important in the future."[9]

Bakelite is made from combining a common disinfectant, phenol, a crystalline mass extracted from from coal tar[10], with formaldehyde, a gas produced by oxidation of methanol or methyl iodide[11]. The strength and ductility of this new material, combined with the low cost of production, made it ideal for manufacturing. In 1909, Bakelite was introduced to the general public at a chemical conference. Interest in the plastic was immediate. Bakelite was used to manufacture everything from telephone handsets and costume jewelry to bases and sockets for lights bulbs to automobile engine parts and washing machine components[12].

To produce this new polymer Leo Baekeland needed both a laboratory, and a bespoke vessel. Located at The Smithsonian National Museum of American History, Washington DC, USA is this vessel, The Bakelizer, the steam

[7] https://en.wikipedia.org/wiki/Michael_Phelan_(billiards)
[8] https://en.wikipedia.org/wiki/Michael_Phelan_(billiards)
[9] https://thepatentprofessor.com/it-will-not-burn-it-will-not-melt-insights-into-one-of-the-greatest-inventors-of-of-the-20th-century/
[10] https://www.dictionary.com/browse/phenol
[11] https://en.wikipedia.org/wiki/Formaldehyde
[12] https://www.thoughtco.com/story-of-synthetic-plastic-1991672

pressure vessel fabricated to facilitate the chemical reactions needed to form the thermosetting resin Bakelite. It was affectionately referred to as 'Old Faithful'[13]. November 9, 1993, The Bakelizer was designated as a National Historic Chemical Landmark. At the inauguration the lights dimmed as Arthur P. Molella stepped to the lectern to express his appreciation for the great honour bestowed on the Smithsonian Institution by the American Chemical Society. "I must say," began Molella, head curator of science and technology for the Smithsonian's National Museum of American History, "I've always been awed by the homeliness of that artifact." The object of his affection certainly looked the part. Squatting in a corner like a cement mixer was a 6-foot-tall, egg-shaped, fat iron object on a heavy metal stand. No wonder the Smithsonian keeps stuff like this in the basement. Appearances, however, were deceiving, for Molella's audience was in fact gazing at the original "bakelizer" - the apparatus used by Leo Hendrik Baekeland to make the world's first plastic - bakelite, of course. On Nov. 9, the chemical society, composed of 145,000 Americans who mix things in test tubes for a living, designated the bakelizer as the "First National Historic Chemical Landmark."[14]

Figure 1: The Bakelizer. https://bakelitegroup62.wordpress.com/

What is significant here is the 'Old Faithful' is treated as an object of fascination and affection and that the appearance is a strong factor for this warmth. This has direct parallels to the architectural profession, where architects aspire not only to design a building that works, but to make a piece of architecture that is both an aesthetically well designed commodity, but also a building that is well appreciated for what it is. However buildings are often seen as Jeffrey L. Sturchio, chairman of the society's History of Chemistry Division, said at the inauguration in respect to The Bakelizer, "So many things that are a part of our lives go largely unnoticed."[15]

And is this not also the epitome of plastic today, that it goes largely unnoticed? When I subtitle the section of this paper, 'On the origin of species', I make reference to Charles Darwin's book of the same title[16]. But it is the title itself that is of interest here. On the origin of species. Both the origin that I unfold above, but also the species that it has been manufactured, or unfolded. As an architect I prefer to expose and explore material as though it had an origin (historically), and is a species – that the composition of the material in question and its inherent DNA, metaphorically speaking, should and could be a means to achieving a high level of architectural design articulation and detail.

[13] The Bakelizer: National Museum of American History, Smithsonian Institution : a National Historic Chemical Landmark, November 9, 1993. American Chemical Society, 1993

[14] The `Egg' That Hatched Plastic Society Designates Homely `Bakelizer' as Chemical Landmark
By 1993, The Washington Post. https://www.questia.com/newspaper/1P2-32840971/the-egg-that-hatched-plastic-society-designate

[15] The `Egg' That Hatched Plastic Society Designates Homely `Bakelizer' as Chemical Landmark
By 1993, The Washington Post. https://www.questia.com/newspaper/1P2-32840971/the-egg-that-hatched-plastic-society-designate

[16] https://en.wikipedia.org/wiki/On_the_Origin_of_Species

**Dissecting the species**

For plastics to be able to be reused there is the argument that, due to the many types of polymer types, the first step is sorting. Polymers perform in different ways and have different melting points meaning it is difficult to use if they are mixed. In Denmark, where I am based, there has always been a good tradition into environmental awareness, and a culture for recycling and reusing products. Denmark, for example, has one of the lowest rates of landfill – landfill being the consequences of not recycling waste. Only between 5-6% of waste goes to landfill, and the percentage is falling. This is due largely in part to a combination of landfill taxes, and a ban on all waste that is suitable for either recycling or incineration, where energy can be recovered[17].

> Denmark has a high environmental protection level and thus establishment of new landfills requires careful environmental and technical evaluations of the suitability for waste disposal of the selected location, which has become a well-developed discipline in Denmark. Once established the operation and completion of landfills includes procedures for acceptance of waste and on-site verification, building-in waste, monitoring, leachate collection and treatment, closing down landfills and completion of aftercare period[18].

Maybe this is also in part due to the country is small in size, there is not an oasis of land unlike India for example. (See Case Study 3: Research:Live2//Smart Cities). Land is precious. Either way there is a very good sorting, recycling and reprocessing plastics in Denmark. Plastic types are therefore collected, sorted and reprocessed, taking the raw material back to granular composites and sold for production for new, recycled, products. Below are three cases studies that I unfold, and are comparative because the first – Case Study 1: Research:Live2//façade moulding - uses this base product described above, and the second – Case Study 2: Research:Live2//curtain shingle - we source waste plastic and shred ourselves, both giving different characteristics of the final architectural components that we have designed and produced. In the first two cases it is under the pretext written above, where plastic is understood as a species – that the composition of the material in question and its inherent DNA, metaphorically speaking, is a means to achieving a high level of architectural design articulation and detail. In Case Study 3: Research:Live2//Smart Cities, we use the knowledge accumulated in the first two and apply it to a specific complex urban regeneration challenges and describe how, through project and material development, complex challenges to improving the urban landscape can serve as catalysts for processing and reusing locally discarded plastic wastes and open up new business opportunities and job creation in the construction industry.

**Case Study 1: Research:Live2//façade moulding**

Due to the exposure of buildings facades to external weather conditions, in this case study we chose to use polycarbonate plastic[19] as a material of study. As an architect it was also a preferred material as a reaction against a housing trend of polycarbonate covered carports that have littered our suburbia. We offer an alternative view on how to reuse these eyesores

[17] https://dakofa.com/element/landfilling-in-denmark/
[18] https://dakofa.com/element/landfilling-in-denmark/
[19] https://en.wikipedia.org/wiki/Polycarbonate

once they have been subjected to wear and tear and need to be replaced. The polycarbonate panels often used for domestic carports are blue tinted so we have endeavoured to source recovered polycarbonates with a similar colour.

The material was sourced from a recycled plastic processing company. They received the discarded polycarbonate from various sources including domestic waste, and through a process of shredding, washing and heating, produce an end product of granular composites that are pure in their make-up, and clean. Ready for another round of mass produced products. Our interest started there with looking at ways of heating and casting the granular composites that emphasised the methodology of production – a kind of tectonic study approach whereby the act of making became the aesthetic of the product.

Denmark has a long tradition, whereby the outer skin of buildings are seen as a climatic barrier protecting the inner layers of moisture and temperature variations, like a skin protecting the building within. Traditionally the preferred material has been brick as clay can be locally sourced. Due to advancements in building demands – higher constructions, sustainable agendas, internal comfort, especially natural daylight – other materials are being adopted, normally using a dry assembly technique and promoting prefabrication. Panels. Our research development was to begin tests into using recovered plastic as a potential cladding, with a focus on the statement of intent written above, i.e. plastic to be understood as a species – that the composition of the material in question and its inherent DNA, metaphorically speaking, is a means to achieving a high level of architectural design articulation and detail.

Figure 2: Example of jig used for applying compression on plastic at predetermined positions. Photo. Chris Thurlbourne

For polycarbonate to be remoulded it needs to be heated to temperatures in the region of 200-230 degrees for it to become soft, but not burn. Form making through extrusion is common practice, but we chose a more straightforward approach, namely melting in formwork under predetermined compressions. We developed therefore a series of jigs that could be placed in the oven whereby we were able to apply compression on the plastic at predetermined positions. This created different deformations on the plastic product where it was possible to record the act of melting and compression. The results were such that the plastic product, in this case a cladding for a building façade, began to record the process of fabrication and at the same time project polycarbonate plastic products (artefacts) as a handmade, crafted material akin to handmade clay products for example. Once we had understood the range of possibilities by testing for example various mould material types, pre-load compression, post compression and temperature variation, we then designed and built a 1:1 prototype for the purpose of demonstrating and developing new building component types using plastic waste (Polycarbonate), and establish a mock-up of a cladding system to promote knowledge transfer for local production. This is still ongoing.

Figure 3: Polycarbonate façade cladding prototype. Photo. Chris Thurlbourne

**Case Study 2: Research:Live2//curtain shingles**

Following from Case Study 1 we began looking at another plastic type, namely High Density Poly Ethylene, or HDPE as it is referred to.

> High Density Poly Ethylene (HDPE) is a thermoplastic polymer made from petroleum. As one of the most versatile plastic materials around, HDPE plastic is used in a wide variety of applications, including plastic bottles, milk jugs, shampoo bottles, bleach bottles, cutting boards, and piping. Known for its outstanding tensile strength and large strength-to-density ratio, HDPE plastic has a high-impact resistance and melting point[20].

HDPE has a very high strength to density ratio and is very resilient. It is also often produced as a translucent material and is very flexible. These qualities tended our research into testing new architectural components that could benefit from these qualities. As daylight is an important element in designing building and spaces here in Denmark we developed a design approach of studying how smaller, flexible HDPE plastic components could be made and articulated as a filter between inside and out. How again the inherent qualities of the material, and the processes of making, could both be revealed in the final product, but also exposed and utilised as an architectural daylight/sunlight screen.

In this case study we chose to source, prepare and shred the material ourselves, rather than sourced from a recycled plastic processing company. To achieve this we needed to make a shredder. This felt like walking the footsteps of Leo Baekeland and his "Old Faithful". We wanted to compare production technique results using industrially sourced recovered plastic and unprocessed recovered plastics. Our machine produced plastic flakes that were more variant in size than the polycarbonate granular composites. They ranged from approximately 2-10mm. We were also less rigorous in sorting and cleaning. Labels

[20] https://www.acmeplastics.com/what-is-hdpe

from previous use for example were allowed through the shredder. Our material sources were all domestic waste and ranged from cleaning liquid containers, to plastic plant pots.

Figure 4: The Shredder. Photo. Chris Thurlbourne

For HDPE to be remoulded it needs to be heated at slightly lower temperature than polycarbonate, in the region of 200-degrees, for it to become soft but not burn. We chose a different production technique whereby we endeavoured to melt and form panels with a consistent surface finish, but as thin as practically possible. We chose therefore a post-production compression technique, whereby the plastic flakes were placed in a form, softened in an oven and then pressed into shape after being removed from the oven, but still soft. Here we could achieve relatively thin panels – shingles – that are lightweight, flexible and offer a good degree of transparency. When allowing light to come through the shingles the composites of the material are revealed. We choose to mix colours of the HDPE flakes along with different degrees of flake transparency. This was possible because we sourced many product types, from plastic bottles, plant pots and cases. This was a way of presenting the materials composition that became too different degrees visually apparent depending on the way light was invited to fall in and through the shingles. We developed therefore HDPE shingles that could offer a light screen, like curtains, to spaces with specific attention to achieving a high level of architectural design articulation and detail that would contribute to the quality of spaces in question. Due to the lightweight and flexibility we also developed a system of HDPE shingles whereby the shingles could be modulated to open and close, depending on the light conditions. The prototype made was for an exhibition space and we choose to install the work inside the space but as a screen to the large floor to ceiling

Figure 7: Shingle cladding exhibition façade. Photo. Chris Thurlbourne

windows. The movement was therefore achieved by mechanical means. Other options explored were externally fixed HDPE shingle panels where wind could articulate the hinged shingles.

Figure 5: Shingle cladding

Figure 6: Shingle cladding model façade. Photos. Chris Thurlbourne

**Case Study 3: Research:Live2//Smart Cities**

On 11th April 2018 Aarhus municipality, together with the Aarhus School of Architecture (AAA) made a memorandum of agreement with Udaipur municipality under the umbrella of the Smart Cities program. The agreement was titled: 'Joint Project on Sustainable Urban Water management under the Memorandum of Understanding between the City of Aarhus and the City of Udaipur'. The specific role of AAA was to provide assistance into how to address the complex urban regeneration challenges along a stretch of the Arad River running through Udaipur. Today the river is not being meaningfully utilized as a contribution to the urban fabric, beyond being a glorified waste deposit area. The challenge therefore was to develop ways of bringing the river back into play as part of an urban leisure area. Due to a strong sustainability agenda laid out within the Smart Cities program our work focused on researching how disposable waste can be reused, rather than sent to landfill. There is an abundance of plastic waste circulating throughout in the western Indian state of Rajasthan and the rest of India and so the research work developed in Case Study 2 became relevant, namely the identification of waste plastic types and sources, together with experiments into processing the material for preparation. Through local knowledge and quick screening we were convinced there was ample plastic waste to be sourced within a 10km radius of the river. The research therefore focused on the following three agendas:

1. Developing new building component types using plastic waste, and demonstrating how new technology in digital fabrication techniques can be combined to craft specific building parts from recovered plastic waste into architecturally refined building components

2. Establishment of knowledge 'incubators' through testing and mock ups to demonstrate how sustainable tectonics of waste material can solve complex urban regeneration challenges
3. Development into knowledge transfer for local production, and how complex challenges to improving the urban landscape can serve as catalysts for processing and reusing locally discarded plastic wastes and open up new business opportunities and job creation in the construction industry

Research development took the starting point in providing knowledge and design of urban regeneration through a masterplan of the model stretch of 1.5km of the Arad River utilizing the familiar approach of design through disassembly – namely providing design proposals whereby material needed for construction is able to be salvaged and reused when the design project is no longer needed. Material decisions became therefore a leading factor identifying opportunities of recovering waste plastic, and sourcing recovered bamboo. Bamboo is a very strong and resourceful material with a building tradition of reuse many times. The overall design principle was therefore adopting recovered bamboo for structural and spatial design, and design jointing clamps that could be configured to offer many varieties of form making through assembly. With the aid of new technology in digital fabrication techniques advanced jointing clamps could be formed using recycled plastic.

Figure 8: Masterplan. Arad River, Udaipur, India. Photo. Chris Thurlbourne

With research work developed in Case Study 2, we developed a process for assembly whereby knowledge transfer for local production could easily be disseminated – by providing both knowledge, and a physical kit of parts. This kit consists of instructions for making locally constructed plastic shredding machines that could be put together to provide opportunities for onsite shredding of collected plastics. Once the plastic has been prepared it will therefore be possible, again locally, to begin production of the bespoke jointing clamps designed in parts that could be put together in numerous configurations thereby offering many varieties of form making through assembly. The specific research task was therefore to design and manufacture aluminium moulds for plastic injection moulding. As the design task was focused on offering variety of assembly configurations – and complex 3 dimensional geometry digital fabrication techniques of designing and making were adopted.

The research production to date has focused on establishing a library of design possibilities from few component parts with a design manual of potential implication on the Arad River model stretch.

Figure 9: Arad River, Udaipur, India. Photo. Chris Thurlbourne

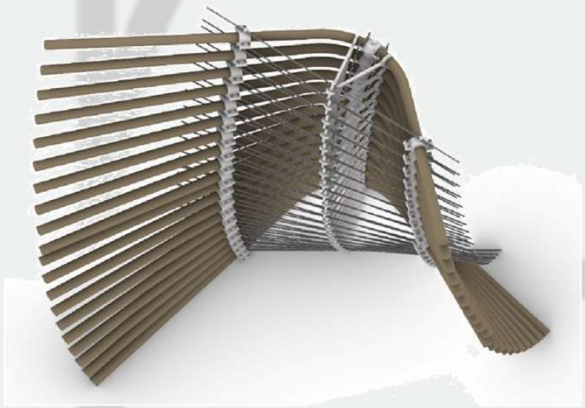

Figure 10: Design prototype. Arad River, Udaipur, India. Photo. Chris Thurlbourne

**Conclusion**

The three case studies above present methods of research by design and production demonstrating potentials in seeing plastic waste more as a resource rather than a burden. The research is still ongoing where we will begin exploring other plastic types and potential applications. In the research presented in this paper there is a strong emphasis, or end goal, on knowledge transfer for local production and establishments of knowledge 'incubators' that can facilitate live testing, thereby taking the research beyond paper by reaching out to a building industry for further development and application. It is this forum of the construction industry which is surely where this knowledge belongs.

# FACTORS AFFECTING THE MICROCLIMATE IN THE CITY CORE AREA OF PUNE CASE STUDY: PUNE

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**Abstract:** The modern city of Pune has many distinct neighbourhoods. These include the numerous peths of the old city on the eastern bank of the Mutha River. Peths are considered to be the cultural heart of Pune. The Old Wadas (residential units) are getting replaced by high storied buildings. The constant development is leading to increase the number of buildings and reducing the open areas of the neighborhood and it is also affecting the resident's activities. It is important to maintain the existing city fabric and developments should be made considering the environmental factors as well. The selected area for the study is Rasta Peth a planned in grid iron pattern in the early 19th century. The aim was to study the development in dense areas of Pune (City Core Area) from environmental perspective. The methodological approach was to conduct survey to understand the micro-climate of the area which included measuring temperature, onsite vegetation and wind analysis, further the existing neighbourhood is simulated in Envi-MET V4.4.1 software to understand the existing built form of the neighbourhood, its effect on the users and the climate. From findings, it can be concluded that in a residential neighbourhood built form only cannot support the liveability of its residents. The traditional façade pattern gives a particular identity and character to the neighbourhood and sense of belonging as well.

***Keywords:*** *Open spaces, residential neighbourhood, activities, attachment.*

## INTRODUCTION

Characteristic of Indian cities is known by its architectural and cultural significant buildings like Temple, Church or a Mosque, and residential areas around them. Historic traditional buildings in the core areas of the cities and towns play a very important role.(P.Gopalakrishnan , G.Subbaiyan June 2012) Many issues are generated while developing the core areas that include old buildings, the problem is generated while regenerating these areas or integrating new developments into the existing fabric of the city core area.

Most of the cities in India have focusing on conventional infrastructure requirements, many cities are still discovering how to deal with the challenge of urban renewal in a broader sense. These city centres are not only valuable old assets but opportunities for Revitalization of local economic development and national cultural identity. (P.Gopalakrishnan, G.Subbaiyan June 2012)

The social life of urban form refers to how cities are structured as spatial environments around and through social relations, practices, and divisions. Hence, urban form is not only about buildings and spaces between them, skylines and city boundaries but also about densities and distribution of people and functions, the spatial relationship between social groups, spatial markings of legal boundaries and entitlements, urban environments and the submerged or social infrastructures that shape and segment them (Tonkiss, 2013). The scales at which urban form can be considered or measured include the individual building, street, urban block, neighbourhood, and city. (Jenks and Jenks, 2009).

## BACKGROUND

Pune is situated at approximately 18° 32" north latitude and 73° 51" east longitude. The city's total area is 15.642 sq. km. Pune lies on the western margin of the Deccan plateau, at an altitude of 560 m (1,840 ft) above sea level. Pune has a hot semi-arid climate bordering the tropical wet and dry with average temperature varying from 20-28°C. The city experiences three seasons; summer, monsoon, and winter. Typical summer months are from March to May, with maximum temperatures ranging from 30-38°C. The monsoon lasts from June to October, with moderate rainfall annually averaging to 741 mm. Winter begins in November. The daytime temperature hovers around 28°C while nigh temperature below 10°C for most of December and January, often dropping 5 to 6°C.

The modern city of Pune has many distinct neighbourhoods. These include the numerous peths of the old city on the eastern bank of the Mutha River. The peths form the heart of Pune city, and are referred to as the old city. They are

considered to be the cultural heart of Pune. (*Peth a place for traders and craftsmen and their residential units wada).*The *Old Wadas* (residential units) are getting replaced by high storied buildings. The old structures in the city core area of Pune had front court, central court and backyard. Each unit had their own open spaces which maintained a balance between the open spaces and the built environment. The constant development is leading to increase the number of buildings and reducing the open areas of the neighborhood and it is also affecting the resident's activities. It is important to maintain the existing city fabric and developments should be made considering the environmental factors as well. The selected area for the study is Rasta Peth a planned in grid iron pattern in the early 19th century.

The lack and poor quality of open space in urban neighborhoods can be a serious restriction for the wellbeing of the inhabitants as it does not support developing healthy life-styles, including spending time outdoors, walking, playing, *etc.* Spending time outdoors importantly reduces the exposure to indoor air, which is often polluted by the use of different artificial materials. (Katarina Ana Lestan 2014).

**SIGNIFICANCE OF STUDY:**

The historic core of Pune is neglected, despite of rich cultural – historical value and evidence of the city's past for future generations. These assets are not taken into consideration in development plan of the city. Pune has many distinct neighbourhoods. The constant development is leading to increase the number of buildings and reducing the open areas, which is also affecting the resident's activities.

The building by laws and their successive modifications have consistently increased the allowable FSI (Floor Space Index or lately termed as FAR: Floor Area Ratio) in the core city. This results in increased land values and more pressure on the property owners to redevelop their old buildings. With increase in the FSI, this portion of remaining property goes on increasing, thus the probable profits from redevelopment, increasing the pressure to demolish the old buildings. The problems in the core city area have increased with no comprehensive traffic policy and no provision on effective mass transport in the city. Road widening is the only tool used to address the traffic problems. This has taken a toll on the buildings in the core city abutting narrow roads. Infrastructure redevelopment has not kept pace with private redevelopment. So there is over load on all kinds of infrastructure. Due to all this, life in city is perceived difficult, compared to the perception of a better life in the suburbs.

These existing fabric and traditional architecture keeps the surrounding cooler due to courtyards and tree plantations. The paar not just acts as gathering point but it shades and cools the surrounding and helps in the maintain the micro climate of the neighbourhood. The narrow plots and dense placement of them keeps the air temperature cooler. The vernacular architecture of Pune city needs to be maintained.

**ARCHITECTURAL CHARACTER**

At first glance, the character of Pune's core city appears to be chaotic, however looking a bit closer, one discovers unique characteristics and several quite particular pattern. Most of the traditional houses are deep, with narrow facades facing the streets. This pattern of building and courtyard is the most important feature of the building typology of Pune's core city area. The streetscape rarely opens up into an open space or parks. The shared life of the city is instead focused on the spaces just in front of the houses, porches or platforms called katas. Places around the monuments such as temple areas, in chowks and holy places squeezes into the cityscape. Typical meeting points are the paars, (*platform built around a tree with a small shrine beneath it).* These features form an important part of the cityscape. The walkable scale of the neighborhoods incorporates all the important basic needs and spiritual activities into everyday life. These intangible values of how life is lived within the city and oriented around these holy places are irreplaceable.

Fig.1 Paar sitouts

Fig.2 Typical street in Pune

Fig.3 Internal lanes of a neighborhood

Fig.4 Temples at intersections in Pune

**STUDY AREA**

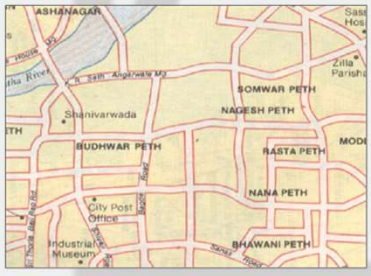



Fig.6 Map of Pune

Fig.7 Map of Rasta Peth

The selected area for the study is Rasta Peth a planned in grid iron pattern in the early 17th century. The neighborhood is a residential neighborhood. It is characterised by architecturally and culturally significant buildings such as a Temple or a Mosque, and the old residential structures. Traditional old buildings in the neighbourhood play an important role. There are many old structures more than 80-100 years old each of the unit has its own front yard or porch in a different way for few it acts as evening gathering point to sit and gather few act like a common place between shared residential units. The front yards are also used for parking night time. The social life of this neighbourhood refers to how cities are structured as spatial environments around and through social relations, practices, and divisions. Hence, this urban form is not only about buildings and spaces between them and skylines but also about densities and distribution of people and functions, the spatial relationship between social groups, urban environments and the social infrastructures that shape and segment them .The old structures have front court, central court and backyard which maintained a balance between the open spaces and the built environment. The constant development is leading to increase the number of buildings and reducing the open areas of the neighborhood and it is also affecting the resident's activities.The analysis of existing fabric of the neighbourhood and upcoming developments. The purpose is to obtain development proposal for dense areas of Pune city or similar type of development to maintain the existing fabric and the character of the city.

Fig.8 Shadow Pattern of the Neighbourhood.

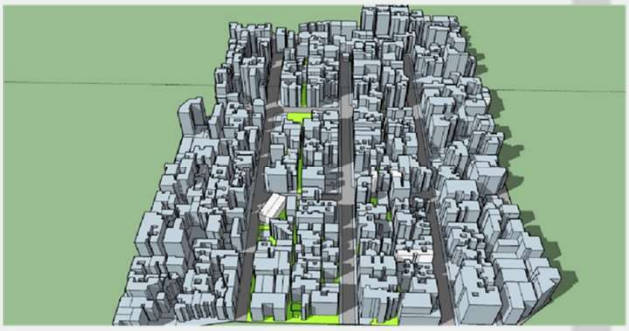


Fig.9 View showing the Morphology of the Neighbourhood.

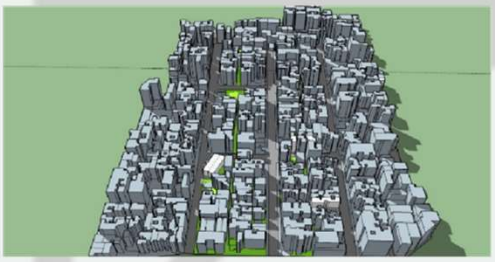


Fig.10 View showing the shadow pattern

Fig.11 View showing the shadow pattern along the street

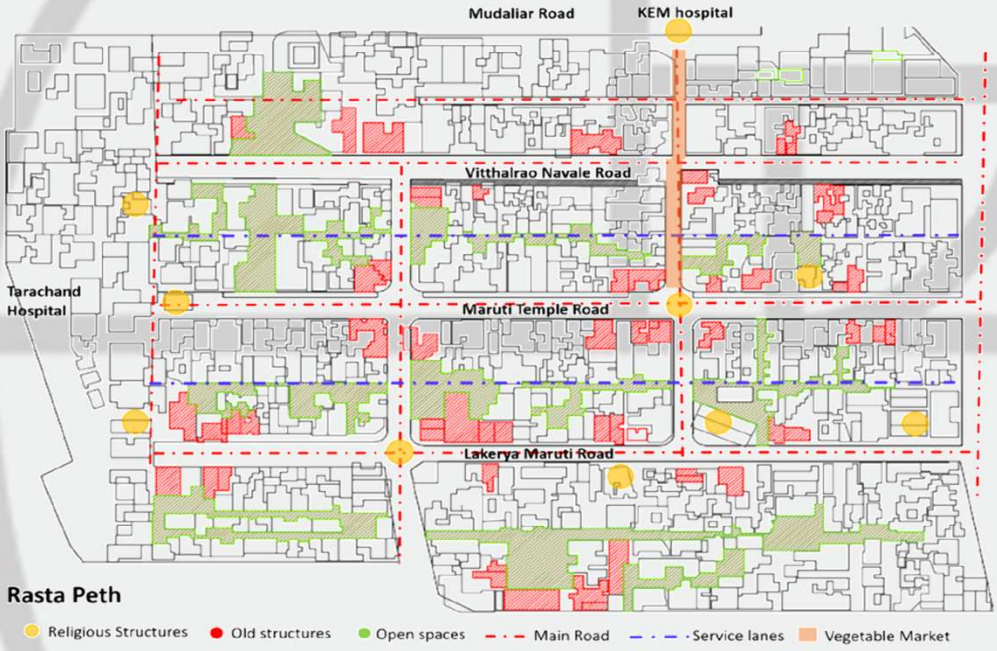



Fig.12 : Map of Rasta Peth

**RESEARCH METHODOLOGY**

The research was conducted with three methodological phases which consist of mapping of existing fabric, studying the built unbuilt area, studying the morphology and microclimate analysis of the area, understanding the existing and new developments in the study area.

**Data collection:**

The data was collected from primary and secondary data sources. The primary data was collected by interviews, questionnaires, activity mapping and observation. Secondary data was collected from journals, articles and internet. The data collection focuses on the types of existing development and upcoming developments in Rasta Peth Neighbourhood.

**Observation:** The observation helped to understand the neighbourhood from a user point of view. The observation schedule is observations made at a particular place and time in the neighbourhood to describe the use of open space, the daily activities of the neighbourhood. The observations were made at specific points and focus areas to document the use and issues related to new developments in the neighbourhood open spaces and access to them. The onsite study was helpful to understand the behaviours of the residents. The each focused point was observed at four different times of the day Morning, Afternoon, Evening and Night.

**Secondary data:** The data obtained from journals, articles, literature, newspaper which helped to add more information to the study. The information obtained focused on the different types of open spaces and importance of open spaces in a city, in a local context and in a neighbourhood.

**Mapping:**The mapping of the focus area was the first step in the analysis. The first one shows existing open spaces inside the selected area. The second map shows the density of the selected neighbourhood and the connectivity in the neighbourhood. It helped to identify the different types of open spaces and the areas which lack open spaces around the buildings and access to them. It also identifies the current use of existing open spaces. The maps were generated using ArcGIS software. Mapping of the selected area was done to understand the morphology of the neighborhood, to study the existing vegetation of the area, shadow analysis.

**Observation:**The observation method is used to analyse the various activities happening in the neighbourhood. The intersection with temples and sit outs around the tress and in between the buildings was selected as focus points for observation. The Lakerya Maruti temple intersection was selected because it's a connecting point to the complete neighbourhood.
The Maruti Road has many small temples on the main road with benches provided by government older residents in the neighbourhood prefer sitting on them in the morning before 10.00 am as it is cooler in the morning than later time of the day. At night same places is used by college going students as a gathering area. The kids play on the main road at night on weekends 10.00 pm onwards.

Shiral Seth chowk intersection has all the food shops and stalls in the lane early morning and evenings it is crowded. The trees provide shade throughout the day, users prefer sitting under them for eating, chatting, gathering. On the weekends the weekly vegetable market for the neighbourhood gathers there, multiple activities happen here during the weekdays as well as during the weekend.

The neighbourhood is planned in grid iron pattern so all the lanes are interconnected. The backyards of residences are connected throughout creating open spaces with tree plantations which keeps the area cool and shaded throughout the day. The front yards of the houses are various types which have small sit outs which act as gathering in the evenings and used for small kids to play.

The neighbourhood roads are well maintained and shaded so kids of the neighbourhood prefer playing games on streets on the weekends or in the afternoon 2.30 pm to 4.30 pm, during the weekdays as it is calm and cool. Chowks or Junctions were crucial meeting places for community discussion and participation.
The lanes in between the buildings if maintained properly can provide gathering space for the residents. The existing lanes are clean and maintained, facilities should be provided so it can be used for better purpose. The neighbourhood has service lanes which are also backyards of houses currently used as dump yards if used properly can be used as connecting lanes to the main roads. The service lane maintenance is very poor, which makes them inaccessible to the residents.
The porches and front yards of the old residential units are used by children for playing, in the morning it is used as common study place, the women of the house gather in the afternoons for various activities, and at night same place is used for gathering and chatting.
These characteristics are the identity of the neighbourhood. The temples in the neighbourhood are the cultural identity. The residences are developed around these temples. They not only act as a gathering place but also provide a common platform for celebrations during festivals and develop a sense of belonging in the neighbourhood.

**Service lanes**

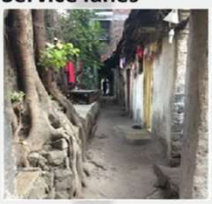


Fig.12 Internal lane Fig.13 Internal lane Fig.14 Internal lane

The lanes and roads are connected through and through with small houses along the side. The central space between buildings is used for parking and also a connectivity between two roads. Connected from one house to another which opens up into a small cluster housing.

**Courtyards**



Fig.16 Architectural Character Fig.17 Architectural Character Fig.18 Architectural Character

Each building has unique façade. Most of the buildings open up on the streets. Old structures aging more than 100 years are well maintained. Each of these old structures has front yard which acts as a gathering place from residents. These traditional buildings are cooler than the newly constructed structures.

**Porches**



Fig.16 Courtyard Fig.17 Courtyard Fig.18 Courtyard

The courtyard not only acts as a sit out or gathering place but also everyday chores like washing clothes and utensils also happen here. Temples in courtyard act as a common gathering space for everyone. These courtyards are cooler than rest of the surrounding.

**Main road**



Fig.19 6m Main road Fig.20 9m Main road Fig.21 9m Main road

The walkable scale of the neighborhoods incorporates all the activities in everyday life. Trees plantations on all the main roads keeps them shaded throughout the day. The footpaths along the main road are used for parking.

**Religious structures**




Fig.22 Lakerya Maruti Fig.23 Maruti temple Fig.24 Ayappa Temple Fig.25 Synagogue

| Sr. No. | Building Age | | | Building Height | | | Vegetation Type | | | Vegetation Location | | Open Space | | Road Width | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Less than 10 Yrs | 11- 90 yrs | More than 90 Yrs | Low rise | Mid rise | High rise | Low | Medium | Dense | Along the road | Inside the building | Courtyard | Along the road | 9m with footpath | 9 m | 6 m | East - West | North - South |
| Case 1 | | | | | | | | | | | | | | | | | | |
| Case 2 | | | | | | | | | | | | | | | | | | |
| Case 3 | | | | | | | | | | | | | | | | | | |
| Case 4 | | | | | | | | | | | | | | | | | | |
| Case 5 | | | | | | | | | | | | | | | | | | |
| Case 6 | | | | | | | | | | | | | | | | | | |

There are temples at the cross junctions which make the identity of the place and also a common gathering point for the residents during festivals and everyday activities.


Fig.25 Map showing building heights

Fig.26 Table showing different criteria's selected.

**Simulation:** The existing neighbourhood is simulated in a Envi-MET V4.4.1 software to understand the existing built form of the neighbourhood, its effect on the users and the climate. The use of existing open spaces in between the buildings, the front yards, courtyards and backyards, streets. The microclimate analysis of the selected area was done, which explained the factors that affect the area. Six different areas from the neighbourhood were selected for analysis with different site conditions for microclimate analysis. In ENVI-met simulation was done for March 03, 2019, a summer day with low temperatures of 26 °C at 09:00 h and high temperatures of 38 °C at 13:00 h, no precipitation, and no cloud cover.

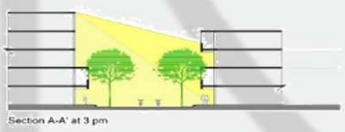
**FINDINGS/ ANALYSIS &INFERENCE** Three areas were selected based on various site conditions and site observation.

**Case 1**

Fig.27 Showing selected area for simulation Fig.28

The selected area has maximum structures aging from 11-90 years and more than 90 years, very few structures age less than 10 years. The area has combination of mid-rise and low rise structures, mid-rise structures are along the main road. The area has combination of mid-rise and low rise structures, mid-rise structures are along the main road.

**Shadow Analysis:**





The streets are not shaded throughout year but has maximum shading in the month of August at 11.00 am and the minimum shading in the month of December 11.00 am.

The streets are not shaded throughout year but has maximum shading in the month of December at 3.00 pm and the minimum shading in the month of March 3.00 pm.

**Thermo Imaging**

Fig.29

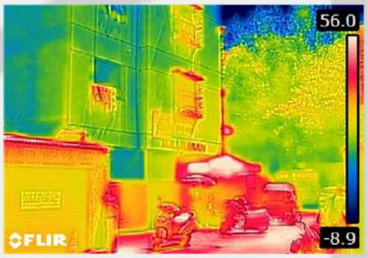



Fig.30

The streets are not shaded but the trees and building cast shadow on the street thus making it more comfortable for pedestrians. In the above thermal image, the east facing street which is exposed top sun having more temperature up to 36 deg. The street is partly shaded with the building and tree shadow.

Fig.31

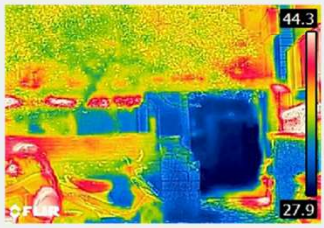



Fig.32

The narrow streets and taller buildings cast shadow on the street thus making it comfortable for users. The street is shaded throughout the day. In the above thermal image , the north facing street which is shaded having less temperature up to 27 deg. Whereas the area which is not shaded is having more temperature up to 36 deg.

**Wind Analysis:**

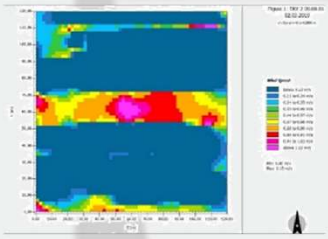


Fig.33

Light winds are experienced throughout the area. A lot of wind variations is seen on the main road, while minimum wind is seen near the inner lanes. The courtyards and open spaces receive good amount of winds.

**Temperature Analysis:**

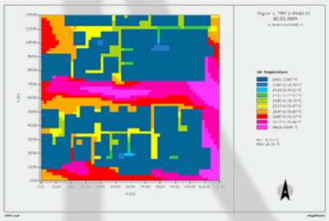


Fig.34

Temperature difference of 1 °C is seen on road and in between the building clusters. Temperature is reduced on the road around the trees by 0.50 °C. The main road has maximum temperature.

**Humidity Analysis:**

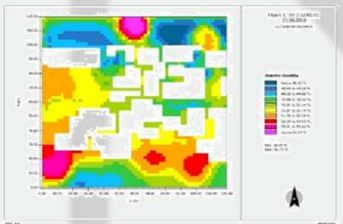


Fig.35

Minimum humidity is experienced on the main road more humidity is seen in areas around the trees.

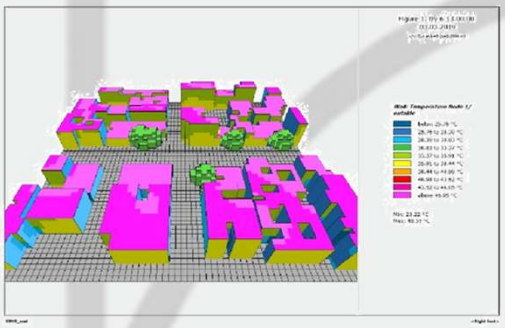


Fig.36 Surface Temperature

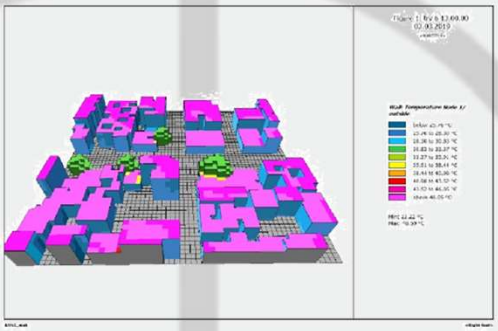


Fig.37 Surface Temperature

Temperature is less on the Northern facades, the open spaces around the trees are much cooler than the exterior. Temperature is more on the Southern facades, the areas around the trees temperature difference of 3 °C is experienced.

**Findings:**

- Road - The street was warmer but there was no air movement was noticed in the internal lane. w.r.t. North- South facing street is 1.6: 1 resulting in shading of the streets throughout the day.
- Orientation- The streets which are East - West oriented show temperature difference from 29.92 - 30.82 °C. The streets which are oriented North - South oriented show temperature difference 30.23 - 30.82 °C. East -West oriented streets show higher temperature difference than North – South oriented streets.
- Wind - Difference in wind speed is seen at a distance of 10m where observed speeds vary between is is 0.37 to 0.48 m/s to 0.72 to 0.83 m/s
- Vegetation - Trees with low foliage with 9m height are seen on the main road, the area around the tree is lower by 1°C.The wind is cooled by the vegetation and reaches the buildings.
- Open space - The open spaces around the buildings with 15m width and courtyards inside the building with minimum distance 4m temperature is lesser by 2°C. There are many open spaces in this area thus helping in better ventilation.

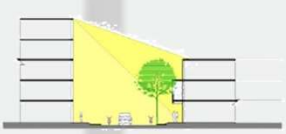
**Case 2**

Fig.38 Showing selected area for simulation

Fig.39

The selected area has maximum structures aging from 11-90 years and more than 90 years, very few structures age less than 10 years. The area has combination of mid-rise and low rise structures, mid-rise structures are along the main road. The area has combination of mid-rise and low rise structures, mid-rise structures are along the main road.

**Shadow Analysis:**



Section A-A' at 3 pm

Section A-A' at 11 am

The streets are not shaded throughout year but has maximum shading in the month of August at 11.00 am and the minimum shading in the month of December 11.00 am. The streets are not shaded throughout year but has maximum shading in the month of December at 3.00 pm and the minimum shading in the month of March 3.00 pm.

**Thermo Imaging:**

Fig.40


Fig.41

Typical architectural features of the street are use of chhajjas resulting in strong horizontal lines, projecting vertical blocks on brackets, balconies with delicate latticed screens cut direct sun and glare of reflected sun in the street. In the above thermal image , the northern facade of the street which is exposed top sun having more temperature up to 36 °C. Whereas the area under the balcony is shaded having less temperature up to 22 °C.

Fig.42


Fig.43

The streets are not shaded but the trees cast shadow on the street thus making it comfortable for pedestrians. In the above thermal image, the south facing street which is exposed to sun shows higher temperature. Whereas the area under the balcony is shaded having less temperature up to 22 °C.

**Wind Analysis:**

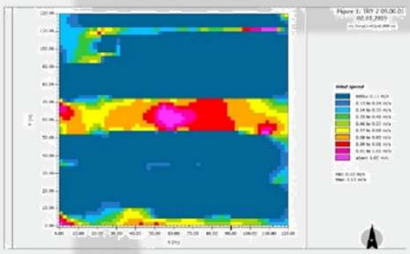


Fig.44

Light winds are experienced throughout the area. A lot of wind variations is seen on the main road, while minimum wind is seen near the inner lanes. The courtyards and open spaces receive good amount of winds.

**Temperature Analysis:**

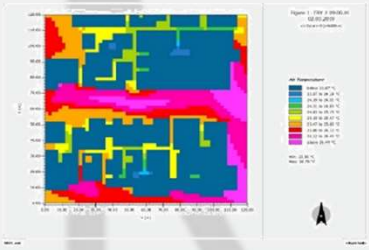


Fig.45

Temperature difference of 1 °C is seen on road and in between the building clusters. Temperature is reduced on the road around the trees by 1 °C. The main road has maximum temperature.

**Humidity Analysis:**

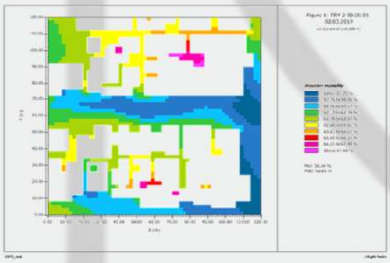


Fig.46Minimum humidity is experienced on the main road more humidity is seen in areas around the trees.

Fig.47

Fig.48

Temperature is less on the Northern facades, the open spaces around the trees are much cooler than the exterior. Temperature is more on the Southern facades, the areas around the trees temperature difference of 3 °C is experienced.

**Findings**

- Road - The Street was warmer but there was no air movement was noticed in the internal lane. w.r.t. North- South facing street is 2 : 1 resulting in shading of the streets throughout the day.
- Orientation- The streets which are East - West oriented show temperature difference from 25.47 - 26.44 °C.
- Vegetation - Trees with medium foliage with 12m tree height are seen on the main road, Temp around the tree is lower by 1 °C than surrounding areas. The road is cooled by the vegetation.
- Wind - Difference in wind speed is seen at a distance of 10m where observed speeds vary between is 0.35 to 0.45 m/s to above 1.02 m/s
- Open space - The open spaces around the buildings with 9 m width and minimum distance between the building 2 m temperature is lesser by 2°C. There are many open spaces in this area thus helping in better ventilation.

**Case 3**

Fig.49

Showing selected area for simulation

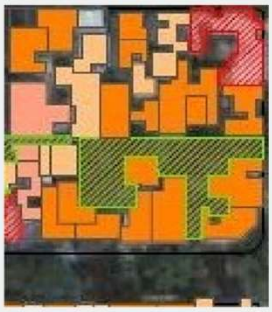
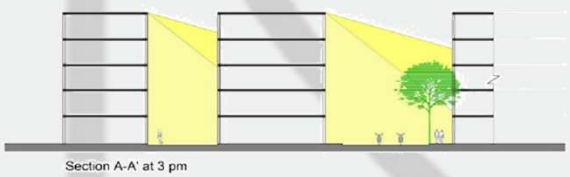


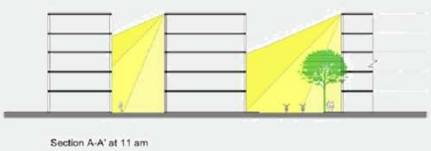
Fig.50

The selected area has maximum structures aging from 11-90 years and more than 90 years, very few structures age less than 10 years. The area has combination of mid-rise and low rise structures, mid-rise structures are along the main road. The area has combination of mid-rise and low rise structures, mid-rise structures are along the main road.

**Shadow Analysis:**



Section A-A' at 3 pm



Section A-A' at 11 am

The streets are not shaded throughout year but has maximum shading in the month of August at 11.00 am and the minimum shading in the month of December 11.00 am. The streets are not shaded throughout year but has maximum shading in the month of December at 3.00 pm and the minimum shading in the month of March 3.00 pm.

**Thermo Imaging:**

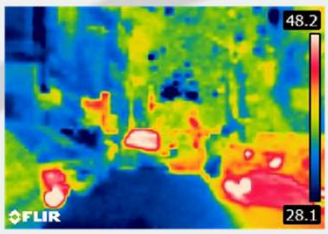



Fig.51 Fig.52

The streets are shaded, the trees and building cast shadow on the street making it more comfortable for users throughout the day. In the above thermal image , the North facing street which is exposed to sun having temperature up to 36 deg. The street is fully shaded with the building and tree shadow with temperature 28 deg.

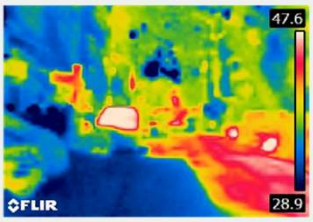



Fig.53 Fig.54

The narrow streets and taller buildings with trees cast shadow on the street thus making it comfortable for users. In the above thermal image , the north facing street which is shaded having less temperature up to 25 deg. The complete street is shaded throughout the day.

**Wind Analysis:**

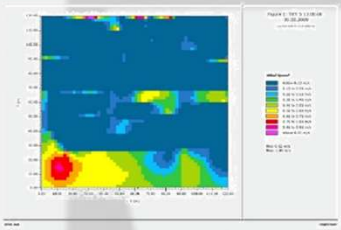


Fig.56

Light winds are experienced throughout the area. A lot of wind variations is seen on the main road while interior areas get less winds. The courtyards and open spaces receive light winds.

**Temperature Analysis:**

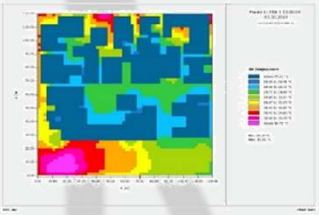


Fig.57

Temperature difference of 1 °C is seen on road and in between the building clusters. Temperature is reduced on the road around the trees by 1°C. The main road has maximum temperature.

