Aditya College of Architecture, Mumbai

SHREE AMEYA PUBLIC CHARITABLE TRUST'S
ADITYA COLLEGE OF ARCHITECTURE
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ACA'S 4TH

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THEME

ARCHITECTURE BY THE EDGE

10th ANNIVERSARY

10 YEARS OF IMPARTING
QUALITY ARCHITECTURE EDUCATION

VISION MISSION AND QUALITY POLICY

VISION

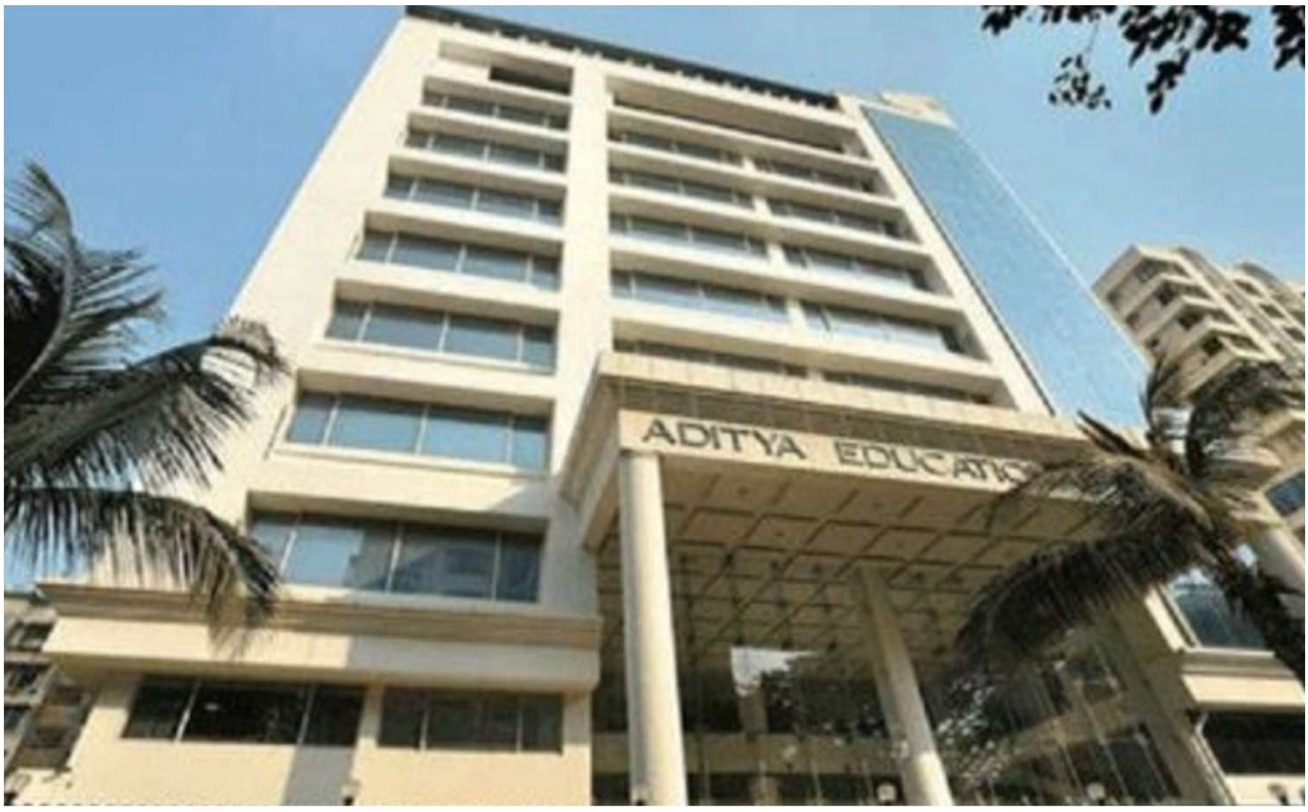
- To be globally recognized as an epitome of learning and innovation
- Imparting multifaceted architectural education driven by social sensitivity and supported by state of the art of infrastructure

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 staff of Aditya College of Architecture are committed to offer excellence in architectural education, by pledging to our core value of Agility, Innovation, Integrity 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 regulatory requirements to continually enhance the satisfaction of our students."



ABOUT ADITYA COLLEGE OF ARCHITECTURE

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
THEME: ARCHITECTURE BY THE EDGE

Water represents a new beginning and vitality!

Many cultures have considered water to be sacred, and civilizations near significant bodies of water developed. Thus, we could argue that architecture was born from water. Water is a fundamental component that gives many architectural designs their physical, spatial, and sensory qualities. With its size, location, and proportion, water has the power to change any area. It functions as a dynamic axis in any situation thanks to its dimensional quality. Architecture has always been involved with water, frequently serving an aesthetic function but more importantly acting as a hub for human activity. It has been used for ages as a transportation system to facilitate trade and business, but it has also offered chances for leisure activities on a variety of dimensions. A pleasant area may be created by water or its presence by altering the microclimate of a location. Any community can experience a macro-level change in a location. Since the beginning of civilization, the aesthetic value of water has been of utmost importance. Since water symbolizes a potent cleansing element, it has been used in several rites throughout most religions. Water is a symbol of rebirth, death, and life. Water is a finite resource that is incredibly important to humanity. The successful use of water from an environmental, scientific, aesthetic, or creative standpoint currently depends on our capacity to manage it. Water-related disasters are becoming increasingly frequent due to extreme occurrences including climatic change, warfare, and political instability. Additionally, the water and the diverse natural habitats of organisms that depend on water have been negatively impacted by the rise in human population. Many socio-political disputes centre on water, and it is anticipated that future wars will be fought because of water. It is thus prudent for us to end this pattern of indifference by speaking out against it and bringing attention to the water situation. Additionally, a conversation is required to embrace more sustainable lifestyle choices. With this insight, we bring forth the IDRC 2023 with the theme ‘WATER AND ARCHITECTURE’. The aim of this research conference is to raise awareness of the critical issue of water as a finite resource and the necessity to restore the sacredness associated with its usage in architecture. The metaphysical and the physical are connected through water. It acts as a bridge to link us to the future and a reminder of our relationship with our ancestors. We want researchers to advance this concept of water and its relationship with the built environment considering the present water crisis we are experiencing.

MESSAGE FROM THE FOUNDER TRUSTEE

Shri Harishchandra Mishra
Founder Trustee &
Chairman

It gives me immense pleasure to see how Aditya College of Architecture has flourished with its abundant academic knowledge, immense industry exposure, and innovative strategies in the field of education and research. I heartily congratulate Aditya College of Architecture for organizing the 4th International Design Research Conference 2024 (IDRC) on the theme "Architecture by the Edge. This year, IDRC aims to bring attention To the crucial matter of water as a limited resource and emphasize the importance of reinstating the reverence linked to its utilization in architectural practices. We hope that IDRC 2024 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 2024 a grand success. May our team succeed in transferring knowledge.

MESSAGE FROM THE PRINCIPAL

Prof Jamshid Bhiwandiwalla
Principal, ACA

ACA has been organizing the International Design Competition annually for a decade now since its inception in the year 2013. It provides for an international platform to showcase the works of young designers and to establish connections amongst the global architectural student's community as well as academia. Hence it gives me great pleasure to announce the theme of "Architecture by the Edge" for the 10th edition of ACA's International Design Competition IDC 2023 and 4th edition of ACA's International Research Conference - IDRC 2023. Water is a finite resource that is incredibly important to humanity. The association of water from an environmental, scientific, creative or aesthetic standpoint currently depends on our capacity to manage it. Architecture has always been involved with water, frequently serving an aesthetic function but more importantly acting as a hub for human activity. It has been used for ages as a transportation system to facilitate trade and business, and has also offered chances for leisure activities. Similarly, issues associated with water-related disasters are becoming increasingly frequent due to extreme occurrences including climatic change, warfare, and political instability. The aim of this research conference is to address the critical issue of water as a finite resource as well as raise awareness on the recent concepts of water resilience. I look forward to your wholehearted participation and engaged learning!

PILLARS OF ACA

Prof. Ar. Gurunath Dalvi
Mentor and Advisor, Ex President IIA

Prof. Ar. Rita Nayak
Director-ACA

Prof. Ar. Jamshid Bhiwandiwalla
Principal- ACA

Prof. Ar. Rasika Chodankar
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- **Ar. Arun Nadar**

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SENSITIVITY THROUGH INVISIBLE WATER: MARRAKECH AS A MULTIFACETED CITY

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ABSTRACT

Marrakech is one of the four imperial cities of Morocco, declared as a UNESCO World Heritage site in 1985. The city centre was once surrounded by a vast palm groove which is called the Medina or the 'red city'. The urban area has been expanding beyond its Medina walls moving towards globalisation. This city is also famous for its rich water artefacts such as Water fountains, Khettaras, Riads, Hammams etc. which are among the main tourist attractions as well. With this strong character, set in the centre of the fertile, irrigated Haouz Plain, south of the Tennsift River, the city is also called the 'Oasis city'. In recent years, with climate change, water scarcity and globalisation, the expansion of the city has left many multi-layered problems. One major issue is represented by the urban voids in between the city centre and the recent developments, acting as neglected spaces that together with water scarcity fades the character of the Oasis city and its heritage. Through an urban design exploration point of view, the research understands the city's main character of water, its accessibility, and its importance for the community. An investigation of the value and state of the water artefacts in the city using GIS data, existing literature, and possible approaches to bring back the Oasis City in the 'in between' urban voids of the city have been explored. The research aims to metaphorically evoke the idea of water in urban design to bring an intangible notion of water.

KEYWORDS

Water, Urban, Artefacts, Intangible

INTRODUCTION

Marrakech is the fourth largest city in Morrocco. Located inland approximately 240km south of Casablanca, it was founded in 1062 by the Almoravids an imperial dynasty. Marrakech has a population by the year 2023 has reached approximately one million inhabitants. (Department, 2023). The city's economy relies mainly on tourism, handicraft production and commerce. The city of Marrakech is dependent on various natural resources for its development. One of the majors being water. Water as a resource is now scarce in the city (Aljazeera, 2018). To mitigate such risks, the Marrakech Local agenda 21 project was launched in 2002. (Habitat, 2021) Under this project an environmental profile was prepared. The key roles of the project focused on sustainable water management, improving the tourism and the urban and cultural heritage of the city. The project involved around 400 actors towards this vision. With such crucial roles of various actors and the scarcity of water, the research attempts to bring in the role of water in urban design for the city of Marrakech.

PURPOSE OF THE RESEARCH

The growth of the city has been fragmented leaving some vacant plots which become urban voids for the city. With a radial growth pattern, there is a change in character observed from the cultural city also called as Medina to the suburbs Marrakech with visions towards globalisation. With this growth as mentioned earlier, water scarcity is a key concern in the city. Considering water as the theme of the research, the paper attempts to investigate the impacts due to water scarcity, the state of heritage water artefacts and their value in the current times. The paper aims to understand the notion of water in urban context and how the theme of water in a situation of scarcity can be used as metaphor in urban design.

RESEARCH METHODOLOGY

The research investigates the issue of water in Marrakech through press review and virtual walk around the city. After these investigations various actors involved related to water are studied and an interrelation diagram with respect to the water elements is derived. After a general understanding of the context using the press review and understanding the various actors involved at local and global scale. The research maps the water elements such as drinking water fountains, Hammams, Riads, Khettaras etc which we call as the 'Water Artefacts' for Marrakech. The mapping is

carried out using QGIS software and the observations through the press review and virtual walk. These studies help to understand the role of heritage water artefacts and their current role in the water urbanism for Marrakech.

PRESS REVIEW

To understand the problems and the current crisis the city faces, a press review was carried out which showcases the issues related to water. Fig (1) shows the collection of data obtained through the press review. The press review was carried out to get a preliminary understanding of the city without getting into a detailed statistical review. This methodology aids to conceptualise the design ideas and problem setting during the conceptualisation of the design project. The press review highlights the steps taken by some actors towards developing sustainable strategies, the dilapidated state of water artefacts in the city, the reduced ground water table and strategies such as fog harvesting etc proposed in the city. The press review gives evidence of current situations the roles of various actors involved under the larger theme of water such as the Radeema, UNESCO, We Are Water Foundation etc. Apart from these formal actors, the press review highlights role of various private actors such as individual users in the

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city which create a water competition in the city. The key issues seen through the press review are water scarcity, water competition, climate change and neglected water heritage. (Swiss, 2021).

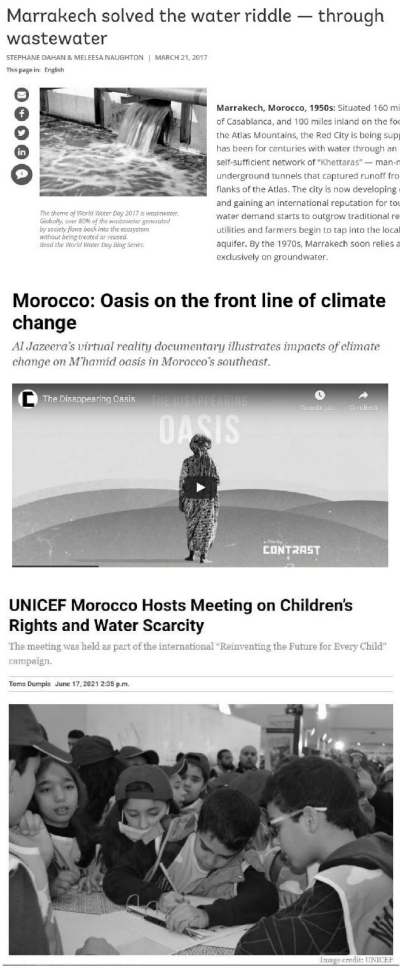

Figure 1 Press articles related to water in Marrakech. Compiled by Authors

A WALK THROUGH THE CITY

The research begun in September 2021 during the Covid -19 pandemic which limited the visit to the site and a virtual walk-through satellite images as well as through photographic data was carried out as an additional method to understand the city of Marrakech. The walk explored the various water artefacts in the city and their current state. The virtual walk helped to verify and understand in depth the issues that were highlighted through the press review as shown in figure 2. On one side of the city the heritage water artefacts such as the drinking fountains are not functional due to water scarcity, the other side private houses, resorts and hotels have large swimming pools. Marrakech is also known for its leather production; tanneries are important through an economical point of view to the city (Environmental Alternatives Unlimited, 2004).

Figure 2 Observations during the virtual walk mapped by authors.

The process of making leather involves lot of usage of water and resulting in water pollution. This unequal distribution of water in the city has caused a social divide as well as a water competition in the city. Water competition is an issue directly linked with the local and governmental actors in the city. These observations from the press review and the virtual walk make it a mandatory step to understand the relation between the actors at various levels in the city.

WATER AND ACTORS

Figure 3 shows the various stakeholders, both at international level and governmental level and their relation to various intervention and strategies towards Urban design. The process of mapping the actors highlights the criticalities of maintaining transparency, coordination for the city. Marrakech is a cultural city with rich water heritage such as the Khettaras, Fountains, Hammams, Riads etc. These become the focus while mapping the actors related to water. The diagram also investigates the relation of the various local actors and users which get associated to the water artefacts. The diagram was developed in parallel to the literature and press study carried out for Marrakech.

THE WATER ARTEFACTS

Water fountains, Raids, Hammans and Khettaras are one of the most crucial water elements for the city of Marrakech, Apart from Khettaras they hold a social-cultural importance. Khettaras are traditional water systems for irrigation for agricultural lands. These water-related elements are a heritage for the city, and the authors call them 'Water Artefacts'. These artefacts become the guiding force for the urban analysis and design process Through the walk in the city and primary understanding of the city map, it can be concluded that the Water artefacts in the city are directly linked to the urban spaces and help in defining the character of the city. It can be said that through the study of water artefacts, the "DNA" of the city can be understood (Chataignier, 2017). The research maps the water artefacts in the city using various tools ranging from historic maps to satellite images and GIS data.

KHETTARAS

Khettaras are an ancient underground water systems used to carry water for irrigation of farmlands. (Stephane Dahan, 2017). Around hundreds of Khettaras have been registered in around Marrakech. The growth of the city has reached the agricultural

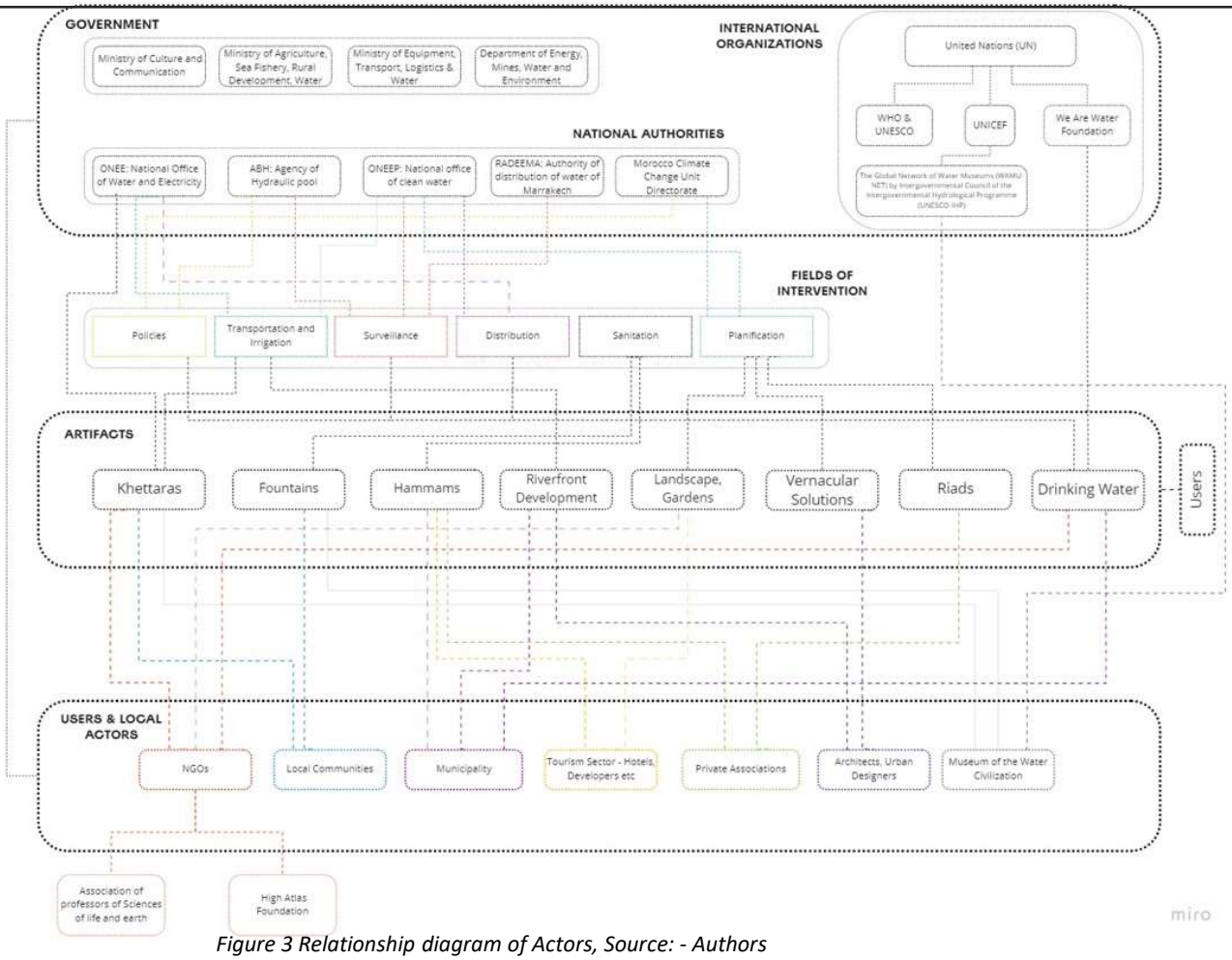

Figure 3 Relationship diagram of Actors, Source: - Authors

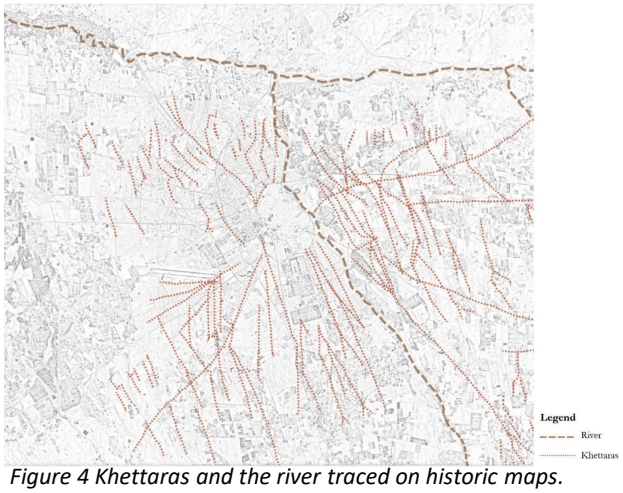

Figure 4 Khettaras and the river traced on historic maps. Source: - Authors

Figure 5 Private water Artefacts Source: - Authors

area, and an urban sprawl is observed. This urbanisation has led to over exploitation of the Khettaras through pumping of water as well as various bore wells have reduced the ground water table significantly. (Mohammed El Faiz, 2010). This urbanisation has left few Khettaras functional with limited stream of water while the rest are dry and redundant in the urban landscape. The study maps the Khettaras through the historic maps (Maps, 2020) and evidence though satellite imageries. Figure 4 shows and interpretation of the layout of Khettaras and the river at a territorial scale around the city. The Khettaras are planned around the Medina gardens which helps in irrigation of the surrounding agricultural fields. The following analysis shows the course of the river and the overall layouts of the Khettaras through the historic maps. It is interesting to observe the how through time the Khettaras are now part of the larger city of Marrakech. The Southwestern part of the city has a dense network of Canals and Khettaras with water basin becoming the main spine for the irrigation

system. While Khettaras are more of a water irrigation system. The water artefacts such as fountains, hammams and riads are more related to the socio-cultural fabric of the city.

PRIVATE WATER ARTIFACTS

Artefacts such as Riads, Hammans have become the new tourist attractions. Most of them have been converted into heritage resorts or spas etc. They are associated to a commercial, hospitality or tourism business making them valuable though an economical point of view. Figure 5 shows the mapping of private gardens and pools which include some of the Riads and Hammans. Some artefacts especially located in the Medina (city centre) are accessible to public with entry tickets thus they have been categorised as semi-public.

PUBLIC AND SEMI-PUBLIC WATER ARTIFACTS

Figure 6 localises water related artefacts such as pools, fountains and hammams. Due to the water scarcity the water fountains have been closed by the municipality as a measure to save water. This has led to the water fountains as structure open to damage and misuse. This privatisation of few water artefacts while a few being in a dilapidated stage has left to a social void in the urban spaces of the city. The study of the public and private water artefacts helps to understand their interface with the urban spaces in the city and how it is crucial to revive them in order which can revitalise the urban spaces in the Medina (city centre).

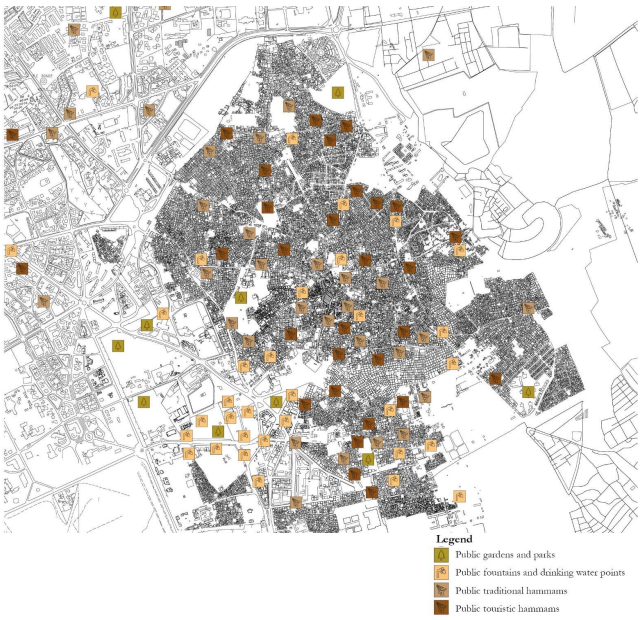

Figure 6 Public and Semi-Public Water Artefacts Source: - Authors

Figure 7 shows all the water artefacts combined. Through this map we can see that most of the artefacts are concentrated in the Medina area and the distribution reduces as we move away from the city centre. The Khettaras on the contrary are present outside the Medina wall for the agricultural fields.

Figure 7 Water Artefacts and the city Source: - Authors

centre. The Khettaras on the contrary are present outside the Medina wall for the agricultural fields. Based on the design research carried out, a manifesto highlighting the urban conditions was developed. The process of developing the manifesto helps to define goals and future intentions for the design proposal. The manifesto helps in design research in three parts; the process of data collection in and knowledge, the curiosities towards the geography considered for design research and the directions to the designer for ideation in design processes. (Henry Mainsah, 2013).

The manifesto made after the study of the urban conditions of Marrakech showcases the gap between urban morphology between the medina and the new districts. The illustration summarises the study carried out. It highlights the gap in the socio economical structure of the city, where on one end there are large mansions with private pools and on the other side the dilapidated water artefacts in the Medina. This showcases the water competition and scarcity conceptually in the manifesto. The urban spaces lie in a neglected condition and the character of spaces linked to water heritage is absent in areas beyond Medina. The river being dry also becomes an urban void. The manifesto instigates a thought to question as how design interventions to answer the major concerns of water scarcity and competition can be dealt with. Water bodies and artefacts play a key role in activating the urban spaces. The heritage spaces act as an urban catalyst promoting various socio-cultural activities in the city.

SCALES OF COMPARISONS

Based on the manifesto and the research, an area of intervention between the Medina and Menara Garden was chosen for a design intervention. The reason for choosing this area was due to a need for better urban spaces and presence of prevalent Khettaras which brings in the connection of the theme of water for the design proposal. These in-between spaces hold a

Figure 8 Artwork Developed as a Manifesto. Source: - Authors

potential for bridge the gaps of the heritage city and transfer the cultural to the recent developing suburbs of the city. Figure 9 shows the development of the initial idea of the cultural axis, connecting Medina with the areas of intervention adjacent to Menara Gardens, exploring the relations within the urban fabric of the area and a possible first program proposal.

Figure 9 Cultural Axis. Source: - Authors

To understand the scale of the chosen area of intervention, a comparison of scale was done using public spaces known to the authors, this exercise helps the authors comprehend the site. Thus, the area of interventions was compared with Piazza Leonardo da Vinci, Milano, Duomo di Milano, and the city of Venezia as shown in figure 10.

Design Tool Kit Formulation

After the identification of overall problems, threats in the city and the area of intervention chosen, the

Figure 10 Scale of Comparison. Source:- Authors

idea of an oasis city manifested with a reminiscence to the water ponds present once in the area. Two Khettaras pass through the site now in dry state have also been considered to bring in the nostalgia of the traditional water system present in Marrakech. The design approach is to integrate these Khettaras in the form of public spaces. To develop an urban design proposal keeping water as a central theme and in a geography with water scarcity was the main challenge towards the design ideation. With the research carried out and the sensitivity developed towards the context, a concept of 'invisible water' emerged in the research process.

The figure 11 shows the mental mapping carried which helped in developing the concept of 'invisible water' and arriving to a design tool kit. The methodology of design thinking, and ideation helped in the developing the tool kit with various possible list of intervention that might be suitable for the city. The authors have developed a general tool kit, and all the elements in the kit need not suit the area of intervention. The tool kit has been developed as a general list for the Marrakech.

NARRATIVES FROM CASE-EXAMPLES

The research investigated design projects related to water as well as which have a poetic narrative. and sensitivity to water. Through the reading of the design philosophies of the various design projects, a qualitative aspect as well as a sensitive approach was developed for the design proposal for Marrakech The case examples are as follows: -

Smitivan,Bhuj, India: The project is an earthquake memorial with a thought of a tree as a memory a victim who passed in the earthquake.

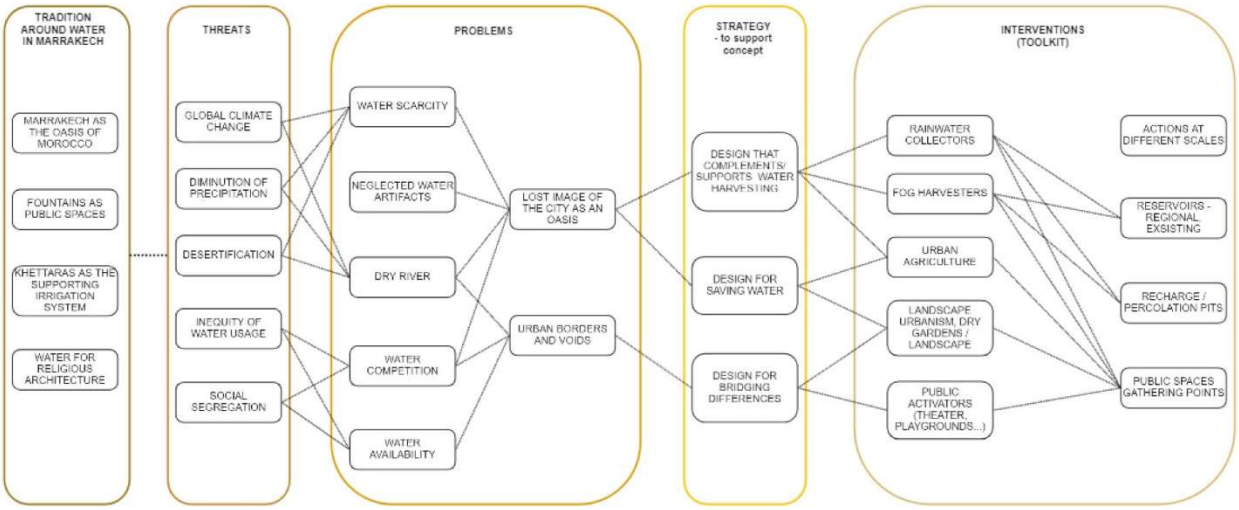

Figure 11 Arriving at the concept of 'invisible water'

The project uses water percolating reservoirs to increase the ground water table help in the growth of vegetation on a once barren mountain which is entirely the memorial site. The Smritivan Memorial is a project that has the power of making a new cultural landscape emerge from the ground (Fig. 4.14). With water reservoirs (Fig. 4.15) and different typologies of open-air public and gathering spaces (Fig. 4.16) the project connects the city with the new landscape and evokes the memory of the lost souls in the Bhuj earthquake. (VSC, 2018).

Ellora Caves, Aurangabad, India: - Ellora is a World Heritage Site located in India. Even if the terrain is different from that of Marrakech, the reference helped us to visualise the hierarchy of levels and their transitions. (Convention, 2018)

Hurva Synagogue, Jerusalem: - The unbuilt project by Louis Kahn for the historical Jerusalem's synagogue (Fig. 4.19) was an inspiration for us for what concern)

the use of massive walls for the definition of the interstitial space and the use of particular architectural prototypes as shading systems. (Margalith, 2018)

Lascaux Museum, France: - The French Museum welcomes visitors to an immersive educational experience of the prehistoric Lascaux cave paintings (Fig. 4.22). This case study helped us to imagine the articulation of the subterranean spaces and the entrance through gestures. (Archdaily, 2017)

Tunnel Borbonico, Naples, Italy: - The Borbonic Gallery, it's an underground cavity that spreads under the city of Naples. It is an example of the character that an underground built environment can produce, while emphasising on the historical water bodies. (Sotterranea, 2018)

NARRATIVES FROM CASE-EXAMPLES

The design attempts to become a cultural axis to between the Medina and the Menara Garden.

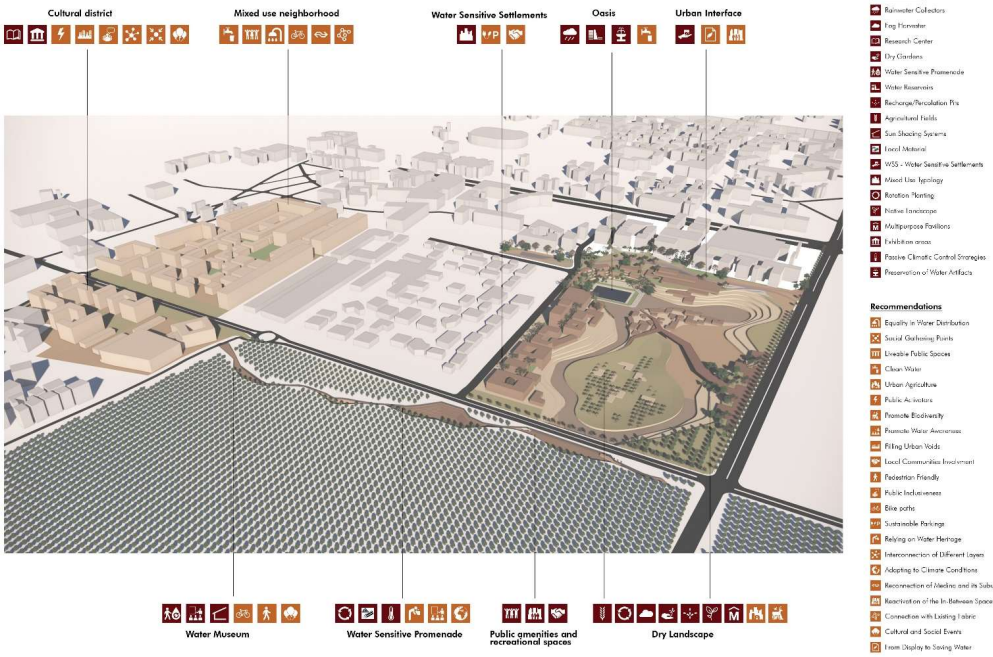

Figure 12 Design Intervention. Source: - Authors.

With the character of Khettaras, a subterranean architecture has been conceptualised. The site will be excavated in some areas and the excavated soil will be used to manufacture brick that can be used as the building material. The design connects various markets and public spaces with the Khettaras at the underground level. The Khettaras once water system is visualised as connection and walkways for people to experience and celebrate the traditional water system. A crack has been proposed in the Menara Garden to symbolise water scarcity which connects the Khettaras. This crack represents water scarcity and invites the visitors to move into the Khettaras which have been converted into exhibits to celebrate the culture of Marrakech and create an awareness about the water artefacts. The design proposal ventures into a conceptual imagery to evoke the nostalgia of water without its presence. The design project suggests various interventions and recommendations to the area of intervention as shown in figure 12, 13, 14.

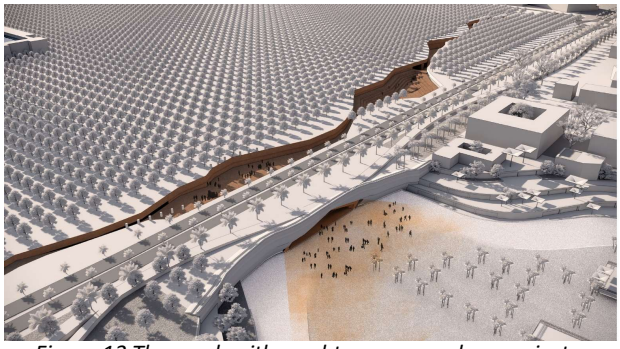

Figure 13 The crack with a subterranean urban project. Source: - Authors

Figure 14 Khettara Museum. Source: - Authors

CONCLUSION

The paper shows a methodology which can be helpful for design research and conceptual development of a project. The theme of water has been the primary object of the research, and it helped in developing a project that aims at enhancing water sensitivity without the use of water but it's through its preservation and metaphorical recalls. Marrakech is a multifaceted city with various plural identities with a strong involvement of local and global actors. Understanding their role becomes a crucial factor as part of urban design research. The paper highlights how methods such as press review, design thinking can help in comprehending a geography efficiently.

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KALLAI RIVER POLLUTION AND ITS IMPACTS: A CASE STUDY ON MOORIYAD, KOZHIKODE

By Hind Rasheed, Assistant Professor, MES College of Architecture, Kozhikode

ABSTRACT

Kallai River, a prime part of the historical town Kallai which lies in the southern end of Calicut district had been glorified since time immemorial for various trade reasons. However, with the outburst of various industries along the Kallai riverbanks and various others factors, Kallai River is stagnant and is now a dying river. Kallai has in fact lost its old glory. The study starts with a brief knowledge on the history and importance of the Kallai, the Kallai River and the current scenario with a detailed urban study. The entire study was done based on DPSIR model approach which clearly allowed spotting the issues right from the grass root level and then identifying the pressures caused by these. The major sources of waste generation and drain outlets into the Kallai River were sited and loads calculated. Simultaneously, water quality testing on the three identified spots of Kallai River were taken to identify the pollution levels and was compared with IS 10500:2012 as the benchmark. Further analysis and recommendations were provided according to each sector type. As per Water quality Test results done for all physical, chemical and microbiological parameters in Mankavu, Mooriyad and Kallai regions, Mooriyad was found to be most polluted with pollutants that are even carcinogenic in nature. It was analysed that various anthropogenic factors, outbursts of industries and unavailability of proper waste treatment systems in the area were the major reasons of decline of Kallai River. The quantitative analysis performed, suggested the ill effects on human health, aquatic life, environment and material damage. Recommendations for revitilisation of the entire River stretch and neighbourhood has been identified as a necessity for a sustainable and healthy livelihood of the residents of Kallai

KEYWORDS

Sustainability, revitalization, conservation, neighbourhood, DPSIR model

INTRODUCTION

Kallai is a small town on the banks of Kallai River which links with the Chaliyar river on the south by a man-made canal, the Canoli canal. During the late 19th and early 20th centuries, the Chaliyar River was extensively used as a waterway for carrying timber from the forest areas in and around Nilambur to the various mills in Kallai. Rafts made of logs were taken downstream during the monsoon season to Kallai, where these were sawn to size in the timber mills doting the banks of the river. During this period, Kallai was one of the most important centres in the world for the timber business. The place was noted for woods of superlative strength and durability like teak, rosewood etc. However, with the ban on the green felling and the land ceiling act and associated nationalization of private lands, supply of teak and rosewood declined substantially in the Kallai market, and this became a cardinal factor for the downfall of Kallai.

AIM / PURPOSE

To revitalise Kallai river using DPSIR (Drivers, Pressures, State, Impact, Response) model.

OBJECTIVES

1. To study about urban river revitalisation and its concepts.
2. To identify the socio, economic and environmental conditions of the areas adjacent to Kallai river.
3. To identify the various anthropogenic factors that affect the river.
4. To conduct a quality assessment of the Kallai river and its surroundings and to compare it with standard data.
5. To analyse and find the current state of Kallai River and the impacts it poses on the surroundings.

CONCERN

Kallai has lost its old glory. Tourism has almost been nil in Kallai since the late 20th century. Economic degradation and population growth has led Kallai to a condition today that need to be addressed. Waste management and the current issues caused with the highly polluted Kallai river are other issues faced by the region. (CWRDM, 2020) Few reasons for the pollution of Kallai river has been the following according to (CWRDM, 2020):

- Silting and sedimentation
- Industrial waste
- Municipal sewage
- Waste dumping by slum dweller, residents, hospital, poultry etc.
- Constant encroachment in the riverbanks.

Due to this, from various articles and reports, it is noted that Kallai river is extremely polluted and need to addressed. The pollution has affected the region socially, economically and environmentally too harming the various flora, fauna, marine ecosystem in the region. Kallai river is no more a resource for the people of the area today!

METHODOLOGY

The project includes a research framework of understanding the present decline of Kallai's glory and Kallai river. The river seems stagnant with waste deposited in the riverbanks due to various anthropogenic activities. The research aims at identifying these factors of cause and understanding what pressures it has created for the environment. An immediate action of revitilisation seems to be of urgent need in the area and hence various case studies were identified of similar context to pick out the best one that suits Kallai. For the same, DPSIR environmental model was chosen as the framework of study and methodology.

The data collection for my thesis project is divided into five major parts including: site analysis and assessment, relevant comparative case studies, past recommendations and best practices, discussions with professionals in related fields and detailed literature review. Gathering data, organising significant information, analysing and synthesising findings and then using them appropriately to develop the design recommendations is the overall process of the research.

Site assessment involves a detailed study of the region and its relation with the study area for the project. Project will require an advanced understanding of historical significance of the city and region, social and economic factors, relation of Kallai and its neighbourhood with the Kallai River . It will also include a study about the Kallai River and its history in past few decades. In addition, site assessment will contain existing land use pattern, parcel study, circulation and existing linkages with the study area. It will help to understand need of Kallai River, expectations from its natural assets, potential connections and scope for the development.

Site analysis includes, taking an inventory of site elements and analyzing these factors relative to the goal and objectives of the thesis project. It involves gathering relevant information about existing conditions such as vegetation, water table, topography (slopes, elevations, gradients), and climatic changes (solar intensity and its direction, wind direction, temperature changes).

After selection of all the case-studies, next step included synthesizing and analyzing the data, project goals, key findings and success of the design of those case studies. Study of similar design recommendations in the past few years, for similar sites or projects and their best practices in comparable urban settlements were very supportive. Discussion with various officials and residents connected to the neighbourhood to conduct discussion to gather information about the city, its waterfront, upcoming projects, and future

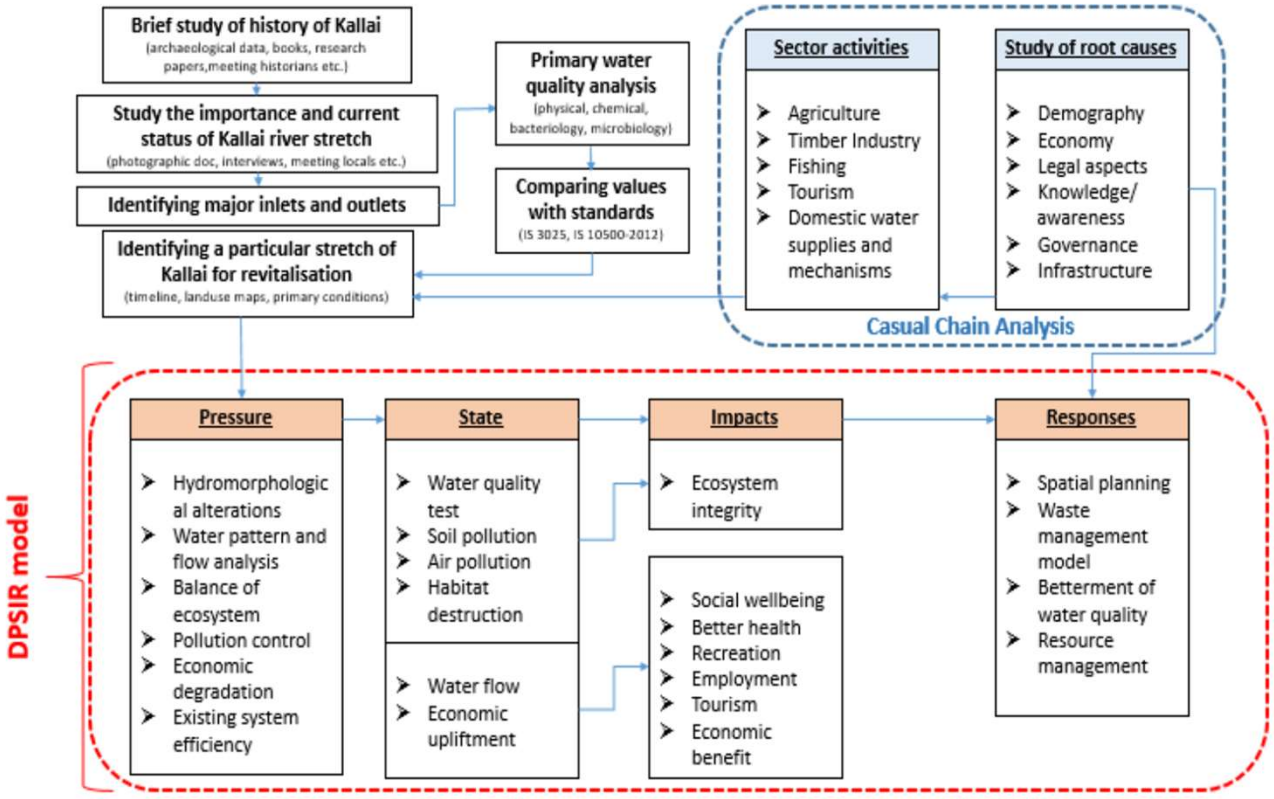


Figure 1 Research Methodology

development recommendations near downtown area, developmental trends. It helped identify about issues faced by city while improving the existing scenario, and get a further idea of the scope and limitations of the project. After analyzing the data from the conversations, it guided towards practical solutions to resolve certain issues.

Conducted a detailed literature review regarding urban development issues, design development of urban village, mix land use development, urban sustainability, waterfront revitalization, and their interaction with inhabitants. The study helped to get the detailed knowledge about these terms and their relation with urban design solution.
The study started with a brief knowledge on the history and importance of the place and Kallai river. The current scenario at the location was thoroughly studied based on the numerous newspaper articles, journals and research papers which introduced Kallai river as a dying river. The major inlets and drains to the river was later identified. A detailed urban study on the neighbourhood with a closer look on each sector was thoroughly made to understand the various drivers that caused the pollution activities in the neighbourhood. The entire study was done based on Drivers-Pressures-State-Impact-Response model approach which clearly allowed spotting the issues right from the grass root level and then understanding their pressures in the river.

A simultaneous water quality testing on the three identified spots of Kallai river was taken to understand which spot was more polluted. A comparative analysis of the readings of the three spots, Kallai bridge, Mankavu and Mooriyad was made considering IS 10500:2012 as the benchmark. Further analysis of the five drainage samples collected was done to identify the most polluted drain flowing to Kallai River. Further urban study, causes of pollution and the current situation and analysis were done based on DPSIR model and recommendations provided accordingly to each sector type.

PRIMARY DATA COLLECTION

STUDY AREA

Figure 8 Image of Kallai River being connected with Canoli Canal and Chaliyar River and outlet to Arabian Sea

The urban study conducted was for a stretch of 1.7km from Kallai Bridge to Mankavu Bridge on either sides of the river bank. The Kallai river which starts from Chirakkulathur in Kozhikode district. This 22km river stretch joins with Canoli Canal from North and Chaliyar River. Kallai River has only one outlet which is towards the Arabian Sea.

The Kallai Bridge which run along separates Kallai as East and West Kallai. The study area in the research particularly focuses on East Kallai where a mixed-use land occupancy is witnessed. This thickly populated area has been thoroughly studied to understand the major drivers of the area causing river pollution.

DRIVERS

The various drivers that cause Kallai river pollution in the area is as follows :

Figure 3 Waste Dump

Figure 4 Silting

Figure 5 Municipal Sewage

Figure 6 Encroachment

Figure 7 Industrial Waste

Source: Interview with Mr.Ishaq , Secretary of Timbre Merchants Association, East Kallai

- No dams or other structures over Kallai river has been constructed, except for three additional new overbridges in the area.
- Many riparian zones have been encroached by private sectors to build industries making them adjacent to the rivers.
- Environmental flow of Kallai river is almost 0 as per reports from SPCB. The sea influx from Arabian Sea makes the river broader near the outlet whereas, at the beginning in Cherukalathur, Kallai river is linear and less in width.

MASTER PLAN

The master plan shown below, identifies the 1.7 km stretch study area. Various hotspots such as the waste dumping points

places of sedimentation, areas of encroachment, spots of industrial waste deposition and municipal wastes are marked.

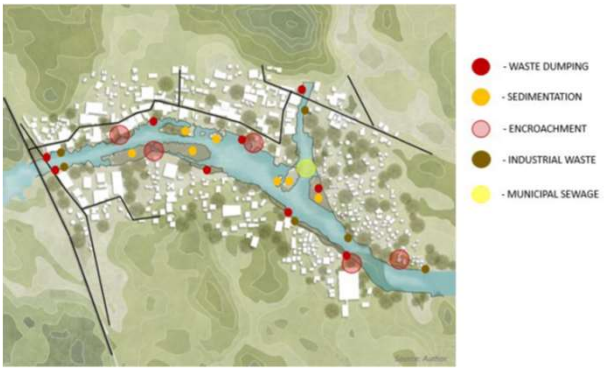


Figure 9 Master Plan of study area

Demographic details of study area:

Total no. of occupants-
Industrial : 74 nos. x 8 workers = 592 people
Residential : 146 houses x 4 nos. = 584 people
Commercial + Hospitality = Avg. 200 nos.
Grand total – 1376 people

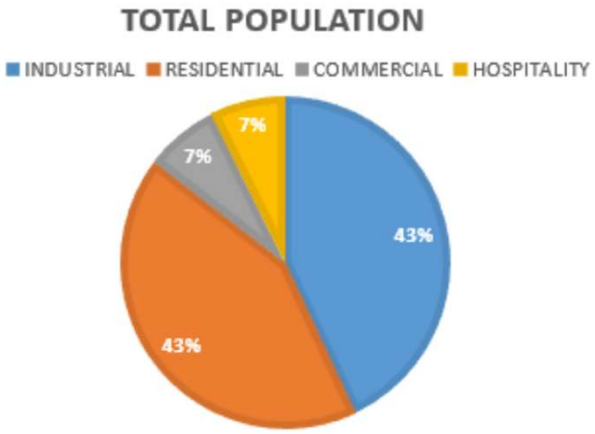
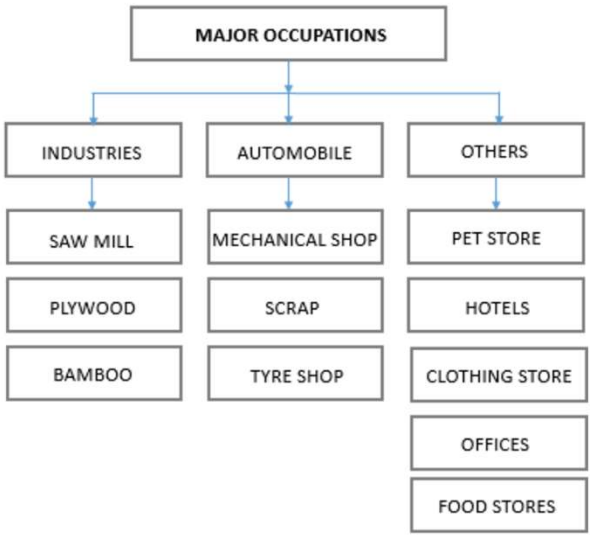
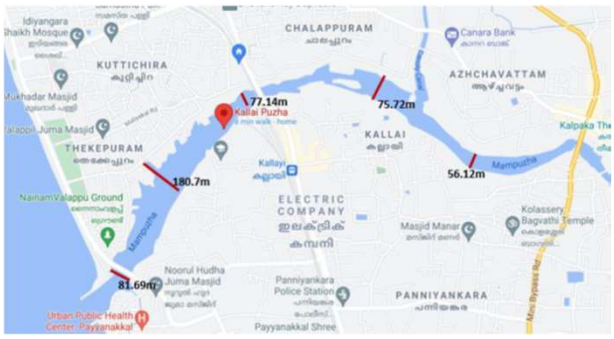


Figure 10. Pie chart showing population data in each sector

Economic details of study area:



LEGAL ASPECTS



For rivers, creeks & backwaters the distance of prohibition is 100 meters or the width of the river whichever is less. (CRZ,2019).
Considering average width of river from the five widths considered is 94 m. Therefore, at last 94m of set back from the river should be considered from Kallai River in case of any construction.

Figure 11. Map showing encroachment points

•Industries built on private lands that have not followed the CRZ rules.
•On the encroached sites, saw mills are seen on stilts from where the timbre is directly picked from the river.
•The encroachment has been seen as one of the prime reasons for narrowing of Kallai river.

BUILT-USE MAP OF EAST KALLAI

The built-use map of Kallai locates the industires, residences, commercial, public-semipublic and religious spots within the study area. This mapping shown in Figure 12 helps us understand the number of buildings in each sector and their concentration.

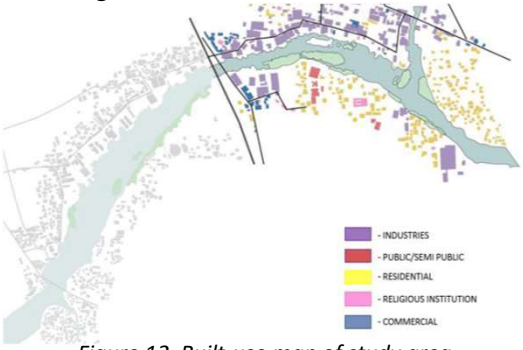


Figure 12. Built-use map of study area

Total no. of industries – 74 industries
Total no. of residence – 146 houses
Total no. of religious buildings – 3 nos. (2 mosques and 1 temple)
Total no. of commercial buildings – 28 nos.
Total no. of public/semi-public buildings - 7 nos.

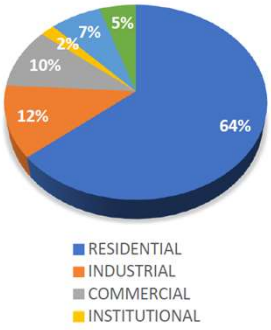


Figure 13. Pie chart showing percentage of built-use by each sector

According to the the built-use map based on site study and research, it is found that the area is mostly occupied by the residential sector for about 64%. The next in line is the industrial sector, 12% which is majorly concentrated to the left part of the area where Kallai River meets Canoli canal. This area is known as Mooriyad. Commercial sector which occupies 10% of the entire area is then followed by instituitional and other sectors.

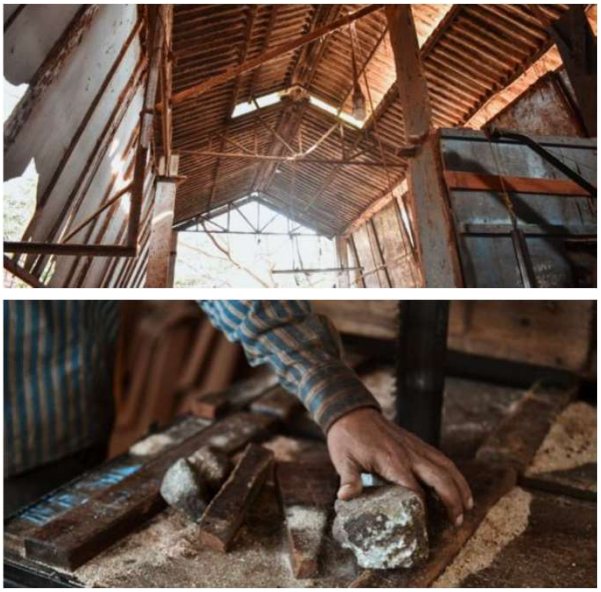


Figure 14. Photographs showing the interior and step of timbre manufacturing

According to the the built-use map based on site study and research, it is found that the area is mostly occupied by the residential sector for about 64%. The next in line is the industrial sector, 12% which is majorly concentrated to the left part of the area where Kallai River meets Canoli canal. This area is known as Mooriyad. Commercial sector which occupies 10% of the entire area is then followed by instituitional and other sectors.

FIGURE GROUND MAP OF EAST KALLAI

A figure ground map was plotted based the site study to show the relationship between built and unbuilt space of the study stretch. This two-dimensional

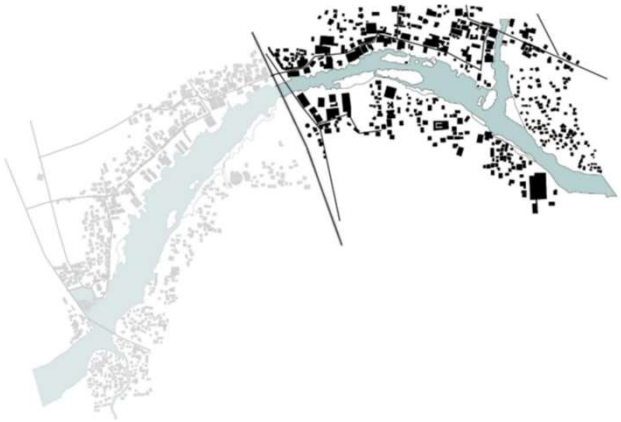


Figure 15. Photographs showing the interior and step of timbre manufacturing

mapping allows for a better urban analysis for designing and planning of the area. As a result, it was found out that the study area had scattered congregation of built structures, thus showcasing a fine grain texture.

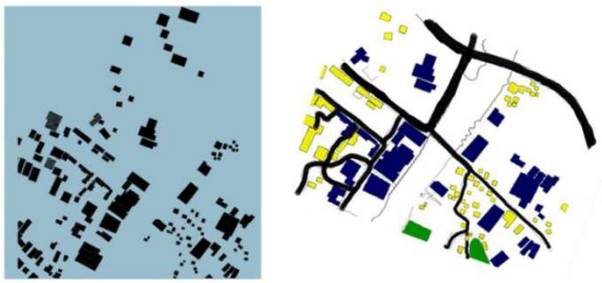


Figure 16. Fine Grain and Scattered

GREEN COVER MAP OF EAST KALLAI

Figure 17. Green cover map of study area

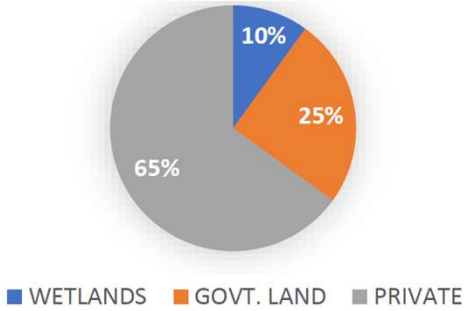


Figure 18. Photographs showing the interior and step of timbre manufacturing

The green cover map including wetlands, government open spaces and private open spaces of East Kallai was plotted. It was found that 65% of it was private open spaces, which was then followed by 25% of government land and the rest 10% as wetlands.

Figure 19. Photographs showing private open spaces

GROUND COVER MAP OF EAST KALLAI

The ground cover map of East Kallai, shown in Figure 20, including gathering space, loading/unloading docks, vegetated land and waste dumping points were plotted. It was noticed that all the industries do not have separate loading/unloading service docks. Few industries park their loaded trucks along the roadside for unloading goods. This causes congestion in the road disturbing the other vehicles and causing traffic. There exists only one gathering space which is used as a playground by the youth in the locality.

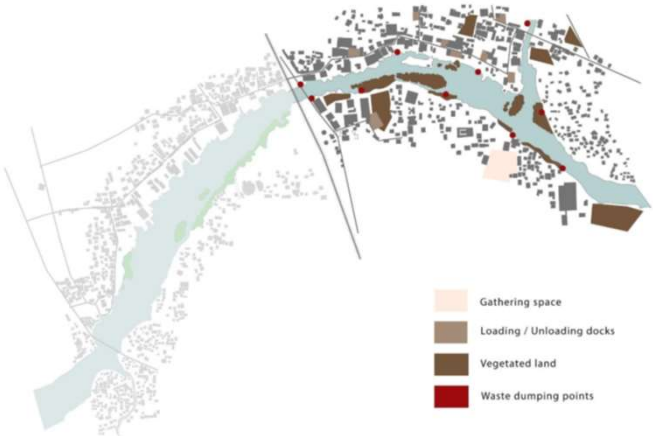


Figure 20 Ground cover map of study area

Figure 21 Photographs showing encroached land and waste dump site within the locality

HEIGHT OF BUILDINGS OF EAST KALLAI

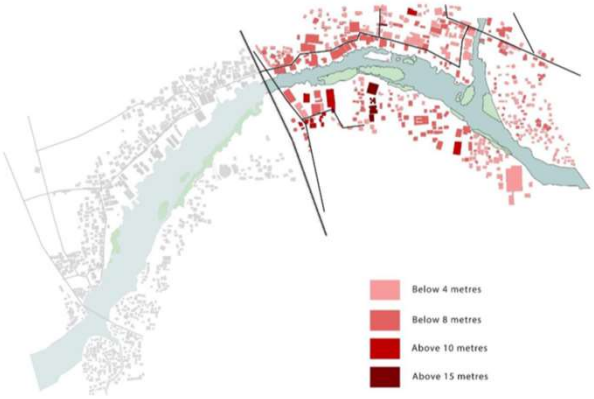


Figure 22. Photographs showing private open spaces

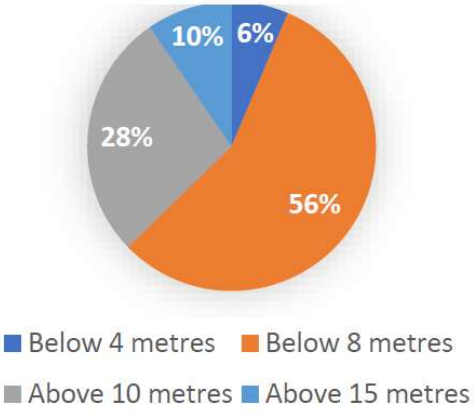


Figure 23. Pie chart showing percentage of buildings of each height category

The height of each building was plotted. It was noticed that about 56% of the buildings were of two storey height, which includes below 8 meters. Whereas the next in line, 28% of buildings were above 10 meters. Only 6% of the total buildings were of one storey height which is 6%. About 10% of the buildings were above three storey height, that is, above 15 meters.

Figure 24. Photographs showing buildings of various heights

AGE MAP OF BUILDINGS OF EAST KALLAI

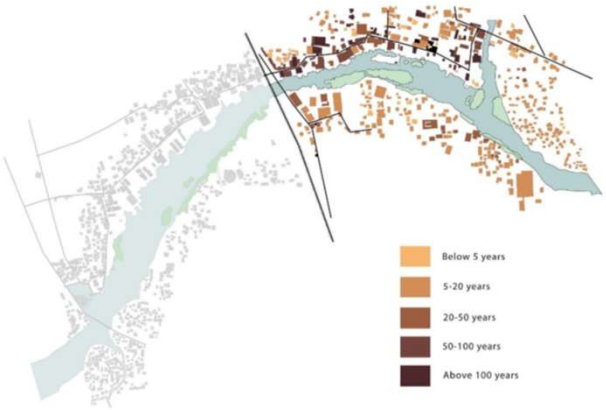


Figure 25. Age map of buildings of study area

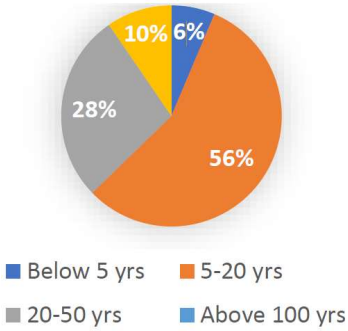


Figure 26. Pie chart showing percentage of buildings of each height category study area

The approximate ages of buildings were identified and a map was drawn out based on the site study and research. It was noticed that majority of buildings fell into the age category of 5-20 years and the least of all, just 6% of all the buildings were above 100 years of age. Most of these old buildings were either dilapidated or abandoned and not put into any use.