**Humidity Analysis:**

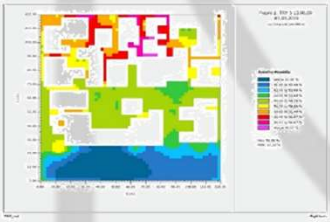


Fig.58

Minimum humidity is experienced on the main road more humidity is seen in areas around the trees and smaller interior spaces.

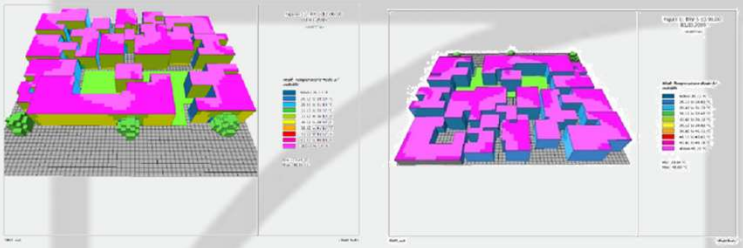


Fig.59 Fig.60

Temperature is less on the Northern facades, the open spaces around the trees are much cooler than the exterior. Temperature is more on the Southern facades, the areas around the trees temperature difference of 3 °C is experienced.

**Findings:**

- Road - The street was warmer but there was no air movement was noticed in the internal lane. w.r.t. North- South facing street is 1.6 : 1 resulting in shading of the streets throughout the day.
- Orientation - The streets which are East - West oriented show temperature difference from 29.72 - 30.78°C.
- Vegetation - Vegetation Trees with medium foliage with 12m tree height are seen on the main road, Temp around the tree is lower by 1 °C than surrounding areas. The road is cooled by the vegetation.
- Wind - Difference in wind speed is seen at a distance of 10m where observed speeds vary between 0.31 to 0.41 m/s to above 0.91 m/s
- Open space - The open spaces around the buildings with 7 m width and minimum distance between the building 2.5 m temperature is lesser by 2°C. There are many open spaces in this area thus helping in better ventilation.

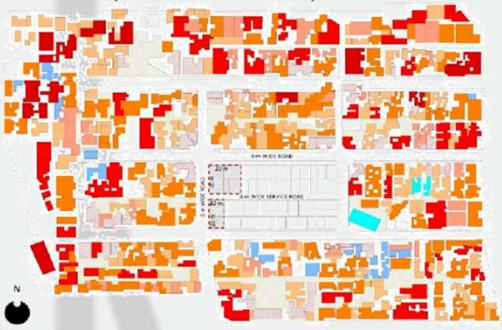
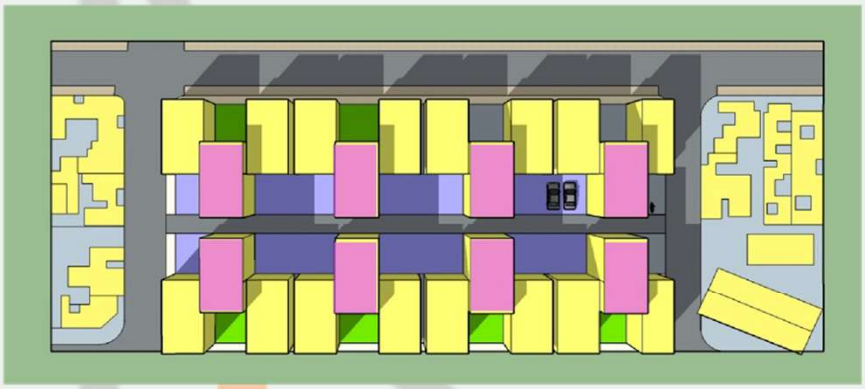


Fig.61 Area selection for proposal



Proposal 1

Fig.62 Proposed Plan

Set back – 1.5 m FSI 2.00 G+3
G+5
Single unit is 75 sq m
2 x 360 = 720 sq m
**One unit – 1050 Sq m**

The service lane is 4m wide. The higher structures are placed at the back whereas the lesser height structures are placed adjacent to the road to maintain the human scale ratio of the buildings. Each unit is provided with parking at the back access is given from the service lane. The front courtyard are provided in front with a tree plantation, courtyard size is 5m x 5m. the service lane is designed in a way to venture

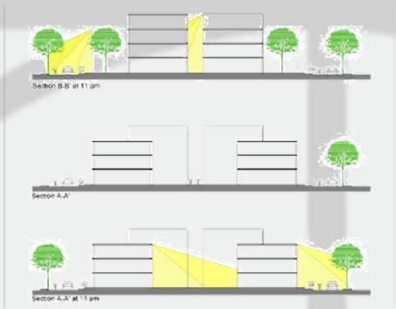


Fig.63 View showing shadow pattern

The streets are not shaded throughout year but has maximum shading in the month of August at 11.00 am and the minimum shading in the month of December 11.00 am.

The streets are not shaded throughout year but has maximum shading in the month of December at 3.00 pm and the minimum shading in the month of March 3.00 pm. Fig.64 View showing shadow pattern and courtyards.

**Wind Analysis:**

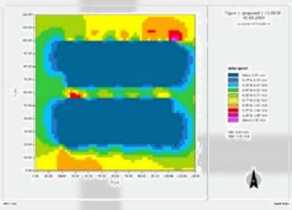


Fig.65

Good wind is experienced throughout the area. A lot of wind variations is seen on the main road, while medium wind is seen near the inner lanes. The courtyards and open spaces receive good amount of winds.

**Temperature Analysis:**

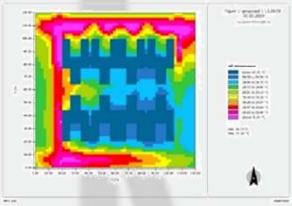


Fig.66

Temperature difference of 2 °C is seen on road and in between the building clusters. Temperature is reduced on the road around the trees by 1 °C. The main road has maximum temperature.

**Humidity Analysis:**

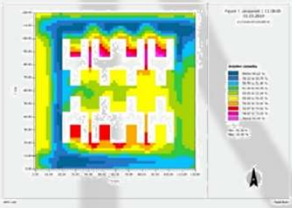
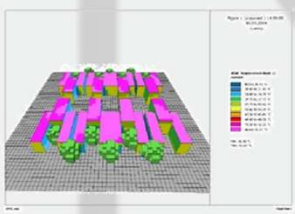


Fig.67

Minimum humidity is experienced on the main road more humidity is seen in areas around the trees and smaller interior spaces.



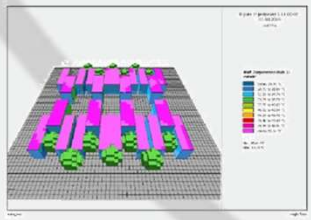


Fig.68 Fig.69

Temperature is less on the Northern facades, the open spaces around the trees are much cooler than the exterior. Temperature is more on the Southern facades, the areas around the trees temperature difference of 3 °C is experienced.

**Findings**

- Road: The Street was warmer but there was no air movement was noticed in the internal lane. Height to width ratio is 1.6: 1 resulting in shading of the streets throughout the day.
- Orientation - The streets which are East - West oriented show temperature difference from 30.10 – 30.28. The streets which are oriented North - South 29.54 - above 29.72 °C. East -West oriented streets show higher temperature difference than North – South oriented streets.
- Vegetation - Trees with medium foliage with 12m tree height are seen on the main road, Temperature around the tree is lower by 1°C than surrounding areas. This cooled wind reaches the buildings nearby.
- Wind – Difference in wind speed is seen at a distance of 10m where observed speeds vary between 0.47m/s – above 1.07 m/s
- Open space - The open spaces around the buildings with 9 m width and minimum distance between the building 2.5 m temperature is lesser by 2°C. There are many open spaces in this area thus helping in better ventilation.

**CONCLUSION:** In a residential neighbourhood built form only cannot support the liveability of its residents. It is necessary to provide open spaces in the neighbourhood for the residents. The open spaces not only provide social value but also environmental and health benefits to the residents of the neighbourhood. The traditional façade pattern gives a particular identity and character to the neighbourhood and sense of belonging as well.

If the structures are built considering the climate and the open spaces it benefits on the health of people, and it has been shown to be more likely to use such space for physical activity if it is of high quality.

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# RECONSTRUCTION OF 'JAIN MATH' FOR REPURPOSE TO A BOUTIQUE HOTEL AT AMBA, KOLHAPUR, MAHARASHTRA, INDIA.

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**Abstract:** Conservation of built environment and historic structures need sensible management of resources, sound judgment and perfect wisdom of proportion. Conservation and repurpose is the process which helps to prolong the life of the heritage structures for its use of today and in future. Term reconstruction implies that certain structural or design changes have made in building; in order to function in its new use. This paper reveals the principle of conservation i.e. reconstruction and repurpose in the application of 1500 years old historic 'Jain Math Wada'. The reuse of Jain Math Wada for a repurpose of Boutique resort different from the original one is adaptive use. The work was carried out in the district of Kolhapur, a fair composite climatic zone. The 'Jain Math Wada' structure was totally numbered, carefully dismantled in stages without affecting its heritage value. The materials, was transported to site Amba, district Kolhapur in Maharashtra state 60 km away from the existing place. The Jain Math Wada was re-constructed wisely for the repurpose of boutique hotel from the construction waste of old heritage Jain Math Wada without losing the cultural values in least cost which is the pride to the owner and cheerful experience to the end users.

***Keywords:*** Conservation, reconstruction, adaptive use, repurpose, historical building.

## 1. INTRODUCTION

India has many religions, many languages and culture since hundreds of years. Because of this India has an exclusive heritage among the richest in the world. Conservation is the process which helps to extend the lifespan of historical building for its use of at present and in future. With the help of Conservation we can preserve the built heritage and if possible enhance the message and values of it. (Chakravarti, N.P., 1948).There were many buildings which were preserved and changed its functioning in the new one. Heritage buildings are the pride and legacy of the ancestors which need to be conserved for the future generations. Built environment should be protected and preserved from being lost forever. The method of conservation of the building is repurpose and adaptive reuse; it describes as the changing a place to suit the existing use. By adopting the heritage building for the new use helps for the reduction of use of new building material which reduces the carbon footprints. Repurpose and adaptive reuse significantly affect the economics and as well as the life style and quality of life. To prolong the life of the heritage building adaptive reuse and repurpose are the good options to preserve our built heritage. (Prihatmanti R.2015). In the study of the historical buildings the client should be included who has appointed and hired it; the study should be such which includes all the aspects of political, social, and economical; of the time zone in which the building was constructed and capable of enlisting the sequential order of activities in the life cycle of the building. (Filden, b., 1892)

### 1.1 History

The Jain Math Wada has the history of 1500 years. This cultural, social, educational and spiritual center of Jain community is situated in Shrukrawarpeth of Kolhapur city, Maharashtra, India. This center all the time guides the entire Jain community and a witness of glorious past of the history. In the precinct at center Jwalamalini Temple is situated and the idol is very ancient. 41 feet tall obelisk is in the courtyard having four faces to it. The math has so many hand written old book, religious texts, granths, and tadpatras in their library which are available in many languages. The books spread the knowledge of wisdom and wellbeing of mankind. Many foreign delegates visit this place and library for the knowledge

of ancient past of India. The part of the math which is conserved is 300 years old. It is the place for resting and cultural exchange. The people who were travelling for pilgrimage from north India to southern India or vice versa. They stay there have food, relax and set out for the next destination. The Mathadhipati guides the Jain community, set the rules and regulations; they also help to perform various rituals. The part of math with central courtyard and rooms around which is dismantled had been used for the staying of the Jain Shravakas. (Sakal news service, 2017)

### 1.2 Need of conservation

Today our heritage is facing greater threats then that of earlier days of wars and invasions. If we observe the current rate of destruction; very few heritage site will remain in future. In the last sixty years, the natural and built heritage of our country is continuously under attack and many of the wonderful sites have been destroyed. Effort to protect our heritage has been very weak and inadequate. (Worthing, D., 2008). The archaeological Departments protect only 'monumental' heritage structure. Non monumental heritage, which gives our cities, towns and villages their exclusive characters; Such grade III Monuments have to preserved, maintained and reused for the adaptive use is the need of the time. (INTACH, 1984)

### 1.3 Values for conservation

Religious philosophies and performs have emerged with built form which are associated with rituals and cultural activities. During that time these places are considered as symbolic forms of political control, identity and social security. (Harvey, 1979). Religious and political conspirators helped for the non-maintenance and destructions of these heritage scape which played great role in the identity of that culture and community. (Bevan, 2006)

This building contribute to determine the character of the locality, and can be representative of lifestyle of a particular Jain community and Kolhapur region. The structure which is reconstructed was built before 300 years as per the information given by the Mathadhipati. This historical religious building still serving and guiding the Jain community. Design of the math is having the central courtyard and the rooms are around it. It is the ground plus one story structure with sloping roof. The walls are thick stone masonry walls and wooden pillars to support the roof .The roof was made up of country tiles and wooden rafters and battens. The walls are plastered with mud mortar. The entrance steps are of ashlars fine stone masonry. Timber floor with mud finish was there.

Listing –It is Grade III type of conservation site. In which External and internal changes, and adaptive reuse is allowed and done in harmony with the existing heritage building. Reconstruction of this building has been done because it was structurally unsafe and they want a big community hall which was not possible in the current building (INTACH, 1984).

## 2. AIM / PURPOSE

The aim of this paper to throw light on the reconstruction and repurpose of the old heritage structure; while conserving its original characteristics and values in least cost.

## 3. OBJECTIVES

To fulfill aim the following are the objectives:

1. To preserve our heritage, our cultural, historical and social values.
2. For the grade III structure the maintenance fund is the problem. By adaptive reuse and repurpose some funds can be generated for the maintenance of the heritage structure.

3. To spread awareness amongst the people for the conservation of our heritage. And adaptive reuse and repurpose as the new source of income for the owner.

## 4. RESEARCH METHODOLOGY

### a) Data Collection, historical and documentary analysis and onsite work.

The initial step towards the process of conservation, repurpose and reconstruction is the formation of the principal parameters of the building envelope and morphology with the onsite hard work. The measure drawings and the photographs of the site, collection of records and historical evidences of the functioning of the site at that time. Collection of all the information and formation of valid documents and 2D measured drawings need to generate using the computer graphics. After the meticulous study need to form a frame work for the work to be carried out. (Galiana, M., 2015)

### b) Analytical study of the structure and its characteristics

Relation between the form and the material is important which need a wise management and study. The study of the structure and its style of construction; the masonry and joinery. The characteristic of the construction features need to conserve should be studied in detail.

### c) Damage Diagnosis

To identify the damage which is caused to the structure in due course of time. The structural audit of the heritage structure need to carry out. Depend upon the report of the structural audit the further line of action should be decided.

### d) Intervention proposal.

Intervention proposal to be formed on the basis of the analysis and outcome of the study. The feasibility of the reconstruction and repurpose to be identified. The cost and onsite process on reconstruction and work frame to be identified.

## 5. PROCESS OF CONSERVATION:

### a) Data Collection, historical and documentary analysis and onsite work.

*Figure 1Facade of Jain Math*

*Figure 2 Courtyard view of Jain Math Wada*

First owner was thinking to propose a big community hall for the math. Our client wanted to build a farm house at Amba. The major material requirement for this farmhouse was timber. He discovered about the demolition of Jain math wada as the old building was getting replaced by a newer bigger building. We along with the client approached the demolition site and proposed to halt it in return to buy the entire wada for its materials. Visit of an architect on client's request to purchase the good quality old wood, gives the realization and importance of conserving the structure.

**b) Analytical study of the structure and its characteristics**

In the inspection of the wada the structural action of all the elements had visualized and understood as whole. It is has Ground floor and first floor with the central courtyard. The walls of the math are made up of stone masonry with lime mortar. The courtyard flooring was made up of stone. The plinth of the wada was made up ashlar fine stone masonry with nice carving. The wooden columns are having stone pedestal at the bottom. The wooden columns, wooden beams, wooden rafters and purlins are taking the load of the entire wada. Beautiful wooden arches are adding beauty to the structure. The buttresses are acting as structural as well as aesthetical member of the Jain math wada. The floor of the wada was made of timber flooring with mud floor on top of it. The roof of the wada was made up of country tile and timber roofing system.

*Figure 3 Internal view of the courtyard of Jain math wada*

**c) Damage Diagnosis**

The structural audit has done and its report were studied. The documentation has been done. The measured drawings of the old heritage wada has completed. Photographs of the wada were taken. Each and every detail of the structure was shoot, the details of the wooden doors, arches, buttresses, cornices have been shoot in detail for the further reconstruction purpose. The entire structure has numbered in a sequence for the dismantle process. The structural members like wooden columns, beams, buttresses, wooden arches and rafters have been carefully dismantled. The damage caused to the structure was identified. Defect mapping was done. Most of the wooden column are decayed at the base. The beams are damaged at the end support. Somewhere they are damaged at the centre.

**d) Intervention proposal.**

Architect insisted client and convenience for the adaptive use for the proposed boutique hotel, at Amba, Kolhapur, Maharashtra, India, a fairly composite climatic zone. It was decided to shift the entire Jain math wada to Amba for the repurpose of the Boutique Hotel through reconstruction. Amba, a tourist place-very scenic and close to fort Vishal Gadh and Pavan Khind, which are historical places and closely related to history of Shivaji Maharaj. Then upon approval the structure was carefully and precisely numbered and dismantled step by step.

### *d.1) Inventory Management*

The inventory management of the dismantled material have been carefully done. The material very wisely and systematically transported to the nearby destination Amba 63 km from Kolhapur, Maharashtra, India. The dismantling of the structure was very systematic and step by step. The materials which are numbered are grouped together. The wooden columns, wooden arches, wooden buttresses, wooden beams, purlins, rafters and stone plinth, stone pedestals of columns are grouped as per numbering was done and with great care they transported to the proposed site at Amba. The material stored carefully. The damaged part of the wooden members were successfully removed. Structural members like wooden column and wooden beams were audited before reconstruction.

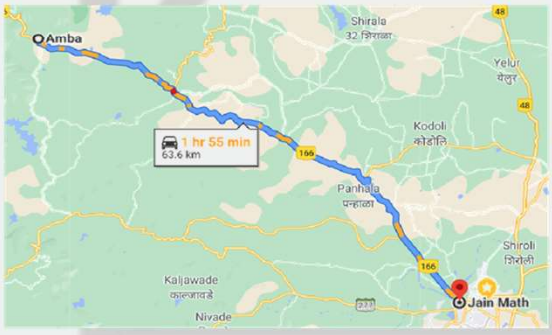


*Figure 4 Location showing Amba and Jain math*


*Figure 5 Location map of Jain Math, Kolhapur.*

Figure 6 Pictures showing the process of dismantling

### *d.2) Reconstruction and Retrofitting*

The available site is around 7 acres. We had selected a site which is close to the fresh water stream. This stream is live and running throughout the year. And a variety of flora and fauna are found all around the area giving a refreshing feel. Figure shows site plan of the proposed boutique resort. The stream at the back side of the resort is live throughout the year. At the ground floor four number of suits are proposed. Entry from the front side is having the same old wooden door with same fixtures are fixed. At the back entry of the boutique resort stone ghat feature has provided. The ghat extends in the water; can be used as dining purpose and recreational purpose.

At the first floor four suits are provided. All the suit are provided with wooden windows which are overlooking in to the courtyard. Through the exterior windows the rooms are extended in to the nature outside. The central courtyard is provided with Stone flooring. It is covered at the top with translucent sheets to allow the daylight to stream inside and

stop the heavy rains of Amba coming in to the courtyard. Two wooden staircases are provided to reach the upper level. One from the front side and the other from the backside. Same timber railing is proposed for the window balconies.


*Figure 7 Plan of the proposed Boutique Resort at Amba and the section showing the Reconstruction*

*Figure 8 Process of Reconstruction stage 1*

The Jain math wada was reconstructed very carefully step by step. The foundation was placed in as per the earlier dimension of the wada. The plinth of the wada as per the earlier numbering was reconstructed without any error. which are made up of timber.

*Figure 9 Process of Reconstruction stage 2*

After the reconstruction of the plinth the wooden Coolum with stone pedestal are placed in position as per the exact grid. The damaged part of the wooden column was removed and necessary strengthening was done by adding additional wooden member to it with suitable joinery. Necessary strengthening has been done. The wooden beams are placed in position to take the load of the superstructure. The repair work of the wooden beams was done and strengthening and retrofitting of the beams was done with great care. Very skilled supervision was done as the entire load is on the columns and beams

The windows are repaired and retrofitted and fixed at suitable location. Necessary addition of windows was done as it was planned as ten room boutique resort with heritage values. At the back side of the resort open window concept has used as full privacy is assured from that side. Wooden decorative intricately carved arches and beautiful buttress and motifs are fitted at perfect locations.

*Figure 10 Details of the joinery and retrofitting of the structural members.*

### *d.3) Cost Comparison*

It is also important to put light on the expenses part of heritage structure. As huge amount of funds are involved in the process of heritage conservation and reconstruction.

The area of the boutique hotel is 2730 sq. ft.

If we construct the same boutique Hotel in conventional way using the r.c.c frame structure. The cost of construction is 2730 sq. ft. x 1800 rs = 49, 14,000/- app. say 50, 00,000/-

By using the reconstruction method and reusing the old material of the wada the cost of construction is 35, 00,000/-

Thus we can save up to 30% of the cost by using the methodology and by doing conservation.

## 6. RESULTS AND INFERENCE

As a result of the Dismantling, shifting and reconstruction the old heritage Jain Math Wada has reconstructed on different location 63 km. away from the original site to serve as a 8 room Boutique Resort at Amba. The entire dismantled part of math again reconstructed with wisdom and great care to serve the tourist, with its original values, beauty, aesthetics and purpose.

*Figure 11Exterior view of the Boutique Resort after Reconstruction.*

*Figure 12Interior view of the courtyard and entrance after reconstruction.*

## 7. CONCLUSION

The methodology used for the reconstruction of the Jain math Wada is useful for the entire process of conservation. It is an effective way of repurpose through the process of reconstruction and adaptive reuse of heritage. The vanishing heritage of our country can be preserved and restored in the same form and look; but for the new purpose.

The method of data collection and documentation had great help for the understanding of the heritage structure and its values and importance in today's context. The method of analytical study and damage diagnosis helped for the decision making; of repurpose, reconstruction and adaptive reuse of the heritage structure.

To preserve our heritage we should promote, educate our client for the adaptive reuse of the heritage building. The moving of entire building to new sites is another form of reconstruction in least cost. The Math was re–evaluated and found useful, so survived, but with reconstruction. It has observed that reconstruction also save on economy and

adaptive reuse generates economy. It is also a pride to owner of conservation, repurpose and reconstruction of our built heritage to a wonderful Boutique resort; which has cultural values associated with it.

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# WASTE HIERARCHY FRAMEWORK FOR CONSTRUCTION AND DEMOLITION (C &D) WASTE IN INDIA: USE OF URBANITE

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**Abstract:** The need for the appropriate infrastructure and build environment has phenomenally increased due to the boom in population and IT Industry. The production of waste that is generated due to the demolition of the old structures is more than the construction of the structure itself. The Construction and Demolition (C&D) Waste in India has reached 24 million tonnes in 2010. This paper shows the project management strategies that have been laid out by the Environment Protection Agency (EPA) which is known as the Waste Hierarchy. The waste hierarchy could be a binding and also a legal framework to handle the C & D waste in India for reducing the burden on the landfill area for the sustainable future of the construction industry. The paper will explore on the onsite debris of concrete waste demolition materials also known as Urbanite, and its various usage in landscape and outdoor requirements. It will address the versatility of the material Urbanite and its merits and demerits, few construction techniques and methods of execution on site. With the strategic planning approach, the reuse of urbanite onsite concrete debris could be sustainably used by reducing the burden on the environment.

***Keywords:*** *Construction and Demolition waste, Waste hierarchy, Urbanite, Reuse of Concrete demolition debris*

## INTRODUCTION / BACKGROUND

As mentioned by State of Environmental Report, Karnataka, 2015 (SOER), *"the term 'waste' refers to all kinds of waste, whether generated during extraction of raw materials, processing of raw materials into intermediate and final products, consumption of final products and other human activities, including municipal (residential, institutional, commercial), agricultural, and social (health care, household hazardous waste, sewage sludge)"* (SOER, 2015). Waste management and disposal include collecting, transporting, processing and disposal of the waste from receiving of waste material to the final stage of disposal of the waste. As there is increase in significant amount of utilization of raw materials, exploitation of natural resources and the waste generated has an increasing number of biodegradable materials. Integrated solid waste management (ISWM) in India includes reduce at source, recycle, composting, combustion and land filling. The UN conference of world commission on Sustainable Development had come up with the 3R's rule of waste management: Reduce: Reduce the generation of waste at source and also utilizing the resource of our nation wisely. Try to maximise the usage of the product. Minimise the use of packaging for the products. **Reuse**: Repeatedly using the item or part of the items and can still be used for the same purpose. Materials at home don't get thrown away after one use. **Recycle**: When the matter is about to get thrown away to the solid waste disposal the product could be segregated and recycled and used for different purpose. They contain the refuse of raw materials and could be recycled easily. This can avoid landfills and incineration (CAG, 2007).

In the past two decades there is phenomenal rise in the construction industry due to rise in the economy and SOER report says that it is growing at the rate of 10% from the last 10 years as against the worlds 5.5% per annum. The built-up area is expected to swell almost five times from 21 billion sq. ft. in 2005 to approximately 104 billion sq. ft. by 2030 (SOER, 2015). In India about 90% of solid waste goes to land filling. The fact that India produces only 0.2 Kg per person per day as compared to the developed countries US produces waste of 3.6 Kg per person per day and Australia produces 0.8 Kg per person per day (MOEF, MSWM, 2009).

*Table 1: Solid Waste Generated (India)*

| | |
|---|---|
| 2015 (Present) | 1.3 Billion Tonnes / Year of Solid Waste. |
| By 2025 | Increase by 2.2 Billion Tonnes/ year. |

*Source: (SOER, 2015) 1*

India has legislation for Construction and Demolition waste (C&D) which has impact on the pollution, sewage disposal, impact on health, over usage of resource and loss of habitat which affect flora and fauna. It is used for land fill and most of it is disposed of in low lying areas, unauthorised landfill sites, water bodies and road sides. There is no appropriate use of these C&D waste materials which can be replaced and recycled from building materials which could save on the natural resources and cost. Demand for housing and infrastructure has generated a huge compilation of Construction and Demolition (C&D) waste. There are also huge demolition activities of old structures to replace them with modern structures. 7 landfill sites were identified by Bengaluru Bruhat Mahanagara Palike (BBMP) for construction and demolition waste.

*Table 2: Percentage of C&D waste materials*

| | |
|---|---|
| Construction waste/ Repair/ Demolition | 40 kg/sq.m / 50 kg/sq.m / 450 kg/sq.m |
| Brick masonry | 30% |
| Soil, Sand and Gravel | 35% |

*Source: (GIZ, 2016) 2*

**Waste Management in India**:

The waste management previously was dealing only with collecting, transporting, storage and disposal of waste in landfill or incineration, but today it includes reduce in consumption, reuse of products, recycling and composting as sustainable approach. This depends on localities and also the citizens should be made aware of the need to manage their waste. The Urban and Local Bodies (ULB) are the institutions who are mainly responsible for the waste management in India. Many of the policies, legislations and concepts are all borrowed from the developed countries which may not hold good for India. Iceland and Norway reduced the landfill deposits substantially between 2004 and 2010. The management of waste should address the type of consumption and options, supply chains, product design, various business models and its reduction of use at source keeping the economy and environment protection in mind.

**Construction and Demolition Debris:** C & D are difficult to handle as it is heavy, bulky and inert and also a mixture of various other materials. To choose an appropriate disposal method is a key to the solution as it cannot be incinerated due to its density. Construction debris contain concrete, glass, asphalt, tiles, wood, gypsum, metal, steel, wallboard, roofing etc. Comptroller and Auditor General (CAG) of India shows that in Delhi the construction waste consists of Concrete (23%), soil and sand (36%) and bricks and masonry (31%). Mumbai generates 2300MT of C&D waste per day. In Construction and demolition, the waste generated could be of two types, construction waste and demolition waste. Waste generation at source can include land excavation, road excavation, building demolition and building materials. (H Luo1, H L Guo1, Y S Gao1, 2018). Considering Dubai municipality's Waste Management Department, the construction waste in 2007 was 27.7 MT which has seen a growth of 163% in comparison of the waste generated in 2006 which was 10.5MT(CAG, 2007).

*Figure 1: C&D Waste*
*Image Ref: https://www.terranovalandscaping.com/90*

*Figure 2: C&D of Concrete Road waste*
*Image Ref: Authors Own*

*Figure 3: C&D Road levelling with C&D Debris*
*Image Ref: Authors Own*

The C&D government has identified different methods of debris and its disposal methods analysing the advantages and disadvantages for the same. There is landfilling, open dumping, burning/ incineration, composting, pulverization before tipping, separation and pyrolysis and some of the few identified methods for disposal of the solid waste management. Out of these burning/ incineration, pulverization, separation and pyrolysis are high cost for installing the unit, composting is the most sustainable approach, landfills provide means of reclamation with easy operation and management and open dumping is the most unscientific way to dispose the debris making it an eyesore in the city and surroundings.

**Limitations:** Construction and Demolition waste management shortcomings like lack of awareness among the public and their participation, lack of technology for recycling and reuse and shortage of skilled workers in enforcing agencies.

**Recommendations:** To create awareness through various media and mass communication, increase manpower in enforcing the system, emphasis on recycling facilities under Public- Private Partnership (PPP) model, promote the use of prefabricated building technology.

New approach to waste management NIMBY (not in my backyard) and NIABY (not in anybody's back Yard) material recovery, zero waste concept, increase producer responsibility, energy recovery, source separation, environmental cost of the product, source reduction. New methods approached around the world for the Solid Waste Management (SWM) like the refuse material could be compressed into building blocks that can be encased with more durable materials (UN Conference, 2008).

## Aim

To manage the C & D waste is by diverting the waste before it reaches the landfill and put for proper reuse/ recycle. This could help in reducing the pressure on the environment. MOEF and NEP should frame some specific waste management policies and to follow the 3R's considering the type of waste generated in India. Strategies have to be set to achieve the objectives planned in the policy which ensures the minimization of waste generated at source and decrease the quantity of waste disposal and also the cost of disposal. A systematic planning approach is to use Urbanite (waste concrete from the demolition site) a concrete debris could be sustainably used by reducing the burden on the environment.

## RESEARCH METHODOLOGY

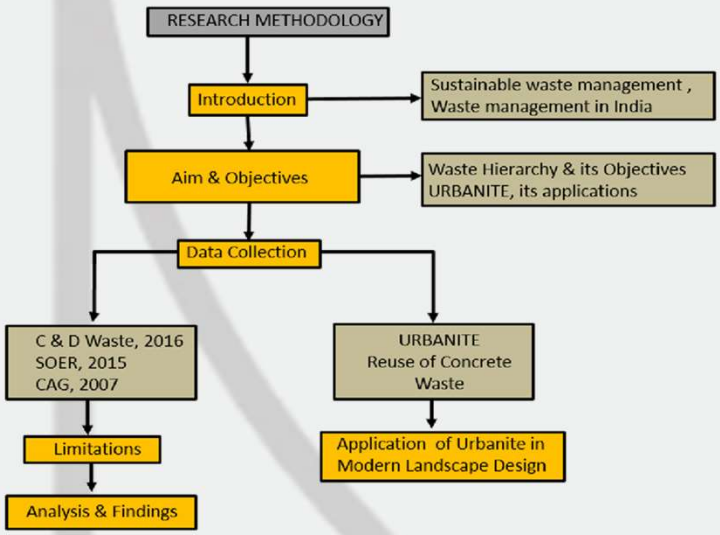


*Figure 4: Reserach Methodology*
*Image Ref: Author's own*

The UN Conference on Environment and Development in 1989 stated that "promote waste prevention and minimisation as the principal objective of national waste management programmes" and that governments should "develop and implement national plans for waste management that take advantage of, and give priority to waste reuse and recycling"(CAG, 2007). The step wise approach to waste management is the common management hierarchy in order of priority formed by the UNEP. Until 2006 the Ministry of Environment and Forestry (MOEF) had laid down the National Environment Policy (NEP) and less attention was paid to the hierarchy for the management of waste in India. There is few thought on reduction and recycling strategies. Comparing all the states in India disposal was found to be the most appropriate solution than minimising and recycling and less priority was given to the waste processing.Central government with Ministry of Environment and Forestry and Climate Change had

published a separate chapter on C&D waste in 2016 under Solid Waste Management Rules 2015, the highlights of this Rules and Regulations are discussed, Duties of waste generator:

1. Responsibility of waste generator is to collect, segregate the materials like concrete, soil and others and also to stock up the construction and demolition waste generated. The local authority would be monitoring this activity.
2. The generator is responsible for the waste not to get mixed with the other waste and should be disposed separately.
3. Anything < 20 tonnes per day or 300 Tonnes per month should segregate concrete, soil, steel, wood and Plastic, bricks and mortar are required to submit the management plan for the waste to the authorities informed about the project and its implementation.
4. Waste generator should keep the waste in their own premise to prevent obstruction to the public movement or drains.
5. Waste generators shall pay relevant charges for the separation, collection, transportation, processing and disposal of the debris by the concerned authorities.

Duties of Service providers and their contractors:

1. They shall provide within 6 months a comprehensive management plan for the waste covering segregation, storage collection reuse and recycling and transportation of the same.
2. They shall remove the debris every day from the area depending on the waste generated and reasonable time frame can be worked for it.
3. They can also tie up with private bodies to clear up the space ( GOI, C& D Rules, 2016) .

*Table 3: Application of C&D Waste Material*

| Application of material made from C&D waste and its products | |
|---|---|
| Sanitary landfill site in layers | With drainage layer on top |
| Daily cover | fresh soil cannot be used |
| Civil construction in sanitary landfill | stone , drain covers , paving blocks are used for pathways or pedestrian areas |

*Source: Shrivastava, S. and Chini, A. (2005) 'Construction Material and C& D Waste in India', Pg. 72-76*

Some of major effects of mismanagement of solid waste disposal like waste clogging in the cities, pollution on earth surface, soil pollution, water contamination, insects, odour, health issues to name a few.

C&D waste are difficult to handle and are heavy, bulky and large volumes of inert materials and also a mixture of various materials. As incineration is not possible it poses the challenging situation to dispose of the waste material. C&D waste generation and handling the waste in a sustainable way is the goal for a safe future. There should be better practices for prospects and possibilities of the 3Rs in handling and minimising C&D waste. C&D waste is a serious issue in developing countries where they have entered the construction boom which currently is India's situation as well (Shrivastava and Chini, 2005).

The Technology Information, Forecasting and Assessment Council (TIFAC) study estimated for the C&D Waste is 22-26 MT/yr in 2010. TIFAC study also shows that the waste generated from demolition site is 450 Kg/m2 as against 45-50 Kg/m2 from the repair and renovation works. (Shrivastava and Chini, 2005). This paper explores on the amount of waste generated through C&D and how this can be managed to minimise the burden on landfill. The C&D waste minimisation and handling is necessary and keep in view of the threat to the environment, as the quantum of demolition waste is more in landfill site and availability of space is minimum. Recycling and reuse of C&D waste should be adopted to minimize this waste (CAG, 2007).

Management of Waste: Way back in 1970's the waste management hierarchy has been tracked. For the waste generated in India, government has to be precise on the management approach to reduce the burden on the environment. The traditional way of disposing the solid waste has been to move it away from the source site only. There is no

implementation on 3R's and disposal of the waste was the main priority. The implementation of ECOMARK labelling program on the recycled and reuse products has been granted only for 3 product categories since 1991. Suitable policies and stricter rules have to be framed in India for all kinds of waste like agricultural waste, e-waste, construction and demolition waste etc.

**Waste Management Hierarchy:**

According to waste management hierarchy, the waste disposal/ recovery is least favoured activity and is the last category in the hierarchy chart. Priority must be given to reduce and minimise the waste generation at source. According to chart prevention or reduction of the quantity and harmfulness to the environment is most desirable option in the hierarchy. Collecting, transporting, recycling and disposal activity gets eliminated from this event. It optimises the use of resource and potential source of pollution by safeguarding the environment. Reduce also means minimising the use of material at source and emphasis on reuse/ recycle. Reuse means to use the article more than once where the item is used again for the different purposes. Recycle involves treatment and processing of discarded material and is used in different form for other purposes. Disposal of waste could be more planned and also can be the by-product of reuse and recycle, it can be inexpensive, and the landfill can be more scientific and minimise the impact on the environment. Few disposal methods are sustainable and energy could be generated from them. Incineration is another disposal method which involves combustion in high temperature. Composting is another method of waste disposal where the biological process decomposes the organic matter. Gasification and Pyrolysis are thermal treatment of waste materials with high temperatures and lack of oxygen.

Recommendations: To emphasise on framing the laws and regulations for disposing of the C&D waste, disposal of old vehicles, waste from packaging material, mining generated waste. The EPA should incorporate the Polluters Pay Principle in the regulations itself. This strategy would be deterrent from open dumping of waste.


*Figure 5: Waste Management Hierarchy*
*Source: (Fagariba and Song, 2017)*

**FINDINGS**

**Present Status:** Until 2010 the MoEF and Central Pollution Control Board (CPCB) the data available on types of waste generated in India, there is no information on the waste being generated in the category of "Other Waste" by items like electrical waste, C&D waste/ debris, agricultural waste, disposal of old vehicles, mining waste, packaging waste. 25% of the states have made a report on the growth of waste, whereas 38% of sampled state had made no projections that could be verified for the performance audit. With the absence of such information the prediction of waste generation in the future is challenging. The MoEF would not be able to arrive accurately the kind of management that can be tailored for all kinds of waste disposal.

**At Central Level:** Lack of rules and regulations existed to handle the other waste category like C & D generation. Lack of records suggest any assessment made by MOEF on the current and the future of effective handling of this waste.

**At State Level:** Only 29% of state in India had assessed the current capacity of waste, handling some kind of waste like the Municipal Solid Waste, biomedical waste and hazardous waste.

**Recycled Concrete Waste:** In demolition waste 90% of the construction waste are inert and known as public fill. Public fill includes debris, rubble, earth and concrete. The disposal is a major management issue which would help in mitigation of economic, social health and environmental concerns. Incineration, recycling, sustainability are some of the solutions to

reuse, recycle and reduce the construction waste. Principles adopted to reduce debris are, design to reuse and recovery, design for offsite construction, material optimisation, waste procurement and disposal, deconstruction and flexibility.

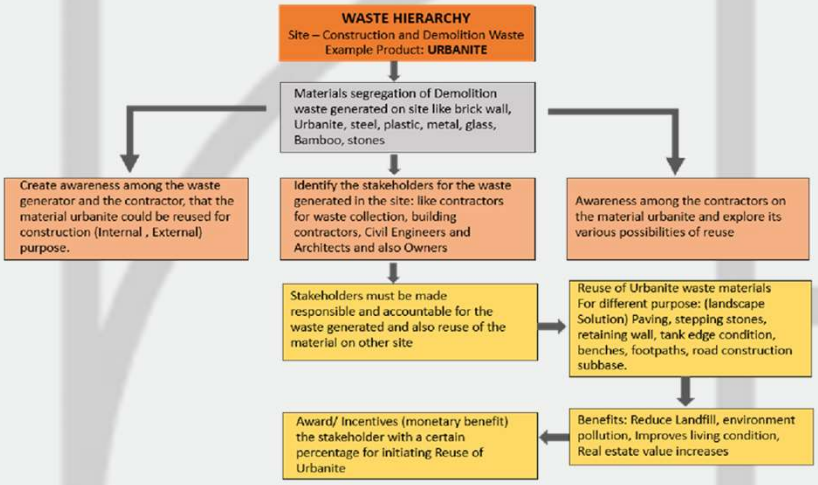


*Figure 6: Analysis of Waste Hierarchy*
*Source: Author's Own (Analysis and Findings)*

**Process of reusing demolished concrete:** Collect the concrete waste from the demolition site after which the transportation for the waste materials to the recycling unit. The waste concrete is then taken to the processing unit where the initial crushing and sieving is taken place after which a final crushing and grinding takes place. This crushed concrete is then forwarded to the construction unit and can be used as a raw material for the construction of roads etc. To reduce the landfill recycling of waste concrete is done to make aggregates, which have low strength materials, impact resistance and have more absorption value. The recycled concrete strength is about 10-15% less than the fresh concrete aggregate. With suitable modifications the same can be used for RCC works. Recycled materials are more efficiently used in cost effective landscape design for example broken concrete i.e. urbanite is used in attractive pathways, benches, steps, retaining walls and edges to create sustainable and eco-friendly environment ('USE_OF_CONSTRUCTION_WASTE_MATERIAL_and_THEIR IMPACT ON LANDSCAPE - Bassu Ar).

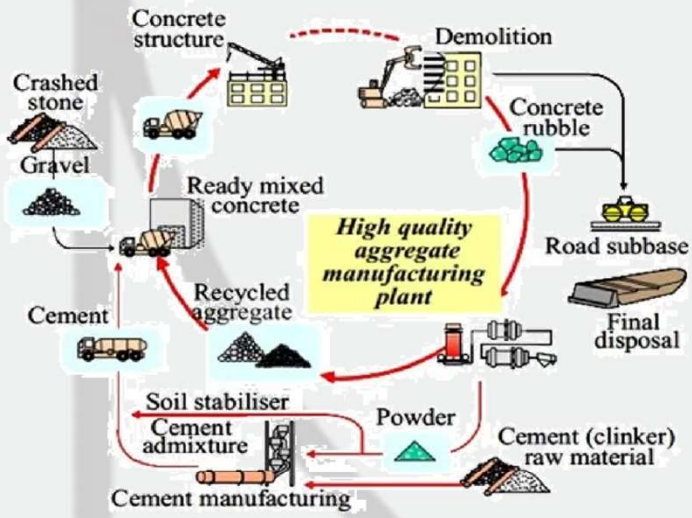


*Figure 7: Recycle of concrete waste*
*Source: https://theconstructor.org/concrete/concrete-recycling/755/*

**URBANITE - Reusing Broken Concrete**

Reuse of concrete for sustainable environment & conserve for the future. As society is adapting new ways for a healthy ecosystem and trying to reuse of demolished building materials with a new approach in outdoor landscaping. One such material is reuse of broken pieces of concrete that is **Urbanite.**

Urbanite is locally available on the landfill sites. It requires society's acceptance and less energy to carry from the demolished site and to install. It can be used more creatively & various ways in outdoor landscaping as in pathways, outdoor courtyard, stepping stones, benches & flowering pits etc.

Urbanite laying technique is the same as paving and stone pathways. The gap between the concrete broken pieces could be filled with sand or gravel or cement mortar or grass. Need to educate and encourage the society to use Urbanite as construction debris material and lessen the burden on landfill. This is a sustainable approach towards the environment and conserving the resources for the future generation. (Urbanite - Reusing Broken Concrete).

**FIXING DETAILS OF URBANITE IN ENTRANCE PORCH, STEPS AND PLANTER BOX**

A PCC bed is laid on the compacted earth of 75mm thick, the first course of urbanite (broken piece of concrete) is laid on the PCC bed and fixed with 1:4 cement mortar. The next layer is laid with a kerb stone border creating a step of 125mm riser height as shown in Figure 8, 9, & 10.

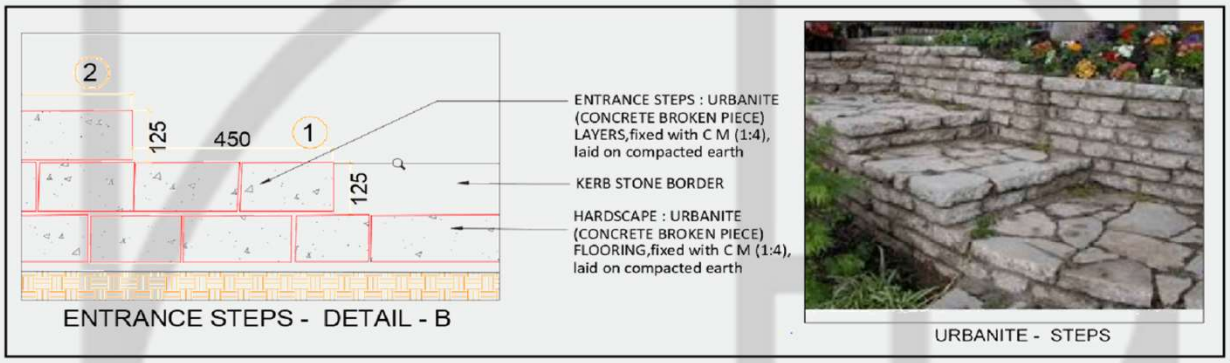


*Figure 8: Detail of urbanite entrance porch with steps*
*Drawing Ref: Author's own;*
*Image Ref: https://www.terranovalandscaping.com/90/*

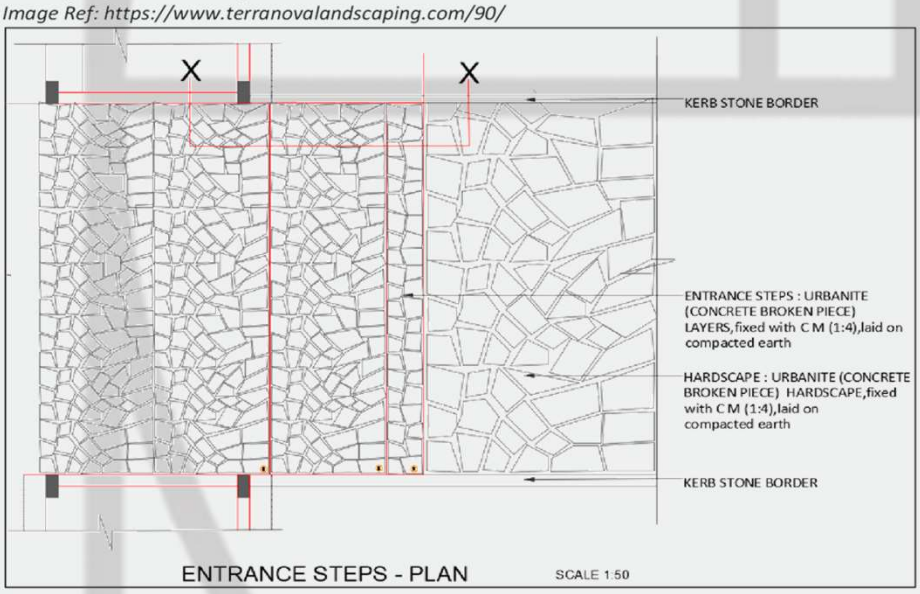


*Figure 9: Urbanite Fixing Detail for Entrance Steps.*
*Drawing Ref: Author's own*

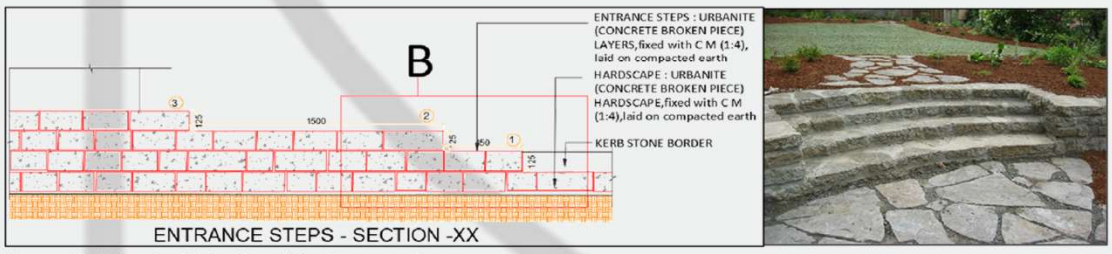


*Figure 10: Urbanite Fixing Detail for Entrance Steps.*
*Drawing Ref: Author's own*

*Image Ref: https://www.pinterest.com.au/pin/840907180178823O7/*

**FIXING DETAILS OF URBANITE IN ENTRANCE PORCH, STEPS AND PLANTER BOX**

PCC bed laid of 75 mm on compacted earth, Layers of urbanite (concrete broken piece) fixed with cement mortar (1:4) on the cement bed. The planter box filled with planting soil and shrubs are planted as shown in Figure 11,12 & 13.