Figure 27. Photographs showing buildings of different age category in the study area

KALLAI EAST- INDUSTRY LOCATION MAP

Total no. of sawmills in the study area – 74 nos.
All the industries within the study area were marked and located in the map, Figure 29. Concentration of building typologies helped find out the sources of waste and amount of solid and wet waste generated to the drainages and Kallai River.

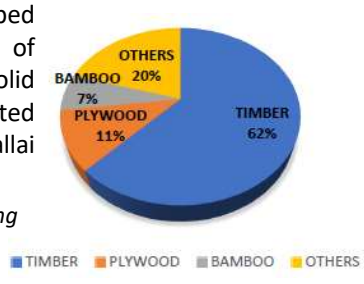


Figure 28. Pie chart showing percentage of type of industries

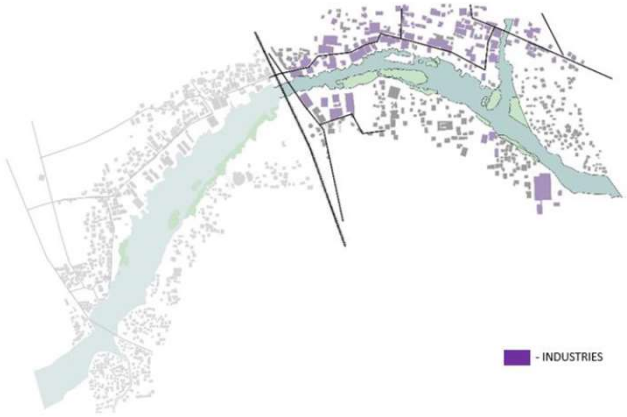


Figure 29. Pie chart showing percentage of type of industries

WASTE GENERATION CACULATION

Waste generation on average per industry per day – 15 kg approximately
Waste expulsions from industries – saw dust, waste pieces, wood peels, other wastes.
Means of throwing by industries – dumping in nearby landfills, thrown directly to river without any treatment , kudumbashree pickup on alternate days for wet waste and dry waste once in a month.
Total waste generated by all the industries within the study area – 15kg x 74 nos. = 1110kg

Figure 30. Photographs of wooden log put into river for seasoning (left) and wooden logs stacked for further processing (right)

Figure 31. Photographs of processed wooden planks stacked for weathering in within the storage areas by the river bank side

STAGES OF TIMBER PRODUCTION

The stages of timbre production from raw wooden logs to processed planks require a number of steps in order. These require energy and they let out waste out of which some are harmful to the environment.

Figure 32. Photographs of wood processing and seasoning at Kallai river

KALLAI EAST- RESIDENCE LOCATION MAP

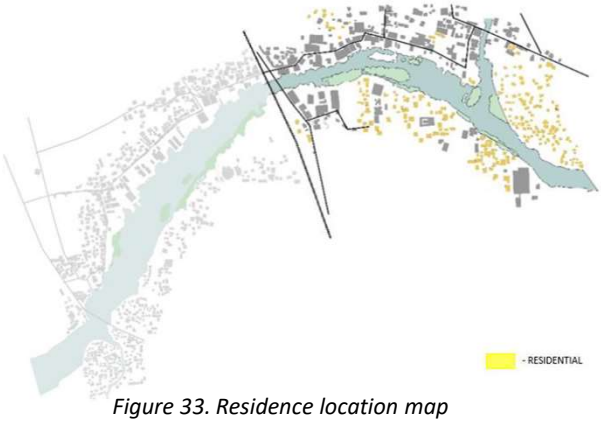


Figure 33. Residence location map

Total no. of residences in the study area – 146 nos.
All the residences within the study area were marked and located in the map, Figure 26. Concentration of building typologies helped find out the sources of waste and amount of solid and wet waste generated to the drainages and Kallai River.

WASTE GENERATION CACULATION

- Waste generation on average per person in urban household – 0.45 kg
- Waste expulsion – plastic, paper, kitchen waste and others
- Means of throwing – landfill, waste collection points, kudumbashree
- Total waste – 0.45 kg x 4 persons x 146 houses = 262.80 kg / day

According to the study conducted,

- Kudumbashree units picks around 20 kg of food waste every alternate days.
- Kudumbashree units pick around 250 kg of plastic waste every month.

Eleven households use their food wastes for biogas. While rest throw away at the backyard. Rest of the sources are unidentified and Kallai river areas are the prime locations identified.

Figure 34. Photographs of street of East Kallai

KALLAI EAST- PUBLIC/SEMIPUBLIC ZONE LOCATION MAP

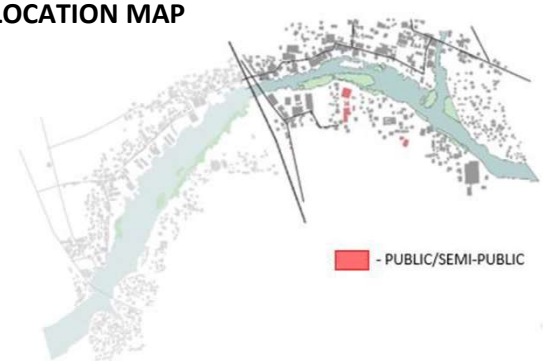


Figure 35. Public/Semipublic Zone Location Map

Figure 36. Photographs of public, semi-public zones of East Kallai

KALLAI EAST- COMMERCIAL BUILDINGS LOCATION MAP

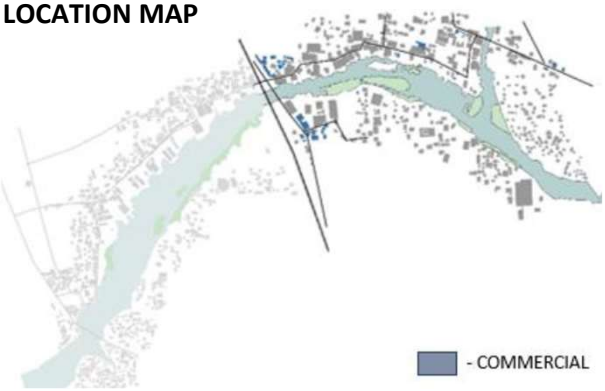


Figure 37. Commercial buildings location map

WASTE GENERATIONS CALCULATIONS

- Refuse on average per commercial /institutional – 0.2 kg/cap/day
- Waste expulsion – plastic, paper, wet waste and others
- Means of throwing – landfill, waste collection points, kudumbashree
- Total waste – 0.2 kg x 200 persons = 40 kg / day

Figure 38. Photographs of an upcoming commercial building (left) and residential building (right)

WELL WATER

Figure 39. Residence location map

All houses in the locality do not have individual wells. The residents who have wells do not use them due to the foul smell and the turbid nature that the water showcases. Around 98.8% commend that the trend of water quality has either been deteriorating or in the same state since the past five years.
All the residents depend on corporation water which is paid. Rate is dependent on usage. (Rs.4/KL as per KWA).

WASTE GENERATION CACULATION

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- The residents who have wells do not use them due to the foul smell and the turbid nature that the water showcases. Around 98.8% commend that the trend of water quality has either been deteriorating or in the same state since the past five years.
- All the residents depend on corporation water which is paid. Rate is dependent on usage. (Rs.4/KL as per KWA).

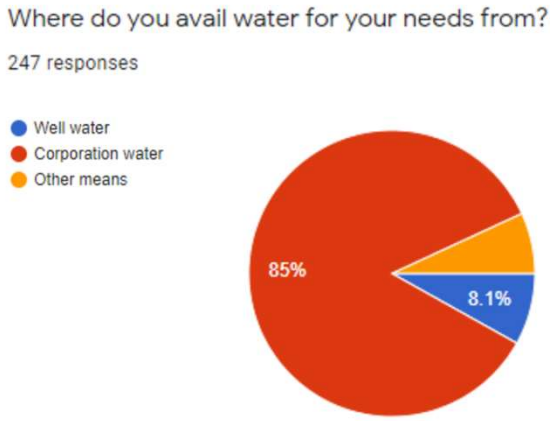

Figure 40. Survey questionnaire response

It can be noted from the questionnaire that only 8.1% of households depend on well water, whereas 85% of the people depend on corporation water for their needs.

DRAINAGES

Five drainages that open its outlet to the Kallai River directly were spotted and marked, as shown in Figure 34. Three of these drains are in the Mooriyad region, where Canoli Canal and Kallai river meet and two of them on either side of Mankavu bridge, where Chaliyar river meets Kallai river.

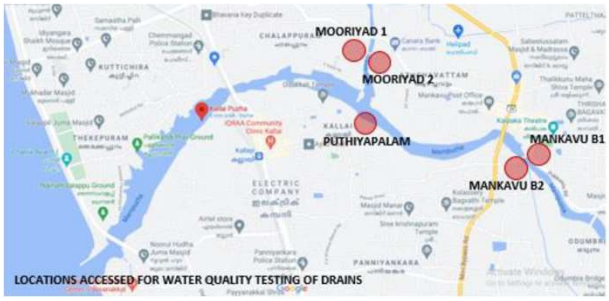

Figure 41. Map showing drainages whose outlets fall directly into Kallai river

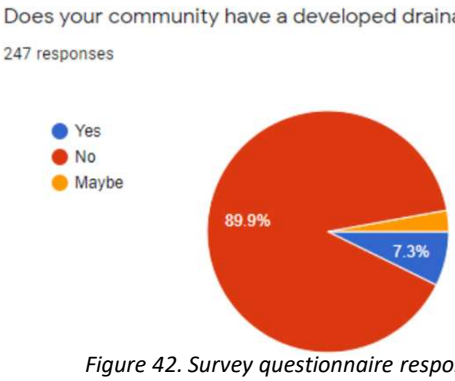

Figure 42. Survey questionnaire response

From the questionnaire it was quite obvious that the neighbourhood did not a have any developed drainage system as 89.9% of its residents say so.
Water quality tests for each of these five drains were conducted to determine the BOD load, total coliform count and faecal coliform count. These would help in inferring how polluted each of the drain was. According to the width and depth of each drain, the area of drain was calculated, followed by its catchment area. The velocity of each drainage was marked by float method. The multiplication of calculated velocity and area helped attain the discharge/flow rate of each drain. It was understood from the readings that Mooriyad1 spot had the most of coliform count and BOD, making it the most polluted out of all the spotted drainages and that it is because of the direct flow of untreated sewage from the Canoli Canal.
Note: Float method is used for measuring flow rate through an open channel. This method involves measuring the surface velocity of the water with a floating object and then multiplying this velocity by the width and average depth of the channel.
The table below depicts that Mankavu B2 is comparatively the least polluted for which BOD count is 80, which is the most least comparatively. Mooriyad 2 faecal coliform count is also highly above permissible limits. The standard set for comparison is IS 10500:2012. From the values obtained and the questionnaire it was quite obvious that Kallai East did not possess a well-developed drainage system and this one of the major cause of Kallai river pollution as the untreated wastes go directly into the Kallai River.
The measurements and calculations of each drainage is tabulated below:

NAME OF DRAIN	LATITUDE / LONGITUDE	WIDTH (m)	DEPTH (M)	AREA OF DRAIN (sq.m)	CATCHMENT AREA (sq.m)	VELOCITY (m/s)	DISCHARGE / FLOW RATE (cum.m/s)	TOTAL COLIFORM COUNT (CFU/100 ml)	FAECAL COLIFORM COUNT (CFU / 100ml)	BOD (mg/l)	BOAD LOAD (kg/day)
				Area= width x depth		*Float method*	*Discharge = Velocity x Area*				*BOD load (kd/day) = BOD load (mg/l) x dishage (l/day)*
Mankavu B1	11°14',75°48'	0.5	0.15	0.075	102435	0.025	0.001875	3400	1500	220	35.64
Mankavu B2	11°14',75°48'	0.7	0.05	0.035	68520	0.108	0.00378	1200	750	80	26.13
Mooriyad 1	11°14',75°47'	0.3	0.1	0.03	128016	0.018	0.00054	8700	6900	300	9.3312
Mooriyad 2	11°14',75°47'	4.7	0.23	1.081	114850	0.021	0.022701	8100	6900	90	176.52
Puthiyapalam	11°14',75°47'	17	1.5	25.5	97876	0.05	1.275	6800	5200	170	18727.2

Figure 43. Drainage measurements and calculations

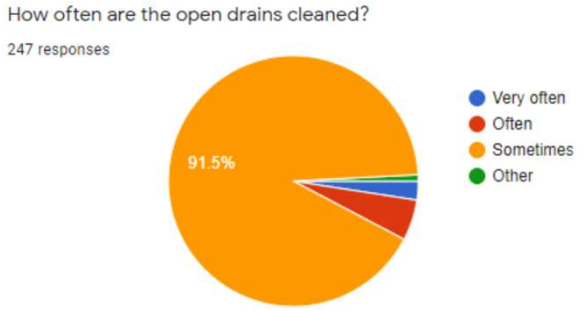

Figure 44. Survey questionnaire response

The maintenance of any exiting structure is as important as proposing it. Here, the existing drains itself aren't properly maintained or cleaned. As per the survey conducted, around 91.5% population answers that drains are cleaned only sometimes and not often.

POSSIBLE TYPES OF WASTES FROM DRAINAGE

Figure 45. Photographs of a drain and waste dumped sites of East Kallai

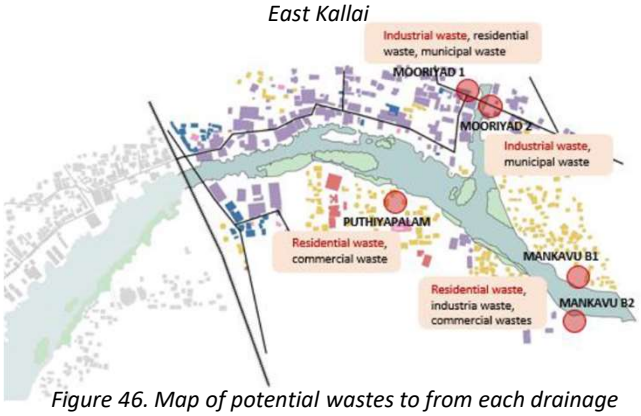

Figure 46. Map of potential wastes to from each drainage

Five major outlets of drains that flow into Kallai river was identified.

Around 89.9% of the population commend that they do not have a developed drainage network and the ones they have are cleaned only sometimes insists around 91.5% of the population, according to the survey conducted.

The major source of waste generation for all these five points were sited.

Figure 47. Photographs of a drains and waste dumped sites of East Kallai

FINDINGS/ ANALYSIS &INFERENCE

AIR QUALITY MEASUREMENTS OF KALLAI

All pollutions occurring in the environment is in the form of a loop that if any one entity is polluted, all the other entities also get polluted as a result in one form or another. This cycle exists in nature. Thus, the polluted drains, water and the open waste dumping is sure to cause atmospheric pollution in the neighbourhood.

The values of particulate matter concentrations of Kozhikode City was obtained from the Central Pollution Control Board database. The parameters considered were PM2.5, PM10, S02, NO2. The monitoring systems shows an average value of PM10 concentration to be severe on a maximum range, while otherwise the net atmospheric pollution level seems to be in the 'Good' scale. The air quality measurements obtained have been tabulated below:

AREA	SUBSTANCE	MINIMUM (24 hourly average)	MAXIMUM (24 hourly average)	ANNUAL AVERAGE
Kozhikode city	**PM2.5** concentration in micrograms per cubic meter	2	13	7
	PM10 concentration in micrograms per cubic meter	20	501	61
	SO2 concentration in micrograms per cubic meter	2	2	2
	NO2 concentration in micrograms per cubic meter	5	29	11

Figure 48. Air quality measurements

- Severe
- Satisfactory
- Good

Since, the measurements showed a slight peak in concentrations of PM10, the impacts of its higher content on human health, environment and others were studied and tabulated.

POLLUTANT	IMPACT		
	Health	*Environment*	*Material Damage*
PM 10	Exposure to such particles can affect both your lungs and your heart. Numerous scientific studies have linked particle pollution exposure to a variety of problems, including: premature death in people with heart or lung disease, nonfatal heart attacks, irregular heartbeat, aggravated asthma, decreased lung function, increased respiratory symptoms, such as irritation of the airways, coughing or difficulty breathing	Particles can be carried over long distances by wind and then settle on ground or water. Depending on their chemical composition, the effects of this settling may include: making lakes and streams acidic, changing the nutrient balance in coastal waters and large river basins, depleting the nutrients in soil, damaging sensitive forests and farm crops, affecting the diversity of ecosystems, contributing to acid rain effects.	PM 10 can stain and damage stone and other materials, including culturally important objects such as statues and monuments. Some of these effects are related to acid rain effects on materials.

Figure 49. Impacts of PM10

WATER QUALITY TESTING

- Water quality testing for Kallai river was made by identifying three spots of uniform distance from each other.
- The first spot selected was Kallai, the area which falls under Kallai bridge as this region experiences most footfall during daytime in Kallai. Also, the area below the bridge has heaps of waste dumped near the riverbanks.
- The second spot, Mooriyad was selected as this is the region where the highly polluted Canoli Canal meets Kallai River.
- The third point, Mankavu, again falls below the Mankavu bridge and is next to the region where Chaliyar river meets Kallai river.

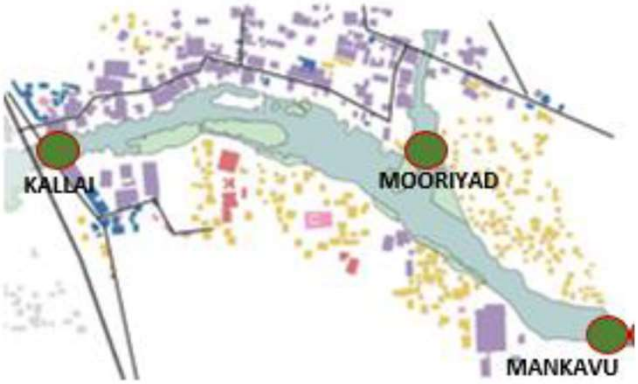

Figure 50. Locations accessed for water quality testing

Figure 51. Photographs of points of water quality sampling – a) Kallai , b) Mooriyad c) Mankavu (from left to right)

WATER QUALITY TEST RESULTS AND COMPARISON WITH IS 10500:2012

- The water quality testing was done for all physical, chemical and microbiological parameters for all the three locations.
- These values were then compared with IS 10500:2012 to analyse whether the obtained values were within the permissible limits or not.
- Based on comparison of results, it could be found out that most of the parameters were highly above permissible limits for Mooriyad region, followed by Kallai and then Manakavu, as plotted in Table 4.

PARAMETERS	REQUIREMENT (acceptable limit)	MOORIYAD	MANKAVU	KALLAI
pH	6.5-8.5	7.01	7.3	7.1
Temperature		25°C	25.2°C	25.1°C
Turbidity	5 NTU	8.5	5.1	6.3
Salinity		30.44		
Total akalinity	600 mg/l	162	132	151
TDS	500 mg/l	29645	25432	30812
Total hardness	600 mg/l	5720	2780	3191
Calicum hardness	600 mg/l	709	326	428
Chloride	1000 mg/l	16850	12003	10200
Nitrate	45 mg/l	2.2	1.8	2.5
Sulphate	400 mg/l	775	631	762
Potassium	10 mg/l	0.04	0.03	0.04
Calcium	200 mg/l	976	484	683
Fluoride	1.5 mg/l	0.09	0.05	0.07
Carbon-dioxode		25	20	21.8
BOD	3 mg/l	13.33	9.6	11.8
COD	5 mg/l	35	28	31.3
Iron	0.3 mg/l	0.16	0.12	0.18
Cadmium	0.005 mg/l	0.16	0.11	0.15
Nickel	0.02 mg/l	0.89	0.78	0.62
Lead	0.01 mg/l	0.5	0.38	0.49
Manganese	0.3 mg/l	0.31	0.27	0.3
Zinc	5 mg/l	0.29	0.21	0.27
Total Coliform	5000MPN/100ml	3280	2376	2970
Total faecal coliform	2500MPN/100ml	2740	1987	2331
Total E.coli count	No relaxation	2348	1863	2119

- Within permissible limits
- Highly above permissible limits
- Above permissible limits
- Just above permissible limits

Figure 52. Water Quality Test results of Mooriyad, Manakvu and Kallai

- A water quality result compilation of previous five years from 2017-2021 were made. June month of these years were later picked out to plot out graphs for inferences.

WATER ANAYSIS DATA OF THE NWMP STATION AT KALLAYI RIVER FOR THE YEAR 2017

MONTHS	PH	BOD (mg/L)	COD (mg/L)	NITRATE (mg/L)	TOTAL COLIFORM (MPN/100ml)	TDS (mg/L)
Jan	7	1	16	0.22	1950	23600
Feb	7	1.5	32	0.04	2200	23300
Mar	7.3	1	16	BDL	2000	31600
Apr	7	0.8	8	0.31	2600	25500
May	7.6	BDL	16	0.64	2600	29500
Jun	7.1	0.73	16	0.01	1200	5150
Jul	7.2	1.7	32	0.39	800	9325
Aug	7.6	0.7	8	0.018	60	23450
Sep	7.5	1.8	32	0.52	700	5920
Oct	8	1.9	32	0.19	210	23800
Nov	7.3	BDL	BDL	0.39	900	28600
Dec	7.2	1.1	32	0.412	6200	31980

WATER ANAYSIS DATA OF THE NWMP STATION AT KALLAYI RIVER FOR THE YEAR 2018

MONTHS	PH	BOD (mg/L)	COD (mg/L)	NITRATE (mg/L)	TOTAL COLIFORM (MPN/100ml)	TDS (mg/L)
Jan	7	2.4	32	0.375	6300	28700
Feb	8	1.2	32	0.5	4300	27500
Mar	6.8	1.2	16	1.1	2200	24800
Apr	7.5	1.4	32	1.3	2000	24225
May	7.8	4.9	32	0.76	400	21260
Jun	8.6	5.67	32	0.07	800	24830
Jul	7.5	1	16	BDL	900	421
Aug	7	1.98	16	0.57	70	6370
Sep	8	2.8	16	0.2	170	11700
Oct	7.9	1	16	0.44	210	1590
Nov	7.17	4.5	12	0.2	14000	12500
Dec	7.68	0.6	16	0.36	5200	31000

WATER ANAYSIS DATA OF THE NWMP STATION AT KALLAYI RIVER FOR THE YEAR 2019						
MONTHS	PH	BOD (mg/L)	COD (mg/L)	NITRATE (mg/L)	TOTAL COLIFORM (MPN/100ml)	TDS (mg/L)
Jan	7.21	3.5	32	0.5	5500	28900
Feb	7.35	2.4	24	0.47	5000	32921
Mar	7.95	1	14.4	0.2	6300	33650
Apr	7.3	3.3	16	0.26	15000	29690
May	7.3	3.4	24	0.11	10000	29500
Jun	6.9	6.76	12	0.28	8600	29000
Jul	6.45	BDL	7	0.364	9600	395
Aug	7.16	4.73	8	0.415	17000	186
Sep	7.48	1.9	12	1.25	6500	2000
Oct	8.89	4.06	16	0.285	6500	11700
Nov	7.21	3.5	32	0.5	5500	28900
Dec	7.62	1.6	32	4.9	9000	22900

WATER ANAYSIS DATA OF THE NWMP STATION AT KALLAYI RIVER FOR THE YEAR 2020						
MONTHS	PH	BOD (mg/L)	COD (mg/L)	NITRATE (mg/L)	TOTAL COLIFORM (MPN/100ml)	TDS (mg/L)
Jan	7.4	0.6	18	4	10000	28100
Feb	7.52	2.13	18	0.586	28000	18500
Mar	0.43	4.34	16	0.8	8500	24500
Apr	7.98	6.54	18	0.9	4000	30000
May	7.3	7.68	17	0.11	3960	29500
Jun	7.1	9.88	21	0.19	3800	29600

WATER ANAYSIS DATA OF THE NWMP STATION AT KALLAYI RIVER FOR THE YEAR 2021						
MONTHS	PH	BOD (mg/L)	COD (mg/L)	NITRATE (mg/L)	TOTAL COLIFORM (MPN/100ml)	TDS (mg/L)
Jun	7.01	13.33	35	2.2	3280	29645

- Water quality test results of four previous years were collected from the State Pollution Control Board, Kozhikode for a comparative study and understanding.
- Test results for three years from 2017-2019 of all months were obtained.
- The pH levels during all years were more or less the same value 7.
- The BOD and COD levels during 2017 had thrice hit below desired levels whereas after 2018 it has seen a massive leap in the coming years.
- Nitrate levels have seen a major hike in 2019 and above years.
- The total coliform count also witnessed a massive leap in few particular months of 2019 and 2020.
- The TDS levels were comparatively lower in 2017 as compared to other years where it remained almost static.
- In 2021, only the month of June was taken as a part of primary readings.
- Hence, the values of few important parameters of month of June for all years 2017-2021 were taken for further inferences.

COMPARISON OF PARAMETERS, JUNE 2017-2021

A further analysis of month of June for five years from 2017-2021 were plotted and inferences were drawn on the fluctuation in the readings and results. It was noticed that the Coliform count, BOD and COD levels have shown uneven increase and decrease through the years as a result of sudden discharge of effluents during floods and increase in organic pollutants.

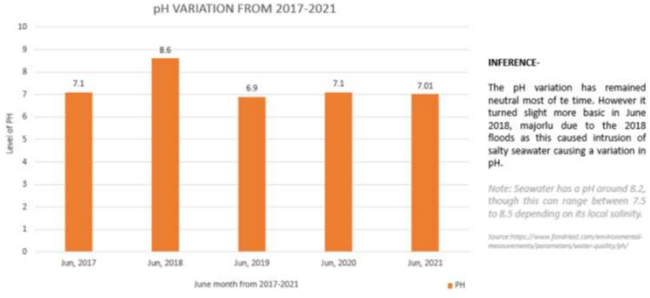

Figure 53. Graph showing pH variation from 2017-2021

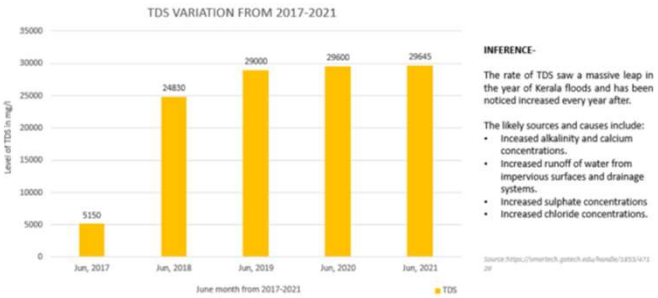

Figure 53. Graphs showing TDS variation from 2017-2021

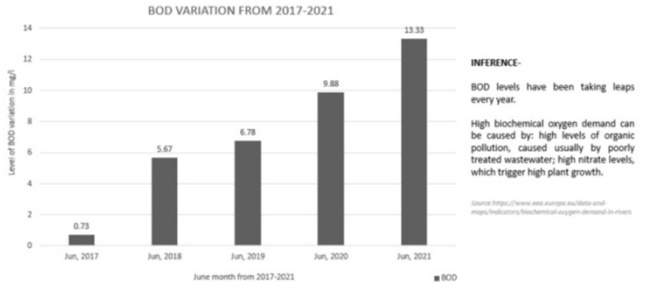

Figure 54. Graph showing BOD variation from 2017-2021

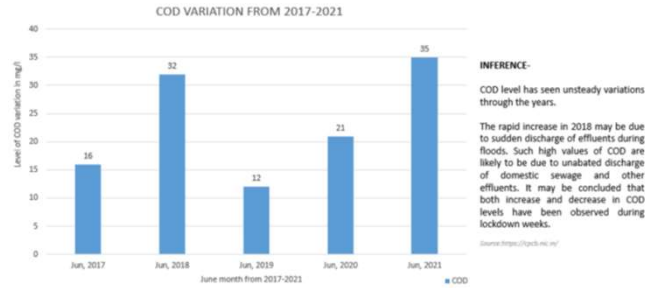

Figure 55. Graph showing COD variation from 2017-2021

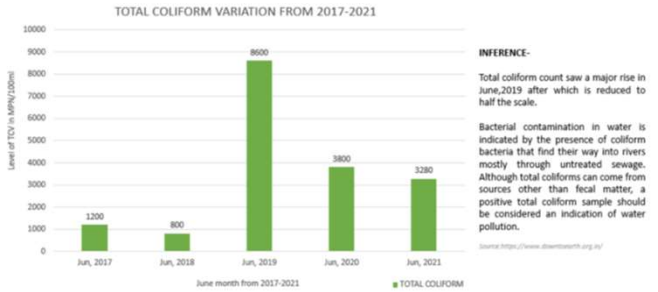

Figure 56. Graph showing Total colifrom variation from 2017-2021

INFERENCES ON EACH PARAMETER

PARAMETERS	RATE OF INCREASE (based on IS 10500:2012)	INFERENCE
Calcium , Magnesium	Total hardness is 9 times greater than prescribed level	Higher presence than standard limit means hardness of water is more and is unfit for domestic purposes.
COD	5 times higher than prescribed limit	Shows presence of organic and inorganic contaminant present in water (waste water).
TDS	60 times higher	Imparts unusual taste to the water, hence indicates this water sample is not potable.
Sulphate	2 times increase	Indicates the presence of corrosive content and contaminants in water sample.

Figure 57. Inferences on each parameter

Nitrate	Lesser than prescribed level	Absence of eutrophication or massive growth of algae in water body. Lesser content may be as agricultural activities (use of fertilisers) does not happened in the nearby surroundings and does not produce any form of nitrate contents in higher levels
BOD	4 times higher	Higher BOD indicates more oxygen is required, which is less for oxygen-demanding species to feed on and signifies lower water quality.
Chloride	17 times higher	Indicates presence of harmful substances in water. Choride increases the electrical conductivity of water and thus increases its corrosivity.
Total faecal coliform count	2 times higher	Indicates improper sanitation facilities and management in the study area.
Total E.coli count	2348 MPN/100ml	Higher presence signifies inadequate maintenance of water sources and the discharge of untreated sewage to the river.

COMPARISON OF PARAMETERS, JUNE 2017-2021

PARAMETERS	REMARKS	HEALTH IMPACT ON PEOPLE		IMPACTS ON AQUATIC LIFE	IMPACTS ON ENVIRONMENT	OTHER IMPACTS
		immediate effects	*on long term exposure*			
TDS	High levels of TDS reduce water quality which contributes to a decrease in phtosynthesis and lead to an increase in water temperature.	nausea, lung irritation, rashes, vomiting, dizziness etc.	expose body to various chemicals, toxins and may cause chronic health conditions like cancer, liver and kidney problems	affect aquatic life, the salts act to dehydrate the skin of animals which can be fatal		
Turbidity	water sample with higher turbidity harbours microbial pathogens, indicates an ingress of contaminants			affects growth of algae (micro-aquatic plants) and other aqautic plants because increased turibidity causes a decrease in the amount of light for photosynthesis, harms habitat areas for fish and other aquatic life	Increase water temperature because suspended particles absorb more heat.	can increase sedimetation and siltation
Total hardness	high in dissolved minerals (calicum, magnesium)	exacerbate eczema (a condition when skin turns red and itchy)	Can be accomanied by astma or hay fever, atopic dermatitis in children	Many fish can only thrive in certain levels of water hardness, and if the levels are outside acceptable parameters, it can cause stress and death.		reduces life of equipments, raise cost of heating wate, lowers efficiency of electric water heaters, clog pipes
Sulphate		high risk of dehydration from diarrhoea due to high levels of sulphate		.	Sulfates contribute to acidification of surface water and soil, and contribute to acid rain and fog that damage ecosystems, forests and plants.	corrode piping and plumbing materials. Hence, plastic pipes are seen widely used here.
Carbon dioxide		headaches, dizziness, restlessness, a tinging or needles feeling, difficulty breathing, sweating, tiredness, increased heart rate, elevated blood pressure	coma, asphyxia (a condition deprived of oxygen and causes suffocation) and convulsions			
BOD	a condition of low dissolved oxygen, imprtant wastewater quality parameter as they are used to measure the efficiency of most wastewater treatment facilities			aquatic organisms get stressed due to low oxygen levels, suffocate and die, harm aqautic life especially fish		
COD	imprtant wastewater quality parameter as they are used to measure the efficiency of most wastewater treatment facilities	waterborne diseases for humans		harm aqautic life especially fish		
Cadmium		disturbances in calcium metabolism, hyper-calciuria and formation of kidney stones	lung cancer, bone diseases, prostate cancer, fu-like symptoms and damage lungs	Fish, plants and animals uptake cadmium from the environment-through food, waer and breathing.	Animals given cadmium in food or water develop high blood pressure, iron-poor blood, liver disease and berve/brain damage	
Nickel		allergy, cardio-vascular and kidney diseases	lung fibrosis, lung and nasal cancer	toxic to freshwater organisms		When ingested through water, in small amounts, it is harmless to humans and in fact necessary in our diet. Inhalation of nickel is the greatest risk of developing health problems, as it becomes highly carcinogenic
Lead		cardiovascular effects, increased blood pressure, incidence of hypertension, decreased kidney functioning, reproductive problems in men and women	causes problems in brain development, causes damage to nervous system in both adults and children	detrimental effects, chronic lead exposure can be so lethal that metamorphosis, neaurology and other developmental progressions will be inhibited in aqautic organisms.	Lead released into the environment makes its way into the air, soils, and water. Lead can remain in the environment as dust indefinitely. The lead in fuels contribute to air pollution, especially in urban areas.	
Total faecal coliform	Untreated faecal matter, that is faecal coli adds excess organic material to the water. The decay of this material depletes water of oxygen. Can be treated by boiling of water, chlorine treatment or other disinfectant chemicals.	typhoid fever, gastroenteritis, dysentry	hepatitis, ear infections	The lowered oxygen levels, kill fish and other aqautic life.		risk of contracting a water-borne illness is increased, total coliforms can come from sources other than fecal matter, a positive total coliform sample should be considered an indication of pollution in your well.

Figure 58. Impacts of each parameter on social, environmental and economical scales

RECOMMENDATIONS

1. Solutions at root level-

•Proper waste disposal measures for each sector,
•Proper drainage system,
•Stopping of encroachment activities by the riparian zones,
•Abiding the CRZ rules,
•Alternate measures for seasoning of wood,
•Stopping of waste disposal directly to river/ at riverbanks.
•Community unity and willingness starting from every household on curbing polluting activities,
•Awareness among public for all age groups about the drivers, state, and the impacts.

2. Recommendations for regulating pollution-

•A holistic approach for all ecosystems to live.
•Cleaner, healthier, and safer environment.
•Improving the social life and culture of people.
•Improving the economic scenario by
- ❑ Improving options of Sustainable tourism,
- ❑ Boating and Fishing as part of tourism,
- ❑ Promoting Kallai cuisine,
- ❑ Café and restaurants,
- ❑ Other small scale business enterprises

•Improving the environmental scenario of the area on a whole scale.
•Regulating all hindrances that flow into Kallai river by options like introduction of sluice gate.
•Achieving a social, economic, environment friendly neighbourhood with Kallai river getting back to the glory it once had.

3. For Industrial sector –

•The problem of glue waste disposal can be resolved by retaining used water in settling tanks where solid sediments are removed.
•Wastewater from pulp and paper industries are also retained in treatment ponds for a period of time to ensure the decomposition of chemical residues before it is linked into the main river.
• The dust and particulate emission during industrial wood processing can be collected in bag filters, cyclone collectors and wet scrubbers.
•Noise abatement could also be carried out by installing noise damping enclosure around the machine.

4. Stakeholders-

Stakeholders are the key holders of any society. Empowering people by getting stakeholders involved in the decision-making process can help create a sustainable change with long-term benefits.
•Waste management workers like the Kudumbashree/municipality workers have to be made sure of timely pickup with proper segregation of wastes from residential, commercial, industrial and institutional sectors.
•The community should work in unity for abating pollution drivers in the area for the betterment of the neighbourhood.
•LSG must make sure on the practical implications of CRZ rules being followed in the area and bring out measures to stop encroachment activities. Political leaders also play a huge role.
•The media can play a huge role in creating an overall awareness on the issue and its impacts far and near.

CONCLUSION

It is noted that few parameters like the 5-fold increase in lead content and 60 fold increase of TDS levels in comparison with IS 10500:2012, identified in the Kallai river are carcinogenic and could prove fatal to health.
• About 75 percent of all the parameters analysed dangerously affect the aquatic flora and fauna and also causes problems for the soil and air concerning it.
• The faecal coliform count which is twice the amount higher than that specified in 1S 10500:2012 within the water suggests a high time for a well-developed drainage system that lets out treated water only into the river body.
• The health of elderly and children are the most easily affected in most of the cases of high fold rise of certain parameters.
• The pollutants have caused water pollution and in turn cause air pollution, soil pollution, ground water pollution etc. as they are all interconnected as a loop.
• The total BOD load from all the major drainage sources to the river is 18,974.82 kg/day, which includes the untreated municipal sewage.
The wastewater quantity from the community including the residential, industrial, commercial, public and semi-public sectors totals as 52,477.5 litres/day which is calculated as 90% of consumed water as being let out as wastewater.
•The annual storm water that runs directly to the river 422159.61-meter cube annually as there are no potential storm water harvesting systems within the community currently.
•The solid waste generation per day within the community inclusive of all the sectors adds up to 1412.8 kg/day in which 60% is picked up by Kudumbashree and the rest 40% disposal is not properly done.
•Most of the parameters prove to be of negative effect on social, environmental, or economical scales in the neighbourhood.
•Recommendations at the grass root level, awareness and unity among the residents are key tools to combating the current situation at Kallai. Adhering to these, can improve the current state and create better impacts.

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IN TROUBLED WATERS: UNRAVELING CHALLENGES IN CONSERVATION OF INDIA'S SHIP BUILDING HERITAGE - A CASE STUDY OF MANDVI

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ABSTRACT

Ships have been catalysts, facilitating trade and commerce, livelihood and more since prehistory and Indians have been avid ship builders since then. From boats made in reed to substantial timber counterparts, India's ship building heritage has linked the nation to diverse sea routes globally. The tradition of handcrafting large oceangoing vessels in timber has continued since then. Many of these practices are closely intertwined with the waterbody nearby for its construction. Increasing water pollution and other physical and social changes have led to a drastic decline in the ship building heritage. Such is the case with Mandvi. The changing course of the Rukmavati River, ever increasing water pollution and lack of awareness among the citizens are some of the issues among many that are directly hampering the ship building craft. The craft that used to be passed on from generation to generation now struggles to survive till the next generation. This paper aims to investigate the challenges that affect the ship building heritage with reference to Mandvi, a town on the Western Coast of India practicing the craft for generations while also examining the possible interventions to sustain this heritage.

KEYWORDS

Ship building, water pollution, Mandvi, handicraft

INTRODUCTION

India's shipbuilding legacy

With a history of more than five thousand years India is a mosaic of customs, rituals, traditions, culture and wisdom transmitted from generation to generation. Having a long coastline of 7800kms, India has been a maritime country. Strategically located within the Indian Ocean, its water has played a pivotal role in its ascent as the hub of global trade and commerce. Strong archaeological evidence illustrates India's trade connections worldwide from as early as 3300BCE. Navigating these distant waters would only have been possible through an extensive knowledge of the surrounding environment. Archaeological excavations at Lothal, Gujarat in 1955 talk about the existence of a dock and its allied activities from the Indus Valley Civilisation. Seals depicting a reed boat give an insight into the long-lasting ship building tradition. The Sumerian as well as Vedic texts refer to a hundred oared ship indicating the existence of sea borne travel and knowledge of ship construction techniques that the Indians possessed. Verses in these texts specifically emphasize sea knowledge referring to ships crossing the 'samudra'. Ancient Tamil literature additionally mentions maritime linkages between India and Rome. Archaeological remains of catamarans and dugout canoes found at Muziris are evidence of the trade links. The Chola kings that ruled Southern India around the 3rd century AD are said to have indigenously built mega-sized oceanic vessels for sea battles that won them Southeast Asia. Due to its strategic geographical location, extensive coastline conducive to trade and the availability of inexpensive labour, India emerged as a fulcrum for constructing traditional timber vessels. Several Arab merchants settled on the Western Coast of India in the 7th century and introduced new techniques in timber ship construction. With the increasing demand, more people engaged in ship building and its allied activities. Dynasties began encouraging shipbuilding and revised rules and regulations for its prosperity. Communities began to be acknowledged for their strength and expertise in building and repairing wooden vessels. Under the reign of Chatrapati Shivaji Maharaj, the Marathas strategically positioned the shipbuilding and ship repair yards away from the tidal waters. Upon the Portuguese arrival in India, they identified the abundance of high-quality timber and effective construction as factors contributing to the longevity of Indian ships. They established numerous shipbuilding yards along the Indian coast under the monarchy and declared Indian wood as a 'luxury'. As the British Empire established its presence in India, they tasked the English East India Company with exploring the country's whereabouts. The Company initially established their base in Surat and gradually spread across the country. Several ship building yards were set up along the coast and the outputs were more durable than their English counterparts. As traders continued to use Indian-made ships to trade goods to England, the European shipbuilders protested. As maritime trade rules and regulations evolved and the need for piracy protection increased, European and Indian merchants increasingly preferred European made vessels over the ones crafted in India. Unfortunately, the craft faced neglect during the later years of colonial rule in India, subsequently leading to its decline. Despite being of a superior

quality, Indian goods were unfairly labeled as inferior contributing to this perception. Additionally, the rise of steam and steel further diminished the significance of these handcrafted vessels leading to a gradual decline in their production. Despite this, owing to the demand from Middle East countries, the town of Mandvi continues to practice the traditional craft of ship building. Mandvi, is a strategically important town, located on the banks of river Rukamati in Kutch, Gujarat. Historically it has been a town of boat makers, fishermen and merchants due to its location on the trade routes that connected Africa, the Gulfs & Makran Coast.

MANDVI'S SHIP BUILDING HERITAGE

Figure 1. Map of Kutch showing Mandvi (Source - https://kutchadsense.com/about-kutch/)

The port town of Mandvi began to emerge as a mix of cosmopolitan and traditional urban settlement from the 16th century. It was during the time of Rao Godji (1760-1778 that Mandvi saw a rise as a port town and emerged as one of the major centres of Kutch. Ramsingh Malam was an adventurer who frequently traveled to Europe and accidentally visited Bhuj. He was a man of great nautical knowledge and settled with King Rao Lakhpat (1741-1760). He imparted knowledge to the local craftsmen for which the craftsmen are known even today. Rao Godji, his successor, was an encouraging ruler and uplifted the traders and seamen. He set up the ship building

Figure 2 Mandvi along the Rukmavati river (Source - Google Earth)

industry at Mandvi and created a dockyard. It was during this time that a vessel constructed at Mandvi and commanded by the local Kutchis sailed safely to England and back. The ship building skill had developed to an extent that a shipyard to anchor and repair 400 vessels was established by the merchants during the reign of Rao Godji. Mandvi came to be known as a town of merchants and not rulers. However, today the town that once constructed more than 30 ships a year now produces only 2-3 a year. The inconspicuous town and its ship building legacy lies unrecognised.

AIM

This paper aims to examine the challenges faced by India's traditional craft of timber-made ships and to explore probable interventions aimed at revitalising this heritage amidst contemporary challenges.

RESEARCH METHODOLOGY

A multifaceted approach was adopted to undertake this research. Majority of the research is based on site visits to Mandvi to observe, interact and comprehend the ship building craft and the challenges faced by the carpenters. Interaction with the skilled shipbuilders provided insights into the traditional techniques used and the evolving nature of the craft. Further, primary data was procured from several documents including the state gazetteer to garner historical perspectives on the ever-evolving heritage. This combination of onsite interaction and literature review facilitated a comprehensive understanding of the cultural economic and environmental challenges faced by the shipbuilding community.

FINDINGS

Mandvi has been producing kotias, padaos, navris and batelas transcending the vast expanse of the Indian Ocean. The artistry of crafting these vessels has been transmitted intergenerationally through an oral tradition. The progeny frequently visits the shipyard imbibing knowledge under the wings of seasoned family members, thereby receiving education within the confines of the workshop. It is evident that no educational institute in the world can rival the hands-on experience provided by preceding generations to their successors. Within the workshop, skills are acquired from the rudimentary stages, in direct correlation with real things and problems primarily through personal engagement on site. The ethos of the craft is ingrained in these carpenters making it distinctive and augmented in value. Boat building is considered as a highly specialised and vocational pursuit by the locals and is often colloquially referred to as 'bada kaam' denoting work on a grander scale than mere carpentry. The construction techniques exhibit pronounced indigenous character, with the vessels taking shape along the silted land abutting the banks of Rukhmavati river. There are no formal yards, and a makeshift arrangement is made instead. After the vessel's completion, the terrain beneath the vessel is dug out employing minimal or no mechanization. The process of flagging off the vessel is done prior to poornima after which the water level rises, and the boat can smoothly be towed out.

Method of construction

At the onset, the head carpenter conducts a comprehensive examination of the specifications with the clientele. Majority of the clients are from Middle East countries like Qatar. Based on the requirements, a detailed schematic of the design is meticulously prepared which is followed by construction of a scaled down prototype model. The miniature model serves as a pragmatic tool for assessing feasibility and capacity. The design is so well ingrained in their heads that they do not necessarily require drawings while construction and the intricate details are effortlessly envisioned and executed.

Figure 3. Rukhmavati river coast before and after flag off (Source - Google Earth)

Building the structure

The first component or the foundational structure is the keel. Subsequently a framework takes shape utilising large planks or '*vakia*' that are gently bent over fire and meticulously chiseled into shape and fixed cohesively. All these techniques are indigenous and in situ. These wooden pieces are fixed together using nuts and bolts. The boat makers handle wood like clay, manipulating it in accordance with the envisioned design. The spectacle of craftsmen engrossed in their work with sheer precision and skill is nothing short of captivating. Horizontal planks are fixed on the frame to create a deck of the boat. In response to the buyer's specifications, cabins are assembled. The '*patia*' or the third layer comprises of the external surface of the vessel and is seamlessly fitted into the '*vakia*'. The intersections between these wooden planks are then filled with a specialised sealant crafted from cotton dipped in palm oil colloquially known as '*raal*' or '*chandrus*'. The cotton is made in the form of a rope and inserted. Initially, fish oil was reported to have been employed before transitioning to palm or vegetable oil as recounted by the artisans on site. The last layer involves two to three coats of anti-fouling paint bestowing upon the vessel's external façade a dazzling aesthetic. The boats-built exhibit remarkable stability standing as formidable contenders against their counterparts.

Challenges faced.

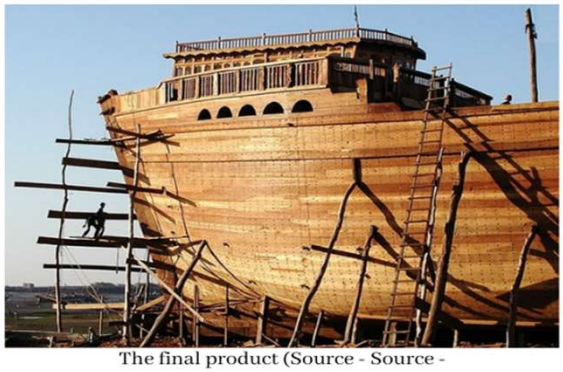
Today, in the contemporary era, owing to the rapid technological advancements and material innovation, the intangible heritage of traditional shipbuilding is

Laying the keel (Source - Amlanjyoti Bora)

Building the frame of the ship (Source - Author)

Laying the 'Vakia' (Source - Author)

The deck of the ship (Source - Author)



The final product (Source - Source - https://www.trawell.in/gujarat/mandvi/shipbuilding-yard)

Figure 4. Process of Ship Building

gradually waning. Globalisation presents formidable challenges to the preservation of age-old ship construction practices. Years ago, approximately 20 boats were crafted but today, this number has dwindled to 2-3 with the primary demand coming from Saudi Arabian countries. Escalating water pollution in the oceans has shortened the lifespan of vessels causing concern among the artisans. A large portion of the Rukmavati river has dried up due limiting the space available. The shift from wooden nails to metal ones that easily rust has increased the maintenance cost of the craft.

The absence of government schemes and incentives towards the benefit of craft involved communities is a pivotal concern. The urban shift of the younger generation in search of better paying jobs in factories or service industries has also contributed to the decline. Many of the craftsmen refuse to share the knowledge to anyone but their family members on the pretext of safeguarding their family pride. Registration of the vessel involved complicated bureaucratic practices making it tedious and time-consuming for the purchaser who then looks for an alternative. Sadly, due to lack of government involvement to boost the trade, many craftsmen have relocated from India to Saudi Arabia and the transition in demand of wooden boats to boats made in steel has lessened the demand for these boats.

Ship building heritage is a mix of oral traditions being passed on from generations without documentation and is a part of traditional handicraft. The fundamental materials involved in the craft persist and are environmentally friendly as compared to the industries of similar scale. Moreover, these handcrafted vessels are cost effective, exuding a regal aura that captivates observers. These ships are massive and the talent of making it by hand is something that needs to be preserved. The craft has evolved through the exchange of techniques, self-examination, and practice. While it initially began for survival including trade and fishing, the vessels developed to become part of the economic growth and naval warfare and are now considered as a status symbol for many.

POSSIBLE INTERVENTIONS

Given the intrinsic values associated with India's shipbuilding heritage, it is imperative to preserve it for subsequent generations. Establishing a custodial body dedicated to its development can contribute significantly to its enhancement. The government, in exploring avenues to promote the industry, can attract more patrons ensuring its sustained growth. These communities have played a crucial role in the upliftment and maintenance of this craft and need to be taken into consideration and consultation towards the enhancement of the heritage. Comprehensive documentation and widespread awareness through interactive programs and workshops with craftsmen or by setting up a museum can play a pivotal role in its protection. Initiatives such as accommodation onboard wooden vessels, provision of a restaurant in between the water, offering rented tours for weddings and other events and facilitating tours into the shipbuilding craft industry can effectively contribute to the financial sustenance and international visibility of the craft. Tourism not only confers recognition but also creates numerous employment opportunities. Integrating the craft into an annual festival can provide livelihood for the community and give an insight into the skillful communities.

Furthermore, the nation can extend initiatives in tourism, culture, sustainable development and more to its neighbors thereby fostering collaborations on a multilateral scale. Utilising its strategic position, India can spearhead projects aligned with the vision of the Security and Growth for All in the Region (SAGAR) initiative. As a participant of various international forums like Indian Ocean Rim Association (IORA), and the Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation (BIMSTEC), India can leverage these platforms to promote sustainable development and tourism.

Many of the recent projects have lightly touched upon components for preserving the traditional ship building industry. Project Mausam by the Ministry of Culture emphasizes the dissemination of shared knowledge, traditions, technologies, and ideas along maritime routes. The Maritime India Vision 2030 recognises ship building as one of the significant economic value additions to the economy providing it a stretegic position in planning and execution. India's 'Sagarmala' initiative launched in 2015 for port led development has generated numerous job opportunities, thereby bolstering intercultural exchanges with its neighbors. Around 95% of India's merchandise trade traverses through seaports offering tremendous scope for shipbuilding under 'Make in India' and 'Make for the World' initiatives. The 'Aatmanirbhar shipping' initiative that aims to rejuvenate modern shipbuilding yards and traditional craftsmanship. Recognising the influence of neighboring countries on India's trade and shipbuilding heritage, collaborative efforts both financial and intellectual to revive these indigenous shipbuilding hubs across the Indian Ocean can establish a robust network. An active involvement of the government will subsequently encourage the younger generation to practice the craft and thereafter bring stability to the business. These communities can then join hands with the other locals to maintain their maritime lifeline, the Rukmavati river.

CONCLUSION

Examining the age-old artistry entailed in the construction of wooden vessels underscores the

critical need to conserve the craft for the future. Safeguarding these traditional skills not only fortifies the foundation of our cultural heritage but also facilitates its evolution to meet contemporary demands. It is imperative for the government and various institutions to collaborate and synergise efforts to harmonously revitalise facet of our culture from facing premature decline. As we navigate the complex waters of safeguarding traditional ship building, it becomes imperative to pr enduring legacy of this cultural practice in the face of modern challenges.

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REVITALIZING THE INDIGENOUS AGRO-AQUA SYSTEM OF KHAZAN LANDS, GOA: FOSTERING NATURE-CULTURE LINKAGE FOR SUSTAINABLE URBAN DEVELOPMENT

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ABSTRACT

Water has been an important element in several community practices where people hold strong association, thus creating strong belief systems that have enabled conserving the natural resource and contributing towards sustainable local development. Local water bodies have enabled these communities to earn a source of livelihood through practices that not only generate economic benefit but also help conserve the water ecosystem. The research aims to explore one such intricately designed practice that has potentially enabled the conservation of resources through a linkage between nature and cultural practices for fostering sustainability in urban environments. The study aims at analysing and revitalizing one such age-old technique that can be conserved in an urban setting, thus addressing water-related challenges in urban areas. It also aims to understand the historical relevance of the practice and its application in modern times. Through an interdisciplinary approach that will inculcate the insights from the study, the research seeks to propose actionable strategies through a framework that can be utilized for developing sustainable and resilient urban environments. The findings aim to contribute towards enhancing a holistic approach to urban development, revitalizing traditional ecological wisdom, and promoting the coexistence between nature, culture, and the urban landscape for a sustainable and water-efficient future.

KEYWORDS

Indigenous practices, water conservation, nature-culture linkage, urban design strategies

INTRODUCTION

In the era of rapid urbanization, indigenous agro-aqua practices have lost their effectiveness over time. Factors like urban sprawl, industrialization, commercialization along natural water bodies, encroachments, and several other consequences have endangered traditional age-old practices. Despite these factors, there are certain practices that have survived but are slowly on the verge of extinction. The linkage between the natural landscape and human culture has enabled the survival of practices in many areas where they have been tied up with community beliefs. This link is strengthened in the way the community adapts and expresses its cultural values through nature. The link further becomes visible through the intentional shaping of several human activities like agriculture, architecture, the local economy, etc. Urbanization has often had an impact on nature and cultural landscapes through habitat transformation, altering the landscapes, which has a negative impact on local ecosystems. This has led to several urban issues, like the loss of biodiversity, altered water systems, and the loss of natural and cultural heritage sites, leading to the loss of their historic significance and a change in land use patterns.

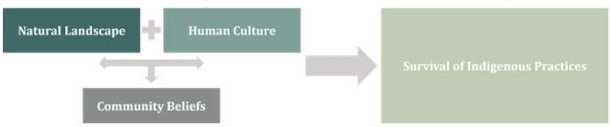

Figure 1 Nature-culture relationship and the role of community for the survival of Indigenous practices Source: Author

The regeneration and revitalization of these urban spaces have become an issue of concern that, through conservation initiatives and strategies, can be addressed and that needs to be shaped depending on the surrounding context and circumstances.

AIM/PURPOSE

The research aims to analyse the indigenous practice of Khazan land in Goa which is a fast-developing urban setting. It further seeks to formulate a methodology for deriving a framework to potentially revitalize the practice to achieve a sustainable and resilient urban environment by fostering the link between the natural landscape and the human culture of the place.

OBJECTIVES

1. Investigating the historical context and significance of Khazan Lands in Goa.
2. Understanding the relationship between the natural landscape and the human culture of the indigenous practice.
3. Analyzing the community belief system associated with the practice.
4. Assess the status and challenges faced by indigenous practices in rapidly developing urban environments.
5. Investigating its contribution towards:

Ecological balance
Livelihood generation
Sustainable urban development

RESEARCH METHODOLOGY

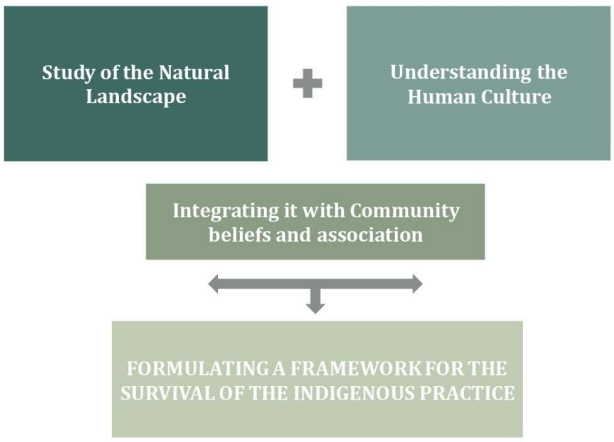

Figure 2. Research methodology (Source: Author)

Study of the Natural Landscape

a.Khazan lands in the western ghats
b.Khazan land and the terrain
c.Contribution towards maintaining the ecosystem

Understanding Human Culture

a.Traditional knowledge system of Khazan
b.Community engagement and beliefs
c.Its contribution towards local development, livelihood generation and contribution towards the local economy
d.Identifying the possible threats and vulnerabilities

RESEARCH METHODOLOGY

Khazan lands are intricately designed agro-aqua systems by the early coastal settlers. The Khazan lands, over a period have not only contributed to maintaining the ecological balance but have also contributed to the economic development of the state.

The Khazan lands can be termed as a nature-culture linkage that have achieved to create a socio-ecological balance through agricultural produce and estuarine fishing.

1.Study of the Natural Landscape:

a.Khazan lands in the western ghats:

Along the eastern stretch of the state across the Mhadei wildlife sanctuary, Khazan occupies approximately 600 sq. Mts. land passing through the Bhagwan Mahavir national park and wildlife sanctuary, and the Cotigao wildlife sanctuary, one of the strongest eco-systems of the western ghats.

The Khazan lands lie in Goa in the western ghats along 2 major rivers of the state which have enabled the formation of such a uniquely structured agro-aqua system.

b.Khazan land and the terrain:

The Khazan fields lie low along the basin of 2 major rivers in Goa, Mandovi and Zuari. Both rivers are part of relatively flat estuaries, which during high tide cause a rush of sea water, leading to salinity entering the river water in dry season. This in turn adds salinity to the streams and creeks.

Communities around these rivers reclaimed the low-lying brackish coastal floodplains and mangrove forest by constructing bunds using locally available materials to prevent the water from getting saline. To control the flow of Tidal water, they constructed openings.

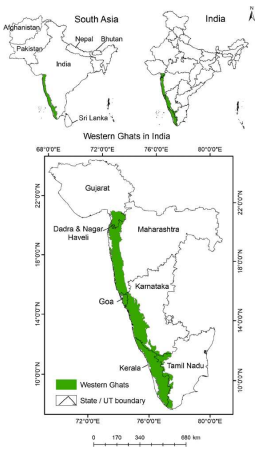

Figure. 3 Western ghats of India (Source: https://www.researchgate.net/figure/Location-map-of-Western-Ghats_fig1_292178919

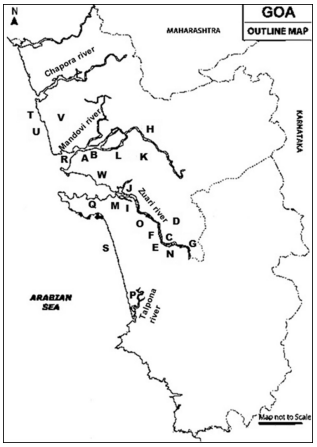

Figure. 4 Mandovi and Zuari river on Goa map Source: https://www.researchgate.net/figure/Map-of-Goa-showing-location-of-sampling-sites-Samples-were-collected-from-23-sites_fig1_324221586

Figure. 5 Khazan lands along the Mandovi river

Source: Google maps

c. Contribution towards maintaining the ecosystem:

The flat estuaries along the two major rivers of the state make it easier for the sea water to flow into the agricultural lands, thus increasing the salinity and reducing the productivity of the agricultural land. Construction of the Khazan systems protect these agricultural lands from the saline water entering during the high tide. The Khazan lands also have proved to be beneficial in protecting the harvest of the Kharif crop. The sluice gates are designed so that during monsoon, they flush out the water and the

Kharif crop harvest is protected.

2. Understanding the Human culture:

a. Traditional knowledge system of the Khazan:

As per oral tradition, these lands were reclaimed around 4000 years ago. The coastal settlers had to deal with the agricultural land being unproductive because of the flat estuaries which caused the saline water to enter these productive lands. The design of the Khazan system is an excellent example of the knowledge system created with the understanding of study related to the climate of the state, vegetation, topography and the coastal eco system.

The designed knowledge system of the Khazan lands is an integrated agro – aqua system that has contributed towards maintain the coastal ecology of the state. The uniquely designed estuarine agro practice is an age-old technique where the word Khazan is said to have been derived from the Portuguese word, Casana which means a big rice field. But as the setup of the Khazan system has been an age-old practice even before the invasion of the Portuguese rulers, the community believe that the name is derived from the local Goan language, Konkani. The derivation is believed to be from the word Kharsan meaning saltiness.

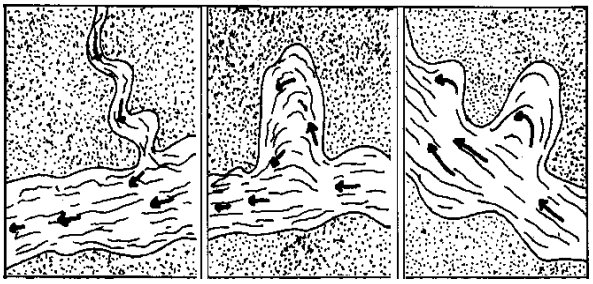

Figure. 6 Image showing the rush of sea water entering the estuaries during high tide. (Source: Biodiversity-in-the-Western-Ghats-An-information-kit)

The image shows the flow of water during high tide rushing through the flat estuaries. This causes increase in salinity of the river water which further through the streams and creeks enters the farmlands. To restrict the flow of saline water from entering the farmlands, outer embankments are created known as sluice gates which during high tide permit only the volume of water which enters the back waters and is stored. During Low tide the water is let out and the fish are trapped in a gillnet attached to the sluice gate.

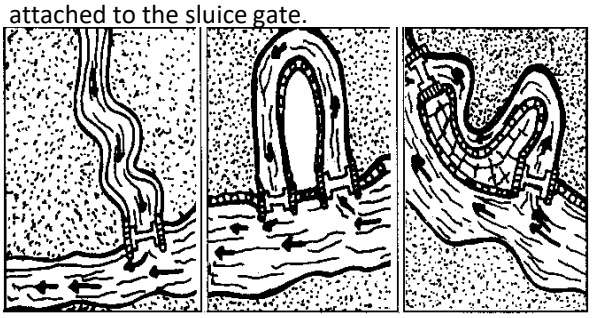

Figure. 7 Constructed sluice gates and bunds (Source: Biodiversity-in-the-Western-Ghats-An-information-kit)

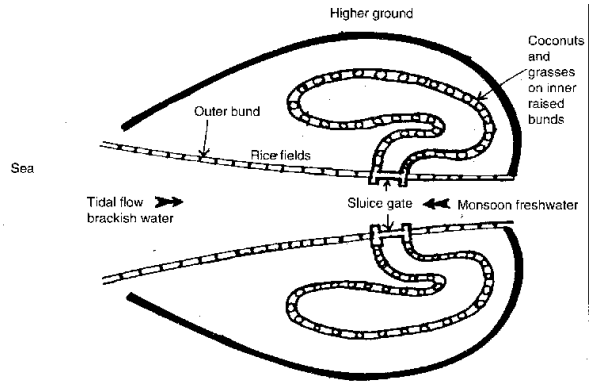

Figure. 8 Sluice gate detail (Source: Biodiversity-in-the-Western-Ghats-An-information-kit)

Sluice gates - The technology of sluice gates is a simple arrangement which function on the movement and pressure of the tides. The mechanism functions with the help of a bamboo pole that operates the sluice gates by restricting the flow of water during high tide. The saline water that enters the farmlands exposes these lands to increased salinity which affects the fertility thus reducing the productive value of the land. These gates also contribute towards regulating the fishing activity of the region where the local village communities traditionally manage the system to avoid overfishing during high tide. The region near these sluice gates is permitted to be used for farming which is to be practiced during low tide.