*Figure 11: Urbanite Fixing Detail for Planter Box.*
*Drawing Ref: Author's own*

*Image Ref: https://www.terranovalandscaping.com/90*

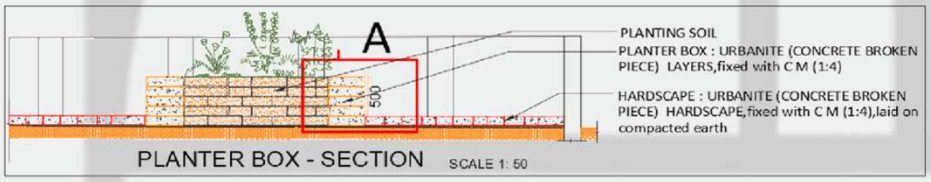


*Figure 12: Urbanite Fixing Detail for Planter Box.*
*Drawing Ref: Author's own;*

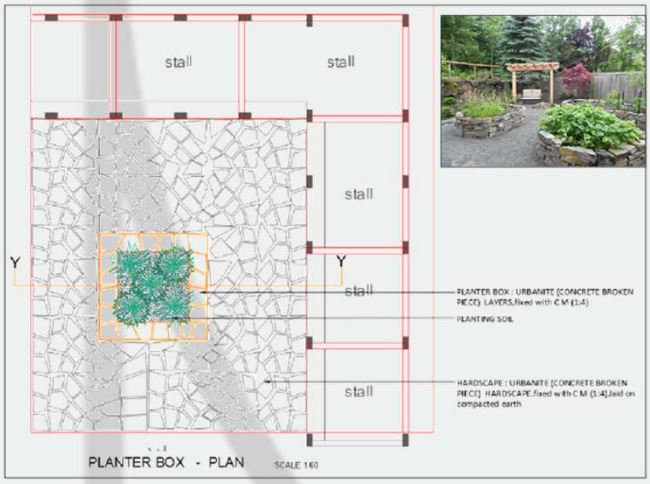


*Figure 13: Urbanite Fixing Detail for Planter Box.*
*Drawing Ref: Author's own; Image Ref: https://in.pinterest.com/pin/7459155607656476/*

**CONCLUSION:** Rapid urbanization, lack of awareness and resources, poor infrastructure and implementation has led to serious waste management challenges. The problem is compounded by the uninterested and careless attitude of public who is not inclined to contributing his/her bit and expect the civic authorities to take the responsibility. The ecosystem does not have the capacity to mend or clear the whole waste on its own, it is sure to pose environmental hazards and also effects the human health. Most of the urban area in India, the waste management status is very poor. There is scope to work in detail on the management plans on each aspect of the waste hierarchy model. The most important area would be to estimate the quantum and type of waste generated and forecast for the coming decades on a specific remediation model to reduce the waste generation here onwards. Allotment of works to the stake holders /agents, their scope, roles and responsibilities, authority and accountability for the respective work is important to be reworked and implementation of action plan for the objectives to be achieved (SOER, 2015).

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# URBAN PUBLIC SPACE: EXPLORING TRANSFORMATIONS IN A CULTURAL NEIGHBOURHOOD IN DELHI

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**Abstract:** India is one of the most culturally and traditionally rich country in the world, with diverse religions and communities. With increased technological advancements, there has been a complete transformation of urban fabric of Indian cities and these changes are repetitive. Cities have become hub of multicultural expressions, incorporating not just the physical fabric but also the social and spatial fabric. Public spaces change into extraordinary space during temporal activities like festival days due to no specified spaces in the built environment for such festivities.

Festivals are the occasion when people occupy space in the city in a different way than the regular condition. Traditionally celebrations were at home within the family, but now it has become a grand experience, moving out of individual homes and coming onto the public spaces in the city. This paper investigates one of the neighbourhoods of New Delhi, Chittaranjan Park, and explores the transformation of this space during its popular festival, Durga Puja. The understanding of the neighbourhood through its varied activities in its market spaces, religious centres, community centres etc which gives the whole space a very lively character, are an essential part of study. Thus, the study exemplifies the significance of these temporal public spaces, in escalating social interactions and cultural consciousness.

***Keywords:*** *Festivals, Transformations, Public Space, Chittaranjan Park, City Planning*

## INTRODUCTION

*"In the city the first thing are the streets and squares, collective spaces, then come the buildings and tracks. The public space defines the quality of the city, because it indicates the quality of life of the people and the quality of the citizenship of its inhabitants."*

Jordi Borja

Urban spaces are collectively shared by the people and serve as the environment in which they thrive. These public spaces usually fill up the urban gaps with life, are directly related with the structure of what we call a city and impact the associations which are formed within them. A good quality public space is one which displays diversity and where people live together with ease, creating the opportunities for people to be outdoors (Efroymson, Jones and Efroymson, 2009).

India has seen immense transformations in its urban public spaces post globalization. With increased globalisation and technology advancements, there has been a complete transformation of urban fabric of Indian cities and the changes are repetitive(Das, 2016). India is one of the most culturally and traditionally rich country in the world with diverse religions and communities which tend to celebrate and live together harmoniously. It is an apt model to study how migration of people and culture changes the local culture to give an amalgamation of co-existing behaviour, activity, and places (Singh and Singh, 2014). Majorly inhabited by migrants from different locations, backgrounds, religions and cultures, India's capital New Delhi has seen a significant influx of people. Cities have become hub of multicultural expressions, incorporating not just the physical fabric but also the social and spatial fabric (Singh and Singh, 2014).

Events or Festivals are the temporary occasions when people occupy space in the city in a different way than the regular state. The sociologist, Zygmunt Bauman, explains the word "fluidity" (Bauman 2000), associated with inconsistency and temporariness, and is the apt word that explains the current period. The lively everyday life in the cities progressively

redefines the idea of time in context of space. Time has become the fourth dimension of space design and many design efforts show that temporariness opens new possibilities such as creation, inspiration, inclination, or experimentation (Campos, 2012). These spaces help people to interact with one another and share their joys and desires (POPESCU and CORBO, 2012). It is also very interesting to observe that these open spaces were not purposely designed, but are being transformed for celebration by the local people. Their way of celebrating festivals and transforming public spaces accordingly, creates a unique urban setting for brief festival time. Public spaces change into extraordinary space during temporal activities like festival days due to no specified spaces in the built environment for such festivities (Fiala, 2009).

**Festivals and their role in shaping urban environment**

Festival is a social event which is found in almost all cultures across the globe. The complex dynamics of festival and various interesting aspects associated with it, its historic and cultural backgrounds and participation of local people has always been a centre of attraction. From the nineteenth century, different experts from varied fields such as religion, anthropology, and sociology have shown interest in the study, investigation and evaluation of festivals (Falassi, 1987). During festivals, the standard schedule of the people involved changes dramatically, creating a temporal element of interest in them which they tend to celebrate with fervor.

Festivals deeply impact neighbourhoods and its inhabitants in varied ways. They add fascinating elements to the identity of place. These festivals craft temporal changes in cities which involve various stakeholders and impart them an opportunity to interact (Silvanto & Hellman, 2005). Most of the time, festivals involve material alteration of space which encourage some social provisions and restrain others. “Festivals generate regulated and liminal spaces” via temporal alteration of community spaces, when “artists stage their productions in halls, disused churches, re-appropriated university spaces, and city centre streets” (Jamieson, 2004). Festivals, rooted in a civic space, aligned to local culture, persuade to relive the urban place. Such events augment the culture of the place and hence draws tourists (Brownett and Evans, 2019), enhancing its imageability. They can also provide a legitimate enticement for the visitors to stay at the place for a long duration (D, 1997). Such festivals also generate a chance for the local people to gain from the cultural opportunity (Miśkowiec, 2017).

**AIM**

The study aims to investigate one of the neighbourhoods of New Delhi, Chittaranjan Park, and explore the transformation of this space during its popular festival, Durga Puja. The understanding of the neighbourhood through its varied activities in its market spaces, religious centres, community centres etc which gives the whole space a very lively character, are an essential part of study. Thus, the study exemplifies the significance of these temporal public spaces, in escalating social interactions and cultural consciousness.

For the duration of festivals, cities are transformed either by varying their spatial components or by giving a unique and explicit identity. Festivals necessitate physical alterations of neighbourhood which encourage community planning and restrain others (Stevens and Shin, 2014). Besides, streets are sometimes closed or some elements need to be added or removed, buildings are repainted and amazing performances are rendered in common urban places. These activities promote visitors to engage and participate in such events. Thus, festivals redefine the cities and make them dynamic through temporal activities and people. These neighbourhoods become a visually pleasant setting as regular places are transformed to celebration places with unusual activities which are unlike the daily routine activities (Jamieson, 2004). Through precise assumption of public places, festivals support the reoccupation and extension of restricted social life and the definition of place (Harcup 2000). By sculpting community experiences in local places, festivals keep on to generate new possibilities for social rendezvous, giving chance to enhance character and construct communal ties.

**RESEARCH METHODOLOGY**

Field visit was one of the crucial methodologies done for the study wherein the researchers visited the site of the festival before and during the festival event and observed the variety of formal and informal activities, understanding the needs

of humans visiting the space during festivities. Methodology consisted of field notes, observations, informal talk with visitors and residents.

The festival which is celebrated among a neighbourhood with the whole community being involved is chosen for the purpose of study as per the topic justification criterion. (Stevens and Shin, 2014) state that urban life is defined by four kinds of spatial conditions – 1. enclosure, 2. centrality, 3. axial connection and 4. permeability. It is the differing nature of these spaces that shape informal social encounters and provide local identity and sense of place (Badar, 2018).

**UNDERSTANDING THE NEIGHBOURHOOD: C R PARK**

Chittaranjan Park, most commonly known as C R Park, is part of South East district of Delhi under the jurisdiction of MCD and is located in Zone F as per planning norms. C R Park has total of 3-entry points; via Outer Ring Road and has a residential as well as mixed land use character. Delhi is divided into 15 zones, A to P and for the purpose of our study, we will be looking at Zone-F which falls to the south of Delhi. Zone F consists of mainly residential built spaces apart from its distinctive green character (Das, 2016). The zone also has city forests and ridge area. C R park comes under ward 190 of Zone F which is mostly residential land use and is one of the major ward bordered by planned development areas such as Greater Kailash, Kalkaji, Nehru Place etc and unplanned settlements like Govindpuri. The present population of total ward as per Census 2011 is 78,000 approximately and that of C R park is around 50,000. The area has maximum Bengali population and is one of the most famous Bengali neighbourhood of Delhi, and thus it boosts of distinctive cultural identity and social groups(DAS, 2016). The area tends to transforms itself during the traditional festival of Bengali, Durga Puja, which display the relationship of culture and religion in the lives of people.

C R Park is its roots in the Bengali traditions and the whole area boots of strong traditional roots. Its markets, festivals, temples, food etc are a reminder of the culture of Bengali and which makes it a colourful and vibrant neighbourhood. The public space in the area is always very lively and effervescent where people enjoy getting together and spending time over food and daily life activities. This makes the whole place very dynamic spatially and the intangibility of the place mix with human behaviour pattern makes the whole neighbourhood an interesting place to study (Das, 2016).


DELHI ZONE MAP


CENTRAL ZONE (WARD 190)

WARD 190

**Evolution**

The neighbourhood got his name from a man known as Chittaranjan Das, who is also called 'Deshbandhu', and was part of the country's independence movement. He believed in Gandhi's movement of nonviolence and fully supported it. In 1954, an organisation was shaped for East Bengal immigrants who lost their homes in Pakistan during the Partition of India. This turn of events eventually led to coming together of people who urged for a colony of their own. Thus, a land was allotted to them in New Delhi on the southern sides in around 1960s, which was termed as 'East Pakistan Displaced Person's Colony' (EPDP). The original layout of the colony had approximately 2000 plots, residential blocks, markets, and social cultural spaces. More displaced families were later on added to the colony resulting in some more new blocks. The major road of the colony is Bipin Chandra Pal Marg. The EPDP colony in 1980s was renamed as 'Chittranjan Park' after the freedom fighter of Bengal, Deshbandhu Chittranjan Das (Manivannan, Srivatsan, 2019).

Chittranjan Park has a very famous Kali Bari temple which was founded in the year 1973. The temple was dedicated to Lord Shiva and the celebrated custom of their festival known as Durga Puja also started with the temple in the same year. Currently the neighbourhood boosts of market spaces, post office, schools, banks, police headquarters, community centres, and temples. The place thus inspires to be an ideal neighbourhood with almost all facilities available within range and there is nothing which is not available to lead everyday life.

Also because of the presence of the fact that the neighbourhood was allotted to Bengali migrants, there can be seen a lot of scope of social connection between the people as they belong to the same community with same tradition and practices (Manivannan, Srivatsan, 2019). The community was built from scratch by the residents themselves who made it a way to incorporate traditional lifestyle of living together socially in the neighbourhood. The case of this neighbourhood was selected as it is the only place where we can see an establishment of one type of community and its practices, making it a distinctive case of socio-cultural and temporal aspects of space.

**Demography and Land use**

The study area, C R Park boosts of residential as major land use as per Delhi Master Plan 2021. The map has been attached for reference. Green cover is roughly 30% and every pocket in the area has small green patches for social interactions or play areas.

| Residential | Commercial | Open space | Institution | Open Ground | Roads | Mixed Use |
|---|---|---|---|---|---|---|
| 35% | 10% | 30% | 7% | 3% | 15% | 3% |

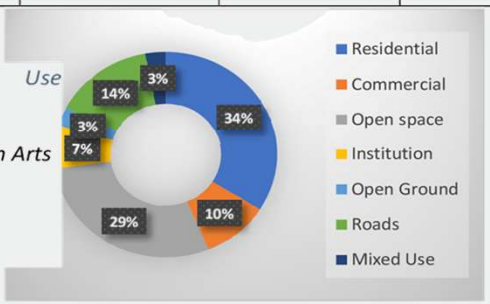


*Figure 1: Land Use Distribution*

*Source: Delhi Urban Arts Commission*

Figure 2: Land Use – Ward 190

The ward 190, as explained before is subdivided into; C R Park, DDA Flats and Alaknanda. Each of these areas have diverse densities and well-defined residential and urban character of the place.

**The Urban Character**

*Figure 3: Freshwater fish market*

*Source: Author*

*Figure 4: Market 1 at C R Park*

*Source: Author*

They are few commercial markets and shopping centres located in C R Park, as shown in pictures. The markets are known as market -1, 2, 3 and 4. Understanding Bengali culture, one can accept the love for fish among Bengali cuisine as one of the integral parts of the culture. For the same reason, we can see one of the main markets in the area is for freshwater fish and another one for street food as these markets are like social interactive spaces among the people and the tourists visiting them to be part of the tradition of Bengal. The commercial markets have a lot of footfall specially during traditional Bengali festival like Durga Puja and this creates a parking problem in the neighbourhood which kind of uses the road in front of the markets as well as internal streets for parking creating inconvenience to the residents.

**The Festival: Durga Puja**

The neighbourhood boosts of the traditional festival of Bengalis, Durga Puja which dates back to the year 1970, around 48 years back when it was celebrated among the inhabitants at a household level and in their individual homes and spaces like terraces and small open parks. It is crucial for the study to understand how festival, as a temporal activity, can be seen as a powerful indicator of the social cultural identity of the community, and of how the whole neighbourhood prepares itself during the 4 days of festive celebrations. Each street, square, open space, road, and markets transform itself during the festive days when everything revolves around humans dominating the space rather than normal condition of the space.

*Figure 6: Kali Bari Temple complex at C R Park*

*Source: Author*

The famous Kali Bari temple came up in C R Park in the year 1973, which then became one of the venues for the festival. The other venue was also a ground known as Mela ground and thus the neighbourhood had 2 venues for the festival till 1976. By the next year, 1977, 2- more venues were added to the list where the Puja was celebrated. These venues include, temple ground and K block ground. The principal spot for such celebrations is the temples in and around C.R. Park which are also the most important interfaces for all the cultural interactions, on a daily routine basis (DAS, 2016). The Bengali community are to a certain extent appreciative to their religious and spiritual belief which can be seen in the planning of the neighbourhood with various open spaces and areas of social interactions. The Kali bari temple complex is one of the most significant venues for all types of celebrations which takes place in the neighbourhood which reflects on the number of such spaces provided at the community level for such practices.

*Figure 5: Market no 1 at C R park*

*Source: Author*

The intent of the study is to also try and understand how these community spaces, including streets and grounds, tend to temporally transform itself into pandals, maidans etc during the festivities. During normal days, these spaces are used for small everyday social gatherings, for playgrounds, or for holding small tournaments. But during festive days, we can see how the space adjusts to cover more than 1,00,000 visitors apart from various other activities going on simultaneously. The celebrations are unique blend of diverse population who takes part in the festival irrespective of their ethnic background. In India, festivals are ways to bring closer different strata's of society, with different ethnic, social and cultural backgrounds to participate and get involved in a good way


*Figure 8: Evolution of Durga Puja festival in neighbourhood in 1970 with only 1-venue*

*Figure 8: 2- more venues added by the year 1973*

*Figure 9: Total around 4 venues started celebrating the festival by 1976*

At present there are around 8-10 venues in the neighbourhood

During interviews, it became quite interesting to watch and comprehend the various experiences a tourist has who visits the festival from a different place in the city and travel for C R park to see the puja. Similarly, trying to understand the feelings of the residents of the neighbourhood brought out different set of experiences who apart from being proud of the fact that they 'own' the place, also talked about less space of everyday life during festival days.

**ANALYSIS**

**Enclosure:**

Enclosure can be understood as the enclosing of space or streets through the use of elements like buildings, trees, walls etc (elements of vertical nature). This quality of an urban space helps one associate a feeling of oneness, or a sense of belongingness to a place. Having a height proportionate to the width of an urban public spaces relates to a feeling of unity and a room like quantity (Salat, 2014). Where if an area does not seem to enclose or the height to width ratio is not comparable, one may feel lost and a sense of place goes missing (R. A. Moussa, 2018).

Every year during the festival, the whole place is lit up and planned in a proper way with roads closed for vehicular traffic and only pedestrians are allowed to roam. Hawkers, Kiosks etc made their way into the whole process wherein tourists have to stand in long queues before entering the 'pandal' and which gives the chance to the people to enjoy the traditional food during the whole process. The degree of enclosure in Durga Puja can be seen at some places because of the surrounding buildings and cannot be seen at other. There are 4-5 major locations in C R Park where pandals are set up and one can see the sense of belongingness and a sense of enclosure when one passes through the streets leading to pandals.

On normal days, the whole neighbourhood is a mixed land use where one can engage in commercial activities during evening time, which tends to bustle with shoppers, eateries, fish market, pedestrian as well as vehicular traffic. The festival is a 4-day festival and before the start, preparations go in full swing where temporary shelters (pandals) are starting to be made, idols of Durga Maa are made by people across the country, space for queue, eateries, kiosks etc are planned for proper management. We can even see the security on all 4-days of festival which is taken care by the RWA.

*Figure 13: Enclosed space is not formed by the festival in all its pandal*

*Source: Author*

*Figure 13: Kali Bari temple do acts as an enclosure space for festivities but enclosure is only limited to this venue and few other venues in C R park*

*Source: Author*

*Figure 11: Road leading to Durga Puja Pandal. You cannot find enclosure as the festival revolves around many streets*

*Source: Author*

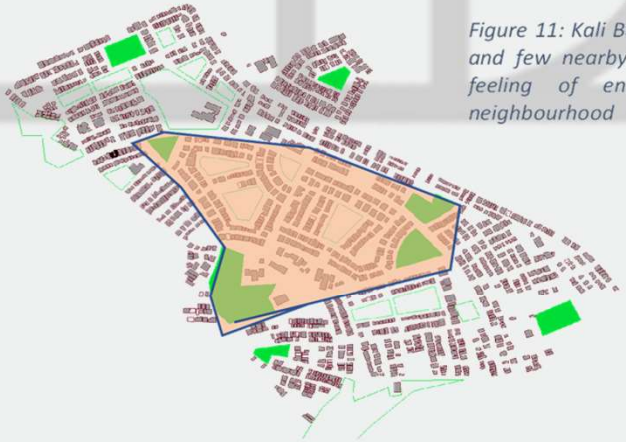

*Figure 11: Kali Bari temple pandal and few nearby pandals gives a feeling of enclosure to the neighbourhood*

Vehicular traffic is stopped during the festival days which make the place look connected to the streets leading to pandal which gives the character of an enclosed space. Tourists from all across the city line up to see the festival as its one of traditional Bengali festival in the Bengali neighbourhood. Density reach its maximum peak with people enjoying the festival in the best attires and with the ambiance set with lights and music.

The event causes a transformation in the character of the space that plays a significant part in the image of the space with the visual and emotional experiences of the viewer as an important consideration (Badar, 2018).

**Centrality**

Centrality of a space is determined by its location and also by its accessibility (Quinn, Bernadette and Wilks, 2017). In Durga Puja, we have multiple locations where pandals are set up, but the most famous pandal is in the Kali Bari temple complex which acts as a central location attracting tourists which hosted its first durga puja in 1977 and still going with the tradition. This location is enclosed by roads and because of the temple setting, it becomes one of the most popular and famous space within the whole neighbourhood to hold religious functions. The temple attracts huge crowds of

people during the festival days, and also organise many cultural functions and competitions among the residents of the neighbourhood.

*Figure 15: Kali Bari temple acts as a central place for festival celebration*

*Source: Author*

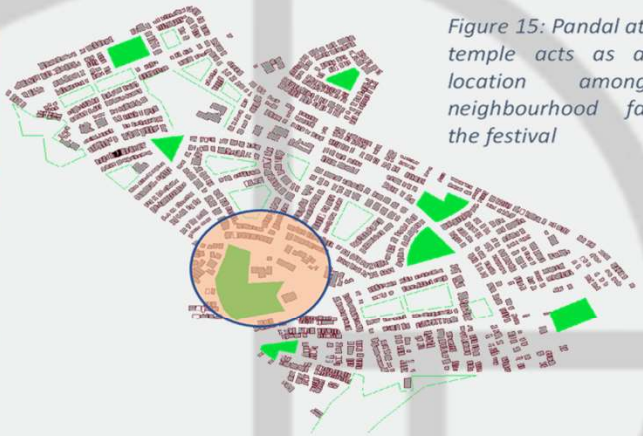

*Figure 15: Pandal at Kali Bari temple acts as a central location among the neighbourhood facilitating the festival*

The festival temporarily transforms the open space into a lively destination. Due to sudden rise in pedestrian traffic, we can observe some traffic jams leading to the neighbourhood. Though there is provision of parking, but its limited and many tourists visit the place by walking or taking public transport. Centrality can be seen in a diverse form in the neighbourhood, because we have multiple locations where the tourists spread, we cannot concentrate on one central location apart from the fact that temple gets the major density but the other pandals also full with maximum tourists.

**Axial Connectivity:**

The concept of axial connectivity means to associate connectivity of people with the space and to form an axis wherein streets play a major part (Quinn and Ryan, 2019). This character plays a major role in our neighbourhood as the whole place boosts of multiple axis, which lead the traffic onto different streets and pandals and they are all interconnected. So axial connectivity allows for better circulation, more social interactions which happen along the axis. Streets play a major role in connecting large public spaces together with people and when we talk about its value during the festival's days, streets bring together all strata's of society where people are just standing and interacting, eating, buying, and enjoying the whole process. Also, a space which was once used for vehicular traffic are now consumed by pedestrians and stalls. Axial connectivity then helps the surrounding areas to be involved in the festivities on the main street.

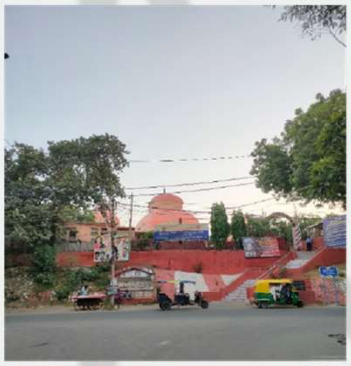

*Figure 17: Axial Connectivity of Kali Bari temple complex with main road*

*Source: Author*

*Figure 16: Road leading from Outer ring road to Durga Puja Pandals, providing axial connectivity*

*Source: Author*

*Figure 18: Axial connectivity which helps in better connected pandals and provides visual comfort to tourists*

**Permeability:**

Permeability is another crucial aspect of urban design which allows for better movement in the public space. It basically deals with how much tourists can enter your space and be comfortable and accessible (R. A. E. Moussa, 2018). Taking an example of other festival spaces, they occur at a defined space for proper movement and crowd management. So, these festivals do not tend to permeate inside the streets into the neighbourhoods. Whereas, Durga Puja is one such festival which is a perfect example of permeability, as one of the major celebrations where tourists reach the streets inside the neighbourhood and enjoy the festivities. Its kind of cuts through the space barriers and transform the whole space with an unusual mood.

Durga Puja started as a festival celebrated inside home and with the passage of time, it came onto streets of C R Park. It provided for an opportunity for the people to come and interact at all levels and participate in the ritual. The level of festivities includes enormous pandals, stalls, security, idols making, eateries etc. Food and shopping are enriching part of the festivities and the whole city is set into a festal mood. The mundaneness of life is interrupted by the staged festivities every evening.

*Figure 19: Enormous crowd at Durga Puja Pandal*

*Source: https://medium.com/@i_mutsuddi/durga-puja-begins-with-full-colors-in-delhi-2a81c36783f2*

*Figure 20: Each Pandal in neighbourhood has roads connected for easy movement. One can move easily from one pandal to another by walking on connected streets making the whole concept of permeability understandable.*

**CONCLUSION**

Over the period, the Durga Puja festival is serving as a catalyst in conserving local culture, character and building a sense of pride in local people. It helps residents to remain culturally integral and also enhance social interaction among them.

The Kali Bari and other nearby pandals are visually enclosed by streets lined with buildings and trees (vertical elements) which gives a home like feel. Centrality can be observed by location and accessibility. In Durga Puja, there are multiple locations where pandals are set up, but the focus is the Kali Bari temple. The concept of axial connectivity is vividly visible through plans shown above which displays how various Pandals are axially connected with a range of temporally pedestrianised streets. This quality of an urban space helps one associate a feeling of oneness, or a sense of belongingness to a place. Permeability through streets leading to different pandals provides an opportunity for the people to come and interact at all levels and participate in the rituals.

Festivals artistically transform public spaces temporarily; and the local people, easily and willingly adapt to these changes. It is important to connect such festivals with the planning and renewal policies. Although, little is thought or planned by the city's planning agencies in this direction. The "Durga Puja festival" can be very effectively utilized as a potential event by these agencies to enhance the neighbourhood in term of public space organization and thus be more inviting for tourists. The research can be helpful in augmenting the city's image to revitalize the public spaces for improving the overall experience of residents as well as visitors.

Although the space and activities of this festival reveal some communal objectives, the festival evidently gives a base system for diverse communal groups to come and perform together. Urban open space acts as a support of various events and festivities, and also helps in creating an image of a place or a neighbourhood. Right through the study, it was understood that festivals help in assisting social interactions among different parts of society thus calling for a more inclusive and dynamic space where the temporary event takes precedence over the static function of city (Vera and Mehrotra, 2015).

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# ANALYSIS OF SHADING CONDITION IN THE STREETS OF ANCIENT VEDIC SETTLEMENTS USING PARAMETRIC TECHNIQUES

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**Abstract:** Literary sources like *Mānasāra* and *Mayamata Shilpashastras, Arthashastra, Samarangana Sutradhara* and similar scriptures pertaining to Vedic period provide several categories of settlements according to their function and scale, the basic module of which are *Gramas* or the wards. These sources also suggest classifications of the *Gramas* by means of settlement patterns comprising urban blocks and streets of different configurations. The categories of streets, namely *Brahmavithi, Mahakalavithi, Rajapatha, Vamanapatha etc.* are also found based on their width, orientation and functions. The heights of the urban blocks are also being suggested and the height-to-width ratio for a specific street category varies for different ward patterns. This paper aims to create conjectural three-dimensional parametric models of selected *Gramas* based on the codes of the literary sources and determine the shading condition in the streets by means of simulation techniques and associate the results in terms of tropism, a behavioural determinant of thermal comfort in outdoor spaces. The paper further analyses the shading percentage of street surfaces for 3 critical days of the year against the height-to-width ratio of the streets, the activity pattern suggested in the codes and evaluates the relative performances of the ward patterns.

***Keywords:*** *Vedic Villages, Settlement Pattern, Outdoor comfort, Tropism, Shadow Condition.*

## 1. INTRODUCTION

During the early and late Vedic period, a number of Vedic literary sources were composed which provides elaborate categorizations of the cities and settlements, hierarchy of the streets and their network system, principles of site planning and folk planning (Dutt, 1977). The design decisions were based on geographical, geological, economic, environmental, religious, mythological, physiological, cosmological, genealogical, astrological and astronomical aspects (Dutt, 1977). Historical and archaeological evidences provide us with a number of fortified settlements that existed during the second urbanization in an air of Vedic religious and philosophical paradigm (Rahman, 2012).

Among the elements of morphological dimensions of urban design, the cadastral pattern is the most permanent one (Carmona, 2003). Considering the characters of traditional settlements, the streets in a city are the open spaces as opposed to the urban blocks which are used for vehicular and pedestrian circulation as well as routes for trade and commerce (Carmona, 2003). The Vedic codes for city planning provides specific instructions for the streets to be used for trade as well as public spaces (Dutt, 1977). The scriptures give elaborate guidance for providing public squares and incorporating plantation for public interest (Dutt, 1977).

Various types of settlements can be found from literary sources according to their respective scales and purpose. However, the Vedic village or *Grama* had been suggested as a basic module or ward from which all these settlements can be formulated. Based on the cadastral pattern, orientation, siting condition and purpose, several village types were mentioned. *Mānasāra* classifies the villages into eight types in terms of their shape, street-planning, folk-planning and temple planning. They are called *Dandaka, Sarvatobhadra, Nandyavarta, Padmaka, Swastika, Prastara, Karmukha* and *Chaturmukha.* Based on only street-planning *Mayamata* classifies the villages into: *Dandaka, Swastika, Prastara, Prakirnaka, Nandyavarta, paraga, Padma and Sripratishthita.*

The streets also had established hierarchy. The street that runs through the periphery of the village is termed as

*Mangalavithi.* The street that runs from east to west is called *Rajapatha;* while the one that runs through central axis is termed as *Brahmavithi.* The short roads lying north to south which connects two easterly parallel streets is called *Vamanapatha.* The central among the northerly streets is called *Mahakalapatha* (Dutt, 1977).

The Vedic treaties contains both direct and indirect suggestions for environmental considerations. Instructions regarding the environmental features are largely focused on the natural forces that are perceptible by means of human senses, such as the sun, wind and rain along with a variety of siting considerations (Dutt, 1977). This research aims to identify that whether the morphological and built-environment parameters suggested in these literary sources concerned the human comfort in terms of 'tropism' in the outdoor spaces which is largely governed by the streets.

'Tropism' is a behavioural determinant for outdoor thermal comfort which can be characterized as the tendency to seek out preferred condition within similar environmental parameters. Very often people choose to walk on a crowded but shaded sidewalks in outdoors, while the other side of the road remain unoccupied, irrespective of the ambient temperature. Thus seeking shade is a spontaneous behaviour of 'Tropism' which is stimulated be solar radiation (Ahmed, 1996).

## 2. AIM

The aim of this paper is to comparatively analyse the shading condition of the streets of the Vedic villages generated with varying morphological and built—environment parameters as per suggestions in the codes and strategies in ancient Vedic literary sources using modern simulation techniques in order to evaluate the environmental rationale of ancient architects and master builders.

## 3. RESEARCH METHODOLOGY

The various stages of the research methodology are as follows:

The research begins with literature survey to understand the Vedic codes and standards from the literary sources to determine the morphological (cadastral pattern, length to width ratio of the settlement, width of the streets, bounding condition, urban blocks) and built-environment parameters (Height of the urban block, Height to width ratio of streets) of the *Gramas* (villages) and deriving the criteria for sampling specific settlement patterns for analysis. This phase also focuses on the possible environmental rationale for deriving at the codes, guidelines and siting considerations; and identify the key parameters to determine the shadow condition. The climatic context has been selected to be Dhaka, as the Tropic of Cancer covers the land area of Indian subcontinent under Vedic influence in a common reference line.

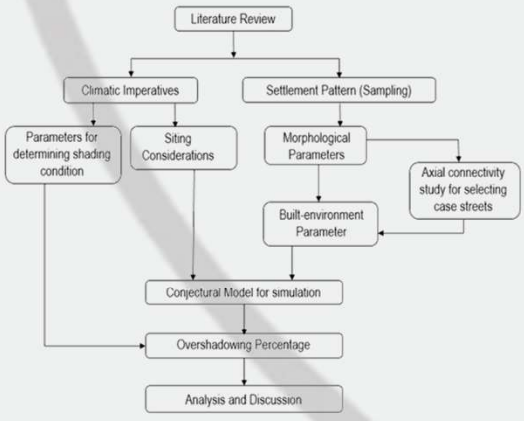


Figure 1: Research Methodology

Settlement Patterns is then generated with the diagrams and morphological parameters as per described in the literary sources using different proportions keeping the same area. Axial connectivity analysis on these patterns will narrow down the study area to more connected streets. Built-environment has been produced by introducing parametric information regarding height of the plots or blocks, bounding condition and building materials on the previously generated settlement pattern. Information regarding building height and material are found from the literature reviews. Suitable three-dimensional conjectural model has been generated for shading condition analysis.

Lastly, discussion and findings will be placed regarding

the comparative analysis and correlation between built environment parameters and simulation results of overshadowing percentage of the streets. The flow diagram of the research process has been presented in figure: 1.4.
SAMPLING AND CONJECTURAL MODEL GENERATION

**4.1 Selection of Case Diagram**

**Sampling:** Among various types of Vedic Villages (*Gramas)*, schematic diagram for eight villages can be found: *Dandaka, Sarvatobhadra, Prastara, Swastika, Chaturmukha, Nandyavarta, Padmaka, and Karmuka* (figure: 2). The first five types of these villages have orthogonal cadastral patterns, while *Padmaka* and *Karmuka* are omnidirectional.

and contains radial cadastral network. For simulating overshadowing percentage the diagrams with specific cardinal direction have been considered and the omnidirectional diagrams have been eliminated. The plot division principle for *Chaturmukha* is geometrically the same (although, the *Padavinyasa* or folk-planning is different in many other terms) as *Sarvatobhadra* for which it was not considered for analysis in order to avoid repetition. Thus, six case diagrams have been selected with orthogonal street and plot division: *Dandaka, Sarvatobhadra, Nandyavarta* (for square settlement), *Nandyavarta* (for rectangular settlement), *Prastara* and *Swastika*.

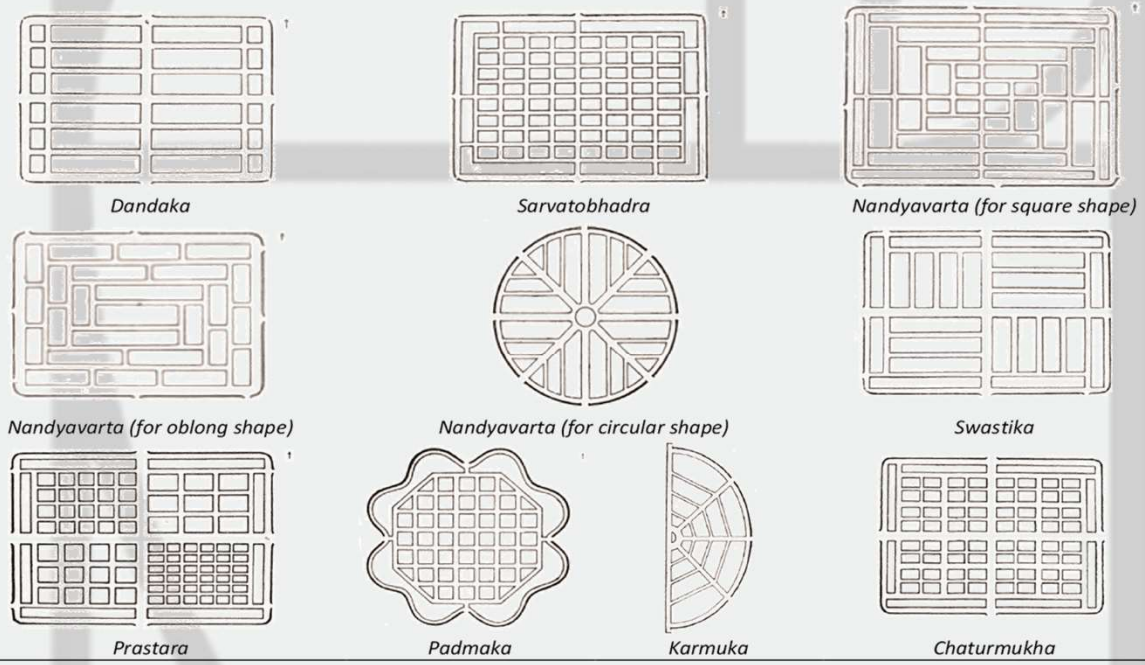


***Figure 2: Diagrams for Vedic villages***

**4.2 Morphological Parameters:**

**Bounding Condition:** *Mayamata* suggests the length of the settlements to be 2, 1¾, 1½, 1¼, $1\frac{1}{6}$, $1\frac{1}{8}$ or 1 times the

breadth. For this paper, the ratio for length to breadth has been considered to be 2:1, 1½:1 and 1:1; two marginal and one mean value of the suggested proportions. The bounding conditions also suggest that the shortest length of a quadrangular village or any settlement has been found to be 300 *dandas* (equivalent to 548.78m). Taking this value one mean value of the suggested proportions. The bounding conditions also suggest that the shortest length of a quadrangular village or any settlement has been found to be 300 *dandas* (equivalent to 548.78m). Taking this value

into account, the length and width of the settlements with the above selected ratios 2:1, 1½:1 and 1:1 are deduced (rounded to meters) to be 780m x 390m, 675m x 450m and 548m x 548m respectively.

**Width of the streets:** The two principal streets, the *Brahmavithi* and *Mahakalavithi* along with the *Mangalavithi* has been considered to be 5 *dandas* wide, which is equivalent to 9m. All the other streets, the *Rajapatha, Vamanapatha, Vithi* and *Marga* has been considered to be 2 *dandas* or 4m wide, with an exceptional *3 dandas* or 6m wide for *Dandaka* according to literary description.

Given the above information, fifteen settlement patterns has been generated from the selected six case diagrams (figure: 3). The patterns are divided into four equal quarters: North-East (NE), South-East (SE), South-West (SW) and North-West (NW). The central roads, *Brahmavithi* and *Mahakalavithi* are termed as BrV and MhV. The peripheral road *Mangalavithi* is termed as MngV. The streets elongated towards east-west direction (*Rajapatha,* which in short will be refer as RP*)* are numbered with alphabets and the streets elongated towards north-south direction (*Vamanapatha,* in short VP) are numbered with numerals. The streets closer to the central have the beginning character and this character, in association with the quarter initials will indicate the position of the street.

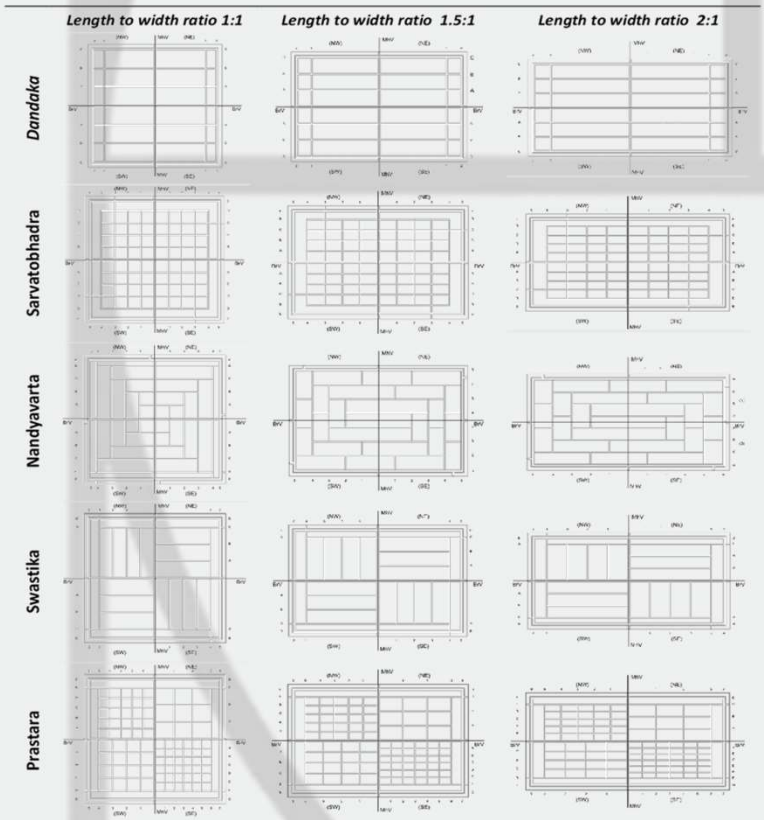


Figure 3: Generated Settlement Pattern of selected Vedic villages with different length to width ratio

**4.3: Axial connectivity study and selection of case-streets:**

'Connectivity' represents the number of immediate neighbours that are directly connected to a street or space. Axial Connectivity (and Integration) shows how good (or bad) a certain place/street is integrated in the whole street network (Turner, 2004). High Connectivity as well as Integration value is directly correlated with convenience for a pedestrian in

traveling street network environments (Mohammad, 2014), hence associated with high population density. As the principle modes of transport in Vedic period were by foot and non-motorized vehicles, the movement space and social space had considerable overlap. 'Social Space' refers to outdoor space where people can engage themselves in economic, social and cultural activities. Street as a social space is augmented by pedestrian movement. Therefore, it can be assumed that, in Vedic period streets with high Connectivity value used to have more social functions than the other streets.

Axial Connectivity Study using UCL Depthmap software reveals the highest connected streets of the generated settlement patterns. The *Brahmavithi* and *Mahakalavithi* for all the settlement patterns are the highest connected streets. The highest connected *Rajapathas* and *Vamanapathas* varies for each type of villages (figure 4). To be noted, the rectangular settlement patterns for *Nandyavarta* have no central roads on any axes. The *Mangalavithis* for all the case diagrams are the least connected streets for which they are not considered for further analysis. As all the diagrams except *Prastara* is symmetric, only the south-east quarter of all the diagrams has been selected for shading condition analysis as the highest cumulative value for both *Rajapatha* and *Vamanapatha* of *Prastara* can be observed in the south-east quarter.

### 4.4 Built-Environment Parameter

Literary sources suggest that all the buildings of an individual urban block should have similar size. In reference to the width of the *Mahakalavithi* and *Brahmavithi* as 5 *dandas,* the maximum number of floors has been considered to be four. The peripheral plots or blocks has been considered to be two-storied and intermediate blocks has been considered to house built forms with three stories. Therefore, the corresponding heights in S.I. unit are 12m, 9m and 6m respectively assuming a floor height of 3m. For simplified result, the blocks has been considered as solids. The resultant three-dimensional built environment of all the fifteen cases has different average height to width ratio (for the selected streets). Table 1 presents these parameters for specific cases. Figure 5 shows the conjectural projection of the resultant built-environment parameters.

*Table 1: Built-Environment Parameters for all the case diagrams*

| Diagram | Length to width Ratio | Average Height to Width Ratio | | | | | |
|---|---|---|---|---|---|---|---|
| | | BrV | MhV | RP | Value | VP | Value |
| *Dandaka* | 1:1 | 1.1 | 0.99 | SE-A | 1.75 | SE-1 | 1.5 |
| | 1.5.1 | 1.1 | 0.99 | SE-A | 1.75 | SE-2 | 1.5 |
| | 2:1 | 1.1 | 0.99 | SE-A | 1.75 | SE-3 | 1.5 |
| *Sarvatobhadara* | 1:1 | 1.1 | 1.24 | SE-B | 2.625 | SE-2 | 2.625 |
| | 1.5.1 | 1.1 | 1.24 | SE-B | 2.625 | SE-2 | 2.625 |
| | 2:1 | 1.1 | 1.24 | SE-B | 2.625 | SE-2 | 2.625 |
| *Nandyavarta* | 1:1 | 1.1 | 1.1 | SE-B | 3 | SE-2 | 2.625 |
| | 1.5.1 | N/A | N/A | SE-C | 1.875 | SE-4 | 1.875 |
| | 2:1 | N/A | N/A | SE-C | 1.875 | SE-4 | 1.875 |
| *Swastika* | 1:1 | 1.24 | 1.24 | SE-A | 1.825 | SE-4 | 1.825 |
| | 1.5.1 | 1.24 | 1.24 | SE-A | 1.825 | SE-4 | 1.825 |
| | 2:1 | 1.24 | 1.24 | SE-A | 1.825 | SE-4 | 1.825 |
| *Prastara* | 1:1 | 1.24 | 1.24 | SE-C | 2.25 | SE-2 | 2.625 |
| | 1.5.1 | 1.24 | 1.24 | SE-C | 2.25 | SE-2 | 2.625 |
| | 2:1 | 1.24 | 1.24 | SE-C | 2.25 | SE-2 | 2.625 |

## 5. SHADOW ANALYSIS

### 5.1 Formation of 3d model for computer simulation

In order to conduct the shading condition analysis of the outdoor spaces, the three dimensional model of the built environment of all the fifteen cases has been produced in Autodesk Ecotect using SI

The overshadowing accuracy has been considered to be 'very high'. The basic information regarding the model has been shown in Table 2.

| Sl No. | Parameter | Specification |
|---|---|---|
| 1 | Location | Dhaka, Bangladesh |
| 2 | Latitude | 23. 50˚E |
| 3 | Longitude | 90.20˚N |
| 4 | Time Zone | + 6.00 GMT |
| 5 | Unit | Unit of Dimension: SI Decimal (m)<br>Unit for Analysis: Percentage (%) |
| 6 | Weather Data | Dhaka |
| 7 | Overshadow percentage | The percentage of shade and shadow casted over a surface by surrounding built forms. |
| 8 | Specified Dates | 04 April<br>21 June<br>22 December |
| 9 | Specified Time | 05.30-18.30 hrs |
| 10 | Value | The results are shown in percentage for every 0.5 hrs |

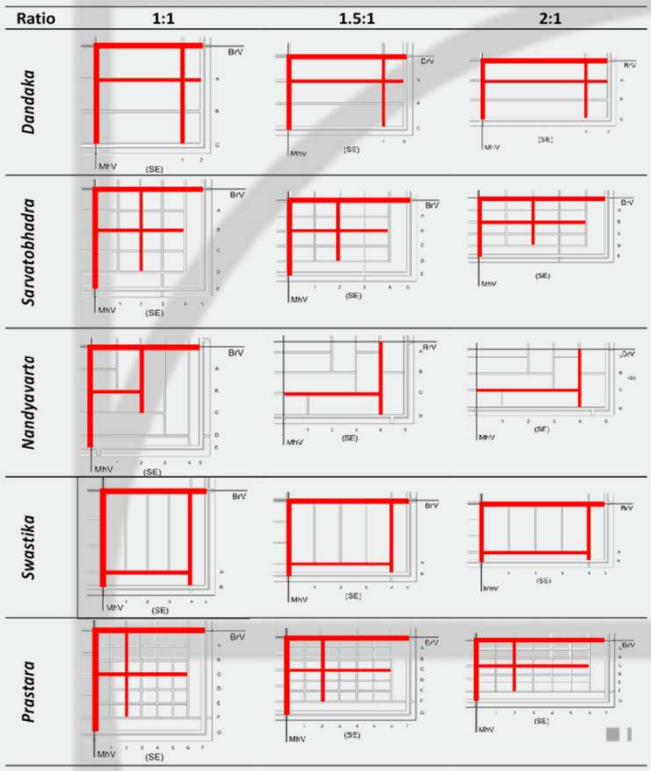


Figure 4: Selected case streets from axial connectivity analysis

Among the three dates, 21 June and 22 December are the Summer Solstice and Winter Solstice respectively for the northern hemisphere of the Earth. These dates have the maximum and minimum solar exposure in a year respectively, although incident sunlight will be largely governed by the sky condition. According to the weather data of Dhaka, 4th April has the highest recorded solar radiation level in a year, which can provide us with the maximum threshold of incident sunlight for this study. April,

June and December also represents three different seasons: the hot-dry, the warm-humid and the cool-dry.