Figure. 9 Image showing constructed sluice gates and bunds (Source: https://www.teriin.org/article/goa-village-strives-protect-fast-vanishing-khazans)

Mud and Laterite Bunds- The sluice gates are supported with bund, which are a major part of the Khazan system. These bunds are economical and sustainable which are constructed using local eco-friendly material like mud and laterite stones. These bunds along with the sluice gates contribute to protecting the nearby farmlands from the saline water entering the lands during high tides. The construction of these bunds is done in a way where the inner walls, which take less pressure are made with mud and the outer walls taking more pressure of the tide flow is made with laterite blocks. Laterite block is a locally available material and harden when exposed to salt water. Laterite blocks also are a

favourable choice to be used for the construction of outer walls as it cannot get damage by "boring agents" like snails.

These bunds stretch about 2000 km in length. The farmlands are connected through cross drains and are made of laterite blocks which enables the circulation and drainage of water. An additional protective embankment are the mangroves that grow along these protective bunds.

b. Community engagement:

The year-old practice of Khazan Land has sustained even in the age of rapid urbanisation because of the active involvement of the community which functions as an organized body.

The Khazan system started as self-governing institutions (Gaukaris) which were granted by Royal Charters to high caste hindus (Brahman). In 1975, the task was transferred to Government supervised "Tenants Association".

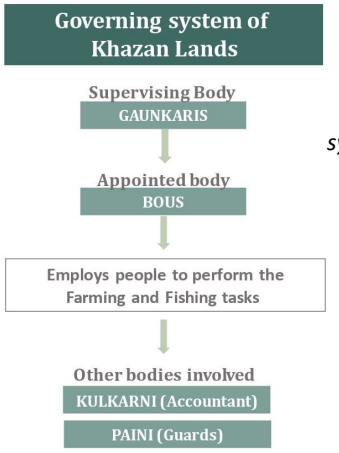

Figure. 9 Governing system of Khazan lands
Source: Author

The governing system of the Khazan land is an organized process where some patches are owned privately, and some are owned by comunidades. The governing system, in both cases have laid down certain code of conduct which have to be followed by all those involved in activities relating to the Khazan system. The code also encourages the local cultivators of the region to be a part to work together and maintain the ecological and economic balance of the region.

The systematic organization of community hierarchy starts with the "Gaunkari' at the top of the list that functions as the supervising body followed by the "Bous" - appointed body. The Bous employs people to perform the related task of farming and fishing. The system further involves important members like "Paini" - guards and the "Kulcarni" - accountant.

The system functions with active community participation and are strongly tied with community beliefs.

c. Its contribution towards local development, Livelihood generation and contribution towards local economy

Biological resources have always contributed towards sustainable local development. Structured agro-aqua systems of Khazan lands have enabled livelihood generation which has contributed towards the local economic development. The economic generation and livelihood generation is done through

•Agricultural produce
•Horticultural produce (Coconut, mango, cashew, vegetables, local fruits etc.)
•Organized semi-intensive fishing
•Backwater fisheries made possible through the flow control of high tide through sluice gates
•Production of crude salt.
•Recreational activities
•Organized tourism and related activities.

d. Identifying the possible threats and vulnerabilities:

• Urbanization: Major population of the state occupies the lands along the banks of the Mandovi - Zuari river. As the Khazan lands lie along these major rivers, the pressure of urban expansion has taken over these Khazan lands thus vandalizing the Khazan system with unorganized haphazard encroachment.

• Infrastructure development: Increased tourism in the state demands development of infrastructure. The urban expansion has resulted in the expansion of Goa's Road network which has severely damaged the Khazan drainage system over a period. The construction of the Mapusa highway as well as the Kadamba bus-stand in Panaji and the rapidly growing high-rise construction in Panaji has been done on reclaimed Khazan lands.

• Environmental degradation: Major deforestation which has taken place over the years for urban expansion in the river catchment areas has affected the setup of the Khazan system.

• Mining activities: Increased mining activities in Goa have caused the loss of soil thus depositing the silt load of the rivers. The sediments flowing along the river water result in reducing the productivity of the farmlands which has disrupted the Khazan system.

• Tourism: Rapidly growing tourism and unorganized development of facilities required for the same is a growing concern and a possible threat.

• Proliferating Prawn Culture: Fishing is permitted on Khazan lands only during low tide. The collection of water during high tide for fishing can increase the salinity of the farmlands thus damaging its productive value. But parcels of the Khazan lands are illegally taken over for shrimp farming as they yield high economic value. Over the years it has been reported that many of these lands have been sold for shrimp farming. The system now functions with false land-use certificates to practice pisciculture for high economic benefit. This in turn will damage the fertility of the farmlands thus making it dead over a period.

FRAMEWORK FOR PROTECTION

Survival of the Indigenous practice of Khazan lands can

be viewed from two aspects: Enabling regulations along the Natural Landscape and strengthening the associated Human Culture by fostering community engagement.

Natural Landscape:

1. Zoning Regulations:

•Incorporating zoning regulations through state agricultural department

•Establishing Specific zones for Khazan lands within urban planning regulations.

2. Buffer Zones:

•Designated buffer zones to be indicated around Khazan lands to protect them from urban encroachment.

•Implement restrictions on specific types of development in the buffer zone to maintain the ecological integrity of the Khazan systems.

Human Culture:

3.Settlement control:

•Formulating regulations for the settlements to avoid encroachment.

4.Community Engagement:

•Creating local community groups with required hierarchy and involving them in decision-making process.

•Encouraging community participation in conservation efforts and formulating sustainable management practices.

5. Infrastructure planning:

• Promoting infrastructure planning integrated with the ecological understanding which will minimize the negative impact of the development on the khazan lands.

• Encouraging the construction of well-planned drainage systems.

6. Incentives for Conservation:

• Introducing incentives for the communities engaged to adopt sustainable practices.

• Supporting research initiatives focused on sustainable land management and conservation practices.

CONCLUSION

In conclusion, the research looks at the possible revitalization of Khazan lands by fostering the link between nature and culture. The historical practices that survived over the centuries have helped maintain the ecological balance and contributed to local economic development by generating diverse livelihood opportunities.

However, the survival of this indigenous practice faces threats from urbanization and the various complexities associated with the same.

To safeguard the uniquely designed practice, the research suggests a framework which will strengthen the link between the natural landscape and human culture.

Revitalizing the indigenous practice of Khazan land will contribute towards achieving the goal of sustainable urban environments.

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URBAN WATER RESILIENCE: ADDRESSING WATER RESILIENCE BY UNDERSTANDING HISTORIC WATER INFRASTRUCTURES

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INTRODUCTION

One of the significant global challenges in the 21st century is protecting and providing water as a resource for our ever-growing population in cities. The NITI Ayog report predicted that 21 Indian cities would run out of groundwater by 2020, nearly 40% of the population will have absolutely no access to drinking water by 2030, and 6% of India's GDP would be lost by 2050 due to the water crisis (Chakrabarty, 2019). Rapid development through urbanization, change in land use, escalating demand for water and increased instances of floods in significant parts of our cities due to climate change are hallmarks of our present urban condition. It was most appropriate that Building resilience in Urban communities (BreUcom) program theme with three partner institutions- KRVIA Mumbai, SPA Bhopal and ITC University of Twente, Netherlands came together to address these concerns of water resilience. The partnership addressed these issues in the setup of historic cities where age-old water infrastructures exist in state of disuse, arguing for their existence that could then create a water resilient framework and associate strategies. In 2015, the historic core of Jodhpur and had mapped its water systems it was proposed that a pilot project of the same be taken up in August 2019 by all the three institutes. The pilot project with the help of Prof. Andre Dsilva of ITC Twente mapped terrain, water bodies, landmarks, households and activities using open-source software GIS and phone based app full form ODK Connect. The study entailed recording and analyzing resident interviews on their usage and perception of existing water resources and their responses during water shortages and floods. Based on the success of the pilot project, a water resilience studio was taken up again in Jodhpur and similar water based cities of Bhopal and Jabalpur simultaneously for the Semester 2 Urban design and Conservation students at KRVIA in November 2019. Tier-II cities that are at the cusp of development showcase unprecedented growth and need to learn from the planning mistakes of our metropolises. It has been found that poor understanding of the existing watersheds and associated land uses in planning procedures are the foremost concerns in resilience building.

KEYWORDS

Water systems, water conservation, urban design strategies

TRADITIONAL WATER SYSTEMS IN HISTORIC CITIES

Historically Indian cities have survived by managing their surface waters, much before they could master tapping of ground and piped waters. Urban settlements over the ages have showcased unique water harvesting systems like town talabs (lakes) by damming rivers, temple tanks and baolis(wells), vavs and jhalaras (stepwells) in arid regions to minimize evaporation as well as serve as community and gender sensitive amenities. The Rajputs and the Mughals had their unique water management techniques that led to elaborate systems respecting the watershed areas that fed these water bodies and reinforced their position in the urban realm. All these in turn helped build strong socio-cultural links with the community. India's water woes and scarcity stemmed primarily from its over-dependence on groundwater and piped water which the British introduce leaving existing age-old surface water infrastructure to disuse.

WHAT IS WATER RESILIENCE?

Resilience has been used to address a wide range of issues and at various scales – from global financial and ecological systems to human development – but cities have become objects for resilience approaches (Chandler, 2016). The ability of systems (social or biophysical) to withstand or cope with shocks while maintaining key functions or structures is known as resilience (Folke, 2016). In the context of water systems, various definitions of resilience are in use: engineering resilience, for example, is a method of assessing the characteristics of constructed water systems and their ability to recover from interruptions. Ecological resilience focuses on eco-hydrological systems' ability to cope with stress. Community resilience focuses on society's ability to cope with water stressors or dangers.

"A focus on strengthening resilience can protect development gains, and ensure people have the resources and capacities to better, reduce, prevent, anticipate, absorb and adapt to a range of shocks, stresses, risks and uncertainties" (Aditya Bahadur, 2015). Building resilience in water systems is still unclear, in terms of what resilience in water systems entails or how it might be accomplished. Furthermore, there is a limited shared understanding

or guidance on which specific water management practices and governance arrangements can increase resilience in water systems, generally or in specific water systems outside of ongoing epistemological and methodological debates in the resilience scholarship. Research calls for more holistic approaches to water resilience that take into account all components of water systems- social, infrastructural or ecological (Rodina Lucy, 2019).

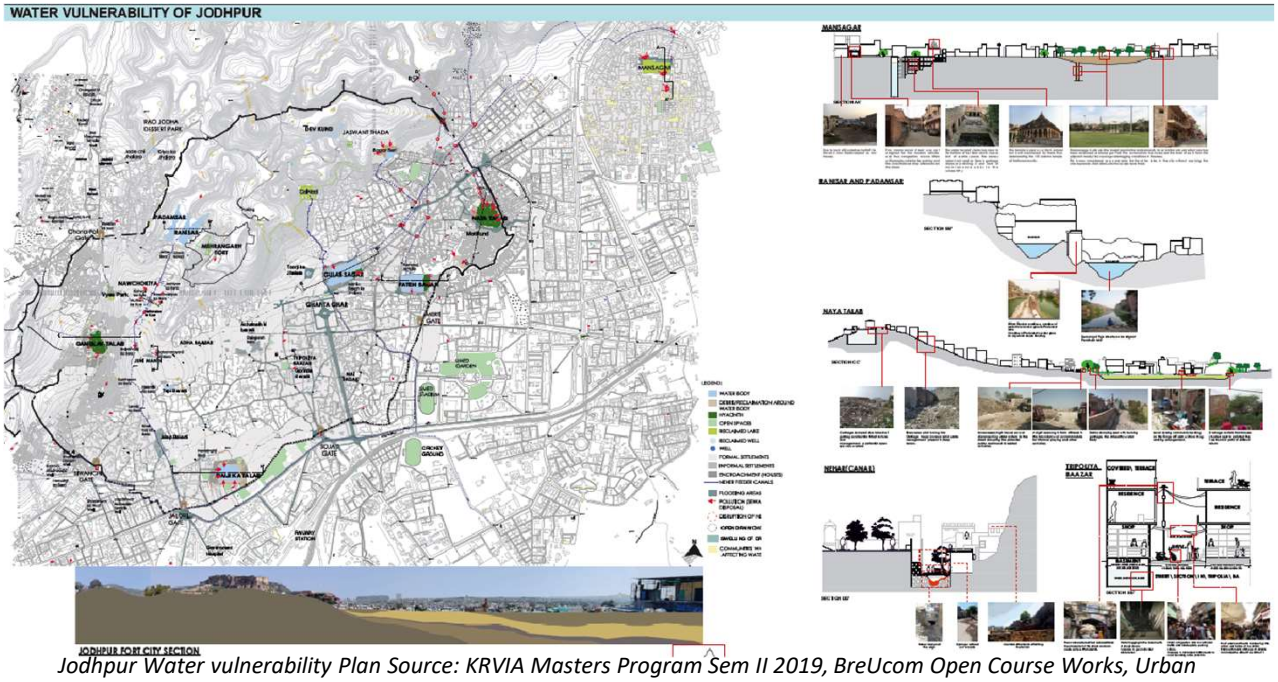
Water resilience literature presents a significant variety of complicated and diverse ideas that tend to draw on a wide range of elements, scales, characteristics, or types of water systems, whether biophysical or social (Rodina Lucy, 2019). Historic cities depict a network of systems that sustain socio-cultural, religious, economic, and infrastructural amenities and institutions, with social and natural resources maintained in harmony with the environment. Flexibility and diversity of response options have been advocated as crucial resilience-building measures for natural resource management because they allow the social system to adapt to change (Schluter, 2007).

CASES OF BHOPAL, JODHPUR AND JABALPUR

The most common thing about all three of these historic cities is that they survived centuries because of their enormous water tanks and their protected watersheds. Bhopal has its Bara and Chota talab fed by its extensive Bhoj wetlands which is now protected under the Ramsar convention. So is Jabalpur with its Sangram Sagar lake and Hanuman Tal. Jodhpur has its Balsmand, Ranisar and Padamsar lakes fed by the protected Rao Jodha geological park. Hence it is evident that study, analysis and protection of land use through its existing watershed is inherent to water harvesting and conservation which in return supports the intricate water systems comprising canals, tanks and wells in each of these historic cities. A detailed mapping exercise by the students in each of these cities for a good 7 days led to the holistic understanding right from the watersheds at the macro level to the water features at the neighbourhood level and their relations with the stakeholder communities. Surveys in general found extensive encroachment along age old watersheds and protected wetlands whereas most surface water features were found to be in utter neglect with sewage and garbage afloat, ground water features like vavs, borewells and wells were running dry due to over extraction. our cities are the world's largest users of groundwater, which makes them groundwater dependent in addition to our irrigation systems that together extract 250 cubic km of groundwater annually through 20 million wells and tube wells. (https://www.hindustantimes.com/analysis/india-must-not-look-at-its-water-crisis-in-isolation, 2019)

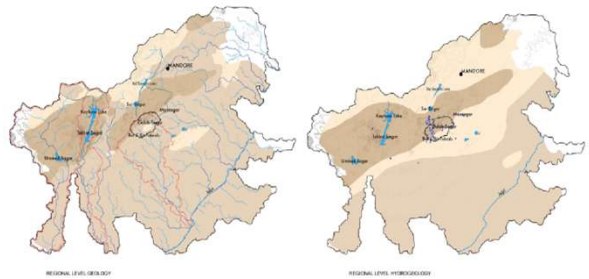
THE DISCONNECT BETWEEN PEOPLE, WATER AND CULTURE

The case of Jodhpur, which I was part of, was unique to how valuable resources such as water and land can be thoroughly misused leading to yearly disruptions to social life and damage to property. Founded in 1495 and situated in the arid west, Jodhpur has survived the last 500 years through its 50 surface water features and 154 ground water features that have been intricately planned. Situated uniquely along the Chonka Daijar plateau comprising of rhyolites and sandstones at an elevation of 395 metres above sea level, houses the five largest lakes along the outskirts , the Balsamand, Lalsagar, Kailana, Takhatsagar and



Jodhpur Water vulnerability Plan Source: KRVIA Masters Program Sem II 2019, BreUcom Open Course Works, Urban Water Resilience Studio

Umedsagar. Earlier accumulating around 700 million cubic feet of water, these lakes are now partly used are now under threat due to extensive mining activities though some of those areas are important local heritage sites considering they accommodate the royal cenotaphs. However in contrast the Ranisar and Padamsar tanks retain and supply drinking water to the fort and have some existing and some disrupted canals to the other ground water features is only because of its protected water sheds, the Rao Jodha geological park by the Mehrangarh Trust.



Jodhpur watershed plans Source: KRVIA Masters Program Sem II 2019, BreUcom Open Course Works, Urban Water Resilience Studio

Post these reservoirs there are hundreds of vavs, baolis, jhalaras and tanks at every neighborhood serving their respective communities and have been part of several cultural practices over the last 500 years since most of the water bodies are associated with religious institutions. Since the 1980s, the city has been supplied piped water from the Indira Gandhi Lift Canal, the unused ground water has been rising to considerable levels thereby causing damages due to excessive dampness in basements and foundations of existing households. Astonishingly in a hot arid region, these excess waters are pumped 12 hours daily from major reservoirs only to be drained into the Jojari nallal, thereby raising questions of management of both water and energy as a resource. Another noteworthy observation is that since existing neighborhood tanks no longer serve the purpose of water supply, however these have been catchments and are soon being destroyed either by dumping sewage, debris or encroached by squatters. Since the core area of Jodhpur is congested and lacks adequate open spaces, short sighted community representatives have reclaimed some of these tanks to playgrounds floods during heavy showers and the loss of valuable watersheds and catchments. Astonishing as all of it sounds, it is through detailed mapping and interview exercises that brings to the fore that a hot and arid city with excessive heat stress has excess water only to be pumped and drained off into nallahs. The neighborhoods flood during the monsoons causing property and economic damages due to poor understanding of watersheds and catchments.

Bhopal watershed plans Source: KRVIA Masters Program Sem II 2019, BreUcom Open Course Works, Urban Water Resilience Studio

In the case of Bhopal and Jabalpur whereby there has been a degradation of the watershed as well as catchment by way of encroachment and insensitive development. The absence of a Master Plan has meant that the city has expanded without due consideration of its land uses, planning guidelines and resources. Watersheds have been encroached upon by housing developments and service infrastructure, and so have lakefronts by way of informal settlements thereby leaving sewage into the lakes. Water quality of Upper Lake which could be directly used till a few years back now needs at least primary treatment before consumption. Among the other lakes too, problems with the quality of water are noticed, several of them in various stages of eutrophication. According to a study by an independent newspaper in Bhopal, among the 31 registered lakes in and around Bhopal, only 21 exist as of 2016 while 11 have been permanently lost (Team DB, 2016). Due to the indisposition and lack of initiation from the local authorities, there have been a continued degradation of the environment of the city during the past years. The last M aster Plan that was approved for the city was in 2005, later editions did not earn approval from the people and executive. The city has been progressing without one for the past 11 years. (Mrunmayi Wadwekar, 2018).

The 16 week Studio, post the mapping exercise started by the tracing the history of development for the regions. The usefulness of history for the understanding of the present and future is generally agreed upon and common for non-specialists to argue that those who do not learn from history are doomed to repeat it. Further the studio looked at the macro and micro concerns and applied the resilience framework with the social paradigm whereby Indian cities have always exhibited a strong connection between the water resources and its inhabitants. Stakeholders are diverse, identifying them and mapping their narratives through detailed documentation and GIS tools, as seen in the studio exercise, legitimize their intentions through the stories they tell. Local communities create symbiotic relationships with the environment for their food production and financial sustenance. Fishing as well as other occupational based communities, have always lived symbiotically with the wetlands thereby in many a way protecting its edges through community participation, however there have been activities showing disconnect between the communities and the water resources considering there are several polluting activities by informal settlements as well as unplanned gated communities along fringes. Irrigation lands in the vicinity of the city are being bought by land speculators, and that has led to increasing prices as well as the loss of agricultural land and associated livelihoods. This has directly contributed to the degradation of the environmental quality along edges of the wetlands by way of pollution as well as flooding.

Mapping exercise of the edges of Bhopal lakes and strategy based Structure Plan, Source: KRVIA Masters Program Sem II 2019, BreUcom Open Course Works, Urban Water Resilience Studio

watersheds and catchments. Astonishing as all of it sounds, it is through detailed mapping and interview exercises that brings to the fore that a hot and arid city with excessive heat stress has excess water only to be pumped and drained off into nallahs. The neighborhoods flood during the monsoons causing property and economic damages due to poor understanding of watersheds and catchments.

RESILIENCE FRAMEWORK AND STRATEGIES

Recently, there has been a significant discursive reframing of urban development efforts away from notions of sustainability towards practices of resilience. This shift in narrative can be clearly traced in literature starting in the early 2000s. A 'narrative of resilience' rather than urban sustainability appears to be the new urban and social paradigm and needs to be critically evaluated (Sudmeier-Rieux, 2014). The vulnerabilities of disruptions in everyday life such as scarcity of water and intermittent floods must be managed both in terms of their immediate causes and effects, as well as their long terms drivers and desired outcomes, which were mainly addressed by formulating a Structure plan under the relevant heads of

- Sensitive Watershed Planning and Policies
- Water Sensitive Urban Design and Systems
- Creating awareness and empowering local stakeholders and institutions

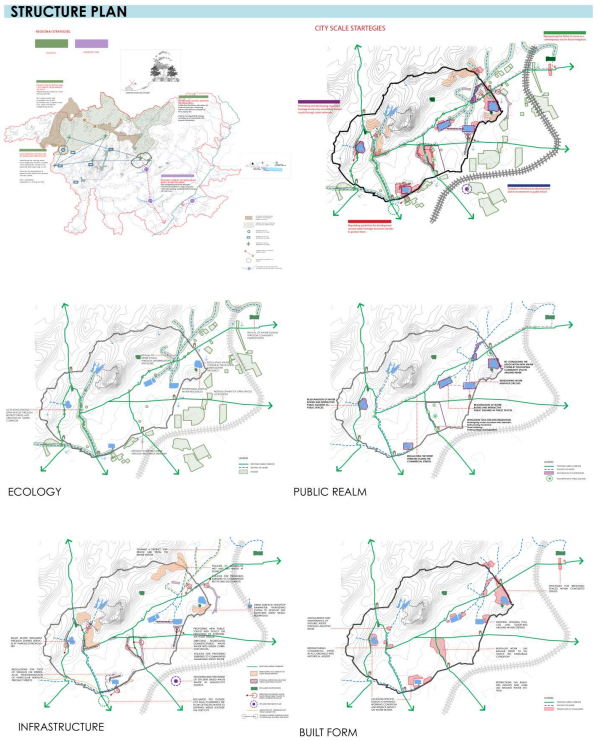
While there exists flexibility on the above strategies adopted, which builds a logic for the term itself based on the relevant context, however the first of the strategies primarily associated with the grassroots by way of involvement with local stakeholders and institutions as a bottom-top approach found to be more effective in our context. In contrast, the other two methods are top-down based approaches to disruptions with critical roles played by planners, architects, engineers and bureaucrats. No wonder urban critics and community activists have a different take on resilience measures than planners and bureaucrats. Those not affected by crises have a different view about measures to be adopted from behind a desk.

Using resilience in its contextual, vernacular, everyday sense creates space for negotiation between different strategies. It opens the possibility for new common understandings to emerge, thereby resolving ideological tensions within resilience discourse, and help to generate a framework that would make resilience both more concrete and more conceptually robust. (Brantz Dorothee, 2020)

Advocates of resilient cities believe that land use planning as a powerful tool serves to be the most relevant policy agenda in safeguarding our cities, and this does need to be critically evaluated. Spatial tools like GIS can help identify relevant watersheds and catchments based on detailed generated terrain maps only to be analyzed to suggest appropriate land uses, leading to framework and policies. Strategies through

the Structure plan addressed the above under the relevant context of Ecology, Public Realm, Infrastructure and built form analysis, thereby leading to water sensitive urban design (WSUD).

Toorji ka Jhalara regeneration project, Jodhpur: Apt example of Water sensitive Urban Design (WSUD)



Jodhpur Water vulnerability Plan Source: KRVIA Masters Program Sem II 2019, BreUcom Open Course Works, Urban Water Resilience Studio

Most students believed creating awareness amongst the stakeholder communities to be the first step towards its preservation, empowerment and creation of a resilient society. During disruptions and disasters, it is proven that the poor, marginalized and weaker section of the society, are the hardest hit. Similarly, it was well understood that not all challenges can be resolved by the state and that a bottom-up approach to disruptions in all its diversity can be addressed at the grassroots by engaging vulnerable stakeholders and local communities thereby giving them a voice to respond to disasters. Numerous strategies addressed empowering local stakeholders, citizen groups and neighborhood institutions to bring about urban renewal in adopting and maintaining the water bodies based on some of the successful case studies as seen in each of the cities. The resultant was these underlying water system with its elaborate physical manifestations are also the ecological framework that forms the backbone of the city which today is well understood as water sensitive urban design (WSUD), bridging the various dimensions of the water sector as well as socio-cultural system thereby aiming towards a more eco-centric, holistic, and adaptive approach to creating "water resilience."

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TRADITIONAL MUGHAL WATER BASED ARCHITECTURE: CASE OF BENAZIR PALACE, BHOPAL

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Aditya College of Architecture

ABSTRACT

Water is an integral part of various cultures, religions and regions. Architecture either for ritualistic or leisure purposes has integrated with water. Traditional Structures like baths, gardens, pavilions, palaces and water systems are the Indigenous knowledge for today's sustainable practices. The paper focuses on analysing the water based architecture particular to Mughal gardens and its water system. The paper also examines the case of Benazir Palace, Bhopal (India), a "Sawan Bhadon". The paper analyses the influence of Hindu and Islamic culture on its traditional water system and the architecture. The paper concludes with a proposal of conserving the heritage structure along with the traditional water management practice.

KEYWORDS

Benazir palace, "Sawan Bhadon", Mughal waterworks, Traditional knowledge system

INTRODUCTION / BACKGROUND

Water and build environment had coexisted throughout history in different regions of the world. Emphasis has been on the need and demand of water in different regions under different cultures over the period. It has been traced from Indus Valley Civilization where the concept of 'Great bath' was introduced to the people to promote hygiene levels and Social Interactions. There is sophisticated understanding of water management dawns with the beginning of well-equipped intricate drainage knowledge system. Later, in Vedic period cultural associations and spiritual significances were inculcated where ritualistic bathing in sacred river became part of society.

Water has also been an integral part in Islamic culture. The verse of Quran states: ((1)
"Those will have gardens of perpetual residence; beneath them rivers will flow. They will be adorned therein with bracelets of gold and will wear green garments of fine silk and brocade, reclining therein on adorned couches. Excellent is the reward, and good is the resting place." (Q. 18:31)

The verse describes the luxurious details of heaven, its relationship with water and natural environment. The intricacy of water and water based architecture acts as a symbol of leisure, paradise and luxury. The Mughals were well versed in water management and meticulous utilization of water resources. They overtook medieval knowledge ahead with advancements in technologies.

AIM/PURPOSE

The paper focuses on analysing the water based architecture particular to Mughal gardens and its water system. The paper also examines the case of Benazir Palace, Bhopal (India), a "Sawan Bhadon". The paper analyses the influence of Hindu and Islamic culture on its traditional water system and the architecture.

MUGHAL TRADITIONAL WATER BASED ARCHITECTURE

Islamic culture has influenced the Persian and Mughal water based architecture. While Mughals in Indian subcontinent had established confluence to Indian architectural styles especially with respect to water bodies. The water based architecture, Mughal gardens based on Charbagh structure (influenced by Persian gardens) had mix of culture, styles and regions. It consists of water distribution system, pavilions, Hamman (baths), fountains, canals and vegetations fabricating the micro-climate within the structure.

Hydraulic system

During the Delhi Sultanate and Mughal Empire, various types of water system were introduced in gardens like Persian wheels, wells, canals etc (2). The water distribution system were based on (3) Principal source of water supply and Inside water distribution. The water supply to the garden were majorly from lakes, wells/step wells, canals or natural springs and were lifted through mechanisms/devices like charas (leather bucket), Rahat or saquia (Persian wheel) etc. Further the inside distribution happens through aqueducts with technically designed hydraulic systems based on "Principle of Siphoning" and "Application of Boyle's law". These principles build pressure through air and gravity leading to flow of water and fountains in the entire garden.

Charbagh Structure

As per Ebba Koch (3), Mughal gardens are divided into three forms of Chaharbagh, 1) Canonical

cross-axial; 2) Terraced & 3) Waterfront structures. The canonical cross-axial structures are usually in funerary gardens with a Tomb. The second type, terraced are based on specific sloped landscape to cater natural supply of water. Whereas Waterfront structures which more intricate hydraulic system were based on raising the water to the gardens.

Pavilion

Mughal Gardens had series of Pavilions as a build structure integrating the surrounding ecology and culture together. The function of pavilions were courts, palace for ladies, for guests and leisure pavilions. One concept is "Sawan" and "Bhadon" Pavilions. These pavilions are based on two principal months of the rainy season in a year as per Hindu calendar. The "Bhadon" month lies between August-September whereas "Sawan" is in July-August. These types of pavilions are located opposite to each other and feature water system which includes tank, a miniature waterfall, Chinikhanas or small niches for oil lamps and leisure space around the tank, as can be seen in Hayat-Bakhsh-Bagh in red fort. For further reference : (4)

Hamman Architecture

On the other side of the world there were advancements in experimentation by Romans on Public baths also called as "Thermae". They developed baths with various rooms which functioned as Caldarium for hot bath, Tepidarium for warm bath and Frigidarium for cold bathing areas. Soon they became the hub of Socialization and Recreation. The bath structures were converted into complexes. Since thermae facilitated large group of people so the need of the small-scale privately-owned baths gave rise to concept of "Balnea".

The term Hamam has its origin from Middle east, Arabic Language where "Hammam" refers to Turkish bath or public baths which were evolved further from Roman and Byzantine period. The earliest hamams in the middle east were built during 8th century by the first Muslim Dynasty which was Umayyad Dynasty.

These Hammams are said to have evolved from the same roman concept of Balnea. Islam consist of two types of Ablutions which are categorized as Minar and Major. The minor ablution is called "Wudu" which consists of washing some parts of body. It is performed usually at the mosque or at home before prayer. The major ablution is called "Ghusl" which consists of purification of whole body. This ritual gave rise to the public baths in the Islamic regions. There locations were strategically planned based on source of water and location of mosques in the walkable distance. For centuries these hammams were the only gathering social space for women of Islamic societies.