### 5.2 Shadow analysis results

The simulation results represent the overshadowing percentage on the street surface for every half an hour from 05.30 hrs to 18.30 hrs. Due to the seasonal change in time form sunrise and sunset, the results for 4th April represents the data from 06.00 hrs to 18.00 hrs and for 22nd December, from 07.00 hrs to 17.00 hrs. Figure 6 shows the overshadowing percentage of all kinds of streets for 4th April, 21st June and 22nd December in the form of line chart.

The data for the *Brahmavithis* (BrVs) shows that, in case of 4th April, the BrVs barely has shadow from 8.00-16.00 hrs and the overshadowing percentage varies between 3%-11%. For 21st June, a critical period remains from 11.00-12.30 hrs, when the overshadowing percentage drastically drops from almost 65% to 0%. From 08.00-11.00 hrs and 12.30-15.30 hrs, the overshadowing percentage varies between 60%- 80%. Results of 22nd December shows that the streets remain in 65%-96% shaded condition within the day. The BrVs are exposed to the sun for most of the time during the hot-dry season, have moderately shading condition during the warm-humid season and have nominal solar exposure during the winter. As all the BrVs have similar height to width ratio, the results are almost similar.

The data for *Mahakalavithis* (MhVs) shows that for 4th April, the percentage drops from approximately 70% at 12.00 hrs to 7% at 12.30 hrs and the streets remain exposed to the sun till 14.30 hrs. The percentage then increases up to 80% within the next one hour. On 21st June, the streets get solar exposure from 12.30 to 14.30 hrs. In 22nd December, the solar exposure period shrinks down from 12.00-13.30 hrs, when the overshadowing percentage remains from 0%-20%. Apart from these critical period, the streets get sufficient shading condition for all the three days.

The results for *Rajapathas* (RPs) for 4th April shows that the overshadowing percentage remains from approximately 7% to 30% during major period of daytime. The only exception is the SE-B of *Nandyavarta* (1:1), more than 60% of which during the daytime except for sudden drop in the early morning and late afternoon. This particular street has the highest height to width ratio. On 22nd December, the overshadowing percentage for all the RPs stay between 85% - 100%.

Results of *Vamanapathas* (VPs) for all the three days shows brief solar exposure for an hour. For 4th April and 21st June, this period stays between 12.30-13.30 hrs and for 22nd December, this period lasts from 12.00-13.00 hrs. Rest of the time, the overshadowing percentage remains more than 60%. The SE-2 of *Nandyavarta* (1:1) and SE-2 of all the three diagrams of *Prastara* have the highest overshadowing percentage as they have similar height to width ratio.

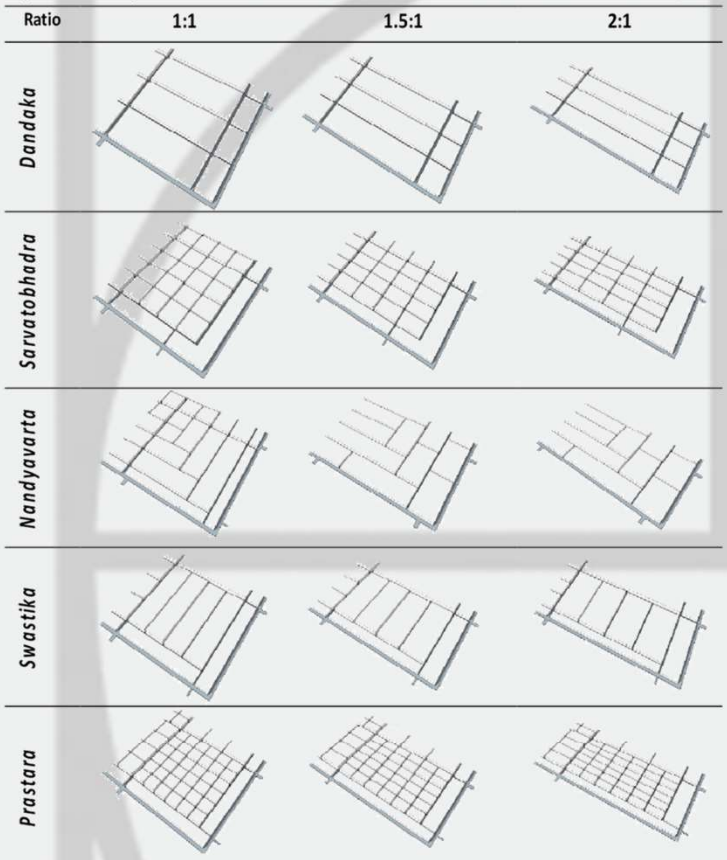


Figure 5: Three dimensional conjectural model of built environment

### 5.3 Average shading condition

Table 3 shows the average shading condition for all the streets for 4th April, 21st June and 22nd December. The data for 4th April shows that the average overshadowing percentage remains significantly low for the east-west oriented streets, the BrVs and the RPs. The north-south oriented streets have more than twice the percentage for shadow coverage. In

21st June, all the streets have almost same average overshadowing percentage due to cloud coverage; even so, the VPs have slightly higher shaded areas. In 22nd December, the BrVs are shaded for more than 80% on average and the RPs have more than 90% overshadowing percentage. The MhVs and the VPs have overshadowing percentage ranging between 65-77% and 75-86% respectively.

## 6. DISCUSSION AND FINDINGS:

This literary sources depicts that the *Mahakalapatha*, was used as the chief commercial route while the *Brahmavithi* was used for military expeditions and inland trade (Dutt, 1977). The results of overshadowing percentage from figure 6 indicates that in terms of the overshadowing percentage, the north-south elongated streets, which are the *Mahakalavithi* (MhV) and *Vamanapatha* (VP) receives more shadow than the east-west elongated *Brahmavithi* (BrV) and *Rajapatha* (RP) in hot-dry season. In case of north-south elongated streets, the both the eastern and western part

of the streets remain in shadow for a significant time during the daytime. Therefore, a user will be less exposed to direct sun in these parts of the streets.

They also have a brief exposure to direct sun during the cool-dry season and also receives higher insolation. The east-west elongated streets has very little solar exposure during the winter. Therefore, the north-south elongated streets invites the direct sun which can be considered to be positive given that in winter, direct exposure can induce the feeling of comfort. The results of warm-humid period on June are almost similar for all streets due to the overcast situation.

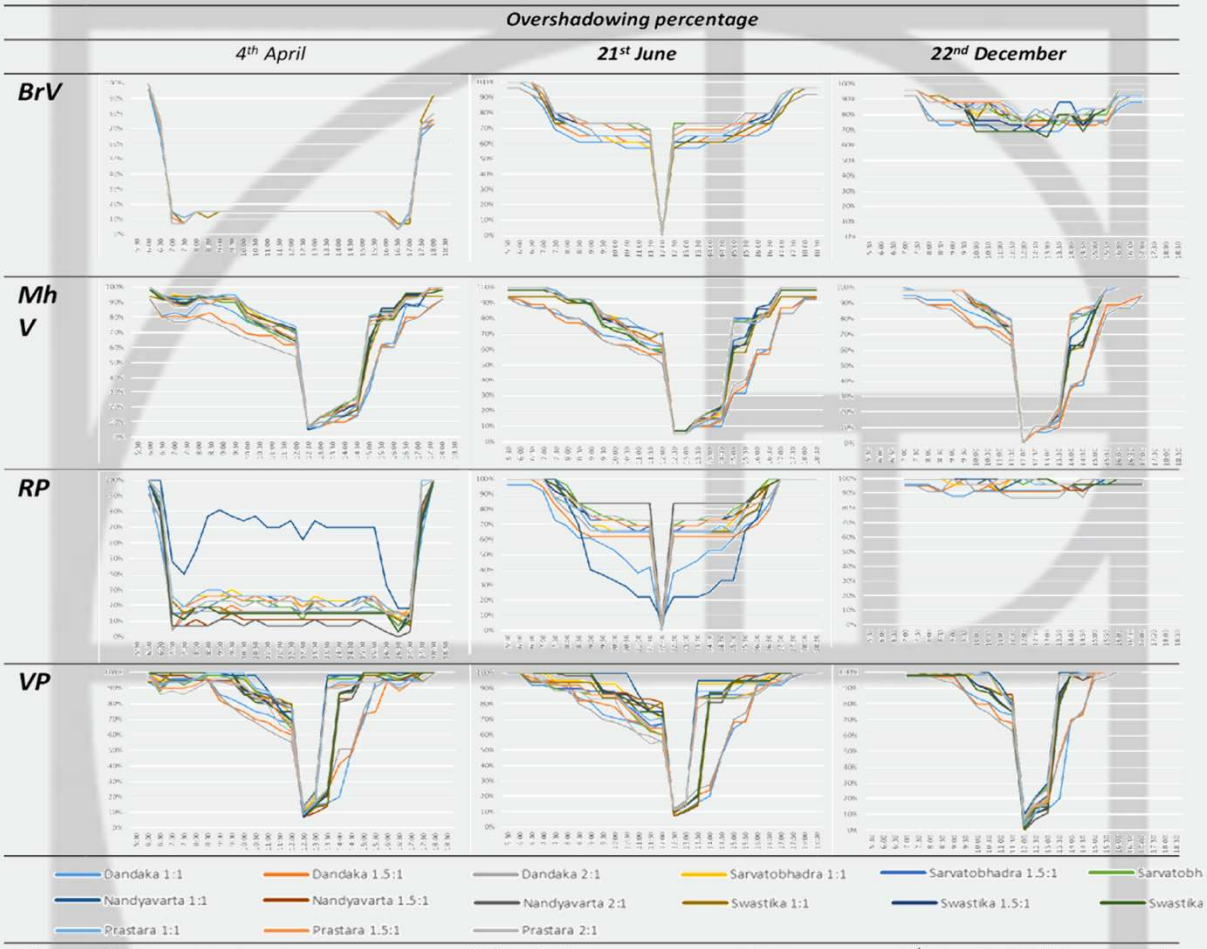


Figure 6: Overshadowing percentage (%) of all the streets with hours on 4th April, 21st June and 22nd December

*Table 3:: Average overshadowing percentage (%) of all the types of street with hours for 4th April, 21st June and 22nd December*

| | | 4th April | | | | 21st June | | | | 22nd December | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ratio | BrV | MhV | RP | VP | BrV | MhV | RP | VP | BrV | MhV | RP | VP |
| *Dandaka* | 1:1 | 24% | 64% | 27% | 74% | 68% | 61% | 67% | 72% | 77% | 66% | 94% | 75% |
| | 1.5:1 | 24% | 61% | 27% | 73% | 70% | 60% | 73% | 74% | 78% | 65% | 95% | 76% |
| | 2:1 | 24% | 59% | 26% | 74% | 72% | 60% | 77% | 73% | 79% | 63% | 93% | 75% |
| *Sarvatobhadra* | 1:1 | 25% | 74% | 34% | 88% | 73% | 74% | 79% | 87% | 85% | 77% | 98% | 85% |
| | 1.5:1 | 24% | 72% | 32% | 88% | 77% | 73% | 81% | 83% | 85% | 77% | 99% | 86% |
| | 2:1 | 24% | 71% | 31% | 87% | 79% | 72% | 83% | 82% | 84% | 76% | 99% | 86% |
| *Nandyavarta* | 1:1 | 24% | 72% | 68% | 90% | 73% | 73% | 61% | 90% | 83% | 76% | 99% | 87% |
| | 1.5:1 | N/A | N/A | 22% | 83% | N/A | N/A | 87% | 85% | N/A | N/A | 98% | 83% |
| | 2:1 | N/A | N/A | 21% | 82% | N/A | N/A | 87% | 84% | N/A | N/A | 98% | 83% |
| *Swastika* | 1:1 | 25% | 71% | 28% | 84% | 72% | 70% | 77% | 82% | 85% | 75% | 98% | 83% |
| | 1.5:1 | 25% | 72% | 26% | 85% | 76% | 73% | 81% | 85% | 83% | 74% | 98% | 83% |
| | 2:1 | 24% | 72% | 27% | 84% | 78% | 71% | 83% | 84% | 81% | 74% | 98% | 82% |
| *Prastara* | 1:1 | 25% | 74% | 35% | 87% | 74% | 74% | 78% | 84% | 86% | 77% | 98% | 85% |
| | 1.5:1 | 24% | 72% | 34% | 84% | 77% | 73% | 80% | 82% | 87% | 77% | 99% | 86% |
| | 2:1 | 24% | 72% | 32% | 83% | 79% | 73% | 82% | 80% | 86% | 76% | 99% | 86% |

'Built-environment parameters' from table 1 and 'average shading condition' from table 3 reveals no apparent correlation between the depth of a settlement and overshadowing percentage. However, direct relationship can be

found with Height to width ratio of the streets and the overshadowing percentage. With greater height to width ratio, the streets remain in shadow for longer period. The level of urban canopy has been found to govern the environmental performance directly related to solar exposure.

As a policy or scheme, the Vedic treaties suggested to expand a settlement along the *Brahmavithi* and favourably towards the east (Dutt, 1977). This expansion scheme thus means that the number of north-south oriented streets as well as streets with more overshadowing percentage will increase. Therefore, it can be stated as a hypothesis that, the Vedic architects were aware of the performance of the north-south streets as public or social spaces and thus encouraged to increase the number of these streets in case of future growth.

7. **CONCLUSION:** This research has dealt with an environmental variable that can be perceived directly with the senses and the findings shows apparent conscious design consideration in terms of outdoor comfort. The planning guideline and the building bye-laws played a significant role for determining the physical parameters of the streets and their suggested use. These parameters has defined that for streets elongated in cardinal axes, north-south elongated streets is favourable for outdoor comfort in terms of 'tropism'. This research with further refinement can thus contribute to identify the correlation between the morphological and built-environmental parameters with the other environmental parameters of outdoor thermal comfort.

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# THE IMPACT OF STREET WALL ART IN CREATING URBAN SPATIAL IDENTITY: SPECIAL REFERENCE TO JAFFNA TOWN, SRI LANKA

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**Abstract:** Jaffna city has unique recognition with its physical settings, socio-culture, and human behaviour patterns which is expressed in their lifestyle. Over time, the hierarchical pattern of the socio-culture and behavioural patterns have been represented through physical settings. It gets its impression with a traditional & religious features, social group, identity, beliefs, and norms. Within a short period, behaviour of people concerning the street wall art have changed in conflicting within the different contexts of the country and this is no different to Jaffna too. The appearance of street wall art makes a conflict in spatial recognition. Thus, there is a huge responsibility in finding the impact and reasons for this change and suggest a suitable solution for it. Place identity and social identity theories were used to form the theoretical framework and were carried to analyse the case study. There are direct and indirect influences of urban spatial identity which were measured in the Jaffna context. Most of the measurements proved that identity related factors have been included in street wall art to create an urban spatial identity. But the user perception was focused on an aesthetical manner where proper maintenance, selection of spaces, clarity of arts should be considered.

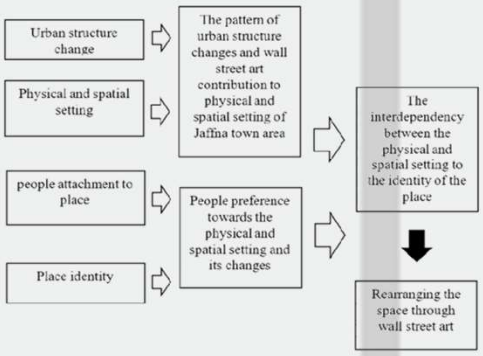
***Keywords:*** *Street wall art, Urban spatial identity, Socio-culture, Behavioural pattern, Physical setting*

## INTRODUCTION

Environment is defined by different perspective views. It depends on an individual's ideology and how much they understand it. The environment is a combination of physical settings, social behaviour patterns and culture, which gives an identity to the environment. During the development of places, the identity of them automatically gains a new framework on a large scale which would consider as a city. Neighbours and families become the smaller-scale parts; (Leila & Robert, 2014). A transactional view of this setting emphasize the interrelationship between the environment and people. Here, people and place as a 'unit' and It shows out the mutual influences.

Likewise, Sri Lanka is defined along with eco-tourism, urban street culture, agricultural activities, historical events etc. Sri Lanka being the Pearl of the Indian ocean, has the geographical shape of Mango in mind of people. The geological formation has two parts. One part as a head (Northern province) and the rest of the parts as a body (Rest of nine provinces). The northern part is attached to a body part by a strip of sand land, elephant passing way of eastern and artificial attachments by trail way, and highway. Storm weather condition makes temporary separation from the body land. Jaffna is the 2nd largest city in Sri Lanka. Naturally, its surrounded by lagoons, composed of flat land, and located at the sea level. It has unique social patterns, religion (especially Hinduism) and culture, colonial and Dravidian architecture, and physical settings. The city's transformation in the spatial identity was in several steps in different timelines.

The present condition of Jaffna has more demand for street wall art. This culture has been trending after the new government in Sri Lanka. Sudden involvement of people in painting projects at public and private spaces could be seen island wide. Such arts are exposed through different colours, textures, and forms. Though they create new platforms for many people, there are a lot of adverse effects as well. These trending issues stimulate to make this research proposal. Thus, the study is mainly focusing on the 'Impact of street wall arts in creating urban spatial identity'.




Source: Author

*Figure 1:* Structure of problem statement

## AIM

Historical sites and architectural aspects of magnificent buildings are threatened by upcoming dominating street wall arts. This leads to the loss of identity of the city in terms of its physical layout. Further, the community is directly attached to the streets. So, the street wall arts should have responsible meanings for the factors of the socio-cultural and behaviour patterns of community. 'Accessibility', 'legibility', 'comfort' and 'vitality' factors will be checked on it whether these mentioned attributes are implemented or not via street wall art.

**Objectives:** Understanding the Impact of street wall arts, study on urban spatial identity and, study of street wall art in creating urban spatial identity.

## LITERATURE REVIEW

**Street art as a global phenomenon:** Street art is an aesthetic involvement by people. Generally, it occurs by instalment of art in public places. The way of presenting art is easily accessible to the public than museums (Irvine, 2012). Overtime street arts have emerged as a part of the urban spaces (Barry & Ian, 2012). Streets are the medium which is combined with transporting facilities, living places, play areas, and interactive elements. Design and the management of the streets must reflect the function of users. The flexibility of the street is more accommodating to street-art culture. It includes various categories according to material and methods used by the people such as, graffiti art, spray- painting arts, stencil art, wheat-pasted poster art, sticker arts, street installations and sculptures. This instant art form is seen from different functional perspectives all around the country. but, in Sri Lanka Street wall arts as, 01. Disruption to society 02. Functioning as public services 03. Creating identity to the community and, 04. Functioning as guidance to the destination.

**A concise reflection of the term 'Urban space' & indicating factors in creating Urban spatial identity:** Space where their new technologies and ideas involve and apply, that place moves to under the category of urban space Darabi (as cited in Niki, 2010). Urban spaces are created with different aspects such as historical based urban identity, architectural design-based, public space-based, and transport access. The identity of urban space is a major part of contemporary deterioration in cities worldwide (Cristina, 2013). It can be seen in many evaluated ways, observed through the line, form, colour, and textures of the physical settings. A history-based urban identity could be created via culture, values of society, the system of society, economic pattern, and environment characters. Main indicators to measure the evaluation of identity are the following, 01. Difference and similarity 02. Continuity and evolution and, 03. Unity and multiplicity.

**Street wall arts in urban spatial identity:** Globally it is seen as promotional elements that consist of more investments for improving the legibility of urban spaces. Comparing with other regenerative objects in urban spaces, street wall arts can promote the community's sense, awareness, civic identity, social interaction, culture, and education. Mainly in the prosses of artwork people are involved without any variation, it promotes to transform the ideas and thoughts within urban context (John, 2006). So, it should be strongly represented or reflect identical local factors.

## THEORETICAL FRAMEWORK

A comprehensive study of the identity of the urban spaces and street as the interconnecting medium between people and spaces. The factors of physical settings and socio-culture & behavioural patterns creates identity to certain spaces. Here two theories are taken into consideration 'Place identity theory' and 'Social identity theory.'

**Application of place identity theory in creating urban spaces through physical settings:** Aspects of this place identity theory is a linkage with identity and place (Hauge, 2007). Physical forms and human activities are the main reasons to construct the place. It includes attachments and meanings (Ujang, 2009). Place identity became a cognitive 'database'. Perception and ideas also consider the physical environment.

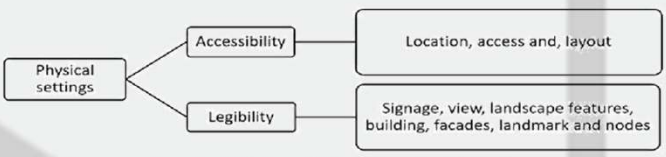



*Figure 2:* Attributes which influence in physical settings

**Application of social identity theory in creating urban spaces through socio-cultural and behavioural pattern:** The fundamental idea of Social identity theory is often used when asking a question, yourself to 'Who am I?'. 'Self-concept' idea includes two types of statements, the similar and dissimilar factors used to compare with others. According to Tajfel's explanation about 'Social identity' it is an individual knowledge of belonging to a particular social group; also, the values and emotions of that, convey to him or her. The quality of entities or groups is highly impacted by social identity, also having positive references such as nationality, religion, culture, family, and neighbourhood.

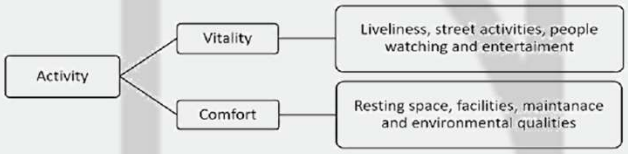



*Figure 3:* Attributes which influence in socio-culture and behavioural pattern

*Source:* Author

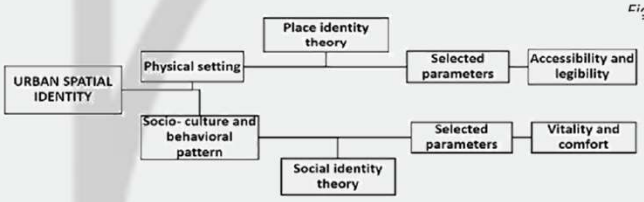



*Figure 4:* Combine study of ' place and 'social identity theories'8

*Source:* Author

**Combined study of 'place identity theory' and 'social identity theory':** Through the theoretical study, Physical setting, Socio-cultural, and behavioural patterns are the remarkable factors proved to create urban spatial identity. This leads to a comparative case study analysis.

## RESEARCH METHODOLOGY

Table 1*Concluded analytical parameters*

| Spatial identity factors | Socio-cultural behavioural pattern | Emergence of Caste systems | Socioeconomic status pattern | Behavioural changes in people | Food culture | Religious features | Physical settings | Traditional activities and signs | Ancient architectural features | Appearance of traditional colours | Guidance to place |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Authors: | | | | | | | | | | | |
| Canter (1977) | | | × | × | × | | | × | × | × | × |
| Jon Panter (as cited in Heidari & Mirzaii 2013) | | × | × | × | × | × | | × | × | × | × |
| Montgomery (as cited in Heidari & Mirzaii 2013) | | × | × | × | | × | | × | × | × | × |
| Fritz Steele (as cited in Heidari & Mirzaii 2013) | | × | × | × | × | × | | × | × | × | × |
| Ralph (1976) | | × | × | × | × | × | | × | × | × | |
| Ujang (2009) | | × | × | × | × | × | | × | × | × | × |
| Heydari & Reicher (2016) | | × | × | × | × | × | | × | × | × | × |
| | | | | | | | | | | | |

*Source:* Author

This research study has dealt with the selected authors mentioned here. This is done by arising many practical questions within the place to find the factors which support the identity of the space. Identity idea is an image of a collective individual's phenomenon. It depends on experiments of past and present. Its means conditions or objectivity of individual will be considered as identity in the future.

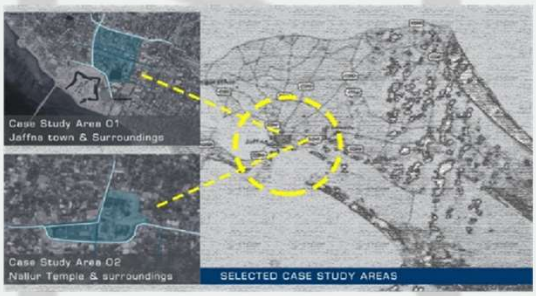
Due to COVID-19, this research has considered questionnaire survey through online methods, 100 samples were collected from people who are experts on this study, the public, school student, university students and people who participated in street wall art.

**Data collection methods:** preliminary observation, physical attributes checking on sites, questionnaire, pictorial analysis and, periodical studies.

## FINDINGS/ ANALYSIS &INFERENCE

**Introduction to case study areas:** Jaffna streets are highly influenced by social behaviour, culture, architectural features, religion, and heritage. Maintaining the same language in appearance to visitors is a notable thing. Because of the high population, there is a high number of houses and commercial areas. Selected two case study areas are highly sensitive urban areas in Jaffna and very well known by country people and tourists. Such as, Case study area 01 (Jaffna town

'Kasthuriyar road' and its surroundings) selected to deep study on street wall art activity. Case study area 02 (Nallur temple road and its surroundings) selected for understanding and for the rooted study on factors that highly influenced to create an urban spatial identity. Results of the comparative analysis will be discussed about the way how presented street wall arts are influenced or not by selected attributes from the case study area one.




*Source:* Author

*Figure 5:* Locations of selected case study areas

**Periodical analysis of Urban spatial identity pattern from Nallur temple to Temple street and its surrounding**

**Religion:** Jaffna has many categories of communities. Based on four major religions, such as Hinduism, Christianity, Islam, and Buddhism. Hindus and Christians are the majorities in Jaffna. Communities gathered within their religious temples. So, their religious beliefs and norms influenced their lifestyles and settings of the neighbourhood too.

**Physical settings and socio-cultural behavioural patterns in identity:** An aspect of religion and culture dominates the presence of a cultural trend and quality of life as well. The hierarchical pattern of culture and social-behavioural patterns are represented through physical arrangements. Signs and symbols talks about their lifestyle via surroundings. They are preserving and sharing their cultural heritage more supportive economically (Ranasinghe, 2018). Traditional activities like farming and fishing play a major role in economic support to community people. Divisions of the communities are based on their profession. From here, the caste system became a major part of the separation of people's lifestyles (Madavan, 2011).

**Influence of caste system:** The caste system played a major role in the early period of the socio and behavioural pattern (Thanges, 2008). There was an exclusion of low caste people from Hindu temples, access to water, land market and education. Low caste people were not allowed into temples and festivals. Because maintenance and management of temples were undertaken by Vellalar community. So, in the past divisions in temples such as 'low caste temples' and 'high caste people temple' are observable. Low caste people were not allowed to use high caste peoples' water resources (E.g., wells). The status of each people depended on the number of lands they owned.

**Culture & heritage:** Jaffna Dutch fort brings out the value of old heritage and culture of Jaffna at the city centre. The present developments have also considered that and working on it by maintaining, conserving, and preserving colonial heritage (Ranasinghe, 2018).

**Identical signs & symbols:** It can be physical objects or social activities. The priority to signs and symbols is given by community members. It depends on historical values, religious influence, cultural values, the behavioural patterns of people, norms, and beliefs (Shamai, & Zinaida, 2005). There are many arguments regarding relationships and conventions about it. The social activities of Jaffna communities are extremely religious based. Each practice is enhancing religious meanings over signs and symbols. Implementing these kinds of things conceptualizes the community via historical identity formation. Combination of various forms, texture, colour, and scale is used as communicative aspects in signs and symbols. In Jaffna, most of them are presented with natural features or things. For example: Organic things as a decorative thing for festivals and ceremonies (Banana tree, coconut leaves, betel leaf, coconut, mango leaves and fruits). Statues or figures of animals and birds as religious representative signs (Cow, Elephant, Peacock and Cock (rooster). Architectural features in the form of buildings, fence, and entrance spaces. The early period had social &

behavioural patterns as identity. In addition, Language as a symbol, traditional dressing styles as a symbol (Saree and Vetti) and food culture as a symbol (Vegetarian foods). *Source:* Author

*Figure 6:* Pongal festival time arrangements of 'Niraikudam' traditional dress, 'Thoranam' and painting cow's image

## Pictorial Analysis to study the impact of Street wall arts from Jaffna town to Kasthuriyar street and its surroundings

Analytical study proves that colours, forms, viewpoints, location, and scale are the major factors for getting attention to memorize spaces.

*Source:* Author

*Figure 7*: Street wall arts in Jaffna town

## Analytical study of the impact of street wall art in creating urban spatial identity in the case study area.

The attention of street wall art makes changes in creating urban spatial identity in Jaffna. It explains that the appearance of street wall art makes changes in physical settings, socio-cultural, and behavioural patterns of Jaffna context which leads to changes in urban spatial identity. For the identification and analyses in case study areas, some measures have been taken for analysis. These measures are used to clarify whether they are represented or not through street wall arts to urban spatial identity. Taken measures such as, religious features, emergence caste system, socio-economic status pattern, traditional activities & signs, ancient architectural features, food culture, behavioural changes in people, the appearance of traditional colours and, guidance to places.

### Brief explanation of analysis on each measures

**Religious features:** The influence of religious features on street wall art plays a major part in identity for urban spaces. Normally religions are used to classify people according to their lifestyle, believes, and norms. But 30 years of civil war resulted in creating a mixed-up society with all four religions. Most of the areas in Jaffna's religious temples are the landmark to certain places, and the impact of it can be seen through physical settings and behavioural patterns of people. Still, signs and symbols make identity to a place. Signs and symbols: Colours (Red, orange, and white) Forms (Figures of god, 'Kopuram', 'Kalasam', 'Vel'). The current trend of street wall artworks brings out these religious features. Out of 100 samples, 88 samples (88%) feel that the street wall art is influenced by religious features. According to the result of this measure, street wall art impacts in urban spatial identity.

**Emergence of caste system:** There were several caste systems. 'Vellalar' society was the largest and the most powerful. They started to form a society around the temples' surroundings. Upper caste people enforced customary prohibitions on lower caste people. The past three decades of war (from 1983 to 2010) have highly influenced the displacement of people, density, size, and distribution of a population. Over a million people have migrated from Jaffna to other places. It affected different caste backgrounds. According to 100 samples, 78 samples (78%) feel that the emergence of the caste system does not influence street wall art.

**Socio-economic status pattern: '**Vellalar' lands and properties are coming to the sale and other caste people have got chances to become landlords. During the war, many people were killed and displaced. By the migration, other caste groups have displaced within and around temples' surroundings which resulted in a mixed-up society with all castes. So, the dominance of caste systems has weakened. The early discriminatory practices have decreased due to present developments. Out of 100 analytical samples, 60 samples (60%) feel that the street wall art is influenced by the socio-economic status pattern.

**Traditional activities & signs:** The number of festivals of Hindu religion is getting more attention than in other religions. Yearly repeating festivals grabs the attention and create awareness on community unity, especially in traditional dance, traditional musical programs, and expression of traditional signs and symbols. The setting of statue or paintings of animals and birds especially; cow, 'YALI', elephant and peacock, etc which are considered sacred in Hinduism on the front walls. People have applied their ideas and concepts by using the abstract form or direct view into the street wall art. For more clarification of this statement, analysed 100 samples, where 92 samples (92%) feel that there can be able to get the idea and the spatial characters which were used to make identity to Jaffna urban spaces. It was made in view of aesthetics.

**Ancient architectural features:** The understanding of space, people, and history show the relationship between the space and history. It helps to recognize the space with certain features, especially in the case study areas that have compacted with many architectural styles within domestic buildings, schools, markets, public, and gathering spaces. When people need to get more importance than the spatial values and qualities, it leads to modernization. The war has made many destructions within the ancient fort and its surroundings in Jaffna. In the modernized society, people like to see some destructed features in the present. So, the appearance of many street wall arts is carried out with 'Dravidian' architectural features. For clarification, an analysis on case study areas with 100 samples is done, where 83 samples (83%) feel that there can be seen ancient architectural features via street wall arts and its support to study Jaffna identities.

**Food culture:** 'Vellalar' society is involved with agricultural practices and they are the landholders in Jaffna. So, some agricultural equipment is also represented in street wall art. Annually, Pongal festivals are celebrated for thanking the sun and farmers for providing food for the world. Some villages in Jaffna strictly follow food culture than city areas. For more clarification about this statement, 100 samples were taken into the analysis, where 52 samples (52%) said that the influence of food culture on street wall art is getting attention in urban spatial identity.

**Behavioural changes in people:** When the changes happen, people start to talk in a positive or negative manner. According to social identity theory, society must be built by cognitive of living people. This trend of street wall art made unity within many places in Jaffna. This can be seen via observation. Mostly pedestrians and vehicle drivers get visual attention into these street wall arts. In some cases, the selection of place made conflict such as, road accidents, destruction to drivers, political influences and, Communities conflicts. For the clarification got 100 samples for analytical study at selected case study areas. There are 56 samples (56%) who feel that the street wall arts could help to identify the behavioural changes in people.

**Appearance of Traditional colours:** Colours matters everywhere. Unique colours used in Jaffna context for enhancing ideas, representing the culture, and communicate with people. Different colour usage shows their preference for cultural values. From the case study analysis, red and white are the highly elevated colours. Even during festival time red is the active colour in wearing traditional dress. Normally Hindu temple walls painted with red and white to gets people attention. The functional view is used to identify places by these contrasting colours. 100 samples were taken to analytical study on the selected case study area. There are 81 samples (81%) feel the influence of traditional colours in identifying the figures of humans and temples.

**Guidance to places:** The method of mental mapping supports to discover colours, form, viewpoint, location, and scale which express the identity of each space. street wall art highly impacts on identity and space recognition. According to

user perception, communication between them made into two part: Abstract way and Direct way. The message communicated in street wall art guides to significant spaces in Jaffna such as Jaffna fort, Nallur temple, Clock tower, 'Manthiri manai', Public library etc. For the clarification, 100 samples have taken to analytical study for street wall arts which guides to places. Sixty-nine samples (69%) feel that street wall arts impact in creating a spatial identity.

### Overall summary of the Analytical Measures

The caste system, religions and ancient architectural styles are the major shaping factors in society. Civil war had been the major reason for changes in socio-cultural, behavioural pattern, and physical settings. That continuity of transformation in identity has taken another challenge with the street wall art trend. The following chart below shows an idea of 100 samples with nine types of measure. The blue colour part in the graph shows the results that identified or accepted the impact of a street wall in creating the urban spatial identity. Eight samples out of 9 given the positive results to the research problem.

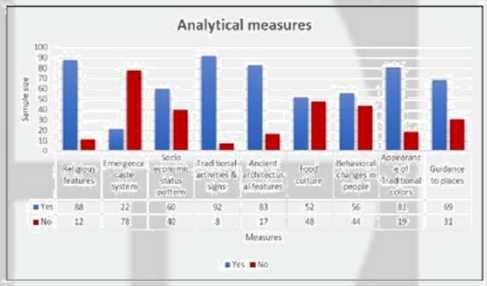



*Figure 8:* Overall summery of analytical measures

### CONCLUSION

Approaching the 'Impact of Street wall art in creating urban spatial identity' carried out with objects such as the Impact of street wall art, the study on urban spatial identity, and understanding the impact of street wall art in creating the urban spatial identity. The arguments were held at selected two case study areas, Jaffna Nallur temple road and Jaffna town Kasthuriyar road & its surroundings. Jaffna Nallur 'temple road' utilized to understand the urban characteristics and identical arrangements and the Jaffna town 'kasthuriyar road' for understanding the categories of street wall arts, appearance, and user perception on identical influences. The outcome of the comparative study proved that; the selection of the sites has a positive contribution to the survey on street wall arts and urban spatial identity.

The identical pattern of Jaffna mostly has been recognized through physical settings and socio-cultural & behavioural patterns of people, it was able to identify through streetscape and proven positively into the study. Certain aspects such as recognition, meaning, expressive requirements, mediating changes, and functions would create an image in everyone's mind. The urban structure has strengthened by attributes such as history, religion, archaeological monuments, cultural values, social groups, and ecological values. So, the expression of attachment between people and space are incapable. The study proves that some measures such as colours, viewpoints, form, location-scale as most stimulating factors in urban communication spaces. The past 30 years of civil war in the Jaffna peninsula demolished the economy as well as made a lot of other intangible changes. Then need for the people and the emergence of modernization gone towards the major transformation. At the same time, a sudden change in people's behaviour made conflict within many districts as well as in Jaffna. According to user perception, this street wall art trend seems like public service, identity-making to the community, guidance to some destinations. For more clarification, research path went through 'theoretical attributes' and checked within case study areas and proved positively.

The study identified nine parameters which linked with the creation of urban spatial identity and human beings such as; religious features, emergence of caste systems, socio-economic pattern, traditional activities & signs, ancient architectural features, food culture, behavioural changes in people, the appearance of traditional colours and guidance to places. The above-mentioned parameters had helped to prove that the street wall arts have been influenced by them to get the attention of people. To reinforce the study more, place identity theory and social identity theory were helpful to identify the real situation of the physical settings and the socio-cultural and behavioural pattern. To carry out this research accessibility, legibility, vitality, and comfort level of case study areas focus via pictorial analytical study,

periodical analytical study. Hence, the results of the transformation were given and proved through a questionnaire survey. A final comparative study has done to establish the impact of the street wall in creating an urban spatial identity.

According to user opinion, certain factors have impact on their attention to communicate with street wall arts such as colour, type of art, views, location, scale, and themes. The emergence of some forgotten or disappeared identities of Jaffna has occurred in the form of street wall arts. From the questionnaire survey, 93 samples (93%) wish to see more historical, religious, and social arts than political advertisements in walls. Thus, those changes are welcomed by Jaffna people, anyhow they must preserve and maintain that quality of drawings in a positive manner to hand over these forgotten gems to the next generation.

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# TITLE: ARCHITECTURE THROUGH REPURPOSE
## SUB TITLE: SUSTAINABLE AND DIVINE DEVELOPMENT OF BUILT ENVIRONMENT

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**ABSTRACT:** Sustainability is the current debate in building technology. The energy consumption of buildings varies according to factors such as social differences, climate, geographical location, cultural habits. The traditional architecture has many features such as orientation with respect to sun, space planning, openings, sunspace provision, construction techniques, and building and roof materials. The importance of the courtyard as a source of positive energy and vibrations in the centre of the house, one of the passive cooling techniques. The primary role of courtyard spaces is to protect the occupants from harsh outdoor conditions and provide environmental functions such as natural lighting and ventilation. Protecting building from solar radiation. Orientation of building has an important function in energy efficient building. Oriented building utilizes the advantage of solar radiations and prevailing wind. This paper emphasizes the use of courtyard, the passive cooling method and orientation of the building in hot dry kalaburagi region. Synthesis of centuries of life experience.

The focus of the paper is to understand the courtyard and orientation want to formulate sustainability. The descriptive study can identify the criteria influenced in decision making in reuse of the building that effected to the sustainable development economic, environment, social and architecture. The paper describes the descriptive and historical study of the proposed methodology for the study. By analyzing more than 400 years old residential building of Raya panduranga Deshmukh house (wada) in kalaburagi. Now some portion of Wada is utilized for rent purpose and to celebrate functions like Birthday, cradle ceremony etc.

**KEY WORDS**: Orientation, courtyard, vernacular, built environment, Sustainable.

**INTRODUCTION**: History creates a great impact on shaping our future. The ancient technologies adopted by our ancestors are extremely iconic. There is an increased recent interest in the research community on the sustainable features of vernacular architecture. This is a result of the need of respond to climate change, desire to decrease energy consumption. The aim of this paper is to document the origins, scope, techniques, content of studies on sustainable features based on natural and physical built environment. The vernacular has been widely understood as "The architectural language of the people with its ethnic, regional and local dialects, the product of non-experts ". Kalaburagi area lies under hot and dry climatic zone have a low precipitation rate. The most important aspect is protection from harsh sunlight and to develop a built form capable of reducing the radiation. The houses are constructed with thick insulation walls, tiny scale openings to keep the hot air outside compact built forms with mutual shading device and provision of the courtyard as a thermal regulator .An intelligent approach to deal with the climate .The vernacular buildings can be reused for economical, social and for self satisfaction.

**BACKGROUND:** Old buildings give neighbourhoods their distinct character and at the time provide connection to the past. Sometimes buildings often survive a specified period to their original purpose. This results in the reuse of such buildings in order to make the existing structure and surroundings active once again. What and why these traditional structures played their role in the various basic socio-cultural, political, economic and architectural aspects. To understand the daily rituals, customs and the lifestyle influenced the evolution and the development of these traditional dwellings. When the original use of a structure changes and on the other hand is no longer required, Architects have the favourable circumstances to change the primary function of the structure, while retaining some of the existing architectural details that make the building distinctive. The sustainable development and conservation of buildings in the

city provide Social, economic and environmental benefits to a community. The conservation of the built structure not only donates to the economic and environment configuration of a community, but also the social and cultural recognition. As societies continue to review their commodities of existing buildings, re-architectural use becomes increasingly important to pursuit building conservation, preservation and repurpose. The main problem is that the Architects and conservationists are facing in protecting the heritage. The condition of the structures under different living conditions, people living in the wada and maintaining it.

**AIM :**

Adaptation of existing buildings for new functions is not new trend. The approach towards reuse was established and formulated as early as the beginning of the 19th century.

**PURPOSE: RE-UTILIZATION OF THE BUILDING**: According to BROOKER and STONE -includes that " the function is the most obvious change , but other alternations may be made to the building itself such as the circulation route ,the orientation, the relationship between spaces, additions may be built and other areas may be demolished". Wadas have been renovated owning to the conflict with the changing life style."Sacred and profane spaces" as part of cultural attribute according to LAWRENCE "preparation and eating of food in spaces associated with the dwelling is common to all cultures. Preparing and eating food reveal the socially and culturally demarcations between male and female, parents and child which are not evident in the use of other spaces and facilities inside the house. It is largely related to history of ideas and values upheld by people in specific contexts at specific points in time. The daily and annual ritual carried out within the household depicts the religious beliefs and customs of the family and the continuity and change occurring as a cultural attribute. Family and social gathering are carried out during the festivals and traditional systems are adopted. The front courtyard kacheri place is utilised for performing rituals, marriages, birthday functions, cradle ceremony, munjavi etc. some portion are given for rent for residential purpose. The present generation head is an Automobile engineer,shri panduranga deshmukh having 500 acres of of agricultural land.He perform the rituals as early generation carried out without any expectations.All divine programmes are done by wada head with their own finance. In every year Ashadamas utasav is followed of sacred deity shri Panduranga with Rukamini and Satyabhama. In Ashadamas daily different Avataras were done from Ashada shudha Dhashami to Ashada madhya Pratipadha.Temple is provided with small shikhara.

Fig1. Ashadamas utasav - ratosatava(author)

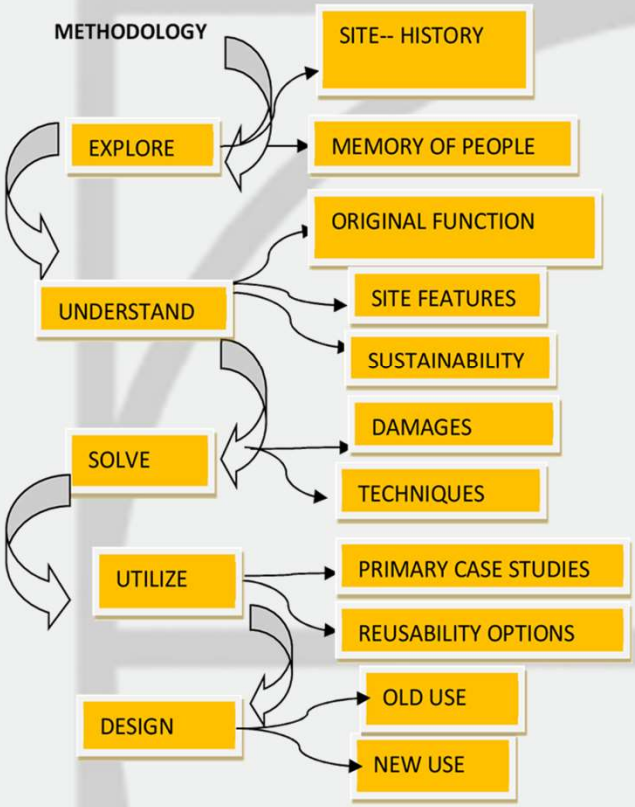
Fig2. Ashadamas utasav- Avtar(author)

Fig 3 Entrance Doorway

Fig 4 Inside area of temple For given for utasav ratosatav.

Fig 5 Some parts of wada setout for hire charge(rent) (author)

Fig 6 Some parts of wada setout for hire charge(rent) (author)




**RESEARCH METHODOLOGY**: The study started with the collection of sources of information through a literature study about wada.The fieldwork gives the information about the wada,photography and recording the observation. The qualitative research method explains the criteria influenced in decision making in reuse of the building that effected to the sustainable development, economic, environment, social and architecture. This paper describes case study of the building that is Bhamani Adil Shahi sultanate, and Nizam period.

**LITERATURE:-**

WADA in Sanskrit it is "VATA" means plot or piece of land .Wada are rich and cherished architectural heritage, reflecting the pride, religion, culture, traditions and the turbulent history of that period. It is known as WADA in Marathi and wade in kannada.It is based on the Hindu code of design known as vastu shastra, which makes the individual to live in balance and harmony with panch tatva.According to vastu the courtyard belongs to Lord Brahma and source of positive vibration to the wada.Today these are re-used and preserved as cultural architectural heritage. The architectural design factors of which rituals of religion are an important aspect. Wada's mainly divided into private, semiprivate and others. A different type of doors depicts the wealth and the social status of the owner. The traditional houses form belongs to ruling classes as well as commoners. Significantly certain variations in size, scale and economical status. But all residences do share some of the basic elements and characteristics. Wada's were designed according to the caste, occupation and status of the family.

Fig7. Location of Karnataka in India

Fig8.kalaburagi in Karnataka

Fig9. Location of wada in Kalaburgi(pinterest.com)

**ANALYSIS AND INFERENCE: ----**

**Kalaburagi** is in the Northern part of Karnataka state, located in the Deccan part of India **. Shri pandurang Deshmukh Wada** is in the heart of the kalaburagi city in Karnataka.Anant madaras Nirantar was from pandrapur, who worked under Bijapur Sultan Ali Adil shah Bahamani king.

Family service continued during Nizam period also. Anant madaras Nirantar was devotee of God Panduranga.He constructed panduranga temple near to the house and beautiful panduranga with Rukamini ,Sathyabhama idols in the wada also.shri panduranga Deshmukh residence is known as Deshmukh wada.In kalyan Karnataka region we find many wadas ,which were beautifully constructed . Some are destroyed, some under ruin condition, few need maintenance to conserve the glory of past. RAYA, Deshmukh and Deshpande were the titles given to a person who was granted a territory of land in the Nizam's territory. They collect the Sara (taxes) and maintain basic services .More than 300 villages are under Deshmukh's control. The origin of wades traces back to Adil Shahi dynasty of Bijapur. They evolved during their reign and flourished till the end of Brirtish rule. The wadas were not purely residences, it is housed kacheri ie administrative office.Ghude in kannada watch tower all four cornersof roof, for watching far distance information, enemy attacks. A small temple installed in side wada primises.Garden facilities were not seen in wadas. Usually they are two or three storied buildings.The main design factor of wada based on social and cultural activities.Building construction materials are stone, mud, wood, teakwood etc. The thickness of the walls is in such a way that they can withstand long exposure to the sun.

Fig10. PLAN AS PER CITY SURVEY (author)

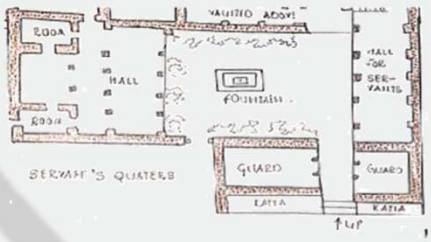
Fig11. PLAN OF WADA(author)

Fig 12.Main Entrance doorway of wada(author)

Fig 13. Main entrance of wada – a combination of Islamic and hindu architectural features(author)

**MAIN ENTRANCE OF WADA**: A huge grand the main entrance is facing the north. The streets and roads were narrow, roads were never straight . wadas constructions were rectangular next to streets. The houses a guard place on either side leading to JALAJA in kannada.wada Beautifull carved horses,decorative mounts and well designed detailing on the door frame. The big main entrance supposed to give an inviting and rich look. Islamic architectural element arch,hindu element stone brackets.katta on bothsides of entrance.

**COURTYARD OR CHOWK** :




**Courtyard or chowk:** The first or front courtyard houses, according to historical evidence ,in India probably around 6500 -6000BC .The origin of traditional Indian courtyards can be traced back to the Indus valley civilisation. Courtyard architecture originated as far back 3000BC in Egypt, Iran and China. Paul Oliver is one of the first researcher who investigated "vernacular architecture and its concepts which grows within communities in which it could adopt itself with social ,climatic and technological condition during ages".Sir John marshall describes the courtyard houses as" To the right of the porter's lodge a short passage led to the central courtyard of the

house, which was open to the sky and provide light and air to the rooms grouped about it on both the ground and upper floors.And here, let me say parenthetically, that the principle of the open court encompassed by chambers was just as - fundamental to planning at Mohenjo-Daro as it was throughout the rest of prehistoric and historic asia and as it has continued to be in India until the present day". Courtyards does not have specific plan,usually rectangular,square and circle.These forms are changing due to ecological aspects such as site limitation,topography,building orientation and function to produce new forms U,V,L,H or Y shapes.Courtyard benefits are psycho-social benefits, cultural religious,economic,climatic and Architectural benefits. Acoustical privacy,enclosure elements works as a noise barrier between inside and outside area. Courtyards have been generally reffered to as a microclimate change, due to their ability to mitigate high temperatures, channel breezes and adjust the degree of humidity(saxon,1986). Courtyard acts like a cool air reservoir,especially in hot-dry climate.

**COURTYARD** divided into 3 categories.

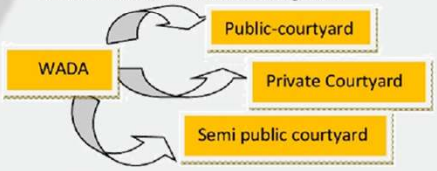



Fig. 15. Kacheri or administrative place. (author)

**PUBLIC-COURTYARD:**The front courtyard ( DIWAN-E -AM )serves as Kacheri or administrative zone and social communication. Here Water fountains placed at the center, serves as climate moderator provides light and ventilation.

Fig. 16. KACHERI and front courtyard ,fountain at the center(author)

Fig.17 Kacheri, both side ladies seating wooden balconies. (author)

Beatifully carved wooden columns with three decorative arches ,different sizes of columns with rich carving .one of the special feature of this kacheri or diwan-e –am is both side ladies balconies .It is small balconies on either sides by intricately carved screens of wood. This balcony has solid wooden columns for supports and a carved wooden railing.

**SEMI-PRIVATE COURTYARD :**

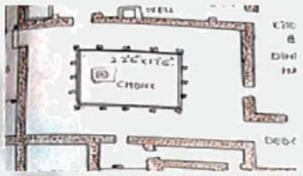


Fig.18. Plan of semi private courtyard(author)

Fig. 19.KITCHEN with double height and ATARI (mezzanine) floor ,Heavy wooden beams,planks and battens with mud roofing(author)

Fig 20. A huge beautiful arch opening inside the kitchen. A beautifull play of Light and shadow effect inside the kitchen. (author)

Fig 21. Belkhindi( roof ventilator) and wall ventilators at a higher level. (author)

Fig 22. A small Panduranga ,Rukamini,Satya bhama idols(author)

Fig.23. view of semi private (author)courtyard

Most interesting part is that when anybody entrance the kitchen huge room. The dramatic play of sun light. How it moves along with time ,beautiful shifting of light can be seen. Roof ventilator( belkhindi) direct flow of light & air flow double height kitchen .It is according to vastu. and wall ventilators for proper air circulation. semi private courtyard also called as DIWAN –A-KHAS..A worshipping place at the corner. In this courtyard covered space roofing is of wooden battens ,planks ,wooden beams. Simple columns less ornate .projection of roof finely decorated to protect from rain and harsh sunlight. Parapet wall playing solid void effect.

**PRIVATE COURTYARD**

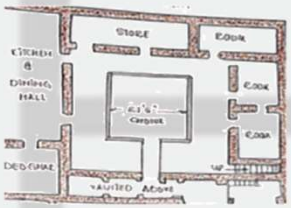


Fig. 24.Plan of private courtyard(author)

Fig 25. Intricately carved wooden column in private zone . (Inner courtyard) (author)

Fig 26. Private courtyard

Fig 27 Private courtyard- ladies zone(author)

Beautifully carved wooden columns. Rich inscription ,detailed lotus flower ,buds, projections. Inner courtyard is a private courtyard for celebrating festivals. Rooms arranged around courtyard consists of kitchen, storage room ,Bedroom, Bathroom, Balantini kholi( delivery room) . this is also having separate entry from the front courtyard. Traditionally Tulsi or holy basil planted in the center of the central courtyard of Hindu houses.

Fig 28. Idol alter with four decorative columns at the center of room(author)

Fig 29. Pooja room with pergola(author)

**Tranquil pooja room:** The room is supposed to be very sacred and only the family members and priests are allowed. The place for worshipping the deity is elevated at the center of pooja room, steps are provided. Surrounding free area for circulation or for offering pradakshina .The festivals celebrated by family are performed in a similar manner as early generations celebrated. There are no windows ,so the design technique used is very appreciative .In pooja room special features can be seen pergolas are provided to admit Light inside .This creates a different perception in the divinity.

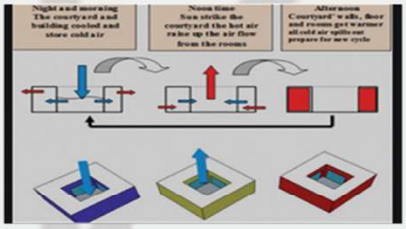


Fig 30. Circulation movement of air in courtyards(intechopen.com)

**ORIENTTION**: "Historically built environment was a result of the responses to many factors in the society , at the physical level it included the knowledge regarding orientation ,climate, building material and construction technique, at the spiritual level, the built form was inter-woven with life style in all daily as well as seasonal rituals"—B.V. DOSHI-1985.

The building orientation makes the best use of the sun's heat and light ,which is the central principle in vernacular design. There is no electricity, therefore all buildings depends on passive cooling in summer and heating in winter in cold weather. Various techniques are engaged for using as much daylight as possible. The use of sustainable daylight providing connection to the outdoors.It is essential for health and for occupants.Orientation and placement, to minimize sun exposure in summer.The size of windows on the west and east sides are minimum in order to reduce heat gains into the house in the early morning and late afternoon. The correct orientation of courtyard helps to develop thermal comfort,moreover solar angel and wind direction may cause thermal discomfort if the orientation not suitable.Belkhindi opening in the slab to provide light and ventilation. Belkhindi and ventilators are at higher levels as they help in throwing out the hot air. To resist heat gain ,increase of thermal resistance and capacity by maximizing the building wall thickness, increase the time lag. Thickness of the stone wall is 5 feet .Projected roof to north and south provide protection from sun and rain, glare from the bright overcast sky.

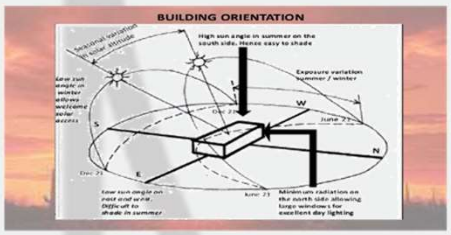



Fig. 31.building orientation in hot dry area(slideshare.net)

Wind flow from south west February month-september

Fig 32. showing the wind flow Warm wind flows out .cool air enters inside the courtyard(author)

Wind flow from North east October month - January

**CONCLUSION**: The modification of building which history is spoiled by a previous use that is undesirable. Several approaches to use as a starting point of alternation .owner and developers primarily interested in the socio-economic values of the building, which are not protected as monument. Due to high density population growing day by day and joint family concept fading fastly giving birth to nuclear families. This may be preservation of the soft values which encompass historical, sociological, psychological, artistic, other cultural, moral and religious sub functions. By conserving the historical living traditional building skills with which it is associated is also in danger of being lost in the absence of sponsorship and government recognition.

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# ENERGY EFFICIENT DESIGN STRATEGIES

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**ABSTRACT**: This document focuses on the use of sustainable design principles, in redesigning a building at a given site. It deals with what changes can be made to design to make the building more efficient in terms of thermal performance, energy use, material palette and environmental performance, while keeping the original essence of a passive design. The objective of this report is to make recommendations to improve the sustainability of a chosen building by optimising its orientation, built form and planning as per the climatic conditions to improve thermal performance while controlling energy demand.

The scope of work also includes: Improvising the building services to improve the thermal comfort of the indoor environment, Optimising window shading, Optimising building materials to improve their thermal and environmental performance and Strategising the measures to save water. The methodology will be to evaluate the performance of the chosen building by Analyzing the original design by climatic factors, orientation, material consideration, climatic strategies. Analyzing strength and weakness of the building.

The study will focus on redesigning the building keeping in mind the adverse climatic conditions and accepting the global warming challenge in future years and evolving the design with energy efficient strategies.

**KEYWORDS**: Sustainability, Orientation, Thermal comfort, Climatic strategies

**Redesign of The Marika Aldertonhouse**

**INTRODUCTION**

This document focuses on the use of sustainable design principles, in redesigning a building at a given site. The building that has been chosen for the following report, is a very famous project by Glenn Murcutt- "The Marika Alderton House", located at the Yirrkala Community in Northern Territory, Australia. It was originally designed on Australian Vernacular Outback Architecture. This report aims to analyse how this building would react if relocated to Townville, Queensland, which shares a similar climatic zone but is a planned town rather than an outback land with the open landscape and slightly varying microclimatic conditions.

It also deals with what changes can be made to Murcutt' design to make this building more efficient for the chosen site in terms of thermal performance, energy use, material palette and environmental performance, while keeping the original essence of a passive design. The report also tries to analyze the improvement in the performance of the Marika Alderton House by improvising it as per the

Building code of Australia's requirements, while working on the weakness of the original design.

**OBJECTIVES:** The objective of this report is to make recommendations to improve the sustainability of the Marika Alderton house when relocated to Townsville by optimizing its orientation, built form and planning as per the climatic conditions to improve thermal performance while controlling energy demand.

The scope of work also includes:

1.) Improvising the building services to improve the thermal comfort of the indoor environment.
2.) Optimizing window shading.
3.) Optimizing building materials to improve their thermal and environmental performance and,

4.) Strategizing the measures to save water.

**METHODOLOGY**

To evaluate the performance of the Marika-Alderton House at Townsville, the house was modelled on the new site with original specifications. An analysis on Sefaira was performed on the original model to judge its performance. The climate of Townsville (Queensland) was studied through climate consultant using the QLD Townsville Aero 942940

weather file. Improvements as analyzed from climate consultant and base model simulation were applied on the Alderton house, to study its effect on the energy use intensity, energy segments and day lighting. The simulations were run on both the models- base case and modified case for two scenarios: original specification and BCA zone 1 baseline. All the cases were considered to be naturally ventilated but had different insulation and u values. The results from all the cases were analyzed and compared to understand the best possible outcome of a passive design house at Townsville.

**CONTEXT**

'The Marika Alderton House 'design edfor Mark Alderton and Banduk Marika is a 1994, sustainable and economic solution that adapts to its original place while maintaining the aboriginal cultural values. It is designed as per Mark's and Banduk's requirements and needs which need to be preserved in the relocation and redesign of the original house. Glenn Murcutt has combined aboriginal ideas and innovative vision, to design this house as per the tropical climate (Dovey,2011).

The residence is a rhetorical example highlighting a sustainable design, that meets the needs of the tropical climate of Australia's Northern Territory. It uses the forces of nature and the design excellence to control the IEQ of the house. Natural factors which Glenn Murcutt considered in designing the Alberton house are:

- Natural Light
- Wind flow
- The topography of the site
- Water flow
- Adverse temperatures (Little, 2006)

Marika Alderton house (Source:ElCroquis,2013 as cited by Lecaro, Lau, Rodrigues and Jarman, 2017)

The primitive design involves a breathable timber floor enveloped by infill paneled operable walls that can be opened to allow the flow of wind. It is covered by a metal sheet pitched roof with wide eaves to protect from the scorching sun.(Atlas of Places, 2019) There were many design challenges associated with designing of Marika Alderton house, such as avoiding the use of mechanical ventilation as it is not a part of aboriginal culture, designing a strong structure that could withstand cyclones and avoiding the entry of reptiles and poisonous snakes.

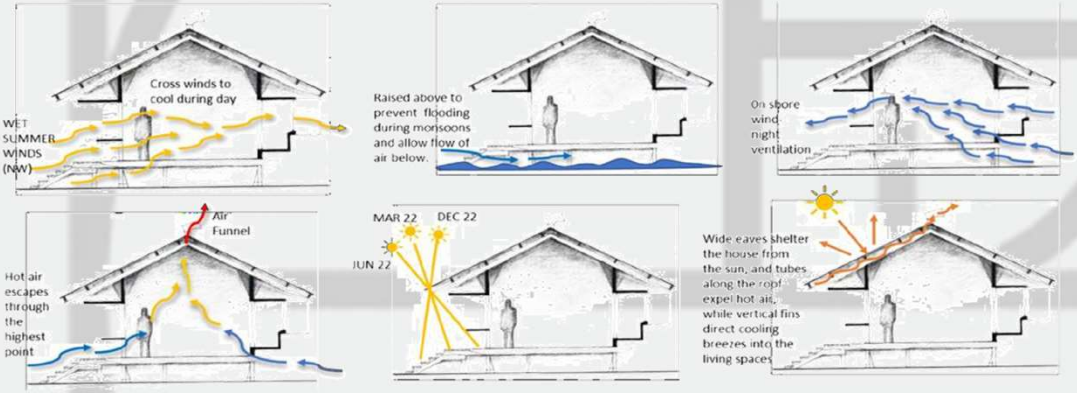
**ANALYSIS OF ORIGINAL DESIGN**

**Climate**: Originally, the Marika-Alderton House is located at the Yirrkala Community in Northern Territory, Australia, which lies in climate zone 1- with hot and humid weather. The summers are hot and humid while winters here are also considerably warm. The average temperature lies around 32°C which can sometimes rise to 39°C. The site is also prone to cyclones and floods as it lies near the Arafura Sea.

Winter solstice sun path( Source: Author) Summer solstice sun path ( Source: Author) Orientation: The Marika Alderton house is oriented towards north direction to utilise maximum sunlight, by letting every occupiable space receive daylight. Even the spatial analysis is based on play of light. For example- the common space is over lit compared to the bedrooms which receive subtle light. The orientation of kid's room on the east and parent's room on the west has also been planned to keep in mind, the aboriginal theory of sun rise depicting new beginnings.

**Material Consideration**: The materials chosen for designing the house included timber, plywood, steel and corrugated iron, which were sourced locally. Murcutt, chose the lightweight materials wisely keeping in mind the old aboriginal shelters and the sustainability factor.

**Climatic strategies:** The Marika Alderton house is a good example showing how to deal with harsh climatic conditions. His strategies have been drawn and listed below:




Climatic strategies of Murcutt's Marika Alderton House( Source: Author)

- Murcutt, raised the building on steel pillars, to provide natural ventilation while also preventing it from floods during monsoons.
- He designed the envelope of the house as a porous and breathable skin to allow cross- ventilation even when the openings were closed at night.
- He also provided wide eaves to protect the house from low angled sun and rain.
- He tried to connect the inside- outside environment by keeping the façade openable, to feel the exterior. This helped to keep the house cool by cross- ventilation.
- To improve indoor comfort, he designed air funnels on the pitched roof, to increase

**STRENGTHS AND WEAKNESS OF MARIKA ALDERTON HOUSE:**

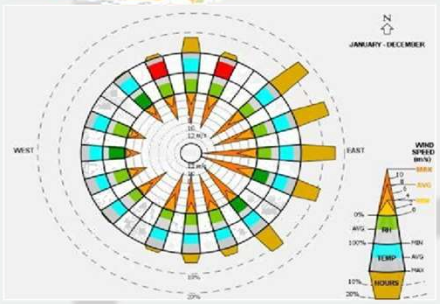
| STRENGTHS | WEAKNESS |
|---|---|
| 360° view of the nature around. | Thermal discomfort for more than 70% of times with temperature ranging between 27 °C to 35 °C. As a result, less than 30% of hours were comfortable. The results were compared to ASHRAE 55 comfort model which suggest temperature between 20°C -27 °C as comfortable. |
| Continuous breeze throughout the year due to the orientation of house and design of fins. | |
| Adjustable openings with shutters to let in light and ventilation based on need. | |
| Made of prefabricated materials, that are sustainable. | |
| Cyclone proofing – raised on stilts and long eaves plus the orientation of the roof keep it cyclone safe. | Visual fatigue due to excessive illuminance levels. The lux levels on a sunny day, even with use of shading devices was +600 lux which might cause lot of visual fatigue as it's too bright. As per the Australian interior lighting standard- AS/NZS 1680.1:2006, the recommended lux levels for an ordinary to moderately difficult task should be between 240-320 lux. |
| Designing a space that according to Glenn Murcutt's own words, touch the earth lightly, that maintains a relationship with the environment around. | |
| Creating a house with a connection to Aboriginal culture, which depicts openness and an outdoorsy area. | |
| Good contrast ratios within space, due to proper selection of materials (interiors – wood), that enable in visual tasks. | No Insulation resulting in lot of heat gain disrupting the thermal comfort. |

**CLIMATE ANALYSIS FOR TOWNSVILLE, QUEENSLAND**

As per the building code of Australia, there are 8 climate zones, of which 4 can be seen in Queensland. Townsville falls under Climate zone 1 i.e. Tropical which is characterized by high temperatures all year round- very warm and humid summers with high rainfall and warm winters.


Queensland Climate Zones as per Building code of Australia (Queensland Government,N2013)

The temperatures are pretty high in Townsville, all year round as it can be seen below. The place experiences two seasons: Hot summer wet season from November to April with average temperature 29°C-31°C during day and 20°C to 24°C during nigh time, and warm winter dry season from May to October with average temperature of 21°C. The annual average temperature experienced in Townsville is 24°C. The highest temperature i.e., 34°C can be experienced in January.




Left: Temperature Range for Townsville Aero ,QLD, Right :Wind Wheel for Townsville Aero ,QLD for all months(Source :Climate Consultant)


Hence, the place is more prone to flooding, tides, strong winds and cyclones than even before. The report aims to redesign the building keeping in mind the 2030 challenge which is predicted to experience “higher temperatures with more frequent hot days, more intense downpours, less frequent but more intense tropical cyclones, and rising sea level.” (State of Queensland, 2019)

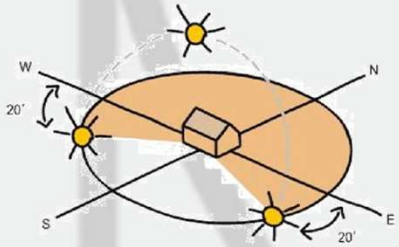



*Figure 2 Sun-path in summer.*

Left :Sun path diagram for Summer in Townsville, Right :Sun path diagram for Winter in Townsville (Source: Townsville CityCouncil,2020)

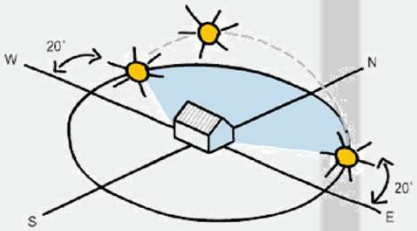



*Figure 3 Sun-path in winter.*

So, to redesign the house keeping in mind the adverse conditions, it is necessary to study the sun- path and direction of flow of winds. From the above diagram and the wind wheel of Townsville region it can be analyzed that the majority of summer winds come from North to North east, East and some south to south-east, while the winter winds are received from South- south east and some also from North East. Cool north easterly winds are the most prominent ones during summers. Wind speed is generally moderate but can help to provide cooling.

**SITE ANALYSIS**

Site: 10,11 & 12 Panorama Ct, North Ward QLD 4810: Latitude: 19°15'13.8"S: Longitude: 146°48'47.4"E

**MICROCLIMATIC CONDITIONS**

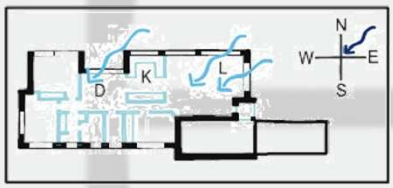
The site experiences cool north east winds in summers. Although the wind speed isn't that high but in a hot and humid climate like that of Townsville, they prove to be very efficient when used for cross ventilation to provide comfort. Sometimes, winds from east and south east are also experienced in summers. In winters, which are generally warm and dry winds from east and south east can be experienced.

Thus, the best orientation is to align the building on the north east axis to get the maximum benefit of sunlight and winds.

SUGGESTED ENVIRONMENTAL SOLUTIONS FOR CLIMATE, SITE AND TYPOLOGY

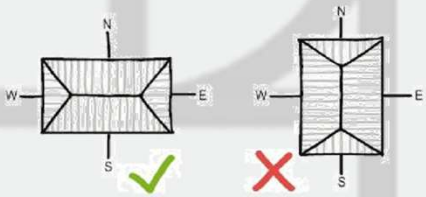
Local environmental conditions like average temperatures, wind, sun and orientation of house when considered can help in designing Passive house in Townsville, while increasing human comfort and phasing out need for air conditioning or heating. The following environmental solutions/ strategies can assist in designing of such a house.

**ORIENTATION:** Location and direction of the house is essential in designing sustainable homes while saving on energy bills .Sun's movement and predominant breeze patterns plays an important partin designing for Townsville. To maintain an ambient temperature without relying on electric heating or cooling with change in design and orientation can assist in minimizing the carbon footprint and reduce the reliance on the electric grid thereby saving money all year round.




Example for good orientation for designing in Townsville region to capture breezes. (Source: Townsville City

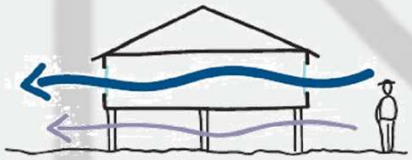
Council, 2020)




- The length of the house should be along the east-west axis to minimise the exposure to effects of sun on the horizon in mornings and evenings.
- The living area should be oriented to north or north-east to allow natural air flow.
- To prevent the early morning or evening low angled sun which will bring the direct sunlight into the house, north-south axis orientation should be avoided. This will excessively heat up the house thereby making reliant on-air conditioning for cooling. (Townsville City Council, 2020)

**CLIMATIC DESIGN**: Due to its proximity to sea Townsville has high humidity levels with average temperatures in the low 30s. Thus, pertinent use of natural breeze becomes essential to maximise air flow in house for natural cooling. Increased access to breeze, convection ventilation and creating optimum air flow in house allows breeze harness. Breeze in summer flows from north-east in Townsville hence to design an energy efficient home it is prudent to allow these to flow through the entire home to maximize cross ventilation. The following ideas would assist in achieving maximum cross ventilation:

- Living areas to be located in the north or north-eastern side. Well placed and maximum number of shaded openings possible would utilize the maximum benefit.
- Narrow plan should be designed to help in cross-ventilation.
- Roof ventilators, grills, open eaves, louvered clerestory windows, gable vents, vented ridges, exhaust fans, solar driven ventilators and raked ceilings are some of the methods that enhance ventilation by removing hot air from the house.



Left :Homes should be elevated for access to faster cooling breezes .Right: Ways to increase convection and create stack effect (Source: Townsville City Council, 2020)

- By elevating the home, access to predominant breeze can be increased. It also allows air flow underneath for faster cooling. Cooler floors would mean less hot air rising. In late afternoon and evenings, faster cooling would be achieved by elevated home as internal heat is dissipated by cooling breeze.

- Uninterrupted cross ventilation is achieved by orientating the walls right. For maximum benefit, north to north east facing windows, walls and doors should be large. (Townsville City Council, 2020)

**SHADING:** All windows in the house should be shaded to achieve sustainability. Shade reduces the heat from sun in the sun-drenched climate in Townsville. It is an advantageous and straightforward way to achieve a cool house.

Left: Sun's position in Townsville. Right: Horizontal shading (Source: Townsville City Council, 2020) In

- Wide eaves or bigger overhangs can help to protect the north and south faces, otherwise a horizontal awning can also solve the purpose.
- Provision of vertical shading is also helpful in avoiding low angled sun. (Townsville City Council, 2020)

**LANDSCAPING**: Landscape integration also adds up to the sustainability of a home. This can be achieved by:

- Shading the landscaped areas
- Planting in a manner to divert winds to pass through the house. (Townsville City Council, 2020)

**MATERIALS & INSULATION:** The building materials need to be chosen wisely to suit the climatic condition of Townsville. They should have the following qualities:

- The materials should be lightweight with low thermal mass and should have the property to release the heat instead of retaining it.
- They should be insulated and light colored.

The roof should be light coloured and insulated as it receives maximum exposure to the sun. Corrugated iron or steel roof sheet should be preferred instead of tiles as it cools quicker because of its properties, helping to maintain thermal comfort. Adding bulk or reflective insulation below the roof with minimum R value of 2.7(BCA standard) is must to avoid outside heat to increase the indoor temperature.

**FLOORS & WINDOWS**

Raised timber floors with insulation underneath prove to be beneficial in both summers and winters. To reduce glare problems, high performance and tinted glass can be used, specially onthe east and west. Well shaded double-glazed units also help to increase indoor comfort.

**SEFAIRA ANALYSIS, DESIGN MODIFICATION & RESULTS**

**QUALITATIVE ANALYSIS:** Based on the analysis of the original design of Marika Alderton House, the Sustainable Housing Information Kit by City of Townville and the Building code of Australia's requirement, it has been found that the original design by Murcutt is a very apt solution to passive design for a tropical climate. It included all the passive strategies that were listed in the City of Townsville information kit. But, since, everything has as a scope of improvement, the house could have performed much better if some insulation was also considered which lacked in the original design. To further analyse the house designed by Murcutt, a quantitative study was carried out through Sefira, which has been described below.

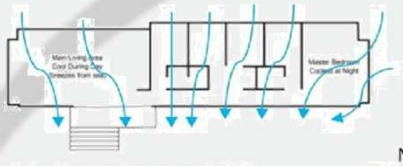
**QUANTITATIVE ANALYSIS:** To study the performance of the Marika Alderton House at Panorama Court, North Ward, Townsville, QLD, the house was modeled on Sketch up and its energy and daylight consumption were studied through Sefaira Plugin.

**IMPLEMENTATIONS & RECOMMENDATIONS**

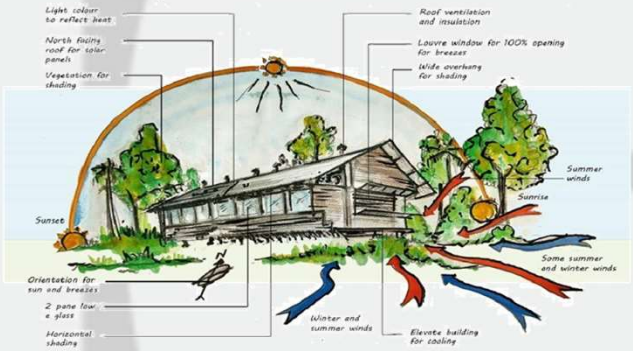
Implemented Built form solutions in Marika Alderton House for Townsville region as per its climate and typology are as follows:

Building Shape , Orienatation

The building footprint is long and thin promoting the ability for cooling winds to pass through the building. Aside from being a functional layout for the building's occupants, the orientation of the building is designed to make use of cross ventilation to penetrate through the building, which will naturally cool the internal and external spaces.



Orientation of the house is towards NE to minimise direct sunlight and capture the prevailing NE cool breezes. It is orientated such that the breezeway is aligned with the prevailing breezes which are from the rear of this block. This design has prevailed the location of the areas in Murcutt's plan as they are correctly zoned to capture the breezes.


An onsite wastewater management plant needs to be in place to ensure water saving. Rainwater falling on the building roof can be collected through an outlet from the roof gutters and stored in rainwater tanks. This water can be treated through UV and then distributed to all fittings and fixtures in the building like basins, bath and toilets. The greywater from the bathrooms, kitchen and toilets can be sent to greywater treatment plant, which can be treated and reused in the toilets for flushing, gardening and washing instead of sending it to the sewer. This blackwater can then be sent to the sewer. Leaks in plumbing fittings also need to be assured to avoid water wastage. Equipment's and fixtures with good water rating of 4 stars and above should be used to improve water efficiency.

**CONCLUSION:**

It is important to note that the software assessment method provided valuable information on the proposed design through daylight and energy analysis. This includes identifying whether predicted annual heating or cooling loads could be a problem in the building. These can subsequently be improved by adapting the design. The new design for Marika Alderton house also complies with the Queensland Development Code to achieve a 6-star equivalent energy rating as it has all passive design features as listed by Queensland Development Authority (Queensland Government, 2011). House orientation, room configuration, shading, insulation, natural ventilation and sealing, building materials and external colours all worked together to create a more comfortable dwelling for the occupants of Marika Alderton house and provided energy savings.

Both the original design and subsequent improvements have maximised shade and cross-ventilation, contributing to this home's excellent performance in the tropical climate. The result is a home that is truly relaxing, comfortable all year round, enabling its occupants to enjoy a tropical lifestyle. The features highlighted in this home could quite easily be adopted in principle for building other homes in Townsville region.

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# LANDSCAPE APPROACH FOR ATTRACTING BIRDS AT RESIDENTIAL YARD AT SHRIRAMPUR TALUKA, AHEMADNAGAR DISTRICT, MAHARASHTRA.

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**Abstract:** Landscape approach for attracting birds at residential yard is micro level site development and could be treated as a prototype for development of residential landscapes. This study is aiming to derive planting policy Guidelines and Policy for developing habitat patches at residential yard for attracting birds at residential yard. Objectives of study are to collect information about habitat, behavior and ecology , by conducting live case study and synthesis of how spotted birds respond to existing landscape and habitats of residential yard. Methodology would be conducted through Literature review and live case study. From the above study it is found that, Total 26 types of birds were spotted and observed in live case study for five months , from March to July. 10 Insectivorous, 5 Fructivorous, 4 Granivorous, 2 Nectivorous, 3 Carnivorus, 2 Omnivorus birds are observed in this study. Molluscivorous, Mucivorous, Ophiophagous, Palynivorous, Piscivorous birds are not found in the case study. From this study it is concluded that, food, water ,Shelter , Mates for Nesting and Reproduction are main components for attracting birds at any landscapes. Patches of woodlands and grasslands along with water feature are extremely important for attracting insectivorous and Fructivorous birds. Flowering shrubs and ground covers are important for attracting Granivorous and Nectivorous birds. Huge trees are recommended for attracting Omnivores, Avivorous And Carnivorous birds.

***Keywords:*** *Landscape Approach, Habitat Enhancement, Birds, Residential Yard.*

## INTRODUCTION / BACKGROUND

Residential yard landscapes are micro level site developments, when we talk about enhancement of habitat and fauna. The role of landscape architect in this research is to understand birds association with different group of birds and propose the planting policy accordingly. This research would be particularly talking about Bird Species and their association with various plant typology. In this study spotted Birds are first classified into groups, based on their food habits and their sizes (Length) and then observed based on certain parameters. From literature study it is found that, researchers and Very few landscape architects have worked for habitat enhancement of birds at Macro scale and Regional scale. Micro level habitat enhancement by using apt planting policy is very important stage, before going for Macro scale and Regional scale, which every landscape architect must consider while designing Residential landscape yards. Hence, This research is needed.

**AIM / PURPOSE :** To derive planting policy Guidelines and Policy for developing habitat patches for attracting birds at residential yard.

**Objectives:**

1. To collect information of different Habitat of Birds
2. To collect information of Classification of birds based of food habit
3. To select a live case study of a residential yard.
4. To collect information about habitat, behavior and ecology , Relationship with human of bird spotted at residential yard.
5. To synthesis how spotted birds respond to existing landscape of residential yard.

**Scope:**

Habitat development starts from micro scale like balconies, Terrace gardens, residential yards landscape patches. Scope of this research is focusing on Insectivorous, Fructivorous, Granivorous, Nectivorous, Carnivorus, Omnivorus and Avivorous bird types, which belongs to different habitats were spotted during live case study. This study was conducted for five months at residential yard by observation method. This research will discuss about distribution and habitat, relationship with human and plants of the birds spotted during study. This research is site specific which comes under western Maharashtra.

**Limitation:**

This study will not focus on urban scale or regional scale habitat enhancement landscape approach.

**Research question:**

How landscape approach of residential yards is important for attracting birds and their habitat enhancement ?

**RESEARCH METHODOLOGY**

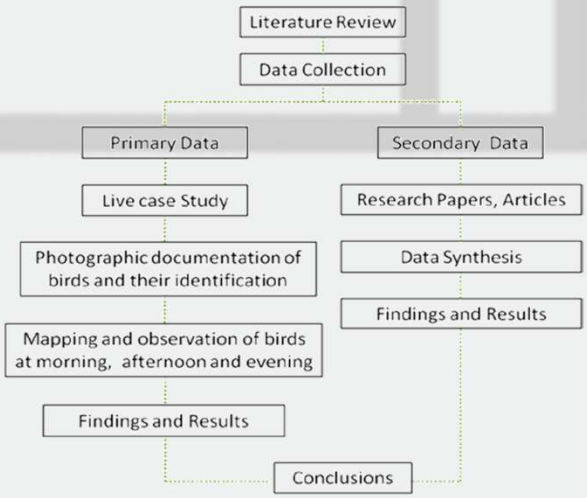


Chart No 1: Showing Methodology

**FINDINGS:** Information About Spotted Birds.

**1. Coppersmith Barbet :** (6 inches Small) **- Food:** Banyan, Peepal, And Other Wild Figs, Various Drupes And Berries, And The Occasional Insect, Caught In Aerial Sallies. It Also Feeds On Flower Petals. **Habitat :** Gardens, Groves And Sparse Woodland. Habitats With Dead Wood Suitable For Excavation Of Nests Are Important. (Mitchell Waite, 2002-2008)

**2. Red-Vented Bulbul:** (8.25 inches Small) **- Food:** Eats Fruit, Flower Buds, And Insects. **Habitat :** High In Trees Or Perched On Wires In Urban And Rural Areas; Generally Prefers Scrubby Edge Habitat Instead Of Dense Forest. (Mitchell Waite, 2002-2008) (Kasambe, May 2017)

**3.Common Iora :** (4.5–6.1 in Small) **- Food:** Insects Such As Grasshoppers, Caterpillars, Dragonflies And Mantises. It Also Consumes Spiders And Small Insects, Fruit, Berries And Nectar. **Habitat :** Acacia Scrub, Forest Edge, And Closed Forests, As Well As Agricultural Land And (In The Common Iora) Gardens (Mitchell Waite, 2002-2008) (Kasambe, May 2017)

**4. Brahminy Starling:**( 8-8 Inch Small) - **Food:** Fruit And Insects. Dry Forest, Scrub Jungle And Cultivation And Is Often Found Close To Human Habitations. They Especially Favor Areas With Waterlogged Or Marshy Lands. (Mitchell Waite, 2002-2008)

**5. Asian Koel:** (15–18 in Large) - **Food:** Variety Of Insects, Caterpillars, Eggs And Small Vertebrates. Adults Feed Mainly On Fruit. **Habitat :**Light Woodland And Cultivation. (Mitchell Waite, 2002-2008) (Kasambe, May 2017)

**6. Laughing Dove:** (9.8 in Medium) - **Food:** Fallen Seeds, Mainly Of Grasses, Other Vegetable Matter. **Habitat :**Grasslands And Cultivation. (Mitchell Waite, 2002-2008)

**7. Scaly Breasted Munia:** (4.3–4.7 in Very Small) - **Food:**Grass Seeds Apart From Berries And Small Insects. **Habitat :**Tropical Plains And Grasslands. (Mitchell Waite, 2002-2008) (Kasambe, May 2017)

**8. Parakeets :** (12 inches Medium) - **Food:**Including Seeds Of Spinifex, Mitchell's And Tussock's Grasses, Wild Oats And Canary Grass. They Also Eat Wild Millet And Farm Crops Such As Wheat. During The Rainy Season, They Search For Newly Sprouted Green Grasses. **Habitat :** Desert, Woodlands, Grasslands And Open Scrub Far From The Densely Populated Cities (Mitchell Waite, 2002-2008)

**9. White-Breasted Waterhen:** (13-13 Inch Medium) - **Food:** Insects, Spiders, Grain, Fish, Worms And Snails, And Some Parts, Shoots And Roots, Of Marsh Plants. **Habitat :** Near Freshwater Marshes And In Habitats With Dense Undergrowth. It Is Very Common In Mangroves, Reed beds, Grasslands, Rice fields, Orchards, Parks And Gardens. Found Near Small Streams And Pools Where There Is Dense Vegetation. (Mitchell Waite, 2002-2008) (Kasambe, May 2017) (Kasambe, May 2017) (Mayntz, 2019)

**10. Greater Coucal Or Crow Pheasant:** (19 inches Large) - **Food:** Insects, Caterpillars And Small Vertebrates Such As The Saw-Scaled Vipers. They Are Also Known To Eat Bird Eggs, Nestlings, Fruits And Seeds. **Habitat :** Jungle To Cultivation And Urban Gardens. (Mitchell Waite, 2002-2008)

**11. Green Bee-Eater:** (9-11 inches Medium) - **Food:** Insects, Especially Bees, Wasps And Ants, Which Are Caught In The Air By Sorties From An Open Perch. **Habitat :**Open Country With Bushes. (Mitchell Waite, 2002-2008)

**12. Black Drongo :** (13-inch Medium) - **Food:** Insects Such As Grasshoppers, Cicadas Termites, Wasps, Bees, Ants, Moths, Beetles And Dragonflies. They Sometimes Fly Close To Tree Branches, Attempting To Disturb Any Insects That May Be Present. **Habitat :** Savanna, Fields, And Urban Habitats (Mitchell Waite, 2002-2008) (Kasambe, May 2017)

**13. White-Browed Fantail:** (6- 8in Small) - **Food:**Small Insects And Invertebrates. **Habitat :** Forest And Other Woodland. (Mitchell Waite, 2002-2008) (Mayntz, 2019)

**14. Indian Paradiase Flycatcher:** (7.5–8.7 in Small) - **Food:** Insects, Which They Capture In The Air Often Below A Densely Canopied Tree. **Habitat :** Thick Forests And Well-Wooded Habitats (Mitchell Waite, 2002-2008)

**15. Magpie Robins:** (7 in Small) - **Food:** Insects And Other Invertebrates. Known To Occasionally Take Flower Nectar, Geckos, Leeches, Centipedes And Even Fish. **Habitat :** Open Woodland, Cultivated Areas Often Close To Human Habitations. They Prefer Open Areas Such As Mangroves, Gardens, Cultivated Areas. (Mitchell Waite, 2002-2008)

**16. Large Grey Babblers :** (11-11 Inch Medium) - **Food:** Insects Of Which Grasshoppers, Caterpillars. Beetles And Ants Were Taken In Significant Quantities. **Habitat :** They Are Locally Common In The Scrub, Open Forest And Garden land (Mitchell Waite, 2002-2008) (Kasambe, May 2017)

**17. Ashy Prinia:** (9 inches Small) - **Food:** Insects **Habitat :** Dry Open Grass Land, Open Woodland, Scrub And In Home Gardens In Many Cities. Usually It Is Seen Clambering About Or Hopping On The Ground. (Mitchell Waite, 2002-2008)

**18. Red Watteled Lapwing :** (13-14 Inch Medium) **- Food:** Insects, Snails And Other Invertebrates, Mostly Picked From The Ground. They May Also Feed On Some Grains. They Feed Mainly During The Day But They May Also Feed At Night. **Habitat :** Well-Watered Open Country, Ploughed Fields, Grazing Land, And Margins And Dry Beds Of Tanks And Puddles. Also Found In Forest Clearings Around Rain-Filled Depressions. (Mitchell Waite, 2002-2008) (Kasambe, May 2017)

**19. Common Tailorbird:** (3.9 to 5.5 in Small) **- Food:** A Mixture Of Caterpillars (Top) (And Other Worm Like Invertebrates) And Many Different Insects – Small Crickets (Second Row, Right), Spiders (Third Row, Left), Etc. No Vegetable Matter. **Habitat :** Open Farmland, Scrub, Forest Edges And Gardens. (Mitchell Waite, 2002-2008)

**20. Purple-Rumped Sunbird :** (4 inches Very Small) **- Food:** Nectar But Sometimes Take Insects. **Habitat :** Disturbed Secondary Forest, Open Woodland, Open Scrub And Savannah, Coastal Scrub And Alpine Forest. (Mitchell Waite, 2002-2008) (Kasambe, May 2017)

**21. Purple-Sunbird:** ( 4 inches Very Small) **- Food:** Nectar But Sometimes Take Insects. **Habitat :** Disturbed Secondary Forest, Open Woodland, Open Scrub And Savannah, Coastal Scrub And Alpine Forest. (Mitchell Waite, 2002-2008)

**22. Carrion :** (22 inches Large) **- Food:** insects, earthworms, grain, fruits, seeds, small mammals, amphibians, scraps ,eggs. **Habitat :**Near areas of human activity or habitation including cities, moors, woodland, sea cliffs and farmland (Mitchell Waite, 2002-2008)

**23. Crested Myna:** (9.5 - 10.2 inches Medium) **- Food:** Worms, Grubs, Grains, Fruit, And Even Garbage. It Is A Highly Beneficial Bird To Farmers, As It Feeds On Insects And Does Not Attack Crops. **Habitat :** Urban To Rural Areas. In Cities, In The Eaves Of Buildings, Along Roads And Alleys, Near Gardens And Parks, In Parking Lots. It Can Be Found Under Bridges, In Trees, In Chimneys, And On Roofs. (Mitchell Waite, 2002-2008) (Kasambe, May 2017)

**24. Asian Koel:** (18 to 24 in Large) **- Food:** Variety Of Insects, Caterpillars, Eggs And Small Vertebrates. Adults Feed Mainly On Fruit. **Habitat :** Light Woodland And Cultivation. (Mitchell Waite, 2002-2008)

**25. Shikra :** (10-12 inches Medium) **- Food:** Reptiles, Small Mammals, Small Birds, Frogs And Insects. **Habitat :** Forests, Deciduous Woodland, Plains, Farmlands, Savanna, Arid Steppe And Urban Areas. (Mitchell Waite, 2002-2008)

**26. Hawk:** (18 to 24 in Large) **- Food:** Smaller Animals Some Of These Small Animals Include Snakes, Lizards, Fish, Mice, Rabbits, Squirrels, Birds, And Any Other Type Of Small Game That Is Found On The Ground. **Habitat :** Fields Or Deserts, With High Perching Places Nearby From Which They Can Watch For Prey. Adaptable And Also Dwell In Mountains And Tropical Rain Forests. (Mitchell Waite, 2002-2008) (Kasambe, May 2017)

**27. White Throated Kingfisher :** (10.6–11.0 in Medium) **- Food:** Fish, Frogs And Other Amphibians, Annelid Worms, Molluscs, Insects, Spiders, Centipedes, Reptiles (Including Snakes), And Even Birds And Mammals. **Habitat :** They Are Found In Wetlands And On The Shores Streams, Ponds And Lakes. (Mayntz, 2019)

**ANALYSIS:**

**A. VERY SMALL (3 - 5 in) TYPE A**

| TYPOLOGY | VERY SMALL (3 - 5 in) TYPE A | | |
|---|---|---|---|
| No | 1 | 2 | 3 |
| **BIRD NAME** | **Scaly Breasted Munia** | **Purple-Rumped Sunbird** | **Purple-Sunbird** |

| PARAMETERS | Food Type | Granivore | Nectivore | Nectivore |
|---|---|---|---|---|
| | Month | March-July | March-July | March-July |
| | Time | Evening | Morning , Afternoon, Evening | Morning , Afternoon, Evening |
| | Season | Summer, Rain | Summer, Rain | Summer, Rain |
| | Ground Cover/ Ground | Spotted | Not Spotted | Not Spotted |
| | Shrub/ Bushes | Not Spotted | Spotted | Spotted |
| | Small fruit Tree | Not Spotted | Spotted | Spotted |
| | Small Flowering Tree | Spotted | Spotted | Spotted |
| | Big Fruit Trees | Spotted | Spotted | Spotted |
| | Big Trees(Non Flowering, Non Fruit Bearing) | Not Spotted | Spotted | Spotted |
| | Flowering Climber/Flowering Liana | Spotted | Spotted | Spotted |
| | Near Manmade Water Feature | Not Spotted | Not Spotted | Not Spotted |
| | On Built For/ Manmade Things | Spotted | Not Spotted | Not Spotted |
| | Human Friendly | Yes | Yes | Yes |