Before the invasion of Delhi Sultanate in India, Bathing was generally performed in the open ghats of the river, lakes, wells etc. which was been followed from the Vedic period. The concept of Hamam in Indian subcontinent was introduced by Muhammad bin Tughlaq where he introduced Turkish hot Baths after which it became a private activity. It also got further segregated with separate spaces for different genders.

Initially these were the small areas attached to palaces or mosque which later developed widely on large-scale during the end of medieval period. Based on geographic and climatic reasons, various types of hammams evolved for different purposes. Example – Hamams in caravanserais, hamam in garden complexes, hamams in palaces, Public hamams, Hamams in Mosque etc. Hence it became a major Islamic building type. Since Mughals have conquered largely Northern part of the country, Turkish hot baths were not desirable hence the concept of cold baths was introduced by Babur.

The hamams in India are generally square, oblong and octagonal halls comprised of chambers which are connected by narrow corridors. Spaces are semi-dark which helps in keeping the space cool. It is designed on the principal as the user penetrated inside the space it will become cooler. There are three common units, Rakht kan which is called as dressing room, sard khana which is the cold room and the garam khana which is the hot room. These can either be in combination of multiple interconnecting chambers or single chamber.

Hammams built in the Mughal dynasty were the most flourished forms example Hammams of Fatehpur Sikri like Shahi Hammams and Khaas Hammam where almost every palace has its own Hamam. Square and octagonal chambers with intricate Marble jaalis called as perforated screens, instruments room, toilets and dressing rooms were provided in Hamam.

The stone flooring comprised of brick hypocausts which was connect with furnaces. Generally, the walls of hamam were made of lakhuri bricks and were covered either by stone panels or Lime stucco. From 16th to 19th century under Mughal and Nawabi rule there were large number of Hamams which were constructed for the nobles and common people of the city.

CASE OF BENNAZIR PALACE, BHOPAL

Background of Bhopal and water-based architecture

Bhopal, capital of Madhya Pradesh, India consists of varying topographies and waterbodies in the form of lakes, rivers and small drains. The waterbodies make up to 22% of total Bhopal Planning area . Major lakes are man-made like Upper Lake (Bhojtal), Lower Lake (Chhota Talaab), Shahpura Lake, Motia Talaab etc with Bhoj wetland as one of the 26 Ramsar sites in India.

Bhopal as a city has developed in conjuncture with these water bodies over a period of time producing settlements, water systems and water-based architecture (Table 1)

Sr. no	Ruler (prominent)	Ruled from	Waterbody associated/ initiated	Settlements formed	Architectural Contribution
1	Raja Bhoj Parmar	1110-1055 AD	Bhojtal (Upper lake)	Bhojpur/Bhopal, Bhojpal	-Temples, dams
2	Rani Kamlapati	1710	Upper lake and Lower lake-	-	-Kamlapati Mahal in Bhopal
3	Nawab Dost Muhammad Khan Bahadur	1723-1728	Halali River	Islamnagar, Bhopal	- Chaman Mahal (Garden Palace); - Rani Mahal
4	Qudsia Begum	1801 – 1881	Introduced portable water supply system carried out by a Scotch Engineer named David Cook (5)	-	- Aish Bagh " (Garden of delight); - Jama Musjid (founded on the site of an old Hindu temple called the Sabha Mandal);
5	Sikander Begum	1844 – 1860	Bhojtal (Upper lake)	-	- Moti Mahal and - Farhat Afza (garden-increase of delight) - Shaukat Mahal palaces
6	Shahjahan Begum	-1844–60 -1868–1901	Motia Talab, water supply to Sahajahanabad	Sahajahanabad	- Ali Manzil (gardens) - Benazir Palace - Orchard - Parween Bazaar - Idgah - Taj-ul-Masjid

Table 1. Chronology of Some significant rulers of Bhopal

Other than above, the rulers and ministers of Bhopal had constructed various types of pleasure/paradise gardens as mentioned in (6).

Major Waterworks initiated in Bhopal

With the expansion of city and its population, the demand for drinking water increased and supply to settlements further upper lake decreased. Cholera was another problem in Bhopal due to unavailability of pure drinking water. As stated in (7),pg 135) Qudsia begum was first to initiate the waterworks for the supply of drinking water in interior parts of Bhopal. The laying of pipes was carried by Scotch Engineer named David Cook who took the water form Bhojtal (Upper lake) through a pumping station and a system of pipes were erected throughout the city. Later, in the reign of ShahJahan begum, the settlements of Sahajahanabad were facing inadequacy of water supply. Thus, number of reservoirs, tanks and wells were created including Motia Talab in 1899. A canal was also constructed, collecting water from lower lake near “Pul Pukta” supplying water to sahajahanabad, Nishat afza garden till Islamnagar as mentioned in (7) Pg. 79.

BENAZIR PALACE, BHOPAL

Nawab Shahjahah begum, ruler of Bhopal established a new settlement north of Bada talab, around the Motia tank, called Sahajahanabad (Table 1) To populate the city, people were encouraged to shift towards the northern side of it in various localities namely Nawab manzil, Baramahal, Amirganj, Kaisarganj, Moghalpura and Khawaspura. Whereas the Royal complex provided a palace, Masjid, summer/Lesiure palace, orchids, Bazaars etc. Buildings constructed were Taj mahal palace, Ali manzil and gardens, Benazir palace, parween bazar and Idgah. The structures were around three cascading Talabs/tanks-Motia talab, Nawab Siddique Hasan Khan talab and Munshi Hussain khan talab maintaining a microclimate around the complex. Benazir palace was constructed as a summer palace to tap the cool air from the tanks integrating terraced Mughal garden along with it. With the features of a summer palace, the functional use was to accommodate the Begum and her guests.

Figure 2. Benazir palace, Source

WATER DISTRIBUTION SYSTEM-BENAZIR PALACE

The source of water for Benazir palace was through an elaborate system of brick lined vaulted drains collecting rainwater. It was part of the extension work of water system done by Shahjahah begum in Sahajahanabad. The channels passed through the Important structurers and gardens in the complex.

Benazir palace is terraced and Waterfront form of Chaharbagh Mughal Garden. Natural contours on site helped in channelizing water throughout the palace. The Inside water distribution system in Benazir is based on Bernoulli's principle as shown in the Figure 2 below through a series of channels of different diameter. The sketch shows small diameter of cast-iron pipe providing water for the fountains. It connecting to an aqueduct of larger diameter leading to the Pavilion's tank with a small reservoir in between. The pavilion's tank further leads water to the Motia Talab.

Figure 2 Shows aqueduct (Left: photograph and Right: cross section conceptual sketch running below Benazir palace from fountains to Pavilion, Source: Author

"SAVAN BHADON" PAVILLION

Archival photographs and sketches as shown in Figure (3a) of the structure shows an H shaped building enclosing a Courtyard and a small garden space connected through a pavilion. Figure (3a) shows trees besides the pavilion for passive cooling. As quoted in the (7) , the architecture of Benazir palace contains "Savan Bhadon". Only one ¬ pavilion of 'Savan Badon' exists today. Whether the other pavilion existed is unknown. The pavilion is connected through underground aqueducts. These aqueducts circulate water in the pavilion through three slits in the wall forming a miniature waterfall. The waterfall flows above Chinikhanas which are small niches used for oil lamps. The pavilion is enclosed from all sides and flowing water in front of these Chinikhanas would illuminate the waterfall and inside of pavilion. These type of miniature water falls were very common during Mughal rule, examples of which can be seen in Shalimar Bagh, Lahore; Mahtab Bagh, Agra and Sawan Bhadon Pavilion in Hayat Bakhsh Bagh.

The Water further travels from wall slits to Chadars. Chaddars/water chutes are water feature slanted to create ripple effect like mountain rivers. They have fishscale pattern called mahipusht to create rippled waterfall and rainfall sound inside the pavilion.

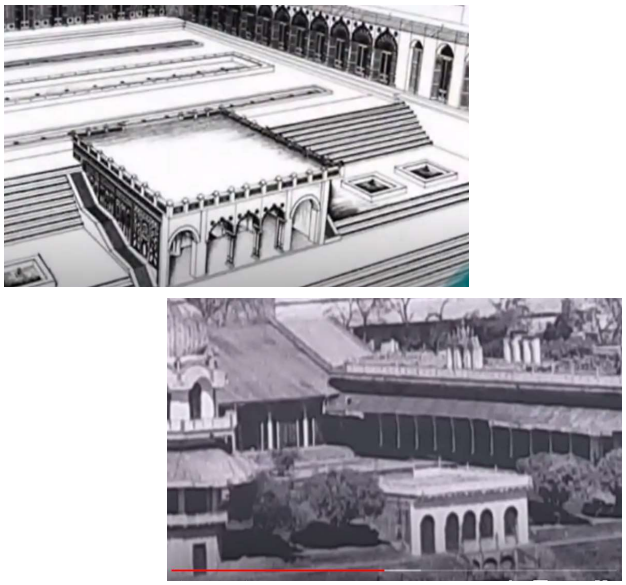

Figure 3 (a) Shows conceptual sketches of Benazir palace with steps and Sawan badon pavillion (b) Shows old photographs of Benazir palace with steps and Sawan badon pavillion, Source: (Rizwana, 2020)

Among the three wall slits, the central one falls on the Chadar (Figure 4). The other two slits directly fall on the pavilion's tank floor. A tank is built below it to collect the water which also has mahipusht on the surface for the same effect (Fugure 5) acting like a larger chadar. The tank is slightly sloped towards the the talab. The depth of the tank is based on the slope of the edge of the motia talab.

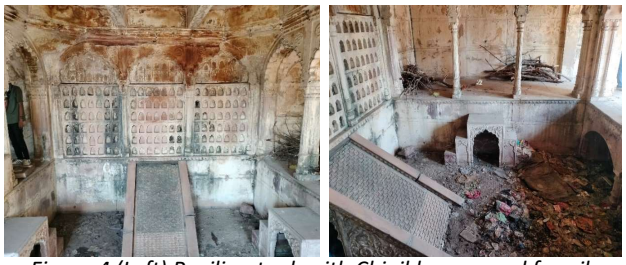

Figure 4 (Left) Pavilion tank with Chinikhanas used for oil lamp (Photograph by Author)

Figure 5(Right) Channelize water from tank to the Moti talav (Photograph by Author)

The water collected inside the Pavilion tank is further channelize to the Motia Talab through tunnels as shown in Figure 5. Externally, the pavilion is surrounded by steps which leads to Motia talab (Figure 3) like a ghat, prominent in Hindu architecture. There is influence of region on the structure.

The immediate edges of the Pavilion is surrounded by long Chadars/water chutes from two sides as shown in Figure 3, Figure 7.

The water on the chutes would be coming from the slits on both edges of the chutes. The roof of the Pavilion arranges for a sitting space for the guests with a view of three talabs, Taj Mahal Palace and Taj-ul-Masjid.

Figure 5 (Left) Floor of Pavilion's Tank with (Photograph by Author)

Figure 6 Side wall of Pavilion with Intricate designs (Photograph by Author)

Figure 7 (Right) Ramp used as water chute made of stone with fish scale pattern (Photograph by Author

ANALYSIS

Benazir palace is an example of Indo-Saracenic architecture with respect to concept of "Savan Badon", Ghats and Mughal water distribution system. The utilization of slope in the structure into build terraces uniquely accommodates Mughal garden into it. The architectural features like pavilion, fountains, water chutes with vegetation further adds to ecology of the structure by inducing passive cooling for a comfortable microclimate.

Today, the historic water system and supporting Architecture of the complex is not functioning as originally intended. Initially there were no settlements around the complex. But with time when the urbanization expanded around, leading to degradation of the water distribution system and a source of water for the palace. The structure itself has going through a lot of additions and alterations throughout the period. The sawan bhadon pavilion is converted into a dumping yard of the waste. The courtyard became land of wild bushes. Water channels are no more functional and is in the condition of deterioration.

CONCLUSION

The materials, construction technique, architecture design of Benazir palace are the proof of traditional knowledge system of water management and passive cooling techniques in Mughal architecture. Its waterworks hold historic, architectural and scientific value. The entire water system of this 18th century building was a fully functioning system which today is in the verge of degradation due to negligence, vandalism, inappropriate interventions and encroachment. There is an urgent need of restoring this water based structure for reviving sustainability.

The study concludes that understanding and reviving by restoring this water system of the complex offers great potential for modern sustainable water management practice and contribute to sustainable solution of passive cooling in today's drylands.

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WATER AS A SOCIAL CONNECTOR : THE CASE OF THE STEP-WELLS OF INDIA

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ABSTRACT

Water is an integral component for the perpetuation of human life. Water is also a finite resource and human beings since time immemorial have taken an interest in water conservation. In an Indian context as well, spanning across the length and breadth of this country, several water storage wells have been constructed. Some of these wells are highly ornamented while others were constructed for purely practical purposes. Both these typologies had one thing in common – they functioned as a social connector, bridging the gap, providing a safe space for people to converse and gather.

This paper seeks to examine the symbiotic relationship between water catchment structures and the social fabric. It also makes the case for conservation and adaptive reuse of such spaces so as to increase the longevity of such structures while making them more relevant with the current generations. The research methodology adopted will examine these water catchment structures under three broad criteria using case studies for each - as a tool for sustainability and aiding in maintaining ecological balance, as a tool for religious functions, and as a tool to create new, meaningful social connections through adaptive reuse.

Finally, this paper will talk about why India needs similar such baoli conservation projects, highlighting the benefits both to the environment as well as the community as a whole.

KEYWORDS

Social Connector, Baolis, Adaptive Reuse, Conservation, Step-Wells.

INTRODUCTION / BACKGROUND

Water has always been a critical component responsible for the perpetuation of the human race. From the River Valley Civilizations, where human beings settled from being hunter gatherers to establishing settlements, they were all done along water bodies - be it Ancient Egypt with the settlements being established along the Nile or the Indus Valley Civilization that was established along the Indus River system. These early civilizations also understood the purpose of water storage and/or rain-water harvesting systems, owing to the seasonal nature of these rivers. As the wheel of time turned, and centuries flew by, the population increased. And with this increased population came the additional need and dependence on water. What remained unchanged however, was people's knowledge with regards to the need for rainwater harvesting. People had long realised the importance of storing both rainwater as well as tapping into the groundwater table to fulfil their water needs. Over a period of time, this construction of wells became increasingly elaborate and ornate, with people constructing what we now know as baolis or vavs or step-wells that transcended several stories below the ground.

WHAT IS A BAOLI? AND WHY IS IT SO SIGNIFICANT IN THE INDIAN CONTEXT?

A step-well, also called a baoli, is an underground water tank that has been strategically excavated and designed to fit with the typical architectural style in the area. Rainwater harvesting or an established natural aquifer could potentially operate as the water source for these step-wells. For this reason, a baoli is a great illustration of a historically employed rainwater harvesting system. Locally this step-well is also called as a vav or a bavdi in some parts of India.

These baolis not only functioned as a tool for rainwater harvesting thus perpetuating the concepts of sustainability before sustainability became a popular buzz-word, but they also held religious significance. But most importantly, they functioned as social interaction spaces or social connectors, where people, especially women, in the process of drawing water from these wells, also interacted with other women, something that traditionally they would not have been able to do freely. Even today modern conservation projects such as Toor ji ka Jhalara and the Bansilalpet step-well project exhibit this purpose successfully, as they do not just function as water storage devices, but they provide urban public open spaces that are interactive, and more importantly free/accessed by paying a nominal cost.

WHAT IS THE PURPOSE OF THIS PAPER?

This paper aims to investigate the synergistic link that exists between societal structures and water catchment areas. In order to prolong the life of these buildings and make them more pertinent to the present generation, it also argues for their preservation and adaptive reuse. Using case studies, the research methodology will look at these water catchment structures under three main categories: as a tool for religious purposes, as a tool for sustainability and helping to maintain ecological balance, and as a tool to foster new, meaningful social connections through adaptive reuse.

In the following pages, I have identified three key baolis that are examples of each of the categories identified above, and they are as follows:

BAOLIS AS A TOOL FOR SUSTAINABILITY AND AIDING IN MAINTAINING ECOLOGICAL BALANCE - THE QUTB SHAHI HERITAGE PARK BAOLIS:

Approximately one hundred monuments from the 16th to 17th centuries are located inside the Qutb Shahi Heritage Park's distinctive necropolis. Seven step-wells, or baolis, can also be seen at the Qutb Shahi Heritage Park. These were originally erected in this location in order to collect rainwater and use it to irrigate the orchards that surround the tombs. These orchards, which had almost vanished over time, have also been replanted. It is important to remember that each of these baolis needed immediate repair in order to be used again as rainwater gathering structures.

A complex of water-related structures, the step-wells constructed between the 16th and 17th centuries exhibit a diverse range of architectural styles and play a significant role in the overall composition of the complex. In the past, the water needed for irrigation of the gardens surrounding the monuments within the park, during the monsoon season would have been collected by these seven step-wells, yielding over nineteen million litres of rainfall. Significantly, these major monuments were crucial in preserving biodiversity and the natural equilibrium.

When the step-wells were visually inspected before being conserved, it became clear that they were in critical need of repairs due to material deterioration and seepage of rainwater from surrounding precincts. It is possible that all of the structures that were renovated under Salar Jung III's well-known undertaking in the late 19th century may have also contributed to this decay's acceleration.

The displacement of hand-dressed and rubble stones, masonry walls, seepage of rainwater, masonry repairs of walls and arches, minor structural damages, and 20th-century alteration of the original immediate landscape settings prevented the original catchment from channelling rainwater towards the baolis were among the conditions negatively affecting the step-wells.

To better understand the significance of these baolis it is first pertinent to establish the architectural descriptions of these baolis, and their cultural and political influence.

The Badi Baoli - located south of the tomb of Muhammad Qutb Shah:

The "Badi Baoli," or large step-well, is a working step-well that collects rainwater from an extensive catchment area and is connected to a system of underground aqueducts that span the length of the site. The "Badi Baoli," which was first constructed in the 16th century, was merely a tank until the 19th century, when the building was modified and the arcaded corridor was constructed, according to an analysis of historical documents. A large arched niche with an arch crown sits above the baoli's north side lower facade. The base of the baoli is reached by flights of stairs on each side of the eastern side. The arcaded passage sits atop a wall composed of rubble masonry on all four sides.

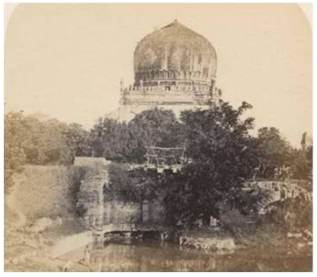

Figure 1: Badi Baoli situated to the South of Muhammad Qutb Shah's tomb, circa 1860 (Image Courtesy of Captain Allan N. Scott - The Alkazi Collection of Photography)

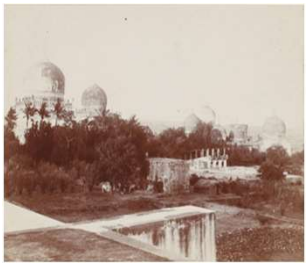

Figure 2: Badi Baoli. Image shows the later addition commissioned by Salar Jung II (late 19th century image - Photographer unknown) Image Courtesy of Sarmaya India (as a part of their web article - Echoes of Golconda – Seeking the Quli Qutb Shahs in Modern Hyderabad)

Figure 3: Badi Baoli situated to the South of Muhammad Qutb Shah's Tomb (2021)
Image Courtesy of Ar. Neha Tambe

Figure 4: Badi Baoli situated to the South of Muhammad Qutb Shah's Tomb
Image Courtesy of https://www.tatatrusts.org/our-stories/article/the-remarkable-restoration-of-the-badi-baoli

There are seven arches on the exterior side, each with cusped mouldings and ornamental arch crowns atop. Below the baoli's parapet, the top of the facade has protruding moulding bands. The parapet is composed of rectangular panels with curving lime plaster copings on top of arched apertures and stucco ornamentation. The evidence pertains to another era, and perhaps was created under the Nizams. On the north side, staircases descend to the corridor level. Up to thirty-five lakh litres of water may be stored in the baoli, with the majority of the water being collected during the monsoon season.

Baoli adjacent to the tomb of Jamshed Quli Qutb Shah:

This baoli was constructed using local granite stone and rubble masonry to the west of Jamshed Quli's tomb. The Baoli is rectangular in shape and measures thirty by

twenty-four metres. Built atop the underlying natural rock formations, the baoli's retaining walls are composed of three distinct layers joined by coping stones and random rubble masonry. The inside of the well can be reached by an enormous flight of stairs on the southern side, and a smaller staircase goes to the middle. There are remnants of the original ramp visible on the northern side of the baoli, along with a large projected platform with two half-arches on the north side. The structure contains a tank and a pipe network.

Figure 5: Baoli abutting Jamshed Quli Qutb Shah's Tomb (2018)
Image Courtesy of Ar. Neha Tambe

Figure 6: Baoli abutting Jamshed Quli Qutb Shah's Tomb (2021)
Image Courtesy of Ar. Neha Tambe

Baoli adjacent to the Idgah:

This baoli, a water catchment tank south of the Idgah, is the largest and most formal of all the baolis in the Qutb Shahi Heritage Park. It was constructed of dressed granite stone masonry. The Baoli spans an area of 20 m by 18 m and has an oblong profile. There are several tiered floors on the south side of the step-well that are accessible through a flight of stairs built in ashlar masonry. The natural rock structure at the base serves as the support for the lowest section of the retaining wall. A large arched bay encloses the landing. These arches were previously adorned with elaborate arch crowns and medallions on the exterior facade.

There is a projecting arch on the south side of the baoli wall, and the original ramp's remnants are evident. Two granite brackets with decorative stone knobs at the bottom support the projection.

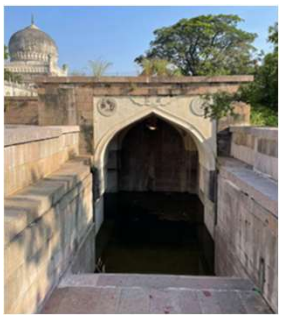

Figure 5: Baoli abutting Jamshed Quli Qutb Shah's Tomb (2018)
Image Courtesy of Ar. Neha Tambe

Figure 8: Baoli near the Idgah (2021)
Image Courtesy of Ar. Neha Tambe

The Baoli next to the Hamam:

This baoli borders the Hamam on its northern side. The surface runoff water from the surrounding region is graded, and it may have been used to supply and store water for the Hamam and maybe the Sarai that is adjacent to it. This baoli has a rectangular layout, measuring twenty-three by twenty-five metres, and is constructed on natural rock. Local granite stone is used in the rubble ashlar masonry of the retaining walls. The base of the baoli is reachable through a set of stairs along the western façade.

Along the southern façade, there is an arched projection that leads to the middle of the façade, where the remains of the ancient water-drawing ramp are situated. A proposed platform is also present along the baoli's northern façade. The baoli's facades have no ornamentation.

Figure 10: A panoramic view of the Qutb Shahi Heritage Park with the baoli abutting the Hamam in the background (beyond the enclosure wall) on the right-hand side (circa 1860) Image courtesy of Col. Horatio Biden - The Alkazi Collection of Photography

Figure 11: Baoli abutting the Hamam (2021).
Image Courtesy of Ar. Neha Tambe

Baoli next to the Commander's Tomb:

Figure 12: Baoli near the Commander's Tomb (late 19th century)
Image Courtesy of Sarmaya India (as a part of their web article - Echoes of Golconda – Seeking the Quli Qutb Shahs in Modern Hyderabad). Original Image by Lala Deen Dayal and Sons.

This baoli was constructed of granite stone in random rubble masonry and is located in Deccan Park, east of the Commander's tomb. The baoli is eighteen by twenty-four metres in size, with an oblong form, and it partially rests on the naturally steep rock.

Figure 13: Baoli near the Commander's Tomb (2021) Image Courtesy of Ar. Neha Tambe

Figure 14: Baoli near the Commander's Tomb (2022) Image Courtesy of https://www.civilsocietyonline.com/cover-story/baolis-tumble-out-of-hyderabads-past/

Baoli located within Deccan Park also called the Bagh Baoli:

Figure 15: Baoli near the Commander's Tomb (2022) Image Courtesy of https://telanganatoday.com/hyderabad-marching-forward-to-get-world-heritage-city-status

This baoli in Deccan Park, which is located farther southeast of the Commander's tomb, is made of granite stone set in a random rubble masonry pattern. The baoli is fifteen metres by nine metres in size and has a rectilinear form. This baoli is also called today as the Bagh baoli and forms the perfect resting spot for the tourists and visitors at the Qutb Shahi Heritage Park.

The Baoli adjacent to Sultan Quli Qutb Shah's Tomb:

Figure 16: Baoli next to Sultan Quli Qutb Shah's Tomb (2019). Image Courtesy of Ar. Neha Tambe

This little baoli is bordered on its eastern side by a tripartite arched structure, and its southern side is dedicated to a series of water tanks constructed with lime mortar and rubble masonry.

Cultural and political significance:

Art, architecture, music, language, performing arts, and culinary arts all flourished throughout the reign of the Qutb Shahi dynasty. The ecological equilibrium and biodiversity have historically been significantly supported by these step-wells that store surface runoff water. These recharge groundwater tanks would have served as a means of storing surplus water, promoting biodiversity inside Qutb Shahi Heritage Park, supporting the abundant gardens encircling the mausoleums with year-round irrigation, and creating jobs for a number of people.

The conservation of the step-wells found inside the Qutb Shahi Heritage Park has increased the number of visitors and sparked interest in the topic of traditional water harvesting structures as a viable way to alleviate India's water scarcity. The stone and lime artisans employed for thousands of man hours as a result of the conservation project. The conservation of the historic step-wells was crucial to fostering relationships with the local population, which gathers twice a year at the Idgah, which is next to the baoli to the south of the Idgah. During the Eid festival, around seventy thousand people congregate at the Idgah.

It has been demonstrated that using water to irrigate gardens in royal contexts has political and social importance. Qutb Shahi monarchs manifested supremacy in the Deccan thanks to their knowledge of advanced hydraulics in the mediaeval era. Overcoming challenging conditions was essential for a regular and consistent supply of water for the people at Golconda fort. This need for consistent water supply was because the monsoons in the region were unpredictable. By ensuring this regular and consistent water supply, the Qutb Shahi sultans displayed their capacity of governance in the 16th and 17th centuries.

Building tanks or step-wells was viewed, metaphorically, as a charitable and altruistic deed. Sustaining verdant gardens in a semi-arid area would have served as a tangible demonstration of the Qutb Shahis' talent, wealth, and political influence.

Conservation of the Baolis and their status today:

The reconstruction of the collapsed sections of the Badi Baoli, which is now a key draw for visitors to the site, marked the beginning of the Aga Khan Trust for Culture's involvement in the conservation project at the Qutb Shahi Heritage Park in 2013. The Aga Khan Trust for Culture, in collaboration with the Department of Heritage Telangana, the state government of Telangana, finished the conservation of all step-wells in 2022. The Department of Heritage Telangana in collaboration with the Aga Khan Trust for Culture (that is responsible for the conservation work being conducted on site) is responsible for overseeing all step-wells and the remainder of more than one hundred monuments located within the Qutb Shahi Heritage Park. The US Ambassador's Fund for Cultural

Preservation provided funding for the conservation of five of the seven step-wells.

Conserving the original appearance, extending the life of the structures, and getting them ready for public viewing were the goals of the conservation of the baolis. The manual de-silting process was started in order to clear the step-well bases of debris and sludge. After inappropriate 20th-century alterations were removed by racking out the plaster and cement pointing from the wall surfaces, traditional artisans repaired the walls using traditional lime mortar.

Moisture ingested earlier, that was a result of using an impermeable contemporary material, such as cement, was dissipated by using a porous substance, such as lime. In order to uncover the original levels and channel rainwater towards the baoli, the cement concrete was removed and restored with traditional lime concrete set at an appropriate slope. Stones that matched in size and texture were used to restore the plinths of the baolis. Small structural fissures were repaired, and the remaining stucco was meticulously rebuilt using lime mortar that precisely matches the original historical documentation.

Therefore, the conservation work done on these baolis guaranteed the restoration of their structural integrity, rebuilding any missing portions, and restoring their original architectural appearance while undoing the damage caused by vegetation and neglect. These works were completed using traditional building materials and techniques. In order to direct surface runoff towards the baolis, immediate landscape setting of the baolis was also undertaken. This entire conservation process will eventually guarantee public accessibility to the baolis. In the end, the baolis' conservation efforts will encourage renewed interest in the site.

BAOLIS AS A TOOL FOR RELIGIOUS FUNCTIONS - THE NIZAMUDDIN BAOLI:

Figure 5: Baoli abutting Jamshed Quli Qutb Shah's Tomb (2018) Image Courtesy of Ar. Neha Tambe

Constructed in 1321–1322, the Nizamuddin Baoli in New Delhi is the only baoli still in existence with subterranean aquifers as a water supply (in addition to gathered rainfall). A popular legend that adds to the mystique behind the baoli states that at the time of construction of this baoli, the Tughlaqabad fort was also being constructed by the Tughlaq sultan, Ghiyasuddin Tughlaq. Since most of the workers working on the fort were followers of the Sufi saint Hazrat Nizamuddin wanted to contribute to the construction of the baoli, but did not want to cross the sultan, chose to work on the fort during the day, and on the baoli at night. At that point, oil lamps were used as lighting devices. Angered by this insubordination done by the workers, the sultan took away all the oil that would be required to light the lamps. It is then that the Sufi saint lit the lamps using the water from the subterranean aquifers. The water is also revered because it is said to have therapeutic properties.

Today, the baoli, which lies next to the Dargah of Hazrat Nizamuddin Auliya and inside the thickly populated Nizamuddin Basti, was severely encroached and in poor condition. A portion of the Baoli collapsed in 2008, necessitating immediate conservation work to stop more harm.

Conservation of Nizamuddin Baoli by the Aga Khan Trust for Culture:

The Aga Khan Trust for Culture then conducted in-depth scientific and archival research, organised community workshops with the local community, and developed a conservation plan that would stabilise the remaining sections of this historic baoli, restore the sections that had collapsed, and remove any additions and repairs from the 20th century that had been made that were harmful to the baoli structure as a whole.

Consequently, the baoli underwent conservation repair after being de-silted to its original depth. The baoli was cleared of all debris and garbage as part of the conservation process and at the request of the Dargah committee and the local community. The baoli was significant to the local culture and religion because the waters were revered, and it was also one of the main water sources for the Nizamuddin Dargah and Basti. Over seven thousand man-days were required for the whole conservation and cleanup project. Skilled local artisans used traditional materials to complete the conservation work, which was overseen by expert structural engineers and conservation architects.

Therefore, this baoli conservation was an excellent representation of an urban water structure conservation that was conducted as a public-private partnership involving a multidisciplinary team, involved multiple stakeholders, and was completed within the boundaries of a living community (as opposed to other water structure conservation projects that are usually designated as having a monument status). This project serves as an illustration of not just conservation, but also the procedures that must be followed to guarantee the project's ongoing maintenance. The Dargah community and the Aga Khan Trust for Culture has also organised community seminars regularly to inform the pilgrims and the locals alike about the

dangers of discarding non-biodegradable items both within and outside of the baoli complex.

Figure 18: Baoli next to Sultan Quli Qutb Shah's Tomb (2019) Image Courtesy of https://www.business-standard.com/article/current-affairs/pil-on-women-s-entry-into-nizamuddin-shrine-hc-seeks-centre-s-reply-118121000243_1.html

Today the baoli is just as popular as it was pre-conservation both with the visitors and the devotees who visit the baoli on their visit to the Dargah. The baoli is also used by the local basti population, especially young boys, who enjoy swimming in the baolis.