Table No-1: Showing Analysis Of Very Small Birds (3 - 5 In) Type A

**B. SMALL (5 - 9 in) -TYPE B**

| TYPOLOGY | | SMALL (5 - 9 in) -TYPE B | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| No | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| BIRD NAME | | Coppersmith Barbet | Red-Vented Bulbul | Common Iora | Brahminy Starling | White-Browed Fantail | Indian Paradiase Flycatcher | Magpie-Robins | Ashy Prinia | Common Tailorbird |
| PARAMETERS | Food Type | Frugivorous | Frugivorous | Frugivorous | Frugivorous | Insectivorous | Insectivorous | Insectivorous | Insectivorous | Insectivorous |
| | Month | March-May | March-July | March-July | March-July | March-July | May-July | March-July | June-July | March-July |
| | Time | Evening | Morning , Afternoon, Evening | Morning Afternoon Evening | Evening | Afternoon, Evening | Evening | Morning , Afternoon, Evening | Morning Evening | Morning , Evening |
| | Season | Summer | Summer , Rain | Summer , Rain | Summer , Rain | Summer , Rain | Summer , Rain | Summer , Rain | Rain | Summer , Rain |
| | Ground Cover/ Ground | Not Spotted | Spotted | Not Spotted | Spotted | Spotted | Not Spotted | Spotted | Not Spotted | Not Spotted |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Shrub/ Bushes** | Not Spotted | Spotted | Not Spotted | Spotted | Not Spotted | Spotted | Spotted | Spotted | Spotted |
| | **Small fruit Tree** | Not Spotted | Spotted | Spotted | Not Spotted | Spotted | Not Spotted | Spotted | Not Spotted | Spotted |
| | **Small Flowering Tree** | Not Spotted | Spotted | Not Spotted | Not Spotted | Not Spotted | Not Spotted | Not Spotted | Spotted | Spotted |
| | **Big Fruit Trees** | Spotted | Spotted | Spotted | Not Spotted | Spotted | Spotted | Spotted | Spotted | Spotted |
| | **Big Trees(Non Flowering, Non Fruit Bearing)** | Spotted | Spotted | Not Spotted | Spotted | Not Spotted | Spotted | Not Spotted | Not Spotted | Not Spotted |
| | **Flowering Climber/Flowering Liana** | Not Spotted | Not Spotted | Not Spotted | Not Spotted | Not Spotted | Not Spotted | Not Spotted | Spotted | Spotted |
| | **Near Manmade Water Feature** | Not Spotted | Spotted | Not Spotted | Spotted | Spotted | Not Spotted | Spotted | Not Spotted | Not Spotted |
| | **On Built For/ Manmade Things** | Not Spotted | Spotted | Not Spotted | Not Spotted | Not Spotted | Not Spotted | Spotted | Not Spotted | Not Spotted |
| | **Human Friendly** | Not Spotted | Yes | No | No | No | No | Yes | No | No |

Table No-2 : Showing Analysis Of Small Birds (5 - 9 In) -Type B

**C. MEDIUM (9 - 16 in) -TYPE C**

| **TYPOLOGY** | | **MEDIUM (9 - 16 in) -TYPE C** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| No | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| **BIRD NAME** | | **Laughing Dove** | **Parakeets** | **White-Breasted Waterhen** | **Green Bee-Eater** | **Black Drongo** | **Large Grey Babblers** | **Red Watteled Lapwing** | **Crested Myna** | **Shikra** | **White Throated Kingfisher** |
| **PARAMETERS** | **Food Type** | Granivore | Granivore | Granivore | Insectivorous | Insectivorous | Insectivorous | Insectivorous | Omnivores | Carnivorous | Carnivorous |
| | **Month** | March-July | March-July | March-July | March-July | March-July | March-July | March-July | March-July | June-July | March-July |
| | **Time** | Evening | Morning, Evening | Evening | Morning, Evening | Morning, Evening | Morning, Afternoon, Evening | Morning, Evening | Morning, Afternoon, Evening | Evening | Morning, Evening |
| | **Season** | Summer, Rain | Summer, Rain | Summer, Rain | Summer, Rain | Summer, Rain | Summer, Rain | Summer, Rain | Summer, Rain | Rain | Summer, Rain |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ground Cover/ Ground | Spotted | Not Spotted | Spotted | Spotted | Not Spotted | Spotted | Spotted | Spotted | Not Spotted | Not Spotted |
| | Shrub/ Bushes | Not Spotted | Not Spotted | Spotted | Spotted | Not Spotted | Not Spotted | Not Spotted | Spotted | Not Spotted | Not Spotted |
| | Small fruit Tree | Not Spotted | Not Spotted | Not Spotted | Not Spotted | Spotted | Spotted | Not Spotted | Spotted | Not Spotted | Not Spotted |
| | Small Flowering Tree | Not Spotted | Not Spotted | Not Spotted | Not Spotted | Not Spotted | Spotted | Not Spotted | Not Spotted | Not Spotted | Not Spotted |
| | Big Fruit Trees | Not Spotted | Spotted | Not Spotted | Spotted | Spotted | Spotted | Not Spotted | Spotted | Spotted | Spotted |
| | Big Trees(Non Flowering, Non Fruit Bearing) | Not Spotted | Spotted | Not Spotted | Spotted | Spotted | Spotted | Not Spotted | Spotted | Spotted | Spotted |
| | Flowering Climber/Flowering Liana | Not Spotted | Not Spotted | Not Spotted | Not Spotted | Not Spotted | Not Spotted | Not Spotted | Not Spotted | Not Spotted | Not Spotted |
| | Near Manmade Water Feature | Spotted | Not Spotted | Spotted | Not Spotted | Not Spotted | Spotted | Not Spotted | Spotted | Not Spotted | Not Spotted |
| | On Built For/ Manmade Things | Spotted | Spotted | Spotted | Spotted | Spotted | Spotted | Not Spotted | Spotted | Not Spotted | Spotted |
| | Human Friendly | Yes | Yes | Yes | No | No | Yes | Yes | Yes | No | No |

Table No-3: Showing Analyasis Of Medium Birds (9 - 16 In) -Type C

**D. LARGE (16 - 32 in) -TYPE D**

| TYPOLOGY | | LARGE (16 - 32 in) -TYPE D | | | |
|---|---|---|---|---|---|
| No | | 1 | 2 | 3 | 4 |
| BIRD NAME | | Asian Koel | Greater Coucal Or Crow Pheasant | Carrion | Hawk |
| PARAMETERS | Food Type | Frugivorous | Insectivorous | Omnivores | Carnivorous |
| | Month | April-July | March-July | March-July | June-July |
| | Time | Afternoon, Evening | Morning , Afternoon, Evening | Afternoon | Evening |
| | Season | Summer, Rain | Summer, Rain | Summer, Rain | Rain |
| | Ground Cover/ Ground | Not Spotted | Spotted | Not Spotted | Not Spotted |

| | | | | | |
|---|---|---|---|---|---|
| | Shrub/ Bushes | Not Spotted | Spotted | Not Spotted | Not Spotted |
| | Small fruit Tree | | Spotted | Not Spotted | Not Spotted |
| | Small Flowering Tree | Not Spotted | Not Spotted | Not Spotted | Not Spotted |
| | Big Fruit Trees | Spotted | Not Spotted | Spotted | Spotted |
| | Big Trees(Non Flowering, Non Fruit Bearing) | Spotted | Not Spotted | Spotted | Spotted |
| | Flowering Climber/Flowering Liana | Not Spotted | Not Spotted | Not Spotted | Not Spotted |
| | Near Manmade Water Feature | Not Spotted | Spotted | Spotted | Not Spotted |
| | On Built For/ Manmade Things | Not Spotted | Spotted | Spotted | Not Spotted |
| | Human Friendly | No | Yes | Yes | No |

Table No-4: Showing Analyasis Of Large Birds (16 - 32 In) -Type D

| 1 | TYPOLOGY | | VERY SMALL (3 - 5 in) TYPE A | SMALL (5 - 9 in) -TYPE B | MEDIUM (9 - 16 in) -TYPE C | LARGE (16 - 32 in) -TYPE D | INFERENCE |
|---|---|---|---|---|---|---|---|
| 2 | TOTAL BIRD COUNT (26) | | 3 | 9 | 10 | 4 | i. **VERY SMALL (3 - 5 in) TYPE A** : Found in landscape of residential yards are mostly nectivorous or **Granivore**. Prominantly seen on **Small Flowering Tree, Big Fruit Trees, Flowering Climber/Flowering Liana** in summer and rain, they are human friendly.<br><br>ii. **SMALL (5 - 9 in) -TYPE B :** Found in landscape of residential yards are mostly Insectivorous or Frugivorous. Prominantly seen on **Shrub/ Bushes, Big Fruit Trees, Small fruit Trees** in summer and rain, very few of them are human friendly.<br><br>iii. **MEDIUM (9 - 16 in) -TYPE C :** Found in landscape of residential yards are mostly Insectivorous , Frugivorous very few of them are Omnivores and Carnivorous. Prominantly seen on **Ground Cover/ Ground, Big Fruit Trees, Big Trees(Non** |
| | FOOD TYPE | Granivore | 1 | 0 | 3 | 0 | |
| 3 | | Nectivore | 2 | 0 | 0 | 0 | |
| | | Insectivorous | 0 | 5 | 4 | 1 | |
| | | Omnivores | 0 | 0 | 1 | 1 | |
| | | Carnivorous | 0 | 0 | 2 | 1 | |
| | | Frugivorous | 0 | 4 | 0 | 1 | |
| | MONTH | March | 3 | 8 | 9 | 2 | |
| 4 | | April | 3 | 8 | 9 | 3 | |
| | | May | 3 | 8 | 9 | 3 | |
| | | June | 3 | 9 | 10 | 4 | |
| | | July | 3 | 9 | 10 | 4 | |
| | TIME | Morning | 2 | 5 | 7 | 1 | |
| 5 | | Afternoon | 2 | 4 | 2 | 3 | |
| | | Evening | 3 | 9 | 10 | 3 | |
| 6 | SEASON | Summer | 3 | 9 | 9 | 3 | |
| | | Rain | 3 | 9 | 10 | 4 | |
| | PLANT TYPE | Ground Cover/ Ground | 1 | 4 | 6 | 1 | |
| | | Shrub/ Bushes | 2 | 6 | 3 | 1 | |
| 7 | | Small fruit Tree | 2 | 5 | 3 | 1 | |
| | | Small Flowering Tree | 3 | 3 | 1 | 0 | |
| | | Big Fruit Trees | 3 | 8 | 7 | 3 | |
| | | Big Trees(Non Flowering, Non Fruit Bearing) | 2 | 4 | 7 | 3 | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | Flowering Climber/Flowering Liana | 3 | 2 | 0 | 0 | Flowering, Non Fruit Bearing) , On Built For/ Manmade Things in summer and rain, Most of them are human friendly.<br><br>iv. **LARGE (16 - 32 in) -TYPE D :** Found in landscape of residential yards are mostly Insectivorous, Omnivores, Carnivorous, Frugivorous. Prominantly seen on **Big Fruit Trees, Big Trees(Non Flowering, Non Fruit Bearing)** in summer and rain, Few of them are human friendly. |
| 8 | ASSOCIATION WITH HUMAN | Near Manmade Water Feature | 0 | 4 | 4 | 2 | |
| | | On Built For/ Manmade Things | 1 | 2 | 8 | 2 | |
| | | Human Friendly | 3 | 2 | 6 | 2 | |

Table No-5:Showing Summary of analysis and Inferences of study (i.e. Table No-2,3,4,5)

**CONCLUSION:**

**Small Flowering Tree, Big Fruit Trees, Flowering Climber/Flowering Liana** are recommended near human activity areas like seating, patios, gazebos, pavilions etc for attracting **very small size birds**, most of them are human friendly and could be found on lower canopy of vegetation. **Shrub/ Bushes, Big Fruit Trees, Small fruit Trees** are recommended near human activity areas like pathways , Water bodies , Windows , Near Balconies, terraces etc for attracting **small size birds**, As very few of them are human friendly and could be found on middle canopy of vegetation, hence difficult to notice. **Ground Cover/ Ground**, **Big Fruit Trees**, **Big Trees(Non Flowering, Non Fruit Bearing)** are recommended near human activity areas like seating, patios, gazebos, pavilions, Water bodies, Near Balconies, terraces etc for attracting **Medium size birds**, As most of them are human friendly and could be found on Uppecanopy of vegetation. **Big Fruit Trees, Big Trees(Non Flowering, Non Fruit Bearing)** are recommended near wall compounds , Avenues, Near Balconies, terraces, Window etc for attracting **Large size birds**.

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# EMBODIED CARBON QUANTITY IN KERALA HOUSING PRACTICES: PRECAST CONCRETE AS AN ALTERNATIVE TO MEET SUSTAINABILITY

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**Abstract**

Construction industry accounts for 39% of $CO_2$ emissions according to UN reports. It has to be made more energy efficient and sustainable to reduce the effects of carbon on the planet. In recent years, there have been several developments in the industry to propel it towards more sustainable practices. But they're not being utilised properly to reduce carbon intensive constructions. This paper analyses the scope of using precast concrete as a more sustainable alternative to cast-in-situ concrete in the context of Kerala. Of the materials used in the construction phase alone, concrete is found to contribute to the majority of embodied carbon (EC). Concrete is also the most used materials in most construction works. Precast concrete has been continuously promoted as a means to reduce this carbon emission by optimising the amount of concrete used in construction. But it is still not widely adopted in Kerala and the industry here still adheres to the conventional methods. From the analysis of existing database on embodied carbon (EC) of precast and cast-in-situ concrete, and a case study of a residential area in Kerala, it has been found that the use of precast concrete alone can reduce up to 10.7% of carbon emissions in the construction phase. This finding, combined with additional measures to control or substitute the use of concrete – can be used to considerably reduce the EC. The future of this research could be to find out measures to better implement the use of precast concrete in Kerala.

**Keywords:** Sustainability, Embodied carbon, Precast concrete, Cast-in-situ concrete

## INTRODUCTION / BACKGROUND

According to environmental reports by the UN, the construction industry accounts for 39% of $CO_2$ globally. There is progress towards sustainable construction and buildings, but not enough to keep up with the growing built up area each year. The building energy demands have increased in between 2010 and 2016 (United Nations Environment Programme, 2017). There are multiple sustainable opportunities and technologies that remain untapped in the construction industry due to poor, lack of awareness and consumer choices. There is an urgent need to address the growth of carbon-intensive buildings in developing nations like India (United Nations Environment Programme, 2017; IPCC, 2014).

Concrete is one of the major contributors to carbon emissions in the construction phase of a building. Even though there are ways to reduce the emissions, like using precast concrete, these are not implemented effectively in the industry here (Dong, et al., 2018). The seven major building materials accounting for more than 90% of building greenhouse gas (GHG) emissions include concrete, a reinforcing steel, and section steel. Among the CO2 emissions generated by these materials, concrete accounts for 70% (Roh, et al., 2013). Efforts to reduce these emissions are being made through different means across the globe, but the building industry in India and similar developing nations have not kept up with newest developments (Wuni & Shen, 2019).Bringing in reforms in the construction industry to adopt better, sustainable options is a need of the hour to reduce environmental impacts.

This study focuses on the environmental impacts a small residential area has at a smaller scale – especially the use of a carbon intense material like concrete. The embodied carbon of the concrete used was calculated with the help of parameters like transportation distance, standardised concrete mix ratios prescribed by the government, etc. The

software used for this calculation is by Circular Ecology, an environmental consultant group that specialises in offering resource efficiency services (Circular Ecology, 2020).

**AIM**

The study is designed to analyse if precast concrete is more sustainable than cast-in-situ concrete in the context of residential construction. The study was carried out by conducting a comparative energy analysis of the embodied carbon produced by both types of concrete used in construction processes. This research will aid in directing the construction industry towards a more sustainable future, especially in a local context in Kerala. Furthermore, it aims to direct more dedicated research towards the implementation of precast and prefabricated elements in the industry here.

**RESEARCH METHODOLOGY**

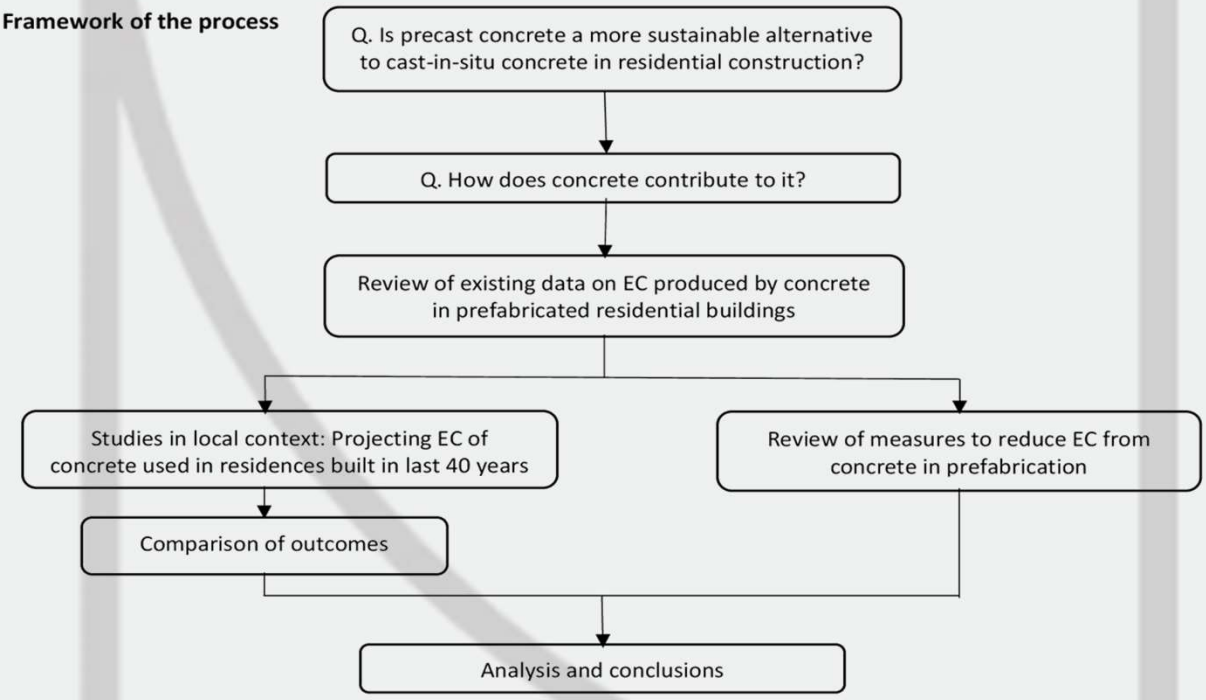
**Systematic analysis of literature**

Analysing available research papers on the energy analysis of the materials used in prefabrication. Most of such research papers have case studies in China or other developed nations. These papers were analysed and compared to understand the pattern of embodied carbon and how they can be reduced.

**Quantitative study**

It seeks to gain an understanding of the different levels of carbon emissions contributed by various materials used in construction through a quantitative analysis of the same. The study focuses on the embodied carbon of concrete, since it is one of the biggest contributors of carbon in conventional construction, and because there's a considerable difference in the quantities of concrete used in prefabrication and conventional construction. This means, there will be a considerable difference in the overall carbon emission of the building due to the difference in quantities of concrete used.

**Framework of the process**



**ANALYSIS**

The literature studies were carried out by reviewing research papers on the life cycle assessment (LCA) of prefabricated buildings and comparative energy analysis studies of prefabrication and conventional construction methods. The first case study, the Micro House, offers a clear view of the carbon emissions of a small scale prefabricated residential unit. The second case study, a prefabricated high-rise residential building in Hong Kong, details the carbon emissions from cradle-to-grave stages. While Ling Dong divides the stages of construction into six based on process (Dong, et al., 2018), while Yue Teng and Wei Pan, in their energy analysis in 2019, creates a five-level framework for assessing embodied carbon based on the degree of prefabrication completed at a factory (Teng, 2019).

**Case Study 1: Micro House, China**

The Micro House is a light weight, green construction which can be transported very easily. The structure has two basic units/modules of dimensions: 6m x 3m x 3m and 6m x 2m x 3m. Most of the construction materials used here can be partially or completely recycled or reused. 85% of the structure comes completed from the prefabrication factory itself, including furniture, plumbing and electrical connections and finishes. It need only be transported and assembled at the site. Concrete is mainly used on site, for the foundation structure (Dong, et al., 2018). The Life Cycle Assessment (LCA) of the structure reveals the cradle-to-cradle emissions produced and other environmental impacts. (Muralikrishna & Manickam, 2017).

Their study describes the life cycle of a prefabricated building in six stages: construction material preparation, elements prefabrication, logistics, on-site assembly, building operation and building disposal (Dong et al., 2018).

**Carbon Reduction Measures in Prefabrication**

From the LCA inventory (an existing database of LCA of building materials), the $CO_2$ emission factor of concrete used for foundation is found to be 0.48 tonne $CO_2/m^3$. With this, the total embodied carbon by the concrete used in this structure was found to be 110.4 kg $CO_2$.

The annual average carbon emission of the Micro House is stated to be 35.7 kg/$m^2$ per year (Dong et al., 2018). According to this, for a 20-year life span, the total embodied carbon was found to be 714 kg $CO_2$.

That is, 15.46% of the total embodied carbon from cradle-to-grave is contributed by the concrete used in the prefabrication and construction phases.

The author identifies reduction measures that can be implemented in different stages of prefabricated construction:

- Using more passive designs and more recyclable and reusable materials.
- Reusable foundation materials will reduce EC to a large extent since it uses large quantities of concrete.
- Implementing renewable energy technology.
- Increasing the service life of the building can reduce up to 34% of total EC (Dong, et al., 2018).

**Case Study 2: High Rise Residential Building, Hong Kong**

This case study by Yue Teng takes a typical prefabricated high-rise residential building in Hong Kong to assess the cradle-to-end carbon emissions. Here, the analysis is done at five levels of units: material level, component level, assembly level, flat level and building level (Teng, 2019). This is a five-level framework developed by Teng and Pan to achieve a more reliable and effective assessment of embodied carbon of prefabricated buildings.

Cast-in-situ concrete contributes 39.8% and precast concrete contributes 19.4% to the cradle-to-grave embodied carbon of the case study building at its material level (Dong, et al., 2018). That is, a total of 59.2% of the total embodied carbon

is contributed by concrete alone. At the component level, concrete and steel consumption contributed approximately 95% to the total EC at this stage. Concrete is a major contributor here too. At the assembly level, concrete and steel consumption contributed approximately 90% to the total EC of this stage. At the flat level, concrete contributes 27.1% and at building level, cast-in-situ concrete accounts for 32.7% of the total carbon emissions (Teng, 2019). The data reveals that concrete is a major contributor in the cradle-to-grave carbon emissions of a building.

**Carbon Reduction Measures**

The author suggests reducing the amount of on-site construction, using more reusable materials, and applying measures to optimise the amount of precast concrete in the prefabrication process will help reduce the carbon emissions in this stage (Teng, 2019). They also suggest using low carbon concrete for both precast and cast-in-situ concrete. In low carbon concrete, some of the cement is replaced by additives that yield less environmental impact. EC of concrete can be reduced by substituting the content of cement with pulverised fly ash (PFA), sing lightweight aggregates and adding slag to the concrete (Teng, 2019).

**LIVE CASE STUDY: TIRUR, MALAPPURAM**

The live case study is based on one of the residential areas in Tirur, shown in Figure 1, a commercial town and municipality in Malappuram, Kerala. It is a culturally and commercially important place in the district. The site has witnessed a steady rise in the number of residences in the past few decades.

Fig.1 Trikandiyoor East Ward, Tirur

The conventionally constructed structures in Tirur use up large amounts of concrete, mostly cast on site and hence very carbon intensive and inefficient. Most of the urban and semi urban areas in Kerala have seen such similar trends in housing (Kerala State Planning Board, 2011). These constructions have contributed a lot to the carbon emissions from building industry in Kerala. Implementing more sustainable materials and building techniques after studying these trends will help in reducing carbon emissions. The study is done by charting the trends of housing in the past years and the approximate EC produced by the concrete used in these housing constructions.

Fig.2 Trikandiyoor East Ward – Base Map

For this study, a base plan as shown in Figure 2 was made with the help of a satellite map of the region and the approximate floor areas of the buildings are measured. Based on this, the approximate volume of concrete used for the floor and roof slabs are calculated, and its carbon footprint is projected.

**Material Availability**

Material procurement, transportation, fossil fuels and related equipment also contribute to the LCA of a structure. Therefore, the study considers the distance from which cement products are procured, since cementitious material is the major contributor to the EC of concrete.

The nearest cement manufacturing plant to the site is in Walayar, Palakkad – 103 kms away. The nearest precast concrete plant is in Kochi, 135 kms away from the site.

**Concrete Grade and Mix**

The mix ratio of Grade 20 concrete is taken, according to the Indian Standard codes - 1:1.5:3 (cement: sand: aggregates). It should have minimum 300 kg cement/$m^3$ and a maximum 0.55 water ratio. (Bureau of Indian Standards, 2007)

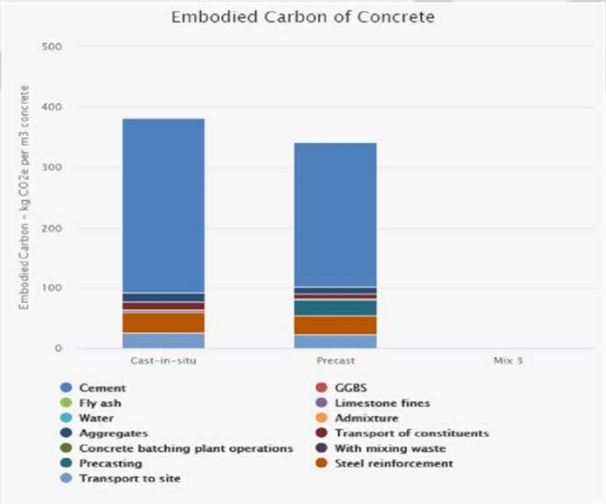



**Fig.3 Embodied Carbon of M20 grade cast-in-situ concrete and precast concrete**

Figure 3 compares the EC/$m^3$ from cast-in-situ and precast concrete. Table 1 shows that cast-in-situ concrete releases 383 kg $CO_2$e/$m^3$, while precast concrete releases 342 kg $CO_2$e/$m^3$. That is, precast concrete releases 41 kg $CO_2$e/$m^3$ lesser than cast-in-situ – a 10.7% reduction. This shows a major reduction of EC when the volume of concrete used in a whole building is considered. From the figure, it is evident that the major contributing material to EC is the cement – 76.1% and 70.4% in cast-in-situ and precast concrete, respectively.

| Parameters | Cast-in-situ concrete | Precast concrete |
|---|---|---|
| **Cement type** | Portland cement | Portland cement |
| **Quantity of cement** | 320 kg/$m^3$ | 265.0 kg/$m^3$ |
| **Water to cement ratio** | 0.50 | 0.48 |

| | | |
|---|---|---|
| **Water content** | 160 kg/m$^3$ | 153.6 kg/m$^3$ |
| **Fly ash** | NIL | 55.0 kg/m$^3$ |
| **Admixtures** | 0.2 kg/m$^3$ | 0.1 kg/m$^3$ |
| **Total aggregates** | 2040 kg/m$^3$ | 1,377.2 kg/m$^3$ |
| **Amount of steel** | 23 kg/m$^3$ | 20 kg/m$^3$ |
| **EC per volume concrete** | 383 kg $CO_2$e/m$^3$ | 342 kg $CO_2$e/m$^3$ |
| **EC per kg concrete** | 0.152 kg $CO_2$e/kg | 0.185 kg $CO_2$e/kg |

**Table 1. Material quantities in concrete**

| **Material** | **Contribution to EC** | | | |
|---|---|---|---|---|
| | **Cast-in-situ** | | **Precast** | |
| | **Percentage (%)** | **kg $CO_2$e/m$^3$** | **Percentage (%)** | **kg $CO_2$e/m$^3$** |
| **Cement** | 76.1 | 291.0 | 70.4 | 241.1 |
| **Fly ash** | - | - | 0.1 | 0.2 |
| **Admixtures** | 0.1 | 0.3 | - | 0.1 |
| **Aggregates** | 4.0 | 15.2 | 3.0 | 10.3 |
| **Transport of constituents** | 3.3 | 12.5 | 2.7 | 9.2 |
| **Concrete batching plant** | 0.5 | 1.8 | - | - |
| **With mixing waste** | 0.4 | 1.6 | 0.4 | 1.3 |
| **Steel reinforcement** | 9.3 | 35.6 | 9.1 | 31.0 |
| **Precasting** | - | - | 7.7 | 26.3 |
| **Transport to site** | 6.4 | 24.4 | 6.7 | 22.8 |
| **Total** | - | 383 | - | 342 |

**Table 2. Contribution to Embodied Carbon**

Table 1 shows the quantities by weight of each material in the two concrete mixes. Table 2 shows the contribution of each element to the total carbon emission of concrete, and it is clear that cement is the major contributor in both cases – 76.1% in cast-in-situ concrete and 70.4% in precast concrete. The reduction in percentage of contribution was achieved in precast concrete by substituting some of the cement with fly ash, which is a lesser carbon intensive building material than cement.

**EMBODIED CARBON OF CAST-IN-SITU CONCRETE**

| **Year** | **No. of residences** | **Approx. floor area (m$^2$)** | **Carbon emissions from cast-in-situ concrete (kg $CO_2$e)** | **Projected carbon emissions from precast concrete (kg $CO_2$e)** |
|---|---|---|---|---|
| 1980 - 1990 | 33 | 2942.41 | 11,26,824.3 | 10,06,198.2 |
| 1990 - 2000 | 14 | 987.06 | 3,78,043.98 | 3,37,574.52 |
| 2000 - 2010 | 18 | 1170.58 | 4,48,332.14 | 4,00,338.36 |
| 2010 - 2020 | 26 | 3649.58 | 13,97,789.14 | 12,48,156.36 |

**Table 3. Embodied Carbon of residences on site**

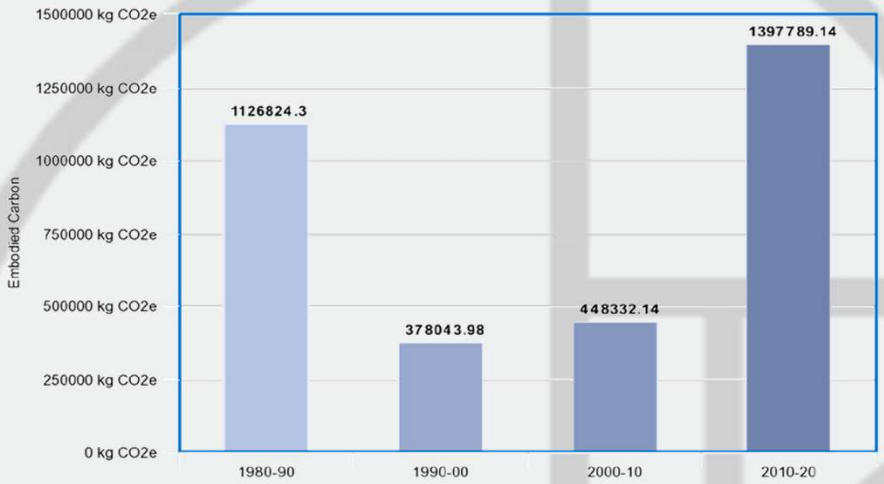



**Fig.4 Carbon emissions of cast-in-situ concrete used in residential constructions**

From the graph in Figure 4, it is evident that the EC produced during 2010-20 is higher than that in 1980-90, even though there are lesser number of houses. This is because of the increase in built area of the individual residences.

**EMBODIED CARBON OF PRECAST CONCRETE**

From the graph in Figure 3, it is found that precast concrete uses a lesser amount of cement for the same results and release a lower amount of carbon. Figure 5 shows the approximate carbon emissions that would have been produced if these residential constructions used precast floor and roof slabs instead of cast-in-situ slabs. The carbon emissions here are found to be 10.7% lesser than that of cast-in-situ concrete.

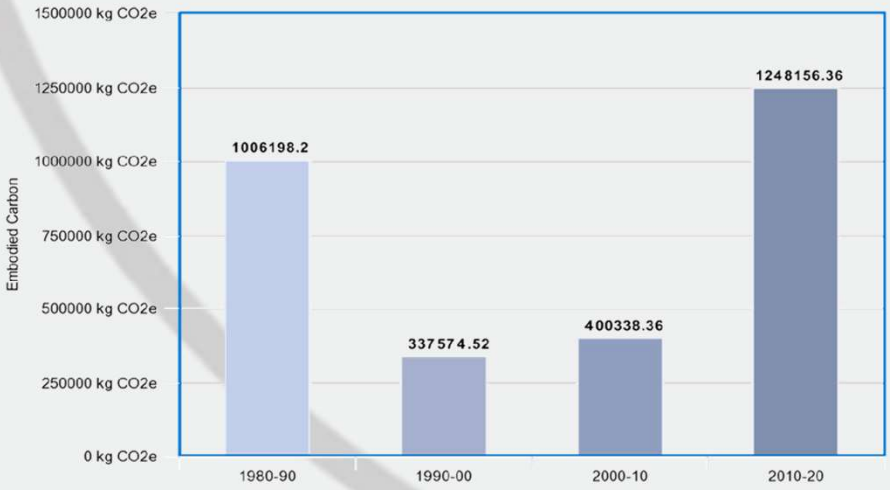


**Fig.5 Projected carbon emissions of precast concrete**

**COMPARISON OF EMBODIED CARBON**

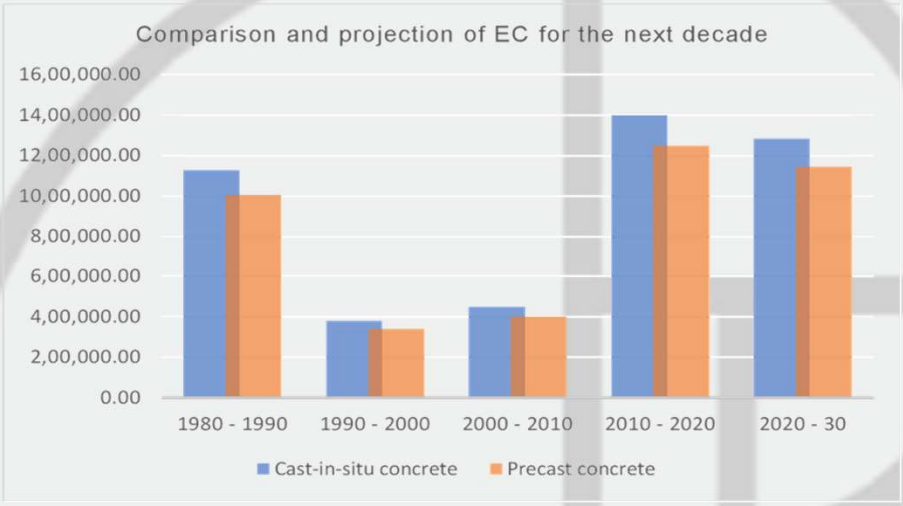



**Fig.6 Predicted EC for the future**

Figure 6 shows the side-by-side comparison of the EC from both types of concrete. The EC that might be produced in the next 10 years from the residential constructions is also projected. From this, it is clear that precast concrete produces less $CO_2$ than its alternative. This 10.7% reduction in carbon emissions is the effect of substituting just a single material in the construction phase. So, it is safe to assume that embodied carbon can be further reduced by implementing other sustainable building materials and methods.

**CONCLUSION**

From the study, it is identified that carbon emissions from the building industry are one of the major contributors to the global carbon emissions, and therefore global warming. So, reducing the carbon intensive practices in the industry and finding more sustainable alternatives is a necessity at present. The study result shows that the embodied carbon of residential construction is projected to decrease in the next decade, but will still contribute a lot to the total emissions. Concrete is found to be a major contributor in the cradle-to-grave emissions of these constructions from both the literature study and the live case study (Dong, et al., 2018; Teng, 2019).

The residential area taken for this study and the predicted embodied carbon can be considered as an example for the semi urban areas in all parts of Kerala – which signifies that a vast amount of emissions is produced from the concrete used in residential construction alone. The paper puts forward precast concrete as a lesser carbon intensive building material than cast-in-situ concrete, which will partially improve the sustainability of the building for this selected site context. Cast-in-situ concrete uses 320 kg cement per $m^3$, and creates a lot of wastage of materials on site, which is inefficient and leads to unnecessary carbon emissions. Meanwhile, precast concrete uses only 265 kg cement per $m^3$. Precast concrete products are cast in factories or plants and have accurate measurements for all materials. Hence, there won't be wastage of materials, the process will be very time efficient since the concrete products are cast in batches, and it replaces some of the cement with materials like pulverised fly ash (PFA) (P & L, 2012). This makes precast concrete more sustainable than cast-in-situ concrete. Therefore, using precast slabs, columns, beams, etc can reduce the carbon emissions by 10.7% when compared to the emissions produced by cast-in-situ concrete. Further changes can be brought into the composition and production of the precast concrete elements so as to further reduce carbon emissions. Material

procurement, transportation, prefabrication, assembly and disposal are all factors that influence the embodied carbon of concrete (Dong, et al., 2018). The future of this paper can be to research in the realm of methods to produce a better-quality precast concrete with reduced emissions.

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# PLACE IDENTITY AND PLACE ATTACHMENT IN URBAN-LAGOON WATER LANDSCAPE, BATTICALOA, SRILANKA.

## Historical Analysis Of The Relationship Between Lagoon Waterfronts, People, Activities, And The City Landscape In Batticaloa, Focusing On Place Identity And Place Attachment In Urban-Lagoon Water Landscape.

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**Abstract:** Batticaloa town has been evolved with the lagoon related activities, established a unique urban-lagoon water landscape in Batticaloa. The integrated relationship of people, place & urban-lagoon landscape is specific, and people have been celebrating the place throughout the past, reflecting sense of place and place attachment. Recently introduced new urban water parks are neglected by people raise the question of how people experience sense of place and place attachment in these new urban parks and how these contribute to the place identity of Batticaloa. Aim of this research is to examine issues related to the sense of place and place attachment in recently constructed urban parks in Batticaloa. The research methodology applies a case study approach; by methods of a historical analysis, it explores the relationship between lagoon waterfronts, people, and activities, focuses on place identity and place attachment in urban-lagoon landscapes, and analyses the current situation in new urban water parks. It utilizes informal interviews and conversations with people in selected case study areas, and narrative analysis and content analysis investigate data. Threefold of place identity, concept of 'insideness' and place attachment as analysis tools of sense of place explain the case study. Findings and analysis indicate that people visiting these urban – lagoon water landscapes are satisfied with the proposed recreation activities; while their concern is about these places are on memories and identity; abandonment of historic identities, activities, spiritual customs, and beliefs on these places are possible causes for the less sense of place and neglecting the place. [1]

***Keywords:*** *urban-lagoon water landscape Batticaloa, place identity, place attachment, people and place.*

## INTRODUCTION

Batticaloa locates on a tiny tongue of land with the Indian ocean situates at east. An estuarine lagoon can be seen around the town. Batticaloa city was formed along the lagoon front, and in the central part of the city, the lagoon front is parallel the town. People's relationship with the places, functions, culture, and religion are tied and significant with water is still can be identified within the society. City landscape was along the lagoon edge, and landscape elements like parks, boat docks, buildings, monuments, historical elements, roads, and paths were formed along the lagoon front. Linkages between the buildings and lagoon front landscape were created by different functions, activities, and cultural attachments. Urban – lagoon water landscape developments and waterfront parks are some of the main parts in the Batticaloa urban landscape, most of the urban parks were built in the edge of the Batticaloa lagoon in last 10 – 15 years. At present, the situation of most of the newly built urban – lagoon front parks and landscape are negative. Other than one or two parks, people have started to refuse most of the parks and landscape developments. The local people and visitors neglect the parks due to several issues. Due to this rejection, these places seem meaningless. How do these changes have affected sense of place, place attachment, and accepting/ neglecting by the people? When we consider

[1] Subahithan, M., and De Silva, W.,2020. Sense of place in new urban water parks, Batticaloa: Place identity and place attachment in urban-lagoon water landscape, Batticaloa. *Abstract published in Proceedings of 8th International Conference on Cities People and Places, UOM Lab – Centre for Cities, 15th -18th December, 2020*. Colombo, Srilanka: University of Moratuwa,2020.

Batticaloa Urban-lagoon water landscapes and waterfront parks, the relationship between people, lagoon fronts and city landscape is changed dramatically throughout the time.

## RESEARCH AIM AND RESEARCH QUESTION

This research study aims to examine lack of place identity, place attachment and sense of place in the newly introduced urban parks to study how people identify lagoon waterfronts for their life and city landscape, throughout the time. Some newly constructed waterfront parks and landscapes are negative, neglecting by the people and draining out of meaning. People's relationship and identification towards the waterfront parks and attachments with city landscape for their life need to be questioned. Why these new lagoon waterfront parks are being neglected? And how people are identifying these lagoon waterfronts for their life and city landscape, throughout the time?

## LITERATURE REVIEW

### Place identity

Place identity is realised as a differing view on people-place relationships. The role of place-identity is to adjust people's self-identity. Proshansky, Fabian and Kaminoff (cited in Hunziker, Buchecker & Hartig, 2007) state place acts as outer memory for place-related dimensions of people's identity, termed place identity. It helps people to retain a cognitive because it enables them to bring with them memories of important places as they transfer to a new environment. Aspect of social and cultural life in urban contexts is a key in place identity, powerfully connected to place attachment and sense of place (Kaymaz, 2013). Breakwell (cited in Hunziker et al., 2007) says changing role of place for people's identity is vital because self-identity is uneven and simultaneously existential cognitive structure based on social interactions and therefore endangered by internal or external changes. Concept of place identity is appropriate to use as an analytical tool for realising people-place relationship.

Relph (cited in Seamon & Sowers, 2008, pp.45) states place identity as its "persistent sameness and unity, which allows that [place] to be differentiated from others". He defines this persistent identity in relations of three different elements. The elements are 1: The place's physical setting, 2. Situations and activities and events happening in the place. 3. Single and group meanings produced by the people's experiences and intentions regarding the place. Relph categorised modes of place identity through insider and outsider concepts. 'Insideness' exposes deep and intense place attachment in which socio-cultural values, meanings, knowledge, and related place quality are represented in a public-recognised area.

### Place attachment

"Place attachment is defined as an evaluative dimension of place; it describes what does the place mean to people, rather than how much does it mean? Briefly, Place attachment describes the bonding that occurs between people and their meaningful surroundings." (Mina & Mustafa, 2012, pp.7640). In the built and natural environments, the physical features of the environment play a role in the formation of these bonds. These physical features are the techniques through which place achieves its influence. According to Setha & Low (cited in Jennifer, 2001), Place attachment is the emblematic connection created by people forming culturally combined psychological definitions in a particular area of land that affords the foundation for the perception and link to the world of human being and their community. Place attachment is a cognitive and emotional experience and involves socio-cultural beliefs, values, norms, and practices that link individuals with the place.

Socio-demographic characteristics of people are affecting place attachment. Characteristics are environmental experiences that include People's type of involvement with place; degree of familiarity with place; people's expertise or knowledge about place, religion and culture, place satisfaction, and place itself. Most place attachment research measure the strength of bond between people and places. Familiarity with place, size of association, place dependence, place

satisfaction, place identity, sense of belonging and place affective are the variables that are used to measure place attachment (Mina & Mustafa, 2012).

**Relationship between Place identity, Place attachment and Sense of place**

Place attachment is emerging from constructive experiences and the good relationship between a person and a place, whereas place identity originates from the emotions, meanings, beliefs, ideas, and attitudes assigned to a place. The place must be identifiable and should have an identity to create a sense of place, leading to place attachment. Relph's concepts describe place attachment is something that begins in and is faced by insiders directly. Insideness is an indicator of how people will connect to a place in the future and how they will utilise it and care for it. Relph's idea to be 'inside' of a place is giving the place attachment. When place identity gives the sense of 'inside', people feel the sense of place attachment, and it creates the relationship. All are enforcing the sense of place.

## RESEARCH METHODOLOGY

**Theoretical framework of the study**

Concept of place identity and place attachment are appropriate to utilise as an analytic tool for realising people-place relations. Threefold of Relph and Concept of 'Insideness' are derived and integrated with the concept of place attachment in the theoretical framework of the study. Elements of threefold combined with the framework to analyse the people – place relationship. Theoretical framework for the study is derived from the understanding of current knowledge in place identity and the concept, use of Relph's idea of to be 'inside' of a place is giving the place attachment. Threefold of Relph is useful to examine and analyse place identity. When place identity gives the sense of 'inside', people feel the sense of place attachment, and it creates the relationship.

**Comprehensive tables developed by analysing literature to collect and analyse data.**

Table 1 – Comprehensive table to analyse Threefold of place identity.

| Data Type | Sense of place | Place attachment | Place identity |
|---|---|---|---|
| **Threefold of Place identity** (Relph, 1976) | Meanings<br><br>produced by the people's experiences and intentions | Culturally combined emotional or affectional meanings (Setha & Low) | Physical setting<br><br>Situations, activities, and events happened/ing |

Table 2 – Comprehensive table to analyse place attachment.

| Data Type | Place attachment | | |
|---|---|---|---|
| **Socio-demographic characteristics of people.** (Mina & Mustafa, 2012) | Familiarity with place, Size of association, Place dependence, Place satisfaction<br><br>Place affective. | Type of involvement<br><br>People's expertise or knowledge about place, religion, and culture. | Strength of bond between people and lagoon fronts |

Table 3 – Comprehensive table to analyse 'Insideness'.

| Data Type | Behavioural | Empathetic | Existential |
|---|---|---|---|
| **Modes of insideness**<br><br>**(**Maria ,2018) | Engaging activities, built structures, Recognising objects, views, and activities with noticeable qualities. | Emotional bond/ engagements of the people, and their involvement with built structures. | Sense of ownership and personal experience of a place and feelings of connection and concern for it |

**Method of study**

Qualitative approach used as a method of study after conducting a literate review on past research. Components and factors discussed in the literature review and theoretical framework are extracted to develop the methodology to assess place attachment and identity. People's relationship with lagoon water landscape captured by observations, questionnaires, informal chats, and interviews. Throughout a historical analysis of the relationship between lagoon waterfronts, people, activities, and the city landscape in Batticaloa, changes happened in urban – lagoon front landscape and its effects on people and their relationship with urban – lagoon water landscape was studied.

People's own and past observations were examined through questionnaires and informal chats with randomly selected people. Informal chats and interview were conducted to collect depth and details regarding the people – place relationship in the case study areas throughout the years. Historical and narrative descriptions were collected through archival document and resources from libraries, informal chats etc. Old photographs and descriptions are tabled according to the chronology to analyse. Content analysis was conducted to classify, summarise, and tabulate the data. Narrative analysis conducted for the data from informal chats, descriptions, and questionnaire.

**Case study areas**

Case study areas had chosen considering the current and past situation of these lagoon water landscapes, historical location, and values. Two existing lagoon front parks and surrounding are selected. A functioning lagoon front park and surrounding (Gandhi Park) and a neglecting lagoon front park and surroundings (New Lake park) had selected.

Figure 01- Im - Source: Author

Figure 02- Image of New lake park and surroundings - Source: Author

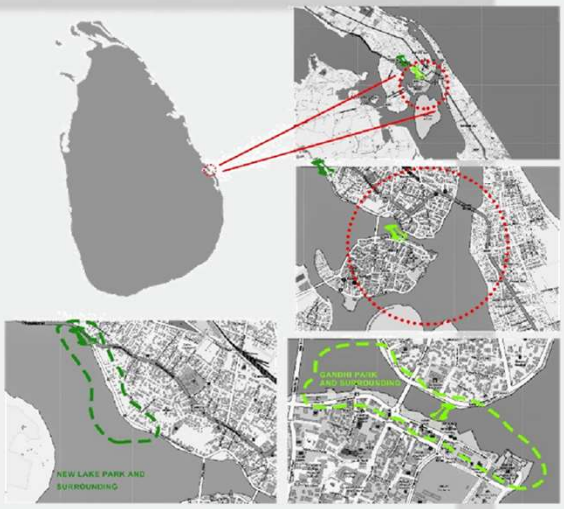


Figure 03- Case study areas - Source: Author

**FINDINGS AND ANALYSIS**

**Case study area 1 - Gandhi Park and surroundings**

Analysis indicates that this place has its own identity by its historical and social-cultural values. The past situation of this place, meanings and activities that happened in this place influence the place's identity and attachment with people. Lack of importance given to historical elements and socio-cultural activities in the proposed activities in the park affects people bond with lagoon water landscape and sense of 'insideness'. Proposed recreational activities influence the dependence, involvements and associations with this place and result an attachment between people and place.

Poor noticeable activities; weak emotional bonds between people and place; lack of engagement with lagoon water are affecting the sense of 'insideness' and attachment. All are enforcing a meaningless place.

**Case study area 2 - New lake Park and surroundings**

This place has its own identity by its social-cultural values and environmental significance. The past situation of this place, meanings and activities that happened in this place influencing the place's identity and attachment with people. People interviewed and chatted have described, this place's natural setting which is destroyed by urban developments, bull slaughtering activities and other inauspicious events happened in this area, which are against their traditions and beliefs. These culturally combined meanings created among the people resulted in lack of socio-cultural activities, involvements, and emotional bond in this place. Proposed exercising activities and recreations are making local people satisfied and depend on this place; it is influencing their associations, involvements, and bond with this place.

**Historical data presentation and analysis - Colonial period**

Table 4 – Historical analysis of threefold of place identity - Colonial period.

| Data Type | Sense of place | Place attachment | Place identity |
|---|---|---|---|
| **Threefold of Place identity** (Relph, 1976) | **Meanings**<br>People's experiences on waterfronts created meanings it established the sense. | **Culturally combined meanings**<br>Traditional and cultural beliefs on waterfronts created affectional meanings. | **Physical setting**<br>Coconut grooves narrow by the side of the lagoon.<br>**Situations, activities, and events happened/ing**<br>Fishing activities, economic and socio-cultural celebrations with lagoon fronts. |

Table 5 – Historical analysis of place attachment – Colonial period.

| Data Type | Place attachment | | |
|---|---|---|---|
| **Socio-demographic characteristics of people.** (Mina & Mustafa, 2012) | **Familiarity with place Size of association.**<br>People were familiar with waterfronts and size of association was high due their day today involvements and activities. It made them depend and satisfied with it. | **Type of involvement**<br>People involved with water in religious practices and beliefs other than recreation and economic.<br>Traditional knowledge, concern and practices made them attached. | **Strength of bond**<br>Variety of activities and celebrations made bonds stronger. |

Table 6 – Historical analysis of 'insideness' – Colonial period.

| Data Type | Behavioural | Empathetic | Existential |
|---|---|---|---|
| **Modes of insideness**<br>(Maria,2018) | **Engaging activities, built structures, views and noticeable qualities.**<br>Socio-cultural, recreational, and economic activities without built structure. | **Emotional bond and engagements**<br>Traditional fishing, transportations, events, and engagements with livestock and waterfront formed the attachment. | **Sense of ownership, feelings of connection and concern**<br>Sense of ownerships created by local people at lagoon fronts made them connected and concerned on it. |

Narrative descriptions collected from people prove that people's type of involvements, activities, emotional bonds, meanings, traditional beliefs, and celebrations with lagoon water landscapes created its own identity. Place identity was established the sense of 'inside' and people felt the sense of place attachment.

### Historical data presentation and analysis - Post-Colonial period

Table 7 – Historical analysis of threefold of place identity - Postcolonial period.

| Data Type | Sense of place | Place attachment | Place identity |
|---|---|---|---|
| **Threefold of Place identity** (Relph, 1976) | **Meanings**<br><br>Modernisation influenced changes in intention of using lagoon. Fishing activities, transport and trading discontinued; meanings faded. | **Culturally combined meanings**<br><br>Meanings created by the people's customs, beliefs, and day-today activities vanished due to inauspicious activities along the lagoon | **Physical setting**<br><br>Urbanisation started, and new urban parks emerged.<br><br>Identical landmarks and elements abandon by modern developments.<br><br>**Situations, activities, and events happened/ing**<br><br>Political protest and meetings around the Dutch fort and town affected the identity. |

Table 8 – Historical analysis of place attachment – Postcolonial period.

| Data Type | Place attachment | | |
|---|---|---|---|
| **Socio-demographic characteristics of people.** (Mina & Mustafa, 2012) | **Familiarity with place & Size of association.**<br><br>Recreational spaces influenced the familiarity and size of association with lagoon fronts.<br><br>People satisfied with introduced recreation and built environment along lagoon front. | **Type of involvement**<br><br>People attached more towards economic activities, and lagoon fronts started using for parking.<br><br>Religious and socio-cultural involvements with lagoon reduced people's expertise and knowledge about lagoon fronts decreased. | **Strength of bond**<br><br>Emergence of modern urban parks started straining the bond and attachment with people and lagoon landscapes. |

Table 9 – Historical analysis of 'insideness' – Postcolonial period.

| Data Type | Behavioural | Empathetic | Existential |
|---|---|---|---|
| **Modes of insideness**<br><br>**(**Maria,2018) | **Engaging activities, built structures, views and noticeable qualities.**<br><br>Engagement of people on lagoon parks, turned towards recreation<br><br>Emergence of Bull slaughtering activities along the lagoon destroyed the identity and sense | **Emotional bond and engagements**<br><br>Modern recreational and economic developments; political activities along the lagoon front affected the emotional bond with natural lagoon water landscape. | **Sense of ownership, feelings of connection and concern**<br><br>Cutting down large tree and mangroves around the town for constructing urban parks, destroyed the sense of the place and concern on lagoon water landscape. |

Post-colonial period analysis done in the above tables expressed that changes were started happening along the lagoon water landscapes of Batticaloa lagoon. A 60-year-old interviewee expressed his experience and knowledge about the past situation of the New lake park and surrounding. He predominantly talked about the bull slaughtering activities happened in post-colonial period. These bull slaughtering activities created an inauspicious thought on the lagoon front among the people. People having culturally combined meanings and beliefs on this lagoon fronts started ignoring this area. It resulted in a poor sense of 'insideness' and attachment with the lagoon fronts.

Narrative descriptions interpret people satisfied with urban developments started happening in post-colonial period. Still, they are feeling loss in the identity of the place and attachment with the place, and it is strained the strength of bond with the lagoon water landscape. Situations of these lagoon water landscape are against the Relph's concept of 'insideness'. It proves that poor reflection of meanings, cultural values, experiences, and place quality are the causes for feeble place attachment and neglection of modern urban lagoon front parks.

**Findings and Discussion**

Since past, Batticaloa lagoon is being used for fishing activities. Other than fishing activities, lagoon fronts were celebrated by the local people for varies activities. In festival days and sporting events, water-related sporting activities like swimming and boat races were carried out along and across the lagoon. An interviewee states, in carnival days, lagoon fronts were celebrated with colourful decorations, socio-cultural and traditional functions. These improved the sense of this lagoon landscape by creating interactions and unity between people and lagoon front. It established the identity of these lagoon fronts and people's attachment towards lagoon fronts.

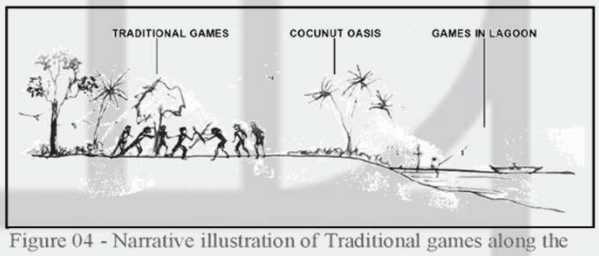

Figure 04 - Narrative illustration of Traditional games along the lagoon. Source: Author

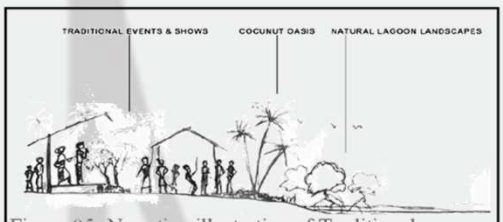

Figure 05- Narrative illustration of Traditional events("Koothu") and dramas along the lagoon. Source: Author

'Gandhi Park' (Case study area 1) was the place, that used to dock boats, canoes, and ferries. (Francis, 1994) states present Gandhi park area was called as Salt field because of Jetty and old crane used to import salt. Surrounding areas were used for economic activities; merchants and sailors used it for relaxing and playing cards. In Dutch and British periods, goods were loaded and unloaded in this place for export and import. (Kanthaiya, 2002) states small boats were used to transport goods between the forts and ships anchored in the sea. Still, we can see the machinery used for loading and unloading. (In present Gandhi park). (Francis, 1994, pp.14) states "Sound from a siren in this jetty indicated the time for local people". In this period, commercial activities and people's involvement in this place have improved the sense of place, and the relationship between people and lagoon front improved the place attachment. Sense of this place was created by the commercial, economic activities and historical landmark. Machinery placed in the lagoon edge for commercial activities acted as a place of attraction, and it made an identity to this place.

Throughout the time, the character and sense of this place have changed due to the urbanisation. 'Gandhi park' had built in this place, and the lagoon water landscape had altered by the new recreational elements without considering people's relationship with this lagoon water landscape. People's need for recreation and entertainments is the main reason for the change. Considering only recreations and lack of interaction with lagoon water have resulted in only some seating, paving, plants, and fences. These landscapes and elements do not reflect the place's historical identity and meaning. Changes in the sense of this place have resulted in lack of attachment between people and the landscape. Because of this situation, these places are neglecting by people. But for example, the landscape of Gandhi park has constructed using the old machinery (Old crane) as a landscape element. Some identities for the cultural importance and

significance of Batticaloa has given by the Batticaloa gate and carvings. Socio-cultural activities and events happening create significant identity and attachment with people. Because of these, this park and landscape maintain a considerable number of users and people are satisfied with the present situation and proposed recreations.

New lagoon park (Case study area 2) is constructed in the entrance part of Batticaloa town. A 70-year-old retired principal explained, this lagoon front was used by the Butchers as they used the waterfront when they were cutting the bulls and goats for business purposes. In the past and present, places used by butchers are secluded by the people because these places are considered as inauspicious places due to their beliefs and norm. Still, the people's attachment with religion is high and beliefs in their religions are affecting their activities, functions, attachment, and relationships between the lagoon fronts. At present, people have a negative opinion about these places. People's responses for the questionnaires, informal chats and discussions indicated that people's feelings are satisfied by the involving activities like jogging and recreation. But most interviewees express their views on past bull slaughtering activities, inauspicious events, and experiences at this area, which affect their attachment with this place. It reveals that local peoples cannot feel the sense of 'insideness' and sense of place inside this park, but they are satisfied and depending on the proposed jogging paths and recreation.

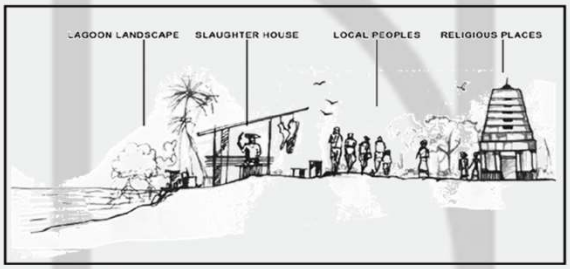


Figure 06- Narrative illustration of slaughtering activities and the situation. Source: Author

**CONCLUSION**

People visiting these urban – lagoon water landscapes are satisfied with the proposed recreation activities; from that, they are accepting they are having a good relationship and attachment with these places. While their concern about these places is on memories and identity; abandonment of historical identities, activities, spiritual customs, and beliefs on these places and these are the possible causes for the less people-place attachment, sense of place and neglection of these places. Concerns on these urban-water landscapes are influencing the relationship between people and landscapes. Traditional and cultural beliefs on waterfronts created affectional meanings between people and lagoon fronts; lack of concern on traditions and beliefs in urban-water landscapes affecting the sense of place and attachment.

People's traditional knowledge, concerns, practices, past activities, and situations from which people had experienced the place identity and place attachment against these lagoon water landscapes throughout time. People's involvement with water in religious practices and beliefs must be considered in urban planning strategies and must be incorporated into design strategies. It will ensure people attached to these places. These considerations will strengthen people's emotional bond with these urban lagoon water landscapes. All modern proposed recreational activities and other activities must integrate with the place's identity and sense of it. Organising socio-cultural activities and events within these urban landscapes will result in a sense of attachment and 'insideness' among the people. These arrangements will ensure good association, involvements and meanings between people and place. The natural setting and unique lagoon-water landscape character which is having a socio-cultural and emotional relationship with local people must be preserved and conserved when developments strategies take place.

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# DESIGN APPROACH TO REPURPOSING URBAN SPRAWL: CONTEXT STUDY BENGALURU

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**Abstract:** This paper aims to discuss a design approach focussing on sustainable practices which must become an integral part of design process for addressing urban sprawl especially in cities like Bengaluru, has witnessed an urban growth rate of 46.68 % (as of 2013). This rate of change is important to note because it reduces the time to plan for sustainable city growth and execute a design strategy that can manage the urbanisation. It is the balance between urban planning and urban growth that can mitigate urban 'sprawl'. For a sustainable intervention at a size of urban sprawl, it is important to rethink and repurpose these urban built environments so that they can come closer to a balanced and efficient dependence on resources, both physical and natural. This is a post facto measure and the design approach is hence inverted. The proposed design strategy explores multiple layers for design thinking in context of urban sprawl, repurposing the built environment. The process has been built by intensively studying the site and surveying with the residents of the area in urban built environment. The purpose is to demonstrate the application of design process for a sustainable practice along the south-west corridor of Bengaluru city.

***Keywords:*** *Design approach, Urban sprawl, Sustainable built environments, urban planning.*

## INTRODUCTION / BACKGROUND

As per the UN Report on World Urbanization Prospects, 2018, the number of city dwellers will grow exponentially, especially in developing countries, with India alone adding to 416 million urban dwellers by 2050 (UNDESA, 2018). This number adds considerable context to the scale of influx urban areas are bound to absorb- socio-economically and physical infrastructure wise. This pace of urban growth also adds tremendous stress on the environment and existing resources. A consequence of rapid influx in urban population is often translated into an Urban Sprawl. The spread of sprawl is seen in cities where there is an industrial growth, job opportunities and favourable climatic conditions for living (Zenou and Patacchini, 2013). These factors account for the inflow of migrants from different geographical locations creating an informal settlement in suburban parts of the city. A typical characteristic of Urban sprawl is the inefficient manner in which it consumes forestlands, farmland, and wetlands and loss of wildlife habitats. It is recognised for its poor planning and heavy reliance on vehicular traffic for long commuting distances between work and home.

The city of Bangalore, in Karnataka, in southern India, has seen an explosive urban expansion in the past two decades. The city has transformed into an IT intensive industrial city attracting all kinds of ancillary industries and thus a cosmopolitan workforce from all parts of the world. Bangalore urban and its rural hinterland have experienced dynamic changes in land cover and land use patterns in the past few decades (C.B.Jagadeesh1, Dr.H.S.Shivakumar Naiklal2, 2015). Urbanization has led to uncontrolled haphazard development resulting in urban sprawl (Ramachandra, Aithal and Sanna, 2012). According to the Directorate of Census operation in Karnataka, Bengaluru city percentage increase in population is seen from 32.66% to 91.34% in the mid-20th century due to migration of people from rural to urban areas in search of jobs and better infrastructure. By 2007, as per Bruhat Bengaluru Mahanagara Palike (BBMP) CDP, the extent of growth of greater Bengaluru and development of IT sector in Electronic city towards south corridor and industrial development along south-west corridor of the city, attracted migrants in search of jobs from different states resulting in notable Urban Sprawl. This transformation in urban form is mainly due to economic, demographic change and efficient transport system.


*Figure 1- City map of Bengaluru showing location of principal industry clusters and infrastructure facilities such as KIAB. Bengaluru, Capital city of Karnataka, India*

**NEED FOR INTERVENTION IN URBAN SPRAWL: SOUTH-WEST BENGALURU**

To understand the growth pattern of Urban Bengaluru it is pertinent to mention the transformation in urban fabric of the city over the past twenty years. The Municipal Corporation was established in 1949 that defined the city limits. By 1961-71 the city grew because of the setting up of industrial townships such as - BHEL, HMT, HAL. Significant clusters of higher education academic institutes, mainly engineering and medical colleges were promoted by the state government leading to an influx of the student population. These high quality education institutes became a primary reason for the setting up of IT industries and Biotech industries who recruited from these local institutes and contributed to the new character of the city.

The historic core area of the city is what is popularly known as 'Pete Area'. It is characterized by extensive, small-scale, commercial enterprises. The work to home commute in this part of the city is essentially pedestrian in nature.

The inner-city layouts like Malleswaram, Basvangudi, Chamrajpet etc., were developed as more planned layouts providing for a security in living as compared to the suburban area with improper planning that resulted in an increase in crime rates. Liberalization of Indian economy in the 1990s led to the development of Electronic City in the South East part of Bengaluru. Electronic City was further developed in phases by the Urban Development Department. The growth of Electronic City and surrounding areas was further boosted by construction of elevated corridors from Silk Board for easier commute. Despite such provisions, the city is constrained to expand physically in the South East direction as Electronic City adjoins the interstate border of Karnataka and Tamil Nadu. The small-scale industrial areas are located on the North West portion of Tumkur Road with no disturbances of heavy trucks inside the city. There is a need to protect these areas from urban sprawls, which can pollute and destroy the man-made lakes within the city.

This change in land use has created an adverse impact on the environment with an unsustainable settlement pattern. It is characterised by - flouting of the zonal bye-laws, unplanned narrow streets, inefficient traffic mobility, inefficient distribution of land use among many other problems. The change in land use affects the hydrological pattern, encroachment and draining of water bodies. Improper management of the wetlands has many consequences like depletion of groundwater, scarcity of drinking water and ecosystem imbalance. Hence, it is imperative to take necessary measures and lay out conservative policies to protect and manage the wetlands. According to the report published by Bangalore Metropolitan Regional Development in 2000, the southwest part of the city has good ground water sources.

In case of a compact city planning, the mixed land use combination is evenly distributed with less impact on the environment (Rodenburg, 2003) when compared to the urban sprawl which spreads irregularly with spatially segregated land use bypassing the various stages of urban development. The usage of private vehicles with more trips made to the workplace lead to air pollution and lack of planning with less green cover and narrow streets lead to urban heat island effect with an increase in outdoor temperature (Wegener, 2004).

For a sustainable intervention at a size of urban sprawl, it is important to rethink and repurpose these urban built environments so that they can come closer to a balanced and efficient dependence on resources, both physical and natural. This is a post facto measure and the design approach is hence inverted. The paper aims to propose a design strategy- that explores multiple layers for design thinking in context of urban sprawl, repurposing the built environment.

**Theories on Urban Sprawl**

Technical theories establish connection between the development of transportation and human activities, i.e., the urban land use and transportation system are interlinked (Wegener and Fürst, 1999). The transit-oriented development in cities gives the flexibility to change land use around arterial roads of the city with a better connectivity to the suburban parts of the city. Improved urban mobility system has made people to live and work in any part of the city (Lowry, 1964). The economic theories suggest that the business districts with easy accessibility are more attractive than the peripheral location which involves more travel (Thünen, 2008). The spatial polarisation between rich and poor intensifies as the urban extents are stretched where rich can make a choice of living away from the city core with a more spacious layout.

People with improved socio-economic condition have a choice of spatial dispersal to suburban vicinity with clean air and spacious living. This change in growth pattern of city due to urban mobility system, good socio economic condition shifts the discourse to discussion of policies reducing urban sprawl and promote smart growth (Fishman, 1987) (Rowe, 1991).

**Methodology for Intervention- Identification of Design Approach**

The scope for intervening as a post facto measure in repurposing-built forms and environment in Urban Sprawl is the principal focus of the paper. It ensues exploring the subject in multiple layers for design thinking in context of urban sprawl, repurposing the built environment. The process has been built by intensively studying the site and surveying with the residents of the area in an urban built environment. The purpose is to demonstrate the application of the design process for a sustainable practice along the South-West corridor of Bengaluru city.

The methodology foremost involves study of two state-of the art initiatives; firstly, the GIFT City, Gujarat International Finance Tech city and secondly Great Haddon, a sustainable urban extension to Peterborough. Identifying best practices from case studies helps the study to structure the outlay in terms of causes and effects; identifying stakeholders, analysis of built environment, and a holistic feasibility study in terms of existing urban development, issues to be addressed and potential solutions prioritising environment protection, particularly lakes, green lands and air quality.

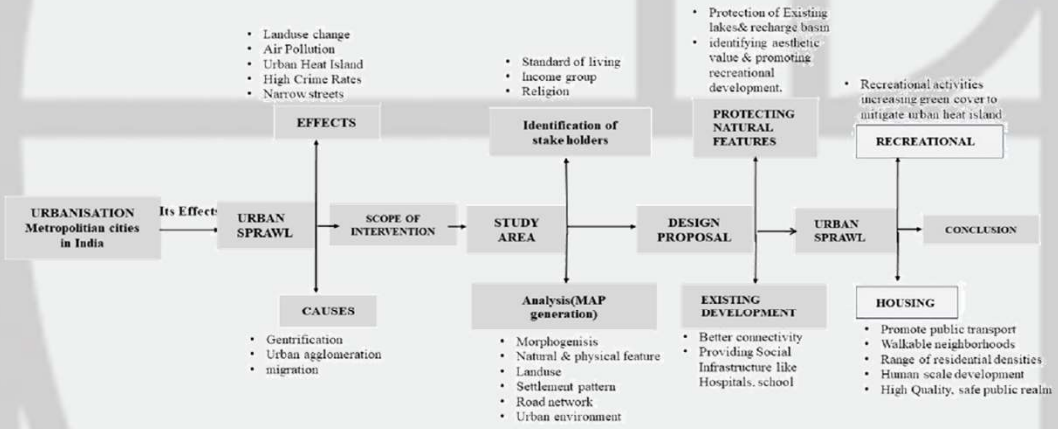



*Figure 2 Research Methodology Process*

**Case Studies**

The case study of GIFT, Gujarat International Finance Tech city, was conceptualized by the state of Gujarat to manage the undesired growth that could lead to urban sprawl. Its notable design and planning features include smart infrastructure with globally benchmarked international quality promising high quality of life (Reddy, Babu and Murthy, 2016). The salient features that can be emulated to combat urban sprawl are the peripheral green spaces, landscaped public spaces, Smart mobility plans based on walk to work approach, pedestrian friendly infrastructure, fast and easy connectivity and efficient public transport to cater to peak hour demands and energy conservation strategies. The case study of Great Haddon, London portrays a well-structured mixed-use centre designed to deliver socially and economically sustainable solutions to the needs of Peterborough's housing needs. The features that can be adopted from this case study are the measures taken to combat a Special Area for Conservation (SAC), buffer area creation around ancient monuments, habitat enhancements methods like landscaped public utility spaces, village neighbourhood centre and attenuations of ponds and surface water drainage.

**ANALYSIS & INFERENCE**

**Study Area:** The area chosen for study purpose is located towards the south-west part of the city along the Tumkur highway developed as small-scale industrial corridor and has a scope of rapid expansion with inflow of migrants for

employment. The site area has been chosen as 2340 acres in view of developing a compact sustainable neighbourhood unit by carefully analysing in detail the natural & physical features, land use distribution, settlement pattern, road network and urban environment for repurposing the growth of urban development avoiding the sprawl in the suburban parts of the city.

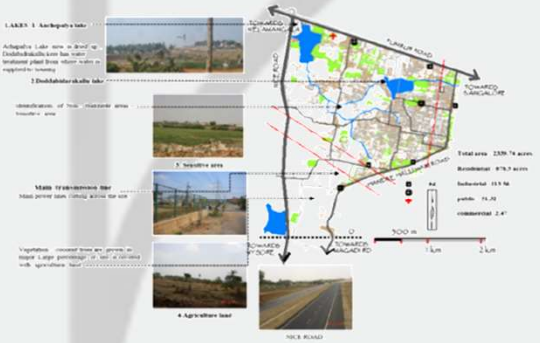


*Figure 3 Study Area Source: Author 1*


*Figure 4: Existing Natural & Physical Features. Source: Author 1*

The two lakes that are the part of the design area are Anchepalya lake and Doddabidarakallu lake and cover an area of 16.08 acres and 18.40 acres respectively. The main water source of both Anchepalya lake and Doddabidrkallu lake is rainfall, storm water & sewage. A report published by KSPCB states that treated sewage from 2nd, 3rd Stages & IV Phase of Peenya industrial areas and STP at Nagasandra is disposed to Anchepalya Kere. A considerable volume of untreated sewage generated from the heterogeneous activities joins Doddabidarakallu Tank through storm water drains/rajakaluves. (KSPCB, 2019). A study carried out by IISc suggest that both Anchepalya lake and Doddabidrekallu lake are highly polluted and eutrophicated due to anthropogenic activities (Aithal, 2015). Bengaluru has only two main sources of water supply i.e., through groundwater and other with the river Cauvery. the perennial Arkavathi river flows from Nandi hills from north-west side of the city and joins the tributary of Cauvery basin. According to the publication by Centre for Science and Environment, rapid expansion of the city due to urbanization has resulted in the decline of the water bodies. Hence there is a need for the protection of recharge basin between the Anchepalya and Doddabidarakallu lake with a scope of waterfront development activities.

**Transformation of Landform & Land use**

**Landform:**The below satellite images shows change in the landform of study area over a period of time and drying up of lake due to changes in climatic conditions. It can be clearly noted that the catchment area and the lake bed have been encroached and the agricultural lands have been replaced by irregular pattern of built forms. This can be attributed to the rapid expansion of the suburban parts of the city.

*Figure 5: Landform in the year 2000(more of agricultural land) (encroachment built up area) Source: Author 1*

*Figure 6: Landform in the year 2010*

**Landuse:** The existing percentage of land use helps us understand the transformation of land use mostly with more of residential area which are scattered villages, residential pockets with no public amenities, less development of planned layouts with a total of 37.5% of residential area with 0.69% of recreational facilities and 2.1% & 0.12% of public and commercial activity. According to the national planning authority guidelines (2010) which states small town has to occupy 75-125 hectare/person when compared to the study area with 50 hectare/person gives us an understanding of more segregated land use development with low density housing leading to an urban sprawl.

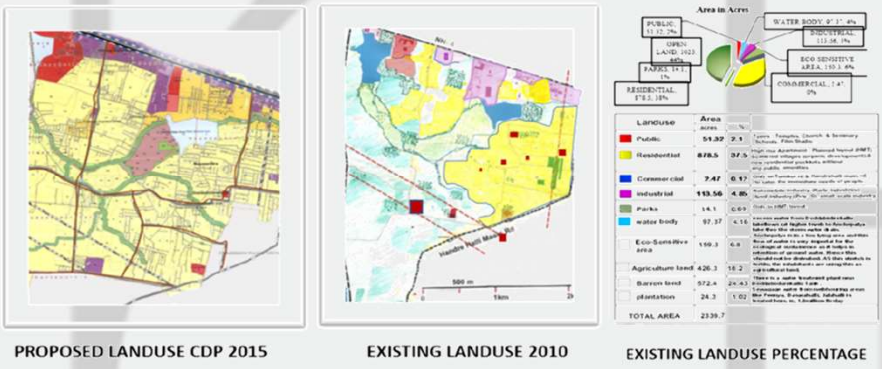



*Figure 7(a): Proposed CDP 2015 (BMRDA)* *Figure7(b): Existing Landuse 2010 Source: BMRDA*

The urban environment in the picture below, characterises the extent of open space in planned layout when compared to organic settlement around the lake. The land below high-tension line is converted to park in Nagsandara layout (planned area) and the vacant land is used as dumping grounds for garbage by the residences within the community. According to the newspaper article published in 2018, the catchment area around Doddabidarakallu lake is used as a dumping ground for garbage and also sewage water outlet from apartments pollute the lake, hence actions are suggested by the residents for the revival of lake to Bruhat Bengaluru Mahanagara Palika (BBMP)


Figure 8: Site features. Source: Author 1

**Identification of Stakeholder**

Table 1 gives us an understanding of stakeholders based on the occupation and income of the people residing in the area. It is found that people earning 3 lakhs/month are mostly businessman & film producers are found in very less percentage, i.e., about 10%; people in the higher middle class category are mostly engineers, doctors and government employees and form 20% of the total population of the area. About 65% - 70% of the people residing in the area belong to lower middle-class category and are mostly autorickshaw drivers, petty shop owners, labourers working in small-scale industries in Peenya area, and farmers earning in between 5-35thousand per month.

*Table 1: Population % based on income and occupation*

| CATEGORY | INCOME | PERCENTAGE | POPULATION |
|---|---|---|---|
| Very rich | 3 Lakhs above | 10% | Businessmen, Film producer |
| High middle class | 1.5 - 3 Lakhs | 20% | Engineer, Doctors, Businessmen |
| Middle class | .35 - 1.5 Lakhs | 14% | Engineers, Bank & Govt employees |
| Low middle class | 5 – 35 thousand | 65% | Auto drivers, petty shop owners,labourers work in peenya and area, farmers |

**Settlement & Street Pattern**

Depending on the street pattern, we can identify 2 kinds of developments; Organic pattern of old settlements and planned Layouts like Nagasandra.

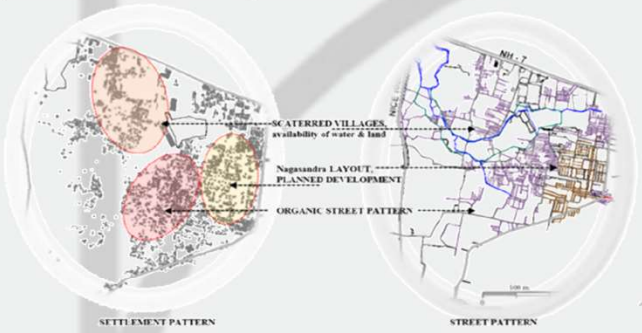



Figure 9: Settlement Pattern. Source: Author

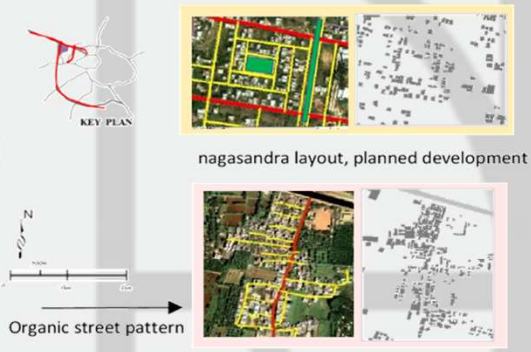



Figure 10: Street Pattern. Source: Author 1

Nagasandra layout is a planned area with wider roads, play grounds & parks. It is a residential pocket with bigger plot size of 50' x 80' and follows grid-iron pattern. There is a clear hierarchy of roads with secondary roads measuring 15m-18m in width tertiary roads measuring 12m-15m in width. Chikkabidarakallu and Doddabidarakallu area have an organic street pattern with narrow, curvilinear streets of uneven width forming irregular, non-geometrical junctions and varied plot sizes. This type of street pattern is responsive to existing natural terrain.

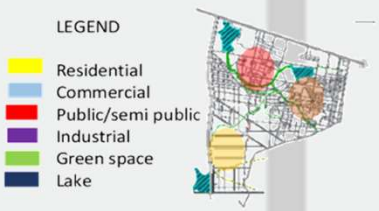
**DESIGN PROPOSALS**

The design approach aims at sustainable practices with a vision of quality urban development improving the quality of life within the neighbourhood unit. The design process suggests the intervention within the existing development by improving the public amenities and clearing the encroachment of land in the catchment area between the two lakes i.e., Anchepalya kere and Doddabidarakallu kere and demarcating it as ecosensitive zone. The segregated land use with irregular settlement pattern can be improvised by planned housing with hierarchy of primary, secondary and tertiary road network, promoting pedestrian and bicycle friendly neighbourhood with recreational activities and Civic Centre. The open spaces like park, playground with more green cover minimizes the effect of urban heat island and air pollution.

**Sustainable Neighborhood Unit**

*Figure 12:* Strategic location – Civic Centre & community centres are located near the junctions to ensure at most utilization. *Source: Author 1*

*Figure 13:* Protected Recharge basin between two lakes by increasing green cover and recreational activities like park *Source: Author 1*




Residential pockets are improved with commercial & community needs within a walkable distance.

Activity nodes at the junctions.

Proposed civic center to serve existing & proposed population and also the surrounding areas

Figure 12 identifies the nodes for the development of civic centers with a walkable neighborhood promoting multifunctional land use combination with public, commercial and recreational facilities within the already existing residential pockets.

**Promote Walkable Neighborhood**

Figure 14 indicates greenfield development which was agricultural land earlier but transformed to residential land use in Masterplan 2015 becoming a part of Greater Bengaluru. The housing proposed is a combination of low to medium density housing with pedestrian friendly neighborhood with public amenities at a walking distance of 240m from the residential sector.

*Figure 14:* Residential pockets are improved with commercial & community needs within a walkable distance. *Source: Author* 1

*Figure 15: Identification of dedicated Bicycle track along the Rajakaluves. Source: Author 1*

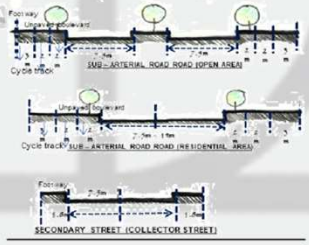



*Figure 16: Proposed Hierarchy of Roads. Source: Author* 1

The design proposal in Figure 15 protects the Rajakaluves, the storm water drains from one river to another, by identifying the buffer zone along these channels in order to avoid encroachment of land for other purposes and promote bicycle road network along the Rajakaluves.

**Proposed Hierarchy of Road Network:** Figure 16 shows the proposed hierarchy of road network, i.e., primary road network with 15-18m wide, where there is scope of more commercial establishment and secondary road network 12m wide leading to residential area with 9m tertiary road network within the residential sector which is more pedestrian friendly.

**Protection of Existing Lakes and Recharge Basin**

The threats and challenges and associated impacts on Anchepalya lake and Doddabidarakallu lake necessitate development of a replicable model for management of these wetlands. Managing the wetlands is a multidisciplinary effort and involves many stakeholders including government agencies and local residents. Some of the actions to be taken for wetland protection include identification of extent of watershed as per survey records; evicting the encroachers; re-establishing the hydrological system in the watershed by unblocking the streams; vegetated swales to protect the streams and to filter pollutants; establishing a riparian buffer of 30m from lake edge as per NGT guidelines and vegetating it with native plants; protecting the valley zone by dense plantation and to establish the strong interlinkage between Anchepalya and Doddabidarakallu lake; decentralizing the STPs and curbing the release of untreated sewage and industrial effluents into the lakes, building constructed wetlands at the inlet for tertiary level pollutant removal. Along with these actions it is necessary to involve the local public in the management of the wetlands sustainably. The landscape design of the riparian zone and valley zone divides the buffer into littoral, upload and recreational areas and propagates ecologically compatible activities to attract the people and to engage them in passive

interaction with the wetland. This will bring out a positive social behaviour and a sense of ownership and vigilance in the community.

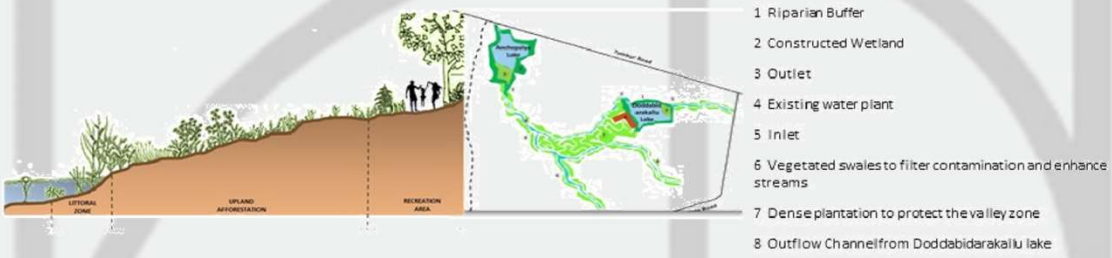



*Figure17: Design proposal to protect and conserve the lakes and valley. Source: Author 2*

**CONCLUSION**

Urban sprawl is an integral issue with city development and most often requires a post facto correction measure by means of repurposing built environments by rethinking the strategic spatial planning methods adopted in the regulatory framework. It becomes crucial to identify the design process by studying in detail the pattern of settlement, hierarchy of road network, distribution of land use, extent and utilisation of open space, identification of natural resources and wetlands within the suburban parts of the city. Post thorough analysis, the design proposal promotes self-sustaining neighbourhood with mixed-use planning, promoting pedestrian friendly community, identifying the dedicated bicycle track and footpath along the proposed hierarchy of road network, civic centre nodes within the walkable distance to reduce the usage of private vehicles minimizing the air and noise pollution, promoting lakefront development protecting natural feature like lakes, open spaces etc. Hence, urban planning strategies by governing bodies have to promote a self-sustaining neighbourhood community especially in the suburban parts of city improving the quality of life for all section of the society within the metropolitan cities across the country.

**ACKNOWLEDGEMENT**

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# REPURPOSING AVAILABLE BUILDING STOCK IN CITY CORES - POSSIBLE APPROACHES IN INDIAN CITIES

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**Abstract:** Cities are shaped by processes and factors like time, technological advancements, political climate. Every significant phase in the life of a city leaves behind significant tell-tales in the form of its buildings. The city keeps re-inventing itself, but the buildings remain, occupying major real estate but neglected and dilapidated due to loss in purpose, infrastructure stress and general apathy. Leading to shortage of quality space in the core areas, congestion, illegal occupancies, and safety issues. Another concern is that, however neglected or irrelevant these buildings might be, they are still important repositories of building material and technology and have a very important role to play in the image of the place along with immense cultural and heritage values. This paper examines the policies and legislative framework regarding Built heritage while stressing on the need for repurposing and retro fitting to be parts of development policies of the future. To examine the current situation, instances are studied from the cities of Mysore and Bangalore and then a comparative analysis is drawn with respect to better urban practices globally. The paper concludes with policy suggestions at various levels of governance with an increased stress on the possible role at ULB level.

***Keywords:*** *Building Stock, repurpose, Retrofitting, Policy Framework*

## INTRODUCTION / BACKGROUND

Cities change. They evolve, grow, expand, and sometimes ebb and die. And every state/ phase of the city leaves behind a few stamps and several pointers on the fabric of the city or the urban environment. In the language of Urban design, these are called Morphological elements. Land Use, Building Structures, Plot patterns and Street Patterns being the most important among them. (Carmona, 2010) (Anon., )While Land Use, Plot and Street patterns usually act on the larger scale of urban design and planning and are influenced by larger contexts like political scenarios, topography, regional dynamics etc.; The building structures act on a scale that is more moderate and tries to connect the human and his/her aspirations to that of the city around. Buildings, structures, or pieces of architecture hence become those elements that bridge a man and his habitat at the macro scale and everyday uses, socio-cultural practices, traditions, and human emotions at a micro scale. By virtue of this property of buildings to act on multiple scales and by its virtue of its easier comprehension, building structures remain the most important aspects of identity and image of an urban area as regarded by all its users, and across various sections of the society. They become an essential part of the collective memory of the city.

While building structures are the most identified and comprehended elements of urban environments, they are also aspects that are bound to change at a very rapid pace due to changes in requirements, newer material and technological developments and real estate stress.

## AIM / PURPOSE

**Examining Repurposing as an important means of conservation and a catalyst for development in Urban Cores.**

Buildings are essentially urban artifacts. (Rossi, 1984) People predominantly remember cities through their buildings. This is true both in the case of monuments and structures of importance as well as other buildings which are widely recognised due to their architectural features, location, purpose and usage or socio-cultural values alike.

*Figure 1 Cognitive map of Route from home to college made by the author. depicts the importance of buildings in the process of identity and cognition to a user.*

*Figure 2 Precints of the Chokkanatha Swamy Temple, Domlur, Bangalore. Focus on Conservation of specific built forms creates a juxtaposed urban environment; Source: Author*

Generally, monumental structures are considered as vital parts of an urban environment and regulations to preserve/conserve them are initiated. These are generally Places of Worship or of Power or of collective historical importance. Unfortunately, buildings or structures of the common man, albeit beautiful and an essential part of the urban fabric, does not enjoy this privilege.

While conservation of monuments is essential, it is also required to investigate the state of buildings that belong to the common man for the following reasons firstly, the architectural style that significantly speaks about the use of spaces, materials and technologies used. Architectural styles in some instances characterise a city (as in the case of Mysore) but most of the times, it remains an intellectual, formal expression of traditional building experience. (Schwalbach, 2009) ; secondly the interaction of the built and the unbuilt- this plays an essential role in the ways the streets function and the ideals that guided built forms.

*Figure 3 Typical House in the urban core of Mysore. Use of techniques like Madras Terrace can be observed. Also the semi public Jagali/Veranda, a link between the street and the house can be seen. Source: Author*

Thirdly, buildings make up streets and streets make up a city. Changes in built form that do not respond to the context makes a street and in turn a city a mere collection of buildings and not a conscious collage.

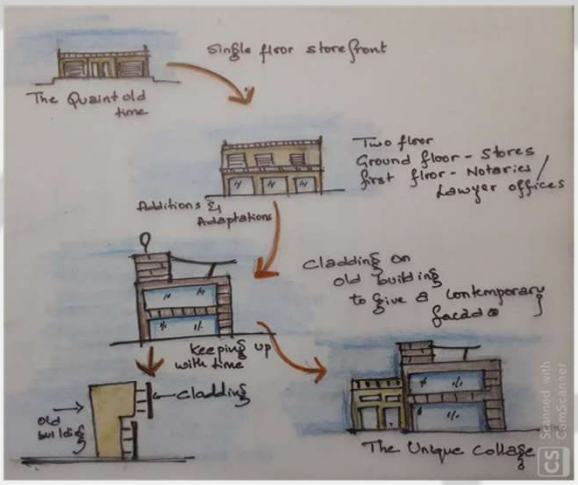


Figure 4Evolution of building structures in the core of Mysore. Source: Author

Finally, in case of most of Indian cities, the urban cores are made of underutilised, under occupied buildings that essentially cause unprecedented real estate demands. Optimum utilisation of these structures can help the city in innumerable ways.

*Figure 5 Dilapidated residential structures like these in the Kalasipalyam area of Bangalore can become anchors of the area if repurposed. Source: Author*

Building stocks are hence, when viewed from the point of view of sustainable development, become economic, social, and cultural capital. (Bullen, 2007) they are most vulnerable to changes as they receive little institutional recognition and support for conservation. This paper will examine repurposing as an important tool, the methods of recognising buildings that are worthy of re purposing, initiatives that can be taken at an ULB level for the same.

**RESEARCH METHODOLOGY**

The research involves understanding the various methods of Adaptive Reuse and re purposing followed by evaluating the situation in the cities of Mysore and Bangalore with the help of specific examples of both successes and otherwise. Further on, policies and provisions for the same are studied. The paper proceeds to infer a checklist for adaptive re-use and concludes with suggested roles for ULB s in the same.

**Defining Adaptive Reuse and Repurposing:**

The Merriam Webster's Dictionary defines Adaptive Reuse as the renovation and reuse of pre-existing structures (such as warehouses) for new purposes (Webster, n.d.) While Repurposing is defined as to use something for a different purpose to the one for which it was originally intended. (Dictionary, n.d.). In the fields of Architecture and Habitat studies, it intends a building to be retained as much as possible in its original condition while being made suitable for current usage or clientele. (Bullen, 2007, p. 3).

In India, A common practice in adaptive reuse has been in terms of public buildings; Mysore, for instance has several palaces and Royal buildings converted to Public offices, museums, Heritage hotels etc. The buildings of common utility, private ownership, and buildings in the public realms, like markets get largely neglected or are brought down eventually.

*Figure 6 Upper floors of Santhepete area in Mysore. Source: Author*

The case of Lansdowne Building in Mysore is one such example. The building, having served as a shopping arcade/Bazaar at its inception for the colonials and moved on to become an important landmark in the city. Its proximity to the Amba Vilas palace and the market areas only helped in it. Eventually, the place went on to have many shops and offices like newspapers, eateries, printing shops, offices of notaries etc. The structure though centrally located and of extreme heritage value was neglected and dilapidated. Unscientific repairs, additions only served to weaken the structure. Adding to this was a failing system of water supply and drainage. Part of the building caved in the last decade. Till date, there are conflicting reports regarding the future of this structure. (Satya, 2019)The main reasons observed for lack of concrete measures at conservation and restoration include a) Material knowledge. There is a need for expert masons and related professionals to be involved b) Investment and Returns- the structure comes under the supervision of the Mysore City Corporation. The process of restoration is seen as a costly one by the ULB. The argument that a newer building with more modern amenities and larger parking space will bring in more revenues to the Corporation is also expressed. c) No consensus among stakeholders- While few shop owners express their opinion that the building needs to be retained as in its earlier case, few feel that a more ' Modern' building with facilities like elevators and parking areas will bring in more people. d) The type of land use makes this place one that is largely accessed and used only during the daytime. This results in safety issues during the night especially in the rear side of the building, that opens to a service road.

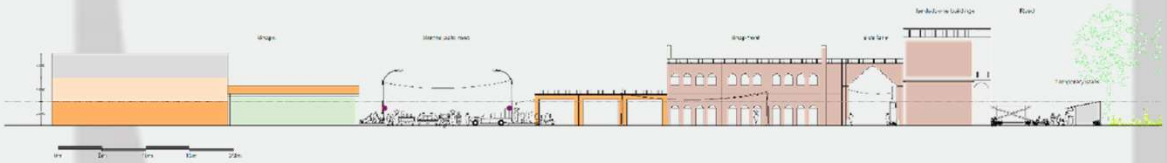

*Figure 7 Architectural Characteristics of Lansdowne Building and Surroundings, Mysore. Source: Author*

There is hence a demand by the locals to raze the entire structure down and put envisage a newer design that is more open to the main road. However, there are many arguments for restoration and adaptive reuse of the structure as well, a) The location and the faced, make the structure a much-remembered landmark. b) Architectural and Historic Value- It is a great example for Mysore-colonial architecture in the region and elements like arcaded verandas, exquisite balconies, and balustrades, wrought iron and wood panelling, stucco features provide aesthetic relief. c) The beautiful boulevard and building together can become a reclaimed public realm.

Another instance studied is the Fort area of Bangalore- Areas in between the Victoria and the Vani Vilas hospitals and the Kalasipalyam bus stand. Though the area is in the historic urban core, as in the case of Lansdowne buildings, this place differs from the former in terms of Morphological evolution, land use, stakeholders involved and the scale of settlements. The main road, K R road is flanked by institutes of historic and public importance like the Victoria and the Vani Vilas hospitals, Vani Vilas College, the fort Ramparts, Medical college, Fort High school to name a few. The residential area behind the K R road, houses Vataras- typical housing complexes of the Old Mysore region, residences that also house cattle as historically, this area has been occupied by Gollas-a community of Cowherds/dairy farmers. The settlement now records less occupancy due to migration of community members to outskirts where pastures are available for cattle rearing, fragmentation of property, the street and blocks are on a pedestrian scale and hence is increasing difficult to park cars. This situation has led to an increased crime rate in the inner alleys and loss of valuable

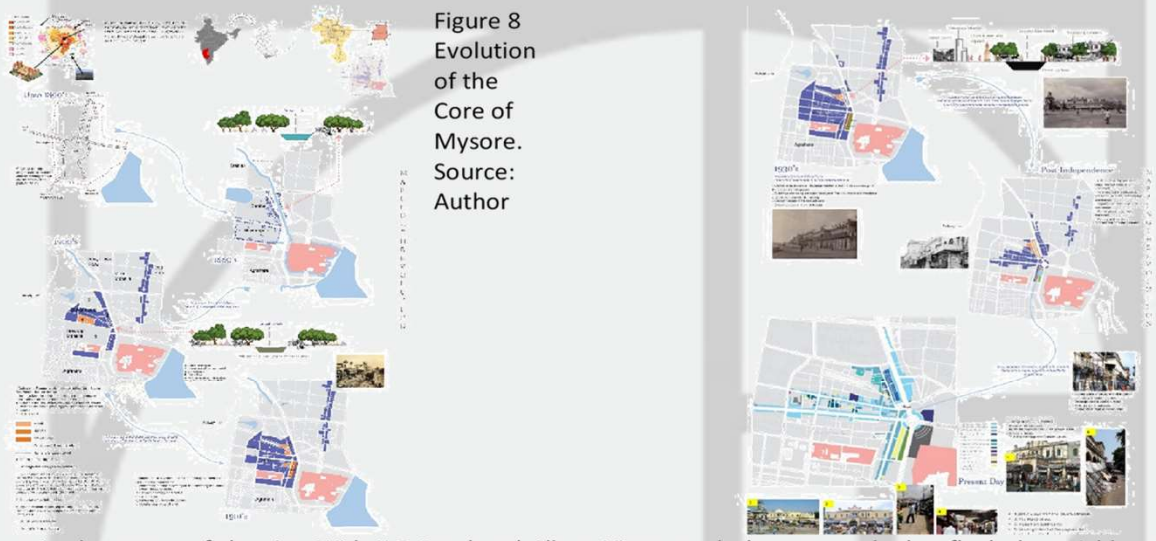

Figure 8 Evolution of the Core of Mysore. Source: Author

space in the centre of the city. With K R Road and Albert Victor road, the two roads that flank the neighbourhood becoming a hub of Private transport buses, the remaining residents are worried for the safety, health, and noise levels as well.