Baolis as a tool to create new, meaningful social connections through adaptive reuse - the Bansilalpet Step-well:

Built between the 17th and 18th centuries at Bansilalpet in Secunderabad (Nagannakunta), some say this step-well got its name when around the step-well, British architect T.H. Keyes created a planned model hamlet in 1933, and a local businessman Seth Bansilal funded the project. Most of the step-well's history is unknown. Its architectural characteristics indicate that it was most likely constructed in the 17th century CE but has some bearings of the architecture of the Kakatiya era, as well as the Nizam era. The step-well had a capacity to store approximately twenty-two lakh litres of water. A 1954 map by Pharaoh & Co. identifies the step-well as Nagannakunta. The map shows that a garden of palmyra and tamarind trees encircles the step-well.

Figure 19: Bansilalpet Step-well, Secunderabad
Image Courtesy of https://newsmeter.in/hyderabad/fresh-look-improved-amenities-newly-renovated-bansilalpet-stepwell-to-be-inaugurated-tomorrow-704529

Figure 20: Bansilalpet Step-well, Secunderabad - Before Conservation
Image Courtesy of https://newsmeter.in/hyderabad/cafe-gallery-amphitheater-once-a-designated-dump-yard-bansilalpet-stepwell-is-now-a-sight-to-behold-704161

Figure 21: Bansilalpet Step-well, Secunderabad - Before Conservation
Image Courtesy of https://10tv.in/telugu-news/telangana/secunderabad-bansilalpet-step-well-being-renovated-and-city-public-hails-the-work-359537.html

Figure 22: Bansilalpet Step-well, Secunderabad - Before Conservation (Image Courtesy of https://newsmeter.in/hyderabad/fresh-look-improved-amenities-newly-renovated-bansilalpet-stepwell-to-be-inaugurated-tomorrow-704529)

After India's independence and post Operation Polo as well, this step-well continued to be used, till in the 1980s when a series of suicides led to this step-well becoming neglected. The local community used it as a garbage dump, and this gem was all but forgotten. This step-well added to the array of water-centric projects around human settlements, symbolising the legacy of the Telangana state.

Figure 21: Bansilalpet Step-well, Secunderabad - Before Conservation (Image Courtesy of https://10tv.in/telugu-news/telangana/secunderabad-bansilalpet-step-well-being-renovated-and-city-public-hails-the-work-359537.html)

Figure 24: Bansilalpet Step-well, Secunderabad - During Conservation (Image Courtesy of https://newsmeter.in/hyderabad/fresh-look-improved-amenities-newly-renovated-bansilalpet-stepwell-to-be-inaugurated-tomorrow-704529)

Figure 25: Bansilalpet Step-well, Secunderabad - During Conservation (Image Courtesy of https://curlytales.com/dating-back-to-the-17th-century-bansilalpet-stepwell-in-hyderabad-blends-modernity-and-heritage-beautifully/)

Following the pandemic, a plan was developed to restore and revitalise the step-well as well as the public spaces in the neighbourhood that surround it. In this sense, the Telangana Urban Development Department worked with the Rainwater Project, a social organisation that specialises in sustainable water management. In order to fulfil the requirements of the restoration and revival of this step-well, the following steps were undertaken:

- Cleaning up plastics and other debris in and around the Step-well as a part of the holistic restoration of the step-well. In this process almost two thousand tonnes of garbage and debris was taken out of the step-well.
- Desilting and dewatering the stone step-well, cleaning and removal of plant debris and vegetation growth from the building was also undertaken during the restoration process.
- During the condition assessment of the step-well, it was found that the structure was not as stable as it needed to be. Structural strengthening of retaining walls was thus undertaken to increase the longevity of the step-well.
- A section of the step-well had become damaged in parts and collapsed in other parts. As a part of the restoration efforts being undertaken, it became crucial to rebuild the step-well's damaged or collapsed section.
- Since the step-well was constructed using lime mortar and plaster, during the restoration process, it only made sense to use a compatible material. Lime plaster was thus used for finishing touches during the restoration process.
- The step-well's surrounding area's quality was improved by adding landscaping, asphalt, and signage as well as other essential urban insertions.
- Guarantee that the neighbourhood around the well carefully appreciates the cultural and environmental significance of the ancient structure, awareness and education sessions were and are being held.

Figure 26: Bansilalpet Step-well, Secunderabad - After Conservation Image Courtesy of https://newsmeter.in/hyderabad/cafe-gallery-amphitheater-once-a-designated-dump-yard-bansilalpet-stepwell-is-now-a-sight-to-behold-704161

Figure 27: Bansilalpet Step-well, Secunderabad - After Conservation Image Courtesy of https://srisrilara.blogspot.com/2023/03/the-ancient-and-most-beautiful-stepwell.html

The newly restored step-well was inaugurated and opened to the public on December 5, 2022. The total cost of restoration came up to approximately INR 2.6 crores. Bansilalpet step-well has a rainwater harvesting capacity of up to thirty-five lakh litres of water. Along with the restoration of the step-well, the project also focused on revitalising the neighbourhood. The step-well today is an example of an exquisitely planned public urban space with only the first level accessible to the general public for security reasons.

Figure 28: Gallery 1 of Bansilalpet Step-well, Secunderabad - After Conservation Image Courtesy of https://www.telegraphindia.com/my-kolkata/places/hyderabads-bansilalpet-stepwell-ravaged-reimagined-then-revived/cid/1922205

Bansilalpet step-well complex includes a tourism plaza and an interpretation centre that has three galleries that tell the narrative of the step-well's rehabilitation as well as its history. The galleries also highlight the significance of conserving water. A replica of the step-well serves as the focal point of Gallery 1, and images of the Step-well both before and after restoration can be found on the walls. The theme of Gallery 2 is water conservation. The step-well is frequently shown in paintings and photographs. First-floor Gallery 3 houses a glass case highlighting items discovered while the trash was being cleared out. Statues, conch shells, and metal items like swords and spear heads are among them. It also has a café, and an amphitheatre.

Why does India need baoli conservation projects and what is the way forward?

India is facing an enormous water deficit especially with growing concerns of climate change and our ever-increasing population. It is thus pertinent to use the nation's historical customs to integrate traditional knowledge on water conservation on a war-footing. In addition to guaranteeing the preservation of landmarks of national significance, the preservation of these step wells offers a rare chance to show how ancient water gathering techniques might help address India's water shortage. More importantly these baolis which have historically functioned as a social connector, can actually help revive the existing communities they are located in, by acting as free or nominally charged public open spaces that function as safe, social and community spaces which is crucial in the incredibly densely packed urban fabric that India has. From school going children to senior citizens, no matter what strata of society they belong to, such baolis offer something for everyone, connecting people from all walks of life not just with our past but also with present and the future.

The conservation, restoration, and revival of historic step-wells guarantees that all the procedures necessary to preserve the cultural importance of these landmarks are executed in a methodical manner in compliance with the recognised best practices developed for the preservation of historic monuments in India. The goal of conservation initiatives should be to make craftsmanship viable, encompassing a range of craft abilities such as stone carving, the use of lime as a building material, the restoration of delicate stucco using incised lime plaster, and the reconstruction of lost decorative aspects.

When conservation work is done with traditional building materials like lime and organic additives, and with tools like chisels and hammers, it will guarantee long-term preservation that will require little preventive maintenance in the future, thereby obviating the need for further conservation.

With access to access to clean water and sanitation being identified as a key sustainable development goal, as well as the fact that we have the fastest growing population in the world, the need for both rainwater harvesting, as well as free, safe, public urban spaces is the need of the hour. Undertaking such urban water conservation projects is both sustainable and meets the needs of the SDGs identified by the UN. With organisations such as the Aga Khan Trust for Culture and The Rainwater Project paving the way forward, the day is not far where abandoned step-wells or baolis can and will be revived and adaptively reused to suit the needs of 21st century India.

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POND-CENTRIC URBANISM: THE HISTORICAL URBAN ENVIRONMENT OF RAJSHAHI

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ABSTRACT

Rajshahi is a historical metropolitan city in the northern region of Bangladesh and Ponds (man- made freshwater reservoirs, locally known as Pukur) have been the centrepiece of urban morphology and culture, serving the city and its people functionally, socio-economically, environmentally and metaphysically, consecutively from its manifestation as a city. Yet, advents of alternatives to the use of surface water and lack of conscious augmentation to adapt with the progressing social norms and culture have severed the ponds from the urban fabric and human life simultaneously. They are filled up, abandoned, disused, encroached, left as negative spaces with stagnant toxic water or unused dump yards, causing socio-political dissension and environmental degradation. The remediation taken by the responsible authorities to save the dying ponds never matches the unprecedented urban growth. This research aims to rediscover the intrinsic pattern of pond-centric urbanism of Rajshahi through a brief historical overview with the qualitative spatial analysis, and the identification of these interaction suggests that ponds are linked to the city with two variables, Social Parameter and Physical Framework. The interrelation of ponds with the city and its people is discussed through these variables with supporting photographic survey and diagrammatic documentation followed by a series of suggestive solutions, applicable as a proper responsive manual for authorities or individuals to follow when redesigning a pond. The Project acknowledges the ponds and water as an admissible part of the city environment and urban design and intends to convert its underlying potential into environmental gain and contribution to socio-cultural upbringing.

KEYWORDS

morphology; physical framework; ponds; social parameters; urbanism

INTRODUCTION / BACKGROUND

Rajshahi is a divisional town and metropolitan city of Bangladesh and a major urban, commercial and educational centre. It has a colourific history of more than 300 years with a co-existence of different caste and creed, culture and belief. Like all other historical cities, this city has its own historical environment. The impact of industrialisation could not radically change the environment of the city as it is part of the Barind region and has a semi-arid climate and also for the backwash effects of Kolkata. Thus, the essence of the environment did not get lost but existed in many parts of the city. One of the major pieces of evidence and a key player of this historical environment and evolution of the city is the numerous ponds scattered in the city. Ponds are a man-made or designed element of the landscape. It contains water, a natural element of the environment. Humans are drawn to the microclimate created by ponds as a result of environmental behaviour towards water bodies. As a result, they are more likely to gather around the pond and engage themselves into different sort of activities. Thus, a pond centric socio- economic culture is created within the city. This culture of pond centric activities forms the spatial pattern of the city and turns its surrounding spaces or void into place. So, the sense of place on and around the pond and water is inherited among the people and the culture of the city historically and metaphysically which creates a contextual background for the research purpose and study. However, after a while, due to the advent of various alternatives to pond water utilities, no remote thought was given them.

As a result, the ponds lost their physical connection to the city. Gradually they became isolated from infrastructure or urban fabric, and thus became neglected. At the same time, with the change or evolution of different social norms and cultures, there has been no adaptation through the conscious development of the pond environment, as a result of which the ponds became socially isolated from human life. In 1961, there were 4,238 ponds, canals, wetlands in the city, in 1981 the number was 2,271, in 2000 the number stood at 729 and now city has only 214 water bodies which showed that In the last five decades, a total of 4,000 ponds have been filled because of the indiscriminate earth-dumping and unplanned urbanisation as the authorities concerned have no control over the vested interested groups' activities (Dhaka Tribune, 2014).

Currently, various agencies responsible for the protection and development of the city have taken some initiatives to protect the ponds through various plans and proposals, but most of them are physical. The High Court gave a directive to stop filling of all kinds of wetland in and around the city on December 13, 2010, following a writ petition(Dhaka Tribune, 2014). Rajshahi City Corporation (RCC) has adopted a development project titled 'Natural Water Bodies Conservation and Development in Rajshahi City' to protect the ponds.

Figure 1: Figure-Ground Diagram of Rajshahi Old City showing the numerous Ponds Scattered around the Urban Fabric

The project is supposed to preserve 53 ponds and construct embankments along the ponds and re-excavate those water bodies. RCC also has an initiative to conserve and renovate 22 natural ponds in the city aiming to retain its surface water resources to protect environment from further degradation (The Daily Sun, 2018). All these initiatives are limited to beautification of the infrastructure around the pond. It also lacks the innate idea of solving various problems of the city by recognising the pond as an active natural resource of the city. At the same time, it does not regard ponds as a valuable social, excluding the possibility of transforming them into modern public realms or active urban spaces through place making and achieving a Quality of Urban Life through Public Space (PPS, 2007) (Garau, p., 2015). Thus, although the existence of the ponds is physically visible, it does not seem to do much good in the context of the city in reality. Besides, there is a lack of voluntary approach towards establishing social connections of the pond with the people. So that the ponds are likely to remain ineffective open space. The proposal recognises the ponds as an admissible part of the environment and urban design by transforming its underlying potential into environmental gain and contribution to socio-cultural upbringing. It is also notable that Rajshahi has already earned global reputation as a clean city for rapidly The project is supposed to preserve 53 ponds and construct embankments along the ponds and re-excavate those water bodies. RCC also has an initiative to conserve and renovate 22 natural ponds in the city aiming to retain its surface water resources to protect environment from further degradation (The Daily Sun, 2018). All these initiatives are limited to beautification of the infrastructure around the pond. It also lacks the innate idea of solving various problems of the city by recognising the pond as an active natural resource of the city. At the same time, it does not regard ponds as a valuable social, excluding the possibility of transforming them into modern public realms or active urban spaces through place making and achieving a Quality of Urban Life through Public Space (PPS, 2007) (Garau, p., 2015). Thus, although the existence of the ponds is physically visible, it does not seem to do much good in the context of the city in reality. Besides, there is a lack of voluntary approach towards establishing social connections of the pond with the people. So that the ponds are likely to remain ineffective open space. The proposal recognises the ponds as an admissible part of the environment and urban design by transforming its underlying potential into environmental gain and contribution to socio-cultural upbringing.

It is also notable that Rajshahi has already earned global reputation as a clean city for rapidly reducing harmful particles in its air and has got the "Environment Friendly City of the Year 2020" award or national scale for its green look and clean air owing to various development initiatives by the RCC such as 'Zero Soil Project' and the campaign to clean up the brick kilns, as well as efforts to make the city greener (The Guardian, 2016)(The Business Standard, 2020)(The Independent, 2017). It proves the sustainable and environment friendly outlook of the people toward the city. which is compatible with the inherent ambience of liveability is expected to be well accepted and nurtured by the people and the community around the city.

Figure 2 Ponds in the Urban Fabric of Rajshahi

AIM / PURPOSE

The research aims to formulate a new intrinsic genre of urbanism by studying the presiding but decaying natural resource of a city and ensure the quality of life for the inhabitants. Ponds are the unique feature of the urban natural environment of Rajshahi city, possessing most of the open spaces of the city ranging 30-40% area of an individual 'Para' or 'Mohalla' (Doza, S., 2008). The social environment is lost by the course of time with the loss of this physical are also. The main objective of the research is to re-establish its connection with the urban realm by studying the dying ponds from various possible perspectives and turning them into active urban spaces through the incorporation of infrastructure and engagement of people. The process leads to the conservation of the living historical environment of the city which opens the door to a contemporary pond-centric urbanism for the city of Rajshahi.

RESEARCH METHODOLOGY

History plays an important role in the study of any city. The main source of data and information of this research is the historical evidence that shows the importance of ponds in the urban fabric and urban life as well as the contribution in the consecutive morphological and cultural development of the city. The history of 250 ponds in Rajshahi city was studied that shows the proof of being 'a city of ponds.' Secondly, important data and necessary information regarding the proposal and planning related to those waterbodies were retrieved from several responsible institutions such as Rajshahi Development Authorities (RDA) and Rajshahi City Corporation (RCC). Moreover, different perspectives of urbanism and liveability were studied, and these perspectives were infused with the existing characteristics of ponds. These studies came up with three viable matrixes showing the interrelation of ponds and the city from the material and the abstract viewpoints. Later Rajshahi old town was selected as the site because it is a general belief that previously it was more vibrant, dynamic and livably, outdoor spaces were more responsive (Doza, S., 2008). Existing 80 ponds of this site was studied in terms of fore-said matrixes on different scales and including maps, drawings, interviews, experience, photographs and other strict in situ analysis. Outcome of these analysis provides different design guidelines which can be used by various responsible institution or individuals like RCC, RDA, ward commissioner or owner of a private pond as a manual while designing or regenerating. Then a design model of city scale, Neighbourhood scale and intimate or user scale is demonstrated through the old city planning, ward wise masterplan (23 no. Ward) and design of an individual pond at 23 no. Ward (Taranbabur pukur) implementing the prior design decisions from the design matrix. how they can be achieved in Rajshahi city through re-generation of urban spaces and place making around the ponds. In the research and analysis part, the connection of ponds with the city and its inhabitants is re-established through the comparison of past and present information while in the design part demonstrates how the aims and objectives of the research can be achieved through proper implementation of the matrix, collectively with proper urban design and placemaking.

RESEARCH AND ANALYSIS

Connection of Ponds with the City:

Pond is an integral part of Rajshahi city from its outsetting. It is possible to retrieve the evidence of recurring relationship of pond with the city looking into the historical evolution. It is believed that the foundation of the city was laid by Hazrat Shah Makhdum, a preacher of Islam in this region by 1400 AD. Though the presence of ponds and waterbodies was evident even before that. The connection of pond with the city with it evolution can be studied in four phases.

Dark Age (before 1700 AD): During this early period, it was a small settlement living in a small area of land near Padma River ruled by mainly a 'Kapalik' community. The city's water demand was mainly met by the Padma River and its adjoining canals. However, there were several ponds occupied by the Kapalik and Tantric communities, which are said to have been used for other religious purposes, including human sacrifice. The Shah Makhdum later rescued the city from the Kapalik kingdom and built his arena there, which became a shrine after his death around 1400 AD. A pond still exists at this shrine on the banks of the Padma, which bears witness to the Kapalik period, although the size of the pond has been reduced to a quarter by filling it for various necessities. The use of ponds at this time instills fear, spirituality, mystery and narrative in the minds of the people here.

Outsetting of the City (1700-1800 AD): At this stage, the city grows as a result of population growth and migration from the surrounding areas. History testifies that the largest migration took place in 18th century when a large number of people from neighbouring Murshidabad came to Rajshahi after being expelled by Maratha bandits. During this time the size and population of the city doubled, and the settlers started settling in the inner part of the city, as a result of which the rivers and canals failed to meet the demand for water. In this situation, people resorted to the ancient culture of digging ponds here to retain water. But as Rajshahi was included in the Barind region, it was not possible to get water by digging. For this reason, they connect the holes dug for the pond to the canals and rivers with the help of channels so that the river water can enter the pond during the monsoon season and provide water throughout the year. Usually in a settlement there was a pond around which the houses were arranged. Thus, in the process of nucleated Settlement a settlement was formed here which later made its debut in the town called 'Para' or 'Mahalla'. It is to be noted that in these neighborhoods there was a well- established waterway communication system from one pond to another with the help of canals which extended up to the river. As a result, some pond banks became commercial, market and other socio-economically important places, marking the beginning and the most important chapter of the city's pond-centric outline. At the junction of the pond and the canal, a kind of net was used to prevent crocodiles,

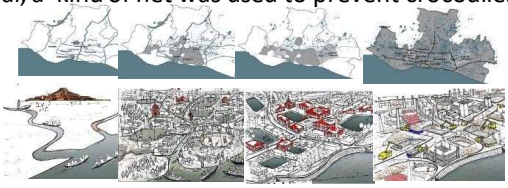

Figure 3: Historical Evolution of the City with Relation to the Ponds

Gharials and other uninvited animals from entering the pond from the river, which from that time onwards reflects the importance and sensitive attitude of the people of the region in pond planning.

Socio-political Shift (1800-1900 AD): When the divisional capital was shifted from neighbouring Natore in 1825, Rajshahi became politically and administratively important. As an inclusive area, it came under the influence of British colonial rule as a potential place for trade in indigo, silk, jute and lacquer. As a result, many social and political dignitaries arrived in the city at that time. These important individuals and organisations at different times used to dig ponds for various purposes such as land acquisition, charity, social services, socio-economic development of the area, etc. and manifests individual and social power. Which adds a new dimension to the influence of ponds in the formation of cities by establishing examples of the social and political impact of ponds on cities and people.

Urbanisation (1900-onwards): Although the effects of urbanisation began in Rajshahi from the time of British intervention, it was in full swing after 1900. It was during this time that the city protection dam separated the Padma River from the city reducing the flow of water in the canals and gradually turned them into paved box culverts, dirt road for horse-drawn carriages was paved, and many new government and private buildings and infrastructure were built, and the communication system is restructured. The demand for additional land was met by filling up a large number of ponds. As a result, the connection of the pond with the physical infrastructure of the city was severed. But the contribution of the ponds as an open space of the city remains intact and it continues to be used as a place or medium of social communication. In addition to this, on the pretext of digging a large number of ponds in the suburban areas, soil was collected to fill various low-lying areas of the city. In the same way, the brick kilns built in the relatively underdeveloped areas to collect a lot of bricks used in the new construction techniques also started collecting soil on the pretext of digging ponds. However, some ponds still provide drinking water to the people as the use of tube wells is still out of reach. This continued till 1947 and no significant pond was dug in Rajshahi during this period. It is evident that the pond had and continues to have a profound underlying relationship with the origin and development of the city. Ponds are the inventors, bearers and carriers of the physical and morphological evolution as well as the culture and behavioural characteristics of the people residing here.

Formation of Variables and Connection Matrix

From this it can be concluded that the pond is basically connected to the city by two variables. They can be defined as Social Parameters and Physical Framework. The shifting and drifting of the existing relationship between them at different times has caused the rotation and evolution of the relationship between the city and the pond.

Social Parameter: They are indicative of the socio-economic and cultural connection of the city and the people of the city with the pond. There are three parameters of this social indicator- Scale, Aspect, Quality.

Scale: It defines the impact of a pond at different scales of the city according to the distance from it. Small or S Scale defines the visually and physically connected places with the ponds.

Aspect: A pond is not only a vital source of surface water but also has an equal impact on urban, biodiversity, infrastructure and socio-economic aspect of a city.

These aspects of the pond and their impact on the city is divided into different scales mentioned above.

Quality: It is the accreditation of the overall environmental quality from only a social stand- point not any scientific quantification. It comprises of physical, water natural and social quality. This environmental quality is regulated by its surrounding infrastructure and elements or another word, by the physical framework of spatial pattern. to water, land to built-form and built form to water. These interdependencies are studied through a framework of Spatial Patten consisting of built form and accessibility around pond.

Spatial Pattern: Five types of basic Spatial Pattern are derived by studying over 80 ponds in old town of Rajshahi. The spatial pattern is formed with the pond water, the surrounding built-form and the accessibility to the pond from its surroundings.

Built form: Mainly Three types of visible Built-forms within the old town.

Accessibility: Five forms of accessibilities around the pond are sketched out.

The expected relationship between the pond and the city is determined with the help of matrix obtained through combination which is shown in Fig. 4.

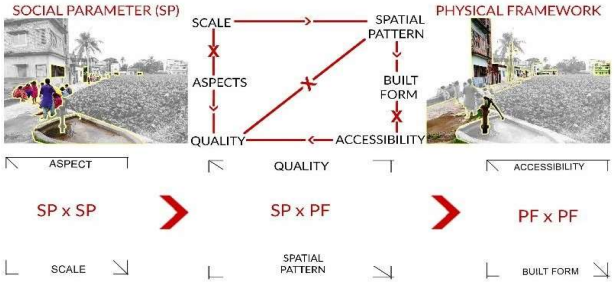

Figure 4: Variables and Connection Matrix of the City

ANALYSIS OF POND MORPHOLOGY USING THE MATRIX

In this analysis section, the matrix of the existing relationship between the variables discussed in the

research section has been applied to the city of Rajshahi and its ponds. In this case, the study has been done on the eighty ponds of Rajshahi Old Town in the light of that matrix and the evidence has been collected and stored through photographs.

Subsequently, it is attempted to express the various information and figures obtained, in a simple and clear manner through appropriate drawings and diagrams as required. This analysis is demonstrated in Fig. 5.

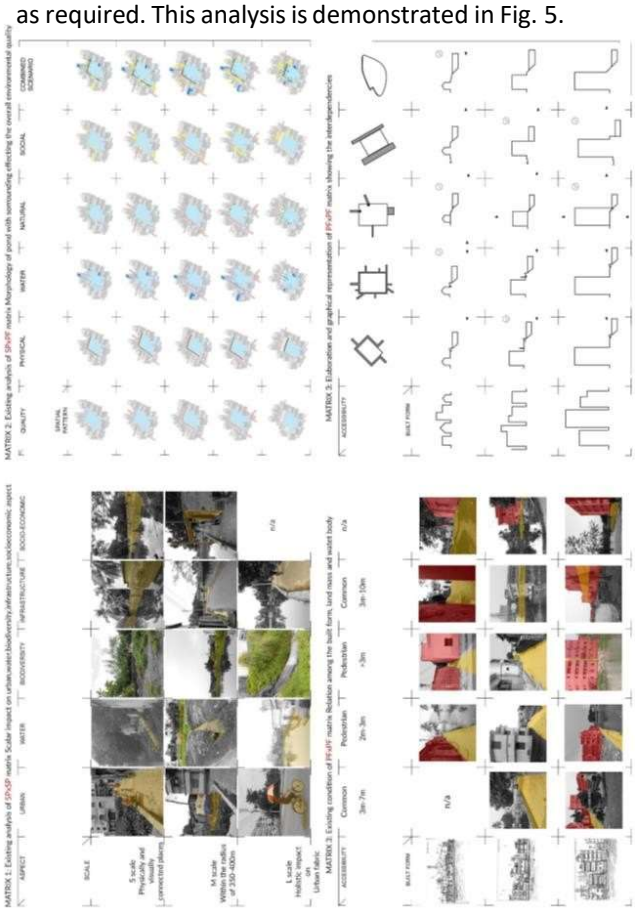

Figure 5: Analysis of Connection Matrix from Data

OUTCOME/ GENERATING DESIGN MATRIX

The design matrix is generated through sensitive appropriate decision making from the existing matrix studied in the previous section. These design matrixes basically serve as the outline of the design of a pond in the context of Rajshahi city, or as a manual in the planning of the whole city, complied with the combined effects of the ponds and assist the responsible agency in making policy or entitled individuals with design decisions. This will re-establish the physical and social relation between the pond and the city by which the maximum positive outcome can be achieved individually and collectively on social, environmental, environmental and financial issues.

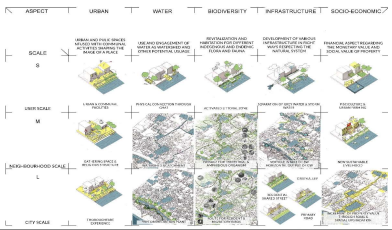

Figure 6: Design of SPXSP Matrix

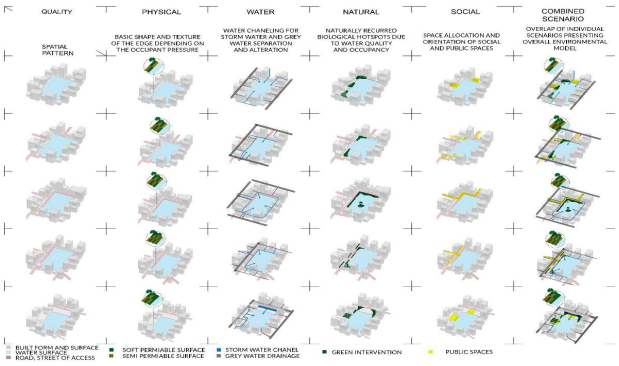

Figure 7: Design of SPXPF Matrix

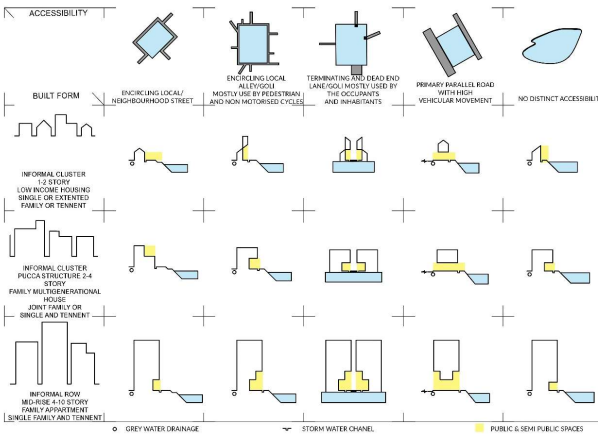

Figure 8: Design of PFXPF Matrix

CONCEPTUAL ARCHITECTURAL DESIGN

Design Direction for Town Planning and Masterplan Design for Rajshahi Old Town

In this section the necessary information and pertinent directions are derived and shown. In the RMDP masterplan 2010-2024 (Fig. 9) the ponds are only marked as waterbodies with no applicable direction or contribution to the city planning. It neither merges with the city fabric nor work as any infrastructure combined with the surroundings. Compared to the image from the satellite and survey, the masterplan does not acknowledge many of the ponds as preserved waterbodies though they have no less potential and impact on the environment and the surroundings. The previous RMDP masterplan for Rajshahi will come to expiration in 2024 and the authority will have to update it soon after. Policies developed in this section will help the planners to make proper decision while they re-design the masterplan for the city taking the existence and the importance of ponds as a vital part of the city fabric on account. The design process and design application on this scale will be conducted by RDA and RCC jointly for better collaboration and arbitration of unnecessary overlap of multidisciplinary conflicts. n Fig. 9 each ward of the old town is allotted with at least one designated ward pond along with other marked ponds that are to be preserved as conserved city waterbody by next RMDP masterplan. The pond and its surroundings are specified on the basis of their importance or contribution as an element of urban design (Lynch, K., 1960). The road network is

studied and re-designed as per three types, two-way Primary Road, one- way Residential Shared Streets and green alleys, taking the destination points on account (Urban Street Design Guide, 2013). S, M, L scale impacted area is marked for further instructions in RMDP planning.

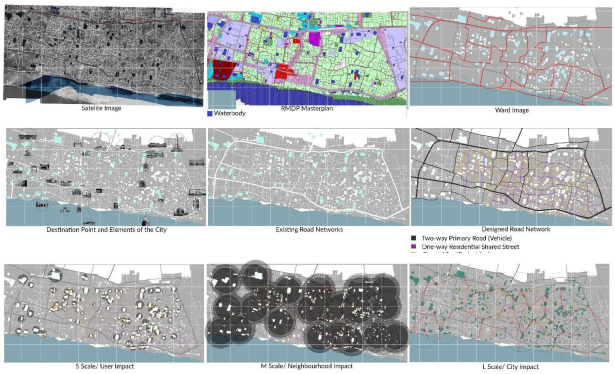

Figure 9: City Scale Design Implement

WARD BASED DEVELOPMENT PLAN (MASTERPLAN FOR WARD NO. 23 OF RCC)

No. 23 ward of RCC is picked for the model masterplan. Because of having the greatest number of ponds within its periphery, it allows the possibility of showing the most applications within single example. Planning and implications at this stage is to be carried out by the RCC and the Ward Council jointly. The setback areas of the buildings and properties are reclaimed to enhance sidewalks zones and introduce Hybrid Zone to grow and nurture belongingness and ensure safety and security through the amplification public-private interaction in the street (Urban Street Design Guide, 2013), (Karssenberg, H., 2016). Different impacts on different scale are assessed. In Fig. 11, the section drawing different implementations from the matrix are shown.