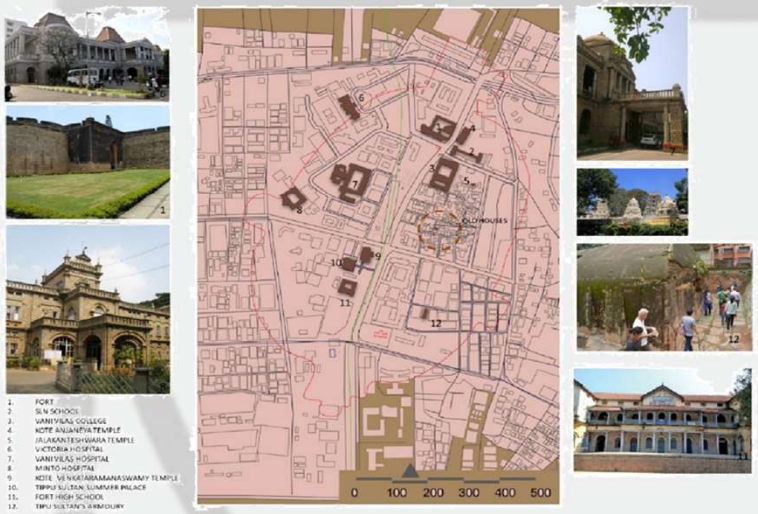

*Figure 9 The Fort Neighbourhood of Bangalore. Source: Author*

**Policy framework**

According to the Zoning of land use and development control regulations: volume - iii of Mysore City Masterplan 2031, the Lansdowne building falls under Group A as well as Group E of the Areas Of Special Control (Historical / Heritage Buildings) listing. (Authority, 2016). While Group A enlists regulations to all areas in the vicinity of the palace and states the area to be a No Development zone stating that "No developments or redevelopments, renovation, repairs including the paintings of buildings or replacement of special features shall be permitted except with the prior permission of the competent authority under these regulations. Before granting any such permission the authority shall consult the Special Heritage committee constituted under these regulations" (Authority, 2016); the Group E specifies that "The identified

Heritage structure has its own Heritage character and value and the same has to be maintained, as such. Any proposals of development/s or improvement/s, made by the owner(State govt. / Central govt./ Quasi govt. / Private) within the premises of the Heritage structure and the Heritage structure itself, has to get such proposals of development/s or improvement/s approved by the special Heritage committee, under these regulations, which takes into considerations the various aspects of importance of the Heritage structure, such as a) Historic / Heritage value. b) Architectural façade c) Visual value and any others, which the Special Heritage committee deems fit". (Authority, 2016)

Though the regulations bring in ambiguity, there is a provision for evaluation of its heritage and socio-cultural values in this case and hence the building continues to remain in status Quo.

In the second case i.e the Neighbourhood near K R Road of Bangalore however, the draft RMP 2030 changes the landuse of the entire stretch to commercial and declares parts of it for slum redevelopment- opening it for gentrification, displacement, and a change in dynamics of the neighbourhood. (Authority, n.d.)

**FINDINGS/ ANALYSIS &INFERENCE**

From the study of these two instances the following inferences are seen.

a) Adaptive Re-Use or Repurposing should respond to Context b) The process in dependent on Land Use and Masterplan provisions. c) When it comes to buildings of public importance, stakeholders are not just the tenants and the owners, but the whole city itself. d) There is a need to make the process economically viable in the long run. e) Repurposing does not happen at the building scale only, it pans across scales and will also need to take the entire neighbourhood into consideration as activities and people flow from one to another. f) Repurposing should take into consideration the changes that might occur in the next 25-30 years.

While in the case of Mysore, considering the Public and Tourist footfall, the Lansdowne Building is a crucial element and can become an extended public realm if it is considered along with the park and the streets flanking it. The corporation, if consciously rents out the place in a manner that the area is vibrant throughout, a lot of issues related to safety and security will be solved. Along with this, there is a need to consider common service areas and public utility facilities including parking and Toilets throughout the core area. This will solve the problems of services and make the buildings useful though old. More importantly, The ULB concerned will have to work out a method of involving the tenants and stakeholders in financing the works through bonds, share and other such mechanisms. This will be a win-win for both the parties.

In case of Bangalore however, there is a need to look minutely into the neighbourhood and its land uses. The presence of many educational and medical institutions opens opportunities for the neighbourhood to provide accommodations to students and medical professionals alike. This will be one step in the direction of walkable neighbourhoods. The other feasible repurposing in the area, considering the presence of animal husbandry is to convert dilapidated structures to hydroponic farms which are rented or leased by the community itself.

**CONCLUSION:** Upon the analysis of these two instances, it is evident that the interventions can happen only with the community/public or users becoming the major decision makers. Repurposing and Adaptive Reuse can succeed only with increased public participation. The Planners, Architects and Designers will have to play the role of facilitators in the process.

Another important finding upon survey and research is the concerns on financial viability in the process of Adaptive Reuse. This can also succeed by citizen participation as elaborated earlier. And for any of these to be a success, documentation and mapping become key. In the absence of documentation, chances of conservation become bleak. The impetus of this lies in the hands of the most basic level of a ULB, a ward. The ward will have to maintain extensive maps, photographic documentations, satellite images updated time to time to understand the changes happening.

While the paper does validate that change is the very essence of existence and the new will always replace the old, it tries to present an argument that with detailed mapping, planning and citizen involvement, certain structures that are robust, can adapt and have a cognitive value can be retained, adapted, and repurposed to create a collage of the old and the new and this will in the long run be a sustainable practice.

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# ARCHITECTURE THROUGH REPURPOSE – A PURPOSEFUL APPROACH TOWARDS BUILT ENVIRONMENT. INNOVATIVE MATERIAL AND ALTERNATIVE TECHNOLOGIES FOR BUILT ENVIRONMENT.

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**Abstract:** The Indian subcontinent which experiences a wide range of climatic zones also has a history of earthquakes. These high intensity and high frequency earthquakes are driving the Indian plate into Asia at the rate of approximately 47mm every year. India has also lost approximately $79.50 Billion to Natural disasters in last 20 years (1998-2007) in which it has recorded 563 earthquakes followed by tsunamis. These natural disasters accounted for 56% of the total fatality cases approximately up to 747,234. Interestingly the loss of lives and economic losses were least experienced in areas where houses, buildings and market places were built using traditional vernacular materials and construction style. These Kuccha houses with semi-permanent roofs made of thatch and straws along with walls made in random rubble stone masonry in mud plaster inside-out were able to withstand seismic pressures up to 7.0 Richter scale. Alternative technology refers to construction methods that are different from the conventional methods of making buildings. Use of wooden logs at sill and lintels in stone masonry may sound completely foreign to people living on Gangatic plains but is a common practice in the Himalayan belts. Similarly, use of Ekra wall techniques using Bamboo splits is a wonderful example of light-weight walling system in Northeast India.

***Keywords:*** *Alternative Technology, Earthquakes, Kuccha houses, Vernacular.*

## INTRODUCTION / BACKGROUND

Alternative technology refers to construction methods that are different from the conventional or mainstream methods of making buildings. It involves use of alternative material which may be local to a community and at the same time be completely unknown or foreign to mainstream construction industry. Use of wooden logs at sill and lintels in stone masonry may sound completely foreign to people living on Gangetic plains but it is a common practice in the Himalayan belts. The use of Ekra wall techniques using Bamboo splits is also a wonderful example of light weight walling system in Northeast India. Various researches from Central Building Research Institute have shown that alternative materials like Mangalore clay tiles, compressed stabilized earth blocks and efficient use of bamboo have performed better in terms of shear and flexural strength when it comes to natural disasters. The research involves identifying three such regional traditional alternative construction technologies for built environment which are suitable to Indian subcontinent. Since every region in India is different in physiographic contexts and local building construction techniques, the technology also varies from region to region. With abundance in availability of ready-mix concrete and reinforcement bars, RCC construction has emerged as the most common construction technology in past three decades. This has also been evident in India, where regardless of the terrain and regional context, RCC construction is rapidly replacing indigenous and vernacular construction practices. As per seismic data reports, most of these so called *pucca* houses have crumbled with huge losses in natural disasters.

## AIM / PURPOSE

***The research aims to identify such foundation, walling and roofing alternative construction technologies from various zones in India.***

Objectives and Purpose of this research are:

- Establishing a distinct ***Kuccha vs. Pucca*** argument and drawing a comparative between their construction technologies based on performances under natural disasters like floods and earthquakes.

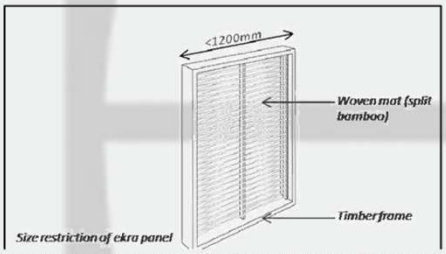
- Identifying alternative materials and identifying their suitable applications with vernacular practices.
- Giving recommendations of do's and don'ts on construction practices.

## RESEARCH METHODOLOGY

For different regions with reference to their native vernacular construction technologies different construction details and styles were identified first. These technologies were then studied with respect to their resilience towards natural disasters. Accurate construction details were then sketched and supported with detailed specifications. Usually due to rising aspirations people across the world want their houses and buildings to be constructed in frame construction using reinforced cement concrete technology. Often due to lack of knowledge of workability of new materials even in rural areas people imitate construction technologies like that of urban houses. Therefore correct and incorrect practices were also identified and documented.

## WALLING TECHNOLOGIES

**EKRA WALL: -** Ekra is a vernacular walling technology predominantly used in north eastern parts of India where the bamboo strips are woven around split bamboo and plastered with mud.



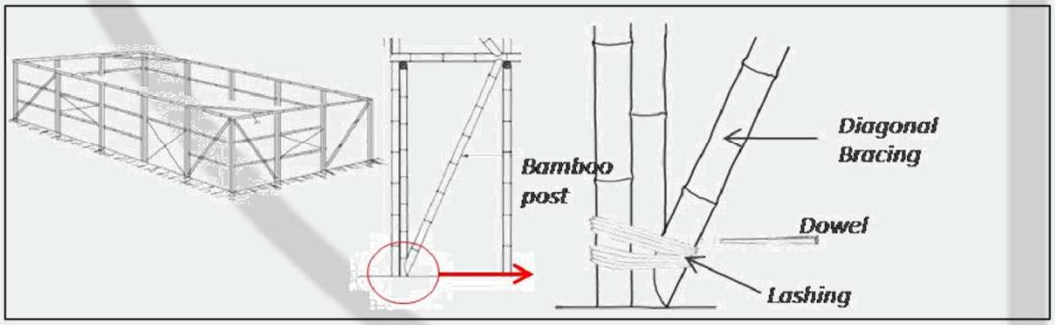

*Picture 1- Image showing a standard Ekra wall panel dimensions*

*Picture 2- Weaving bamboo splits on timber frame.*

*Bamboo splits are carefully weaved along a wooden frame, due to self tension and stresses in the bamboo splits the members require no timber joinery, nails and screws for housing. Ekra wall panels are then connected together using basic timbering joints and plastered with mud. This technology can withstand seismic actions and being light weight walling system it is comparatively safer for inhabitants. However a few construction considerations can make this technology much more efficient.*

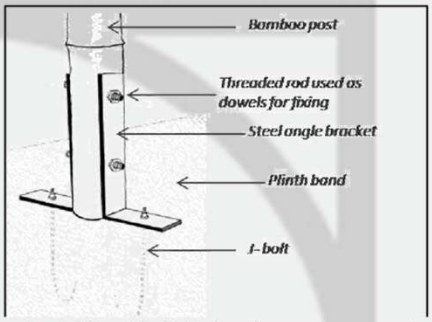
**Considerations for Earthquakes and floods in Ekra walling construction technology.**

- Provide diagonal bracing members of bamboo tied to the framing members at the ends and intermediate points of intersection.

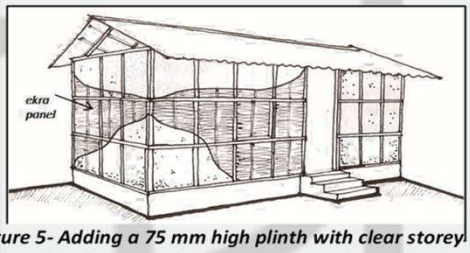



*Picture 3 – Diagonal bracing as a design consideration in order to enhance its resilience in seismic pressures.*

- Provide maximum 1200 mm spacing between adjacent posts and appropriate reinforcement in between ekra infill panels with wood or cane of small dia, say 20-25mm. Tie ekra panels to post using nylon ropes or nails for appropriate strength.
- Fix bamboo post with bolts to the plinth. Embed bolts at appropriate spacing (Maximum 1200mm) at the time of casting plinth beam. Provide appropriate grout length to J-bolt.
- For flood prone areas provide a minimum 75 cm attic height at the eave level and the clear storey height below attic shall be minimum 2.1 m. Total area of the attic shall be minimum 10 $m^2$.
- Provide diagonal bracing or knee bracing
- Also provide slope of 22-30 degree for adequate drainage of roof. (To achieve this slope ratio of ng in the posts above attic level. rise to half of the span of 1:3 shall be maintained).




*Picture 4 – Adding J-bolts to bamboo posts prevents overturning.*




*Picture 5- Adding a 75 mm high plinth with clear storey makes ekra houses resilient to damages due to floods.*

## ROOFING TECHNOLOGY-

### GUNA TILES

*Picture 8- Structures after finishing – Guna Tiles.*

*Picture 6 – Guna Tiles laid in criss-cross manner in arch manner.*

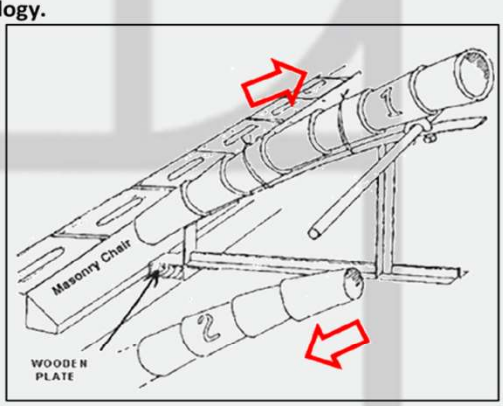
In Southern India this rural construction technology uses clay a locally available material to make small cups also commonly known as kullhad neatly arranged in a series or arches as a roofing member. The construction technology uses iron framework on which mud cups (interlocked into one another) are tied in series or arches in criss-cross manner to avoid joints and fill cavities.

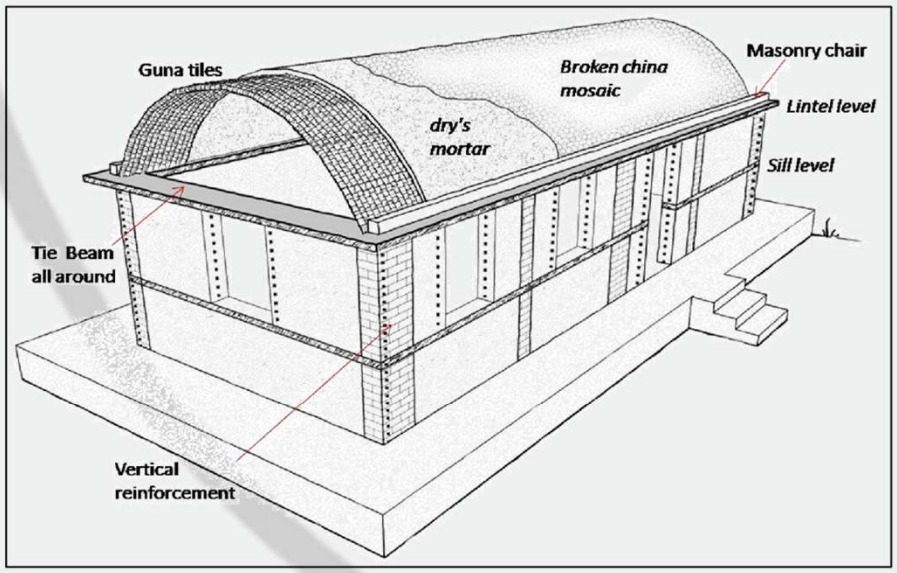
*Picture 7 – Weather Proof plaster on exposed side .*

This alternative technology method of roofing is completely sustainable and green in nature. After the roofing is assembled, all the joints are covered using weather proof paltered surface. Aesthetically the exposed surface from below looks astonishingly beautiful. This light weight roofing system could resist seismic tremors as the load was evenly distributed through the arch action on supporting load bearing walls. In certain seismic zones this technology performed better than a typical RCC framed structure.

**Considerations for Earthquakes in Guna Tiled roofing construction technology.**

- The whole structure to be tied together using a Ring beam all around with *chhajjas* sloping outside and tied to it. Pour 'dry lime/cement mortar in 1:4 on the roof, into the gaps and leaving the top rough to receive the plaster finish.
- Provide vertical reinforcement from foundation till lintel (topmost band) level in each of the brick pier supporting the roof.
- Lay tapering of the tumblers or tubes opposite to the adjacent row to interlock them properly.



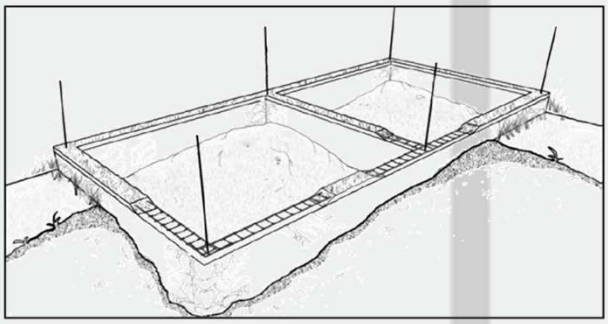

*Picture 9 -With additions of seismic ties at sill and lintel level along with vertical reinforcements at corners ties the entire structure and makes it resilient to seismic pressures.*

## FOUNDATION TECHNOLOGY-

**RANDOM RUBBLE FOUNDATION-** Foundation or sub structure plays a vital role in construction and must be dealt with expertise when it comes to foundations in case of natural disasters. Brick or RCC foundations may not be an appropriate solution for foundation in rocky regions such as in central and southern parts of our country. Using random rubble in such conditions has proved to be resilient to seismic disturbances. Random pieces of rubble stones are interlocked with cement mortar brought in steps till plinth level.

***Picture 10 – Image showing a construction site with random rubble being used for foundation works.***

Adding tie beams at plinth level over random rubble as shown in the sketch is a structural recommendation. This tie smoothly transfers the load of super structure to sub structure and performs well in case of seismic tremors.



***Picture 11 – Sketch depicting placement of tie beam with vertical reinforcement at L & T Junctions.***

## CONSIDERATIONS FOR EARTHQUAKES IN RANDOM RUBBLE FOUNDATION CONSTRUCTION TECHNOLOGY.

- Provide vertical reinforcement at L and T junctions and fill cavity with M20 (1:1.5:3) concrete.
- Provide through stones of full length equal to wall thickness in every 900mm lift and 1.2m apart horizontally and use of long stones at corners to achieve bonding between perpendicular walls
- Provide shear keys in case of bands.
- Connect perpendicular walls using 600-700mm long stones at L and T-junctions, also to break vertical joints.
- Provide Reinforced concrete seismic band of 75 to 100mm thickness at Plinth Band in soil site. RCC band is not necessary in rocky soil.

Detail of Horizontal Reinforcement

| Span | Zone V | Zone IV | Zone III |
|---|---|---|---|
| 5m or less | 2 bar, 10mm diameter | 2 bar, 8mm diameter | 2 bar, 8mm diameter |
| 6m | 2 bar, 12mm diameter | 2 bar, 10mm diameter | 2 bar, 8mm diameter |
| 7m | 4 bar, 10mm diameter | 4 bar, 8mm diameter | 2 bar, 10mm diameter |
| 8m | 4 bar, 12mm diameter | 4 bar, 10mm diameter | 2 bar, 12mm diameter |

Detail of Vertical Reinforcement

| No. of Storey | | Zone V (dia. of bar) | Zone IV (dia. of bar) | Zone III(dia. of bar) |
|---|---|---|---|---|
| One | | 12 mm | 10mm | - |
| Two | top | 12mm | 10mm | 10mm |
| | bottom | 16mm | 12mm | 10mm |

**CONCLUSION**

Vernacular practices are inherited from generations to generations; local artisans and construction workers if guided well through awareness programmes about the merits of their own alternative construction technologies and their resilience towards natural disasters a lot of lives can be saved.

There are a lot more such alternative technologies which can be studied in detail and with basic alterations and modifications they can perform very well in case of natural calamities. Ministry of Rural Development in the year 2014 directed policy makers to use such technologies in central governments rural housing schemes across India.

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# ROLE OF AWARENESS IN PUBLIC PARTICIPATION TOWARDS SOLID WASTE MANAGEMENT

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**ABSTRACT:** One of the major environmental challenges in India is associated with waste generation is its improper segregation and disposal. Solid Waste Management Rules (SWM), 2016 clearly state that waste generators should segregate their waste before it is collected; even though most households in India continue to mix waste while disposing. For successful development of any solid waste management, community participation is essential for sustainability. The five R's of Waste management i.e. Refuse, Reduce, Reuse, Repurpose, Recycle offer tremendous opportunities for household and communities to reduce environment contamination caused by solid waste. The present research work is aimed at investigating role of awareness in changing perception and practice of households towards solid waste management and to find out what are the barriers, predictors and tools in promoting public participation in solid waste management. The study was undertaken in residential society of GH-7, Crossing Republik, Ghaziabad. The primary data were collected from a sample of 30 respondents using a structured questionnaire. This study conclude awareness programs focused on information gain are successful in providing the basic knowledge but to change the particular behaviour or habits specific targeted programs should be designed after complete research and analysis of data.

***Keywords:*** Solid waste management, attitude, awareness, community behaviour

## INTRODUCTION

Waste is being produced since time the humans started inhibiting this earth, producing fire, started cooking and producing some tools for fighting, there was a portion that was used to make this, there was a portion which went on waste. Initially most of these were organic in nature, can be easily bio-degraded, there were no heavy metals. After industrial revolution more products had been produced, and during manufacturing and after usage, lots of lots of waste had been dumped which has certain chemicals. From the 1870s onward, rapid development of coal, fertilizers and, later, that of the petroleum industry weaken the recycling industry. Disposal of packaging material increases by 67% after World War II as consumerism and obsolescence started to get established in developing countries. (Salatin, 2015) Consumers were progressively sold on the idea that single-use items are a necessity of the modern lifestyle. Ease and convenience became the two most desirable qualities in product marketing, the growth of convenience foods (frozen, canned, dried, boxed, etc.) increased the amounts and changed the types of packaging thrown away. This throwaway world was largely made by design, consumer products were made in such a way that they become out-of-date or useless within a known time period. The main goal of this type of production was to ensure that consumers had to buy the product multiple times, rather than only once. In the post-war period, landfills came to be favoured over incineration Waste policies were implemented with mixed results. Developing countries also began to suffer from this curse of developed countries. (Barles, 2014)As per World Bank report ("Kaza, Silpa; Yao, Lisa C.; Bhada-Tata, Perinaz; Van Woerden, Frank, 2018) success of sustained solid waste management is critically linked with public engagement and trust. From household waste storage to waste segregation, recycling, collection frequency, amount of littering, willingness to pay for services, and opposition to the kind of treatment and disposal facilities, all the steps of solid waste management—depend on public awareness and participation. Thus, awareness and attitudes are crucial to the success or failure of a SWM system.

In India out of over 1.45 lakh tonnes per day (tpd) of solid waste generated across the country, only about 53 % is being processed according to the housing and urban affairs ministry. (MOUD, 2019). Solid waste management 2016 Rules put the responsibility of segregation on the waste generator and three fractions: wet (green container), dry (blue container), and domestic hazardous waste. This is referred to as the three-bin system. Apart from these wastes horticulture waste, construction and demolition and sanitary waste should be stored and collected separately. The wet fraction should preferably be used for composting; and the

*Figure 2 Composition of MSW in India*

dry waste should be sent for recycling (CPHEEO, 2016). It also advised integrated solid waste management (ISWM ref fig1) system with an aim to reduce the amount of waste being disposed while maximising resource recovery and efficiency. It also direct local bodies to involve community in all programs through a consultative process.

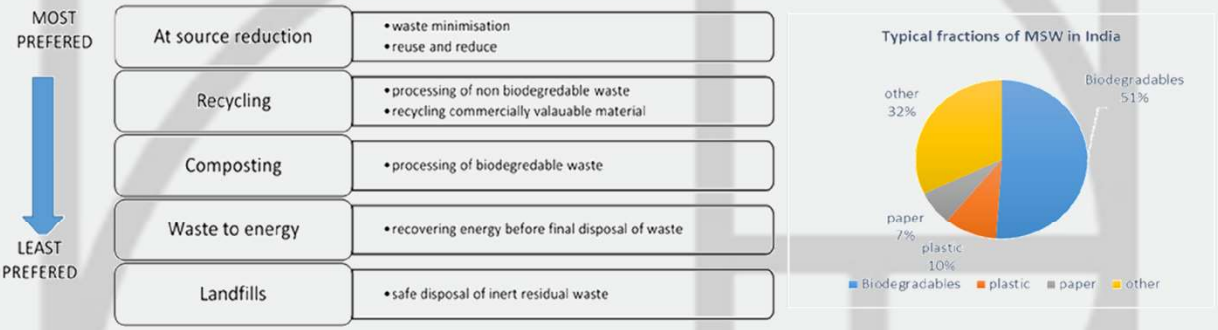



*Figure 1 principles of integrated solid waste management*

Source: mohua

**RESEARCH BACKGROUND**

The volume and composition of solid waste is rapidly changing in India, mixing the biodegradable (wet waste) with dry waste at source also hinders proper recycling and effective functioning of waste to energy plants or biomethanation plants. Unsegregated waste when dumped into landfill sites generate leachate and methane gas which is very hazardous and polluting the surroundings. With over 50% biodegradable waste (ref fig 2) (Isher Judge Ahluwalia,Utkarsh Patel, 2018) there is high potential of making compost which is humus rich soil conditioner or generate biogas. But the poor segregation leads to poor quality compost and acts as a psychological deterrent on the demand for compost.

Several public information, education, communication programs (IEC) are being introduced by Government and local bodies to ensure that the people become aware of the problems of waste accumulation and the way it affects their lives directly. To ensure that the people generate less waste by cutting back on waste generating material and by following clear defined practices of waste management. Various tools (Fig 3) have been used to promote public participation in waste management and create public awareness against big waste generators and provide information to monitor the performance of these sources of waste.

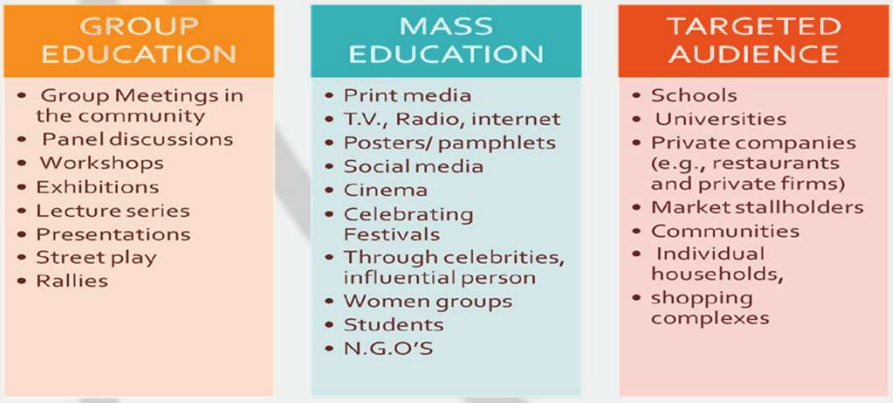



*Figure 3 tools used in IEC programs Source: author*

**CASE STUDIES OF SUCCESSFUL IEC PROGRAMS**

The analysis of few case studies done by author is listed in TABLE 1

*Table 1 ANALYSIS OF CASE STUDIES*

| S.NO | LOCATION | INITIATIVES | KEY FINDINGS |
|---|---|---|---|
| 1 | Curitiba, Brazil | Waste Management Initiatives | • Incentivizing exchange of recyclable wastes<br>• reward for segregation<br>• Resource recovery; helping in revenue generation, employment generation, social inclusion, encouraging the use of public transport,Participation reached 70% in 1990s |
| 2 | San Francisco | zero waste to landfills | • robust public policy- prohibited the use of styrofoam and polystyrene foam in food service, banned plastic bags, mandatory recycling and composting<br>•strong public-private partnerships,<br>•resident education, and financial incentives for waste reduction, penalty for failing to comply |
| 3 | Toronto, Canada | citizen engagement | •interactive website<br>•actively uses social media, YouTube videos<br>•a waste collection schedule mobile application and the 3Rs Ambassador Program, |
| 4 | Bangalore, India | decentralized SWM systems | • kasa muktha program, awareness rallies and street plays, mobile app, power nashta- including corporates<br>•Education on and awareness of neighbourhood cleanliness<br>•Following 2 bin 1 bag initiative website support |
| 5 | Pune, India | public-private partnership | •PPP with waste pickers cooperative<br>•Awareness initiatives, including rallies, one-on-one meetings<br>•political endorsement by local councillors<br>• 5 % rebate in property tax for composting |
| 6 | Panji, India | *decentralized SWM systems* | •source separated into five streams<br>•Public campaign-Bin free in 2003<br>•political endorsement by local councillors<br>• engage local students, celebrities, business leaders<br>• complaint redress through 24 hr. helpline |
| 7 | Nirvana country, Gurugram India | Community composting | •source separated into 3 streams<br>• use of social media and internet,door to door campaigning, workshops<br>• training of staff and helpers of RWA |

Despite having some great initiatives we are still lacking behind because of inadequate public participation.

(McKenzie-Mohr, 2000) States most programs to foster sustainable behaviour have been information intensive, usually based on two assumptions. With first, planners assume that by enhancing knowledge of an issue, such as pollution, and encouraging the development of supportive attitudes, such as using less plastic, behaviour will change. The second assumption suggests that behaviour is strongly influenced by economic motives. Programs are designed to highlight the economic advantages, such as recycling, assuming public will act in their economic self-interest. Information campaigns alone will rarely be able to bring about behaviour change due to the diversity of barriers that exist for any sustainable activity. These barriers to a behaviour may be either internal (e.g., lacking the perceived skill to recycle or composting) or external (e.g., absence of appropriate infrastructure)

(Barr, 2007) Posited that environmental values, situational characteristics, and psychological factors all play a significant role in the prediction of waste management behaviour. It was found that the predictors of reduction, reuse, and recycling behaviour differed significantly. Reduction and reuse being predicted by underlying environmental values (e.g. advocating environmental protection), knowledge (sustainable development) and concern-based variables (e.g. threat to penalty, government policies, convenience). Recycling behaviour was, in contrast, characterized as highly normative behaviour. Access to recycling facilities, convenience play an active role in terms of recycling. Without detailed knowledge of barriers, it is highly unlikely that an effective strategy can be developed. Psychological expertise in research methods and statistical techniques can contribute significantly to the uncovering of barriers and the development of sound strategies.

**AIM / PURPOSE**

The present research work is aimed at investigating role of awareness in changing perception and practice of households towards solid waste management.

**HYPOTHESIS**

Awareness through IEC programs only do not achieve the sustainable engagement of public as required. They must be strategically planned and monitored.

**RESEARCH METHODOLOGY**

One of the important stages in the research process is data collection the researcher used both primary and secondary methods. Secondary study through a review of literature was done to collect predominant viewpoints on solid waste management and public participation. This study was comprised of three major components:

- Processing of Municipal solid waste
- Public participation in solid waste management
- Community behaviour towards solid waste management.

Primary study is comprised of following components:

- Investigation on community awareness, perception and practice towards SWM and their sources of knowledge
- The collection of household's data was on the basis of the survey through personal interviews conducted using the tools of enquiry like structured questionnaire, group discussions and field observations.
- Conclusion and recommendations

**STUDY AREA**

The study was undertaken in residential society of GH-7 which is the part of 360 acre vast Crossing Republik Township located in Vijay Nagar, Ghaziabad. A total of approximate 1980 flats in 9 towers comprising 13 floors each and 34 villas.

The society is currently served by a private organization for collecting waste. Local kabariwalls are authorized to collect recyclable waste.

**INSTRUMENT DEVELOPMENT**

The primary data were collected from a sample of 30 respondents belonging to different age groups, by using a structured questionnaire. The sample selected is based on convenience sampling, a visit to public spaces of society (parks, club and bus stands) were done and questionnaires were distributed. Out of 50 questionnaires distributed researcher got response from 30 participants. Questionnaire is divided into 6 sections (ref table 1)

- First section of questions was on personal information
- Second section of questions (1-5) to judge their general awareness.
- Third set of questions were set to enquire about how many of them practice reduced, reused, and recycled.
- Fourth set of questions (10-14) ask them to rate various tools of awareness.
- Fifth set is designed to check their general perception towards segregation, composting and responsibility towards waste.
- Sixth and the final set ask them to rate various possible initiatives that can encourage more public participation in proper management of waste in society.

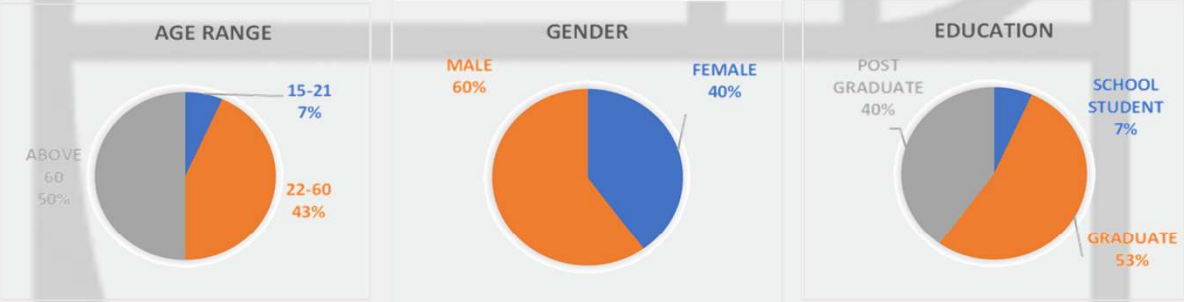



*Table 2 Questionnaire structure*

| SECTIONS | NO OF QUESTIONS | QUESTIONS | MODE OF ANSWER |
|---|---|---|---|
| 1.Personal information | 3 | • Gender<br>• Age<br>• education | Tick the correct one |
| 2.General awareness | 6 | • Heard about concept of reduce, reuse and recycle for waste management?<br>• Do you think that improper management of solid waste is responsible for epidemic like Dengue etc.?<br>• Do you think that throwing waste in street or roadside or water bodies attracts punishment?<br>• Do you think landfills are threat to environment?<br>• Do you know how to segregate dry, wet waste and hazardous waste?<br>• Your source of information is? | Yes/no<br><br>MCQ |
| 3.Practice | 4 | • I segregate my waste, dry for recycle and wet for compost. | Yes/no |

| | | | |
|---|---|---|---|
| | | • I carry my own cloth bag for vegetable/grocery shopping.<br>• I reuse old plastic/ aluminium containers.<br>• I discourage use of use and throw plates/ plastic straw/ plastic cutlery. | |
| 4. Tools | 4 | • Do you think door to door campaigning will attract their support for participation?<br>• Do you think awareness campaigning workshops will be effective tool?<br>• Do you think campaigning through social media will encourage participation?<br>• Do you think training waste collecting/dealing staff is a tool for effective management of waste? | Likert scale of 1-10 |
| 5. Perception | 3 | • Do you think segregation is time consuming process?<br>• Do you think composting and recycling is inconvenient and unpleasant?<br>• Do you think waste management is only job of municipality? | Likert scale of 1-10 |
| 6. Suggestions | 3 | • Do you think incentives/ cash in return to encourage recycling is important?<br>• Proper guidelines and support provided by RWA can initiate segregating and reuse and recycle by residents?<br>• Do you think fine if not segregating can initiate segregation and active participation? | Likert scale of 1-10 |

**ANALYSIS OF DATA**

The information collected have been then edited, categorized and arranged in logical order. Tabular analysis is then done manually to arrive at conclusion and possible solutions.

| **PRACTICE (SECTION 3)** | | | **REMARK** |
|---|---|---|---|
| **Q.NO** | | **ANSWERS(YES)** | • Major sample population not segregating waste, even those who are segregating not making compost<br>• 76 % have better awareness on consumer consciousness and try to reduce the waste generation |
| | | **Percentage** | |
| **7** | **SEGREGATION** | 36 | |
| **8** | **REDUCE** | 86 | |
| **9** | **REUSE** | 73 | |
| **10** | **RETHINK** | 76 | |

**TOOLS OF AWARENESS (SECTION 4)**

- Awareness workshops emerged as most feasible option for spreading the cause
- Door to door campaign as next
- Respondents were not so sure about the possible impact of social media
- Training of staff was considered by most as a step for second phase of awareness

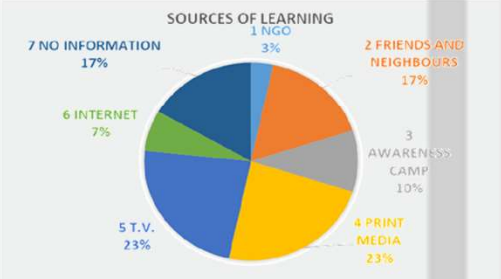

| PERCEPTION/ATTITUDE( SECTION 5) | | | REMARK |
|---|---|---|---|
| Q.NO | QUESTIONS ON | ANSWERS(Yes) PERCENTAGE | • General perception towards segregation, composting and self-responsibility turns out to be positive enough to initiate the awareness campaign. |
| 15 | TIME CONSUMING | 23.3% | |
| 16 | INCONVINIENT/UNPLEASANT | 20 | |
| 17 | JOB OF MUNICIPALITY | 13.3 | |


**POSSIBLE SOLUTIONS (SECTION 6)**

- Respondents agreed to the point that if proper guidelines and support is provided by RWA they will start segregating their waste properly.

Recycling emerged as the behaviour which is governed by incentives and availability of facilities.

| DIFFERENT ASPECTS OF AWARENESS( SECTION 2) | | | REMARK |
|---|---|---|---|
| Q.NO | QUESTIONS ON | ANSWER (yes) Percentage | • The sample population is well aware about the problem of waste management and its ill effects on health<br>• But 50 % did not see landfills as a threat to environment<br>• 60 % know how to segregate waste in three streams<br>• Television and print media emerged as most important source of information |
| 1 | CONSIOUSNESS | 93 | |
| 2 | HEALTH IMPACT | 100 | |
| 3 | POLICY | 93 | |
| 4 | ENVIRONMENT | 50 | |
| 5 | SEGREGATION PROCESS | 60 | |
| 6 | SOURCES OF LEARNING | | |



**GAPS AND ISSUES**

- Most of the residents are not aware about the rising issues related to landfills and its management as thus 50% consider it as no threat to environment.
- No proper segregation of waste is observed as a major problem.
- Interview with the facility management and the vendors reveal that there is lack of willingness among residents. Moreover in most of the flats waste is operated by maids who are not properly trained and even not willing to segregate the waste at source.
- Several cases of injuries are reported by the waste collecting staff from sharp objects or from heavy weight thrown from above while collecting waste from garbage room.
- Respondents don't have knowledge about how to make compost out of organic waste
- No awareness camp or workshop organized in society about the composting, segregation and latest technologies available.
- lack of support from RWA was also evident – lack of will, space and security issues in door to door collection was projected as the reasons for no source segregation

**RECCOMENDATIONS**

- Need of community specific targeted awareness workshop and door to door campaigning
- Need to sensitize residents about the serious issues faced by the waste dealing staff from hazardous waste and improper dumping of construction waste in the garbage chute.
- Proper training of household maids/ housekeeping staff for segregation of waste at source
- Effective use of social groups to discuss problems faced by members and suitable measures to be taken
- Children can also play an active role in encouraging their parents to start, they can also be considered for mass education through different workshops or activities organized for them.
- Issues must be clarified in ways that individual residents can understand that their individual impacts and actions do matter, and that individual actions can influence positive change.
- Continuous motivation and evaluation needed to be done for sustained progress.

**CONCLUSION**

The purpose of this research was investigating role of awareness in changing perception and practice of households towards solid waste management. Awareness and education campaigns targeting public at large had been introduced by local bodies and other agencies. However, despite all of this, there is still a wide gap between knowing and doing. Awareness programs focused on information gain are successful in providing the basic knowledge about waste management but to change the particular behaviour or habits specific targeted programs should be designed after complete research and analysis of data.

Finally this research conclude that there is a need to sustain interest in researches relating to solid waste management, if we are willing to have an overall sustainable development.

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Training & Research Centre
TRC

*The Sri Lanka Institute of Architects is one of the foremost professional organizations in Sri Lanka as well as the Asian region. The institute has been working on the professional practices of architecture in the country as well as education, which have been the primary focuses over the years. we are proud to note that we have seen a lot of improvements in the industry and have played a great role in contributing to the development of architecture as well as the raising of the standards in the country.*

*Sri Lanka Institute of Architects Law No. 1 of 1976 enacted by the National State Assembly vested statutory powers with the SLIA. One of the main objectives of the SLIA is to promote and advance the study, practice and application of and Research in Architecture and kindred subjects and the arts and sciences connected therewith.*

Sri Lanka Institute of Architects

*The Indian Institute of Architects (IIA) is the National body of Architects in the country. Established in 1917, the institute today has more than 20,000 members and plays a major role in promoting the profession of architecture by organizing and uniting the Architects of India to promote aesthetic, scientific and practical efficiency of the profession both in Practice and in Education.*

*IIA is represented on various national and international committees connected with architecture, art and the building industry and is also actively associated with International Union of Architects (UIA) Commonwealth Association of Architects (CAA) and South Asian Association for Regional Co-operation of Architects (SAARCH).*

*PEATA has come to the age of youth on completion of 37 years of its inception. All great institutions have humble beginning. During years 1962 to 1965 architects whenever they met in Municipal offices at V. T., Bandra or at Ghatkopar, they used to talk about their grievances. There is nothing new about it. It is today's phenomenon too. But the murmur then was different. Circulars were confidential. Architects were suddenly confronted with faith accompli "Sorry, now Commissioner has instructed not to approve any plans in the wards". Some influential could get through but rest were left high and dry. They were flabbergasted. In those circumstances several young architects contemplated the positive actions and approach. Side by side the efforts of continuing education by means of work shops, seminars, symposiums, study tour being integral part of activities of any professional body were carried out wherever possible jointly with other like-minded bodies.*

*Amidst the present scenario of unprecedented growth and change across all levels of urban settlements, especially in our part of the world, the need for increased networking and dialogue between the participants of such change becomes imperative. The emerging directions of change and developmental choices as witnessed all around us today raises immense challenges and possibilities towards a dynamic and contributory role of the urban design profession within different societal conditions. It is at this significant juncture that the newly constituted Institute of Urban Designers India (IUDI) as a national level association of urban design professionals, academicians and practitioners has come into being. The field was born out of a quest for quality of the urban environment. This quest continues to date in responding, refining and regulating urban environs that have both functional and aesthetic appeal to those who inhabit it.*

## About Our Association

*The Indian Green Building Council (IGBC), part of the Confederation of Indian Industry (CII) was formed in the year 2001. The vision of the council is, "To enable a sustainable built environment for all and facilitate India to be one of the global leaders in the sustainable built environment by 2025".The council offers a wide array of services which include developing new green building rating programmes, certification services and green building training programmes. The council also organises Green Building Congress, its annual flagship event on green buildings.The council is committee-based, member-driven and consensus-focused. All the stakeholders of construction industry comprising of architects, developers, product manufacturers, corporate, Government, academia and nodal agencies participate in the council activities through local chapters. The council also closely works with several State Governments, Central Government, World Green Building Council, bilateral multi-lateral agencies in promoting green building concepts in the country.*

## About Our Industry Partners

*Carbon Craft design is a Mumbai based design and material innovation company started in 2016. We are a group of Architects and Engineers developing carbon offsetting products for the world's construction demands to mitigate Air Pollution at scale. It all started with this question It then dawned us that it requires an Architectural intervention. There are methods to capture pollution but the next big question is what to do with the captured pollution. We set out to find a way to upcycle this into a new form. With a Technology that makes a real-world impact and an Architectural perspective towards scaling, we aim to intervene the construction industry to make a collective impact in solving this problem. Conventional building materials are all around us due to its modularity and repeatability.*

*Founded in 2009, RUR GreenLife is a socio-environmental organization that passionately works for the planet by employing end-to-end, cradle-to-cradle approach toward urban solid waste management. At RUR, we ideate, design, build & implement customized turnkey 'waste-to-resource' solutions that are sustainable & decentralized. We help households, schools, organizations & corporates optimize waste recycling (>90%) and thus minimize the impact on landfills. They believe to spread eco-consciousness amongst citizens & help them contribute to our planet adopting good green practices.*

# Author's Guidelines

*Aditya College of Architecture (ACA) solicits research papers by academicians, practicing architects and students of bachelors as well as masters. The aim of this journal is to promote, share and discuss various new issues and developments in different areas of architecture. Authors may adopt the content of their articles accordingly.*

1. Research Papers must be sent by email to idrc2020.aditya@aditya-arch.edu.in
   International Design Research Conference Team,
   Aditya College of Architecture,
   Borivali (West), Mumbai 400 092.
   Contact No: +91-9833-300-496 &
   +91-22-611-06135
   Website: http://www.adityacampus.org/idrc

2. The acceptable word range for Full Research Paper is upto 3000 – 5000 words: including illustrations, photographs, figures, tables, and references.

3. All the photographs shall be digital photographs having 300 DPI with minimum 600x1248 size and shall be with proper captions.

4. The acceptable word range for the abstract accompanied with each research paper is up to 250 words. The abstracts which do not meet this word limit may be asked for revisions.

5. Reference style to be followed:
   **"Harvard Angila 2008"**

   Dooley, D. ,2012., Nursing *ethics: Irish cases and concerns*. 2nd ed. Dublin: Gill & Macmillan, pp. 24-32.

6. The review committee decisions will be communicated within a period of 1 to 1.5 week time of the receipt of research papers.

7. Research papers submitted for consideration in Shodhaditya should be accompanied with a declaration by the author that they have not been published or submitted for publication elsewhere.

**SHODHADITYA (June 2020 – December 2020)**

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