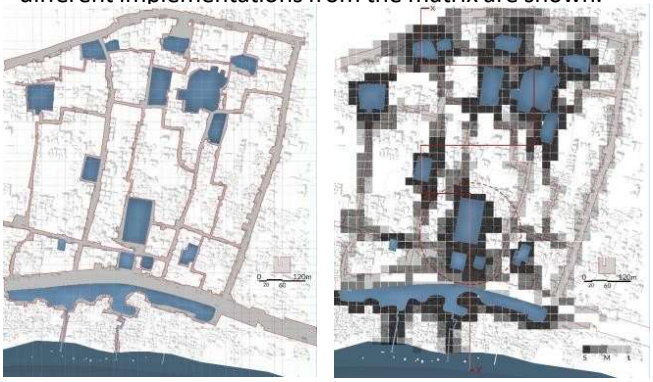

Figure 10: Demarcation of Hybrid Zone (Left) and Scaler Impact (Right) for Ward Based Development Plan

Figure 11: Conceptual Section showing the Implementation of Design matrix in Different Scales

DESIGN OF AN INDIVIDUAL POND (TARANBABUR PUKUR, WARD NO 23, RAJSHAHI)

Taranbabur Pukur is the designated ward pond for 23 No. Ward. The design implementation of which for the intimate scale is shown in this section. It is a historical pond within the city believed to be dug before more than 200 years when the city was taking shape. It is also important due to the position of the pond surrounded by different communities and being a centre point of their interaction though it is decaying gradually. There is also an old 'math' (মঠ) which is a part of its history (bn.banglapedia.org, 2019). The location of the pond with another two adjacent ones creates a unique environmental feature that is explored and tried to make best out of it. Lastly a demanded community space is provided acquiring the ground floor of a private residential building establishing a direct connection with the primary road that run along the city, uplifting its socioeconomic value and increasing exposure and thoroughfare experience. The design process is elaborated in Fig. 12, Fig. 13 and Fig 14, Fig. 15.

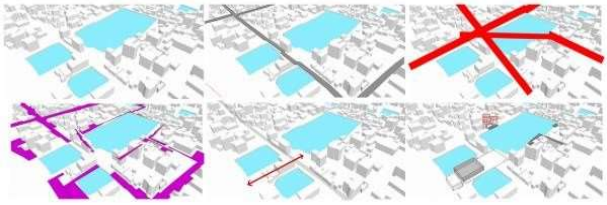

Figure 12: Design of an Individual Pond on City and Neighbourhood Scale

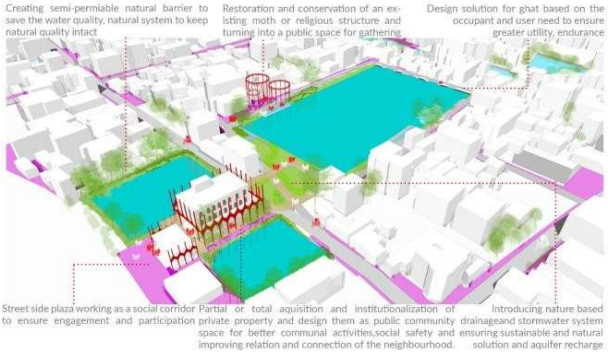

Figure 13: Design of an Individual Pond on Neighbourhood and User Scale

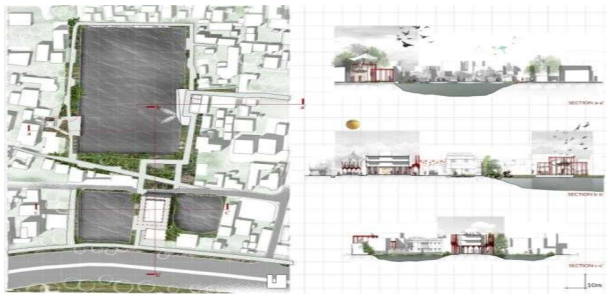

Figure 14: Design of Individual Pond

CONCLUSION

To remain pertinent in the present context, the cities are in a continuous process of change, readjustment

and evolution. Rajshahi city is no exception [8]. Whenever this transformation is positioned and aligned with the purpose of gaining city and human need the city advanced towards a sustainable development. The idea of deriving an intrinsic urbanism and achieving quality of life by bringing about a new and appropriate outcome by restoring the pond-centric culture and infrastructure. It can solve the long-term problems of heat dust and water-clogging efficiently attain sustainable living environment, which is physically and socio-economically resilient by choice not by force.

Figure 16: Conceptual Visualisation of Other Ponds Defining the Images of Pond-centric Urbanism of Rajshahi

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TECHNOLOGY AND WATER CONSERVATION IN ARCHITECTURE: USING RENEWABLE ENERGY AND SUSTAINABLE SOURCES OF TO CONSERVE WATER

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ABSTRACT

Water conservation has become a concern, due to the growth in population, which has led to the rise of buildings worldwide. These buildings are designed to minimize resource usage, lessen ecological impact and promote an environment. There are many countries that have implemented water technologies such as water-cooling towers and rainwater harvesting systems to reduce water consumption and preserve this resource. To assess their goals green buildings are evaluated using water conservation indexes and various rating systems. In buildings utmost importance is placed on conserving water by incorporating materials and systems that minimize water usage in both building operations and landscaping areas. Sustainable water management involves utilizing sources of water such as water for residential zones and a combination of potable and non-potable water for larger commercial areas. All fixtures including faucets, toilets, showerheads and urinals are designed to be highly efficient in terms of water consumption. Implementing low carbon policies that focus on increasing water efficiency is crucial in addressing warming and climate change concerns. This research presents an analysis on the possible method to conserve water in buildings using various advanced technologies and renewable sources of energy to supply water. Which aims to enhance the ability to reduce environmental changes such as global warming.

KEYWORDS

Keywords: water conservation, renewable source, rapid increase, rainwater, sustainable

INTRODUCTION

Water is an important element on the planet for survival. It is a basic necessity for a living organism. Water conservation is of a rising importance due to the increase in population and the slow depletion of water resources. Water is a natural resource, due to its reduced availability, we are paying huge amounts for its supply. Rainwater collection and distribution of it is important for everyday activity. It is where we can accumulate water from the rooftops and deposit it in reservoirs. Similarly, greywater harvesting, efficiently designed sanitary fixtures are some of the common ways of reusing water or conserving water. This can be used only for landscaping, shower and laundry. This water cannot be used for drinking purposes.

As per statistics, (Anon., 2023). Lakes and river beds are with a low water capacity due to lack of rain. In order to cater for the dense population, high rise buildings are built. These buildings might be green buildings that are built world-wide, yet water is not conserved at its fullest. The conventional way of conserving water for a building is by lowering water usage in showerheads, faucets but even renewable energy sources can be used to increase the conservation of water. Renewable energy and water conservation are critical consideration Incorporating renewable energy sources and energy-efficient technologies into the architectural design can lead to significant reductions in both energy and water consumption that can contribute to environmentally friendly and resource-efficient building designs. Observing water usage and performance are the first steps in understanding water wastage. Water and energy use relate to each other. This method is efficient and effective in large commercial buildings that require much water for their occupants, workers and visitors.

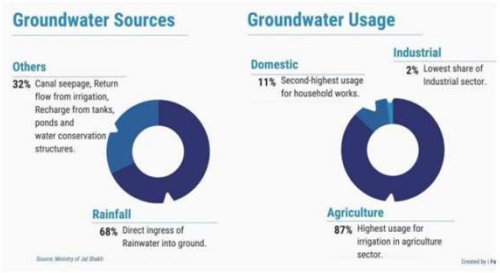

Figure 1 Ground water statistics Source: ministry of Jal shakti

BACKGROUND

steps in understanding water wastage. Water and energy use relate to each other. This method is efficient and effective in large commercial buildings that require much water for their occupants, workers and visitors.

Traditional Ways of Conserving water in India:

1. Kattas- These are temporary structures made from mud and loose stones that slow water flow and store water during dry months. They are cost-effective and widely used in rural areas, often more effective than modern concrete dams. Rejuvenating community-based Kattas can help maintain sustainable water management in India, as personal $_2$borewells and handpumps have led to decreased water levels in open wells.

2. Efficient Sanitary fixtures- Low-flow toilets use advanced flushing mechanisms, reducing water per flush by up to 50-80% compared to conventional toilets. Water-saving faucets are equipped with aerators that mix air into the water stream, providing a consistent flow while reducing water consumption.

3. Jhalara- These are rectangular step-wells with tiered steps collecting subterranean seepage for religious rites, community use, and royal ceremonies. Located in Rajasthan and Gujrat, they are human-made tanks with levels for water storage. Jodhpur has numerous jhalaras for rainwater conservation.

4. Eri- It is an ancient water management system in India that controls floods, prevents soil erosion, and stops runoff during heavy rainfall. It channels collected rainwater into central tanks for irrigation and other purposes.

5. Greywater management- Greywater harvesting is the collection of wastewater from household activities, such as hand basins, washing machines, showers, and baths, to irrigate landscapes. This process removes impurities and lint, allowing it to be used for irrigating flower beds and gardens. Greywater is a sustainable alternative to chemicals and energy, but it can contain harmful bacteria and viruses, making it unsafe for lawn sprinklers.

AIM

This research aims on understanding how water can be conserved using renewable sources of energy using technology. This research aims to enhance water efficiency, reduce wastage, and promote sustainable water management practices through the integration of artificial intelligence, data analysis and advanced sensors. The goal is to create scalable, cost-effective, and user-friendly solutions that contribute significantly to global water conservation efforts, ensuring the preservation of freshwater resources and fostering resilience in the face of increasing water scarcity challenges. It also emphasizes the importance of scalability, sustainability, cost-effectiveness, and practicality in implementing these technological solutions by using renewable energy sources to achieve substantial and lasting impacts on water conservation efforts.

RESEARCH METHODOLOGY

Geothermal Energy HVAC systems:

These are adapted in regions where there are hydrothermal sources like regions around hot springs. These are in places that have low enthalpy regions in India. The geothermal energy points are located in places like Chhattisgarh, Himachal Pradesh, Manikaran, Tapoban, Jammu and Kashmir, etc. Geothermal energy is generally used to produce electricity with a smaller amount of water consumption. It has many benefits, including low emission rates, high-capacity factors, and low cost. It can be used in HVAC systems such that both electricity and water can be conserved

RESEARCH METHODOLOGY

The conventional air condition system absorbs the heat from the building interior and evaporates the water vapour into the atmosphere. In the process of geothermal cooling, a closed loop is used to exchange heat into the ground that cools the interior. During this process instead of allowing the water vapour to get evaporated into the atmosphere, it is channelized into the pipes which take up the cold-water vapours into the ground which gets heated at its boiling temperature due to the earth's heat. This heated air can be used in air conditioning systems. Due to this closed loop of pipes, water in the form of water vapours is conserved instead of leaving it in the atmosphere.

This technique cannot be used in places where there is more humidity. Whereas in the process of geothermal heating, the hot water is contained in a pipe, which cycles above ground. The hot water heats a liquid organic compound that has a lower boiling point than water. The organic liquid creates steam, which flows through a turbine and powers a generator to create electricity. The only emission in this process is steam. The water in the pipe is recycled back to the ground, to be reheated by the Earth and provide heat for the organic compound again. The process of geothermal heating is widely used in many European countries for heating. The heat energy let into the earth can also be used for generation of electricity. This not only helps in conserving water but also to conserve electricity. liveability were studied, and these perspectives were infused with the existing characteristics of ponds. These studies came up with three viable matrixes showing the interrelation of ponds and the city from the material and the abstract viewpoints.

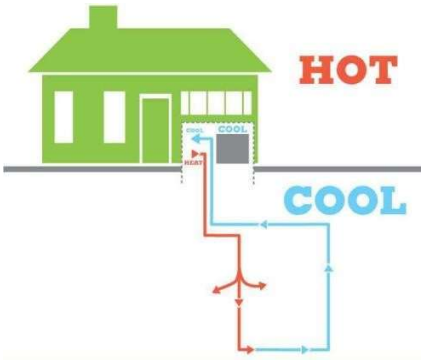

Figure 2 Reverse process of geothermal heating Source: IGSHPA

Ice Stupa for Water Conservation Systems:

In order to adapt and mitigate the impacts of global and climatic changes, the region is experimenting with new techniques that blend traditional knowledge and modern science.

In order to adapt to the impact of global and climatic changes, the cold and dry regions are experimenting with new techniques that blend with traditional knowledge and sciences. One such technique is by building artificial ice reservoirs. (Sourab Maheshwary, 2019) Ice stupas are dome- shaped structures that are created by freezing the underutilised water during the winter months. These ice domes store a large amount of water that melts during summer which is used. By doing this the water in the river and lakes can be conserved.

These are reservoirs where it reduces the loss of the glacial meltwater by taking advantage of the frequent freeze-thaw cycles in cold, arid environments. Unlike lakes, which freeze from the top down, ice reservoirs freeze from the bottom up. The redirection of water into a shadier place with a large surface area, or by sending it into pipes that spray it into the surrounding air—ice reservoirs allow water to freeze back into ice before flowing any further. Over time, layers of ice form on top of each other, creating a water storage system. By doing this the water is reused from its solid form to its liquid form. Due to the shape of the stupa, there is less exposure of wind and sunlight to the dome which prevents it from forming into glaciers.

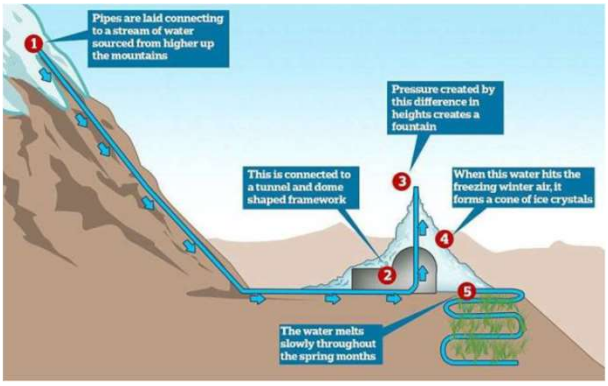

Figure 3 Ice Stupa formation process

Stormwater Management:

Stormwater or snow water runoff is the fastest growing source of pollution in the world. These can be caused by rain and snowmelt that flows over land or impervious surfaces, and can have negative environmental impacts like soil erosion or flooding. In contrast Porous natural landscapes, such as meadows and forests, will readily soak up most of the rain or snowmelt they receive. This is then gradually released into the groundwater, nearby water bodies, and the atmosphere. The storm water can be managed from being polluted by retaining the water in a channelised catchment which is connected in form of pipes from the porous natural landscape allowing it to filter into the earth (which increases the ground water table), return to the atmosphere through evapotranspiration (when water evaporates directly from the land or plants), or be reused for another purpose, such as landscaping. This thus increases the water supply and prevents the ground from getting heated or dried. The alternative approach to conserve storm water in buildings is by having green roofs which take in the water from the terraces and reaching the underground water tank that has various filters which can be used for daily purposes.

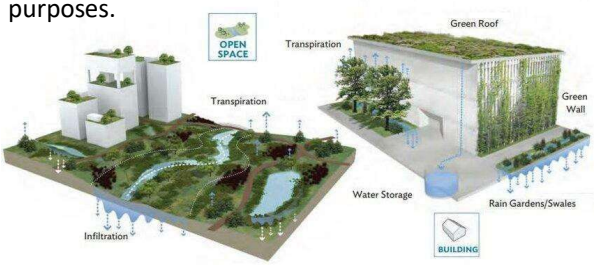

Figure 4 Storm water management in a building and open space Source: Research paper- Asia Institute of Technology

Efficient use of water in construction:

The construction industry requires significant water, and its water requirement can be reduced through effective building design and management. Simple ways to reduce water consumption include using buckets of water for cleaning tools, using high-pressure hoses instead of running water, and using concrete mixers containing fly ash. Various curing methods are available, including ponding, membrane curing, and chemical admixtures. Ponding involves covering the concrete surface with moist canvass and forming small ponds of sand around it. This method reduces the demand for curing water and maintains the satisfactory temperature by preventing evaporation of water. Membrane curing is water-efficient, using a layer of water-proof material, such as wax emulsions, bitumen emulsions, and plastic films. This method is commonly used in areas with limited water availability, such as India, where contractors often use dump gunny bags. GRIHA recommends using chemical admixtures like High Range Water Reducers (HRWR) or super plasticizers as indirect accelerators, as well as wax and resin-based compounds. By implementing these methods, the construction industry can significantly reduce its water usage

Figure 5: construction technologies used in terms of construction materials. Right figure: prestressed slab & Left figure: precast stone block Source: GRIHA manual Volume-4

Efficient use of solar and wind energy to conserve water:

Solar and wind energy does not use water. These are clean sources of renewable sources of energy that do not pollute air and water to generate electricity. These energy sources can be used to replace the thermal and nuclear power stations.

This will also help to conserve and protect the water resource and hedge against future power shortages due to water-dependent electricity production. The turbines of wind mills and the photovoltaic cells of the solar panels also may decrease the dependence on the quantity of power generated from fossil fuels, resulting in lower air contamination and CO2 emissions. This form of energy will also help in maintaining the ground water level and may even lead to the increase in ground water table.

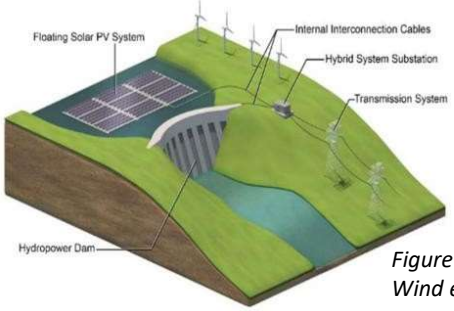

Figure 6: Solar and Wind energy to conserve water. Source: NREL

FINDINGS/ ANALYSIS:

The analysis is in the form of a comparative table that will help in understanding the ways in which water can be conserved using technologies. These water conservation strategies are only for the Indian climatic context which can be used as sustainable technological factor in the conservation of water. This table also summarises the various technological approaches that have been addressed earlier in this paper.

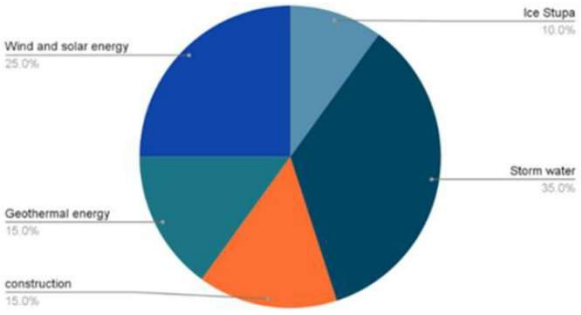

Figure 7: analysis pie chart- water conservation strategies

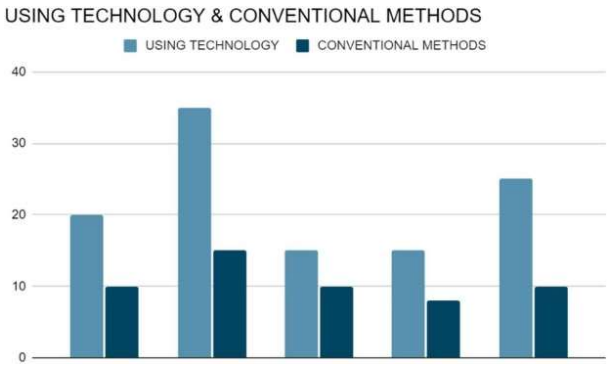

Figure 8: Comparative analysis- water conservation using technology and conventional manner pie

SL NO.	DESCRIPTION	LOCATION	CLIMATE	EFFICIENCY
1	Geothermal Energy	Chhattisgarh, Himachal Pradesh, Manikaran, Tapoban, Jammu and Kashmir	Places that have low enthalpy; absence of humidity	Its efficiency is 10% to 15% as it's the reverse process of geothermal heating. Geothermal heating has efficiency of about 80%
2	Ice Stupa	Jammu and Kashmir, Leh, Ladakh	Cold and dry climate	The efficiency of this is about 27% as it cannot be used in all climatic zones and is restricted to cold and dry regions. The frozen water is an important source in this cold desert due to lack of rain
3	Stormwater Management	In the entire country	All types of climatic regions of the country	Stormwater management not only saves water but also recharges the ground.
4	Constriction Field	In the entire country	All types of climatic regions of the country	Construction industries consume maximum water. Usage of efficient techniques help in saving water almost. It can save about 20% of water.
5	Solar and wind energy	Maharashtra, Karnataka, Rajasthan	In hilly terrains	Water can be conserved using these basic renewable energy sources up to 5% to 10%

With the help of this graph the comparative analysis of using conventional techniques and the modern technologies will help in understanding that the efficiency of conserving water using modern techniques is more than that of the conventional manner.

INFERENCE

Based on the analysis, from the above table and the graphs, it is understood that water, the primary source of living, can also be conserved in the following ways based on the climate and surroundings. Its efficiency rate also shows how even the smallest quantity of water can be conserved using technologies and the conventional ways that will help one survive during the water scarcity period. By using such water conservation strategies, there are possibilities that the other non- renewable sources might not get depleted. It increases the green rating in a building if followed. These sources of water conservation even help in saving electricity. This technological innovation will continue to revolutionize water conservation strategies that will enhance its efficiency and sustainable practices. This helps in better water management of the resource. These strategies might also mitigate the water scarcity in the future.

CONCLUSION

This paper talks about the manner in which water can be conserved using technologies. Which includes the emerging scientific studies, sustainable construction techniques and philosophies that are shaping the future of green buildings and their materials. There are conventional ways of water conservation, but these strategies must be altered by using the emerging technologies and green building aspects that will increase the quantity of water conservation. The main problem of having a low water table level will also be solved.

The importance of water conservation in green building design and construction has grown significantly, with the LEED rating system doubling water efficiency points to ten. Numerous rating systems evaluate water efficiency in buildings, and measures are being taken to protect remaining freshwater resources and avoid future water scarcity. Buildings now reflect environmental and economic concerns, with future buildings incorporating social, environmental, and economic aspects. Rapid feedback collection and communication enable the implementation of counteracting measures, such as global warming mitigation

measures. Green building adoption is expected to change the trend of rising carbon dioxide levels in emerging nations, shifting focus to energy-efficient and green buildings.

The usage of renewable energy sources along with technological aspects not only help in conserving water but also helps in saving the environment from getting the water sources and the air polluted and destroyed to a certain extent. These energy sources also help in saving electricity.

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SUSTAINABLE URBAN STORM WATER MANAGEMENT: A CASE STUDY ON KOZHIKODE CORPORATION

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ABSTRACT

The importance of an efficient drainage system of both storm water and sewage along with inundation in city planning is well recognized. In states like Kerala, where the intensity of rainfall is very high, the importance of a well-developed drainage system is a must. Frequent water logging and inundation during acute monsoon necessitates evacuation of the inhabitants of the low-lying areas. In an unscientifically planned city, the drainage system will be either inadequate or absent in some areas. The existing secondary drains seem to be inadequate to carry the entire storm water runoff of the city particularly during the monsoon season, when the rains are heavy. Lack of centralized drainage system result in polluting Canoli Canal, and Kallayi Arabian river Sea. This study underscores the vital role of an efficient drainage system, encompassing storm water and sewage management, as well as inundation control, within urban planning, particularly in regions prone to heavy rainfall like Kerala. The prevalence of frequent waterlogging and inundation during intense monsoons necessitates a well-planned drainage system to safeguard inhabitants, especially those in low-lying areas. This emphasizes the urgency of establishing a sustainable stormwater management system in the urban area of Kozhikode.

KEYWORDS

Urban drainage, Storm water management, Rainwater harvesting, Sustainability

INTRODUCTION

In Kerala rise of water scarcity and draught caused due to human activities, negligence of existing water bodies and climate changes increases the need of conserving existing water bodies and awareness of sustainable water harvesting methods. In most of the places water distribution uses a huge amount of man power, energy and carbon emission. Availability of safe water is less and public participation for conservation of water is negligible. Role of public in conservation of water conservation and awareness of sustainable water conservation should be spread to the present and future generation. The rivers flowing through the urban areas have dwindled into streams of garbage leading to stinking cesspools where mosquitoes and bacteria breed. Today, the demand of water required for urban areas is piped in or transported from other areas.

Kozhikode Corporation is located in the humid tropical region of Kerala, where the predominant climatic factor is rainfall. Although, the rainfall received on an annual basis is very high, it's uneven distribution results in floods during the high rainfall season, and drought during the low rainfall season. Rainfall is the major recharge source for groundwater in the study area. Both the south-west monsoon and north-east monsoon are active in the study area with the former being the more predominant one.

AIM/PURPOSE

To design, construct and maintain a sustainable storm water management system for Kozhikode town that reduces the potential of flooding, enhances the water quality conditions and protects the existing natural drainage features.

METHODOLOGY

Sub catchment areas for the study area was delineated using GIS from DEM file. Different land use plans were generated for each sub catchment zones and amount of storm water received was calculated. Flow design was generated and major flow direction of the runoff was formulated and amount of water was calculated. Possible retention areas were identified using land suitability analysis of different layers like Slope, Geology, Land use, Road network etc. Existing drainage system study was conducted by field study and data from respective departments. Major urban water logging area was analysed from the previous studies; detailed study and solution was proposed for that area.

STUDY AREA

The Kozhikode city having an area of about 84.0 sq.km only has got a comparatively long sea shore of about 15 km and a substantial length of river and canals. The Canoly Canal formed as a navigation canal running parallel to the city through the city centre is now acting as the main drainage channel. The length of the canal connecting Elathur river and Kallayi river is 11 km and the width of the canal varies from 6 to 20m. Eastern part of the city is about 60m above mean sea level where as coastal area is about 1.2m above sea level. Small hills are situated on the eastern side of Canoly canal surrounded by low lying areas and waterlogged areas. Major portion of the rainfall runoff of the area is discharging in to sea, Kallai River or Canoly canal.

ZONAL PLANNING

The first step in system analysis and design is the demarcation of the catchment areas of respective natural drains. As the discharge in these natural drains

will vary from reach to reach, it is essential for economic reasons that discharge is also estimated at various intermediate points along the reach. Since various hydrologic procedures give flood discharge at the outlet of the catchment area, it is considered convenient to divide the catchment area into sub-catchment areas so that discharges at intermediate points may also be computed. In urban catchments, flow pattern is modified by urban features like roads, culverts etc. because these features cut across ridges and valleys thereby hydraulics of flow of the considerations discussed the changing the natural area. Based on the Kozhikode Corporation has been divided into three zones. A detailed coding procedure has also been adopted for identification of various drains in the study area.

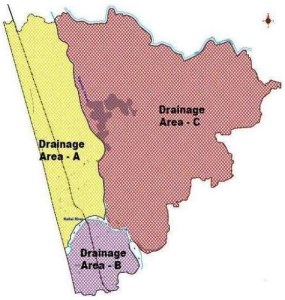

Figure 1 Kozhikode- Storm Water Drainage Zones (Source: Kozhikode Municipal Corporation)

ZONE A

Zone A consists of the area between Canoly Canal on the northa, Kallayi river on the south and Arabian sea on the west, the areas mentioned are thickly populated and central business district area. The road networks are unplanned and closed. So roadside drains have to be adopted as primary and collector drains. So naturally the drains in the zone A should be redesigned for draining in to Arabian sea in the west and draining in to Canoly canal in the east. The side drains of the east west roads have to be redesigned to take the storm water of the adjoining area to the sea or canal collecting the storm water from the north south roads. Integration of the side drains with natural drains have to be achieved. The water logged area adjoining the canal has to be drained off by providing adequate canal inlets and cross drainage works to Mini Bypass. Zone A is further divided to 21sub zones.

ZONE B

Zone B comprises of the area on the southern side of Kallayi River which consist of Kallayi river in the south and Arabian Sea on the west. The drainage system in this area has also to be designed to discharge to Kallayi river or to sea. In this zone also side drains of the roads have to be adopted as primary drains. Integration of the drains and linking of missing links have to be carried out. Zone B is further subdivided in to 9 sub zones.

ZONE C

The zone C consist of the area on the eastern side of the Canoly canal upto the corporation boundary. In comparing with the other two zones density of population is low in this zone. This area comprises of hills and low-lying waterlogged areas. The drainage of the highland is restricted due to encroachment of the natural drainage channels and due to formation of roads superimposing over the drainage channels. The drainage system of this area has to be designed so that the storm water from the highland is drained to the canal through the waterlogged area wherever present. Zone C is divided to 26 sub zones.

STUDY AREA- ZONE A

Zone A consist of the major Commercial Buildings, Historical Buildings, Industrial areas, Hospitals and Hotels of the Kozhikode Urban Area. Land on western side is sloping towards the Arabian sea and land on eastern side is sloping towards Canoly canal. So basically, the storm water are having a flow pattern of water flowing to Arabian sea and water flowing to Canoli Canal despite of the water shed pattern which shows flow of water to Arabian Sea.

Thus, Zone A can be further divided into two zones Zone

A – which flows water to Arabian Sea and Zone B – which flows water into Canoloi Canal.

Subzone Delineation

In an urban area, Watersheds and Contour cannot be used for determining flow accumulation and flow directions. Land use pattern, Soil typology and road networks have major significance in determining the drainage pattern of a city. In most cases, Primary roads act as sub catchment area from the different land uses. Zone A is classified into 21 subzones with major drains that flows into Arabian sea, Canoli Canal and Kallayi River. Slope pattern, Road network and micro water sheds are used to delineate sub zones.

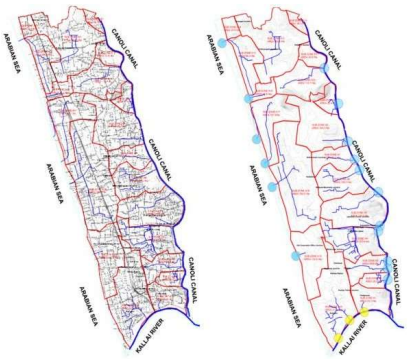

Figure 2 Observations during the virtual walk mapped by authors.

CANOLI CANAL

Kozhikode urban area has a combined sewerage system and the city doesn't have a Sewage treatment Plan most of the wastes produced (Domestic, Industrial, Commercial, Hotel) are disposed to storm water drains. These drains transport these wastes and deposit it to either Arabian Sea or Canoli Canal. Even if its mandatory to not to dispose sewage waste, Industrial and hotel wastes to the Storm Water Drain, from the study it was observed that there are several

illegal drain outlets opening to the public drains.

ISSUES IDENTIFIED

Major issues related to Canoli Canal identified are

Silt formation- Storm water carries sediments from the catchment areas, Canoli Canal is connecting Mangala river and Kallayi river and passes through two major wet lands Perunthiruthi wetland and Kottuli wetland. Flow of water from Mangala river and the wetlands contribute a huge amount of silt formation, catalysing to this process wastes from the urban area also get deposited to the Canal. During monsoon this silt formation increases and this blocks the outlet of storm water drains. Thus the water from the urban catchment areas spread within the catchment areas, this results in urban flooding during monsoon.

Illegal encroachments- vendors near the Canoli canal results in dumping of wastes into the Canoli canal and thus polluting the canal. Under the project of beautification of Canoli canal and Sarovaram park encroachments were removed from Arayadathupalam to Erinhipalam road but Arayadathupalam to Mankavu road lot of encroachments can be seen.

Lack of fencing- Pedestrian pathways along the bank of canal was constructed under the project of Municipal corporation, lack of fencing along the road and footpath makes a chance of garbage disposal into the canal.

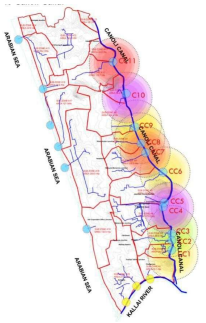

Figure 3 Locations showing samples taken for study

Zone 3 & 4 were reported with more pathogenic bacteria, the reason can be attributed to the presence of hospitals and slaughter houses. The canal receives the waste water from the near by establishments. The data also revealed that, the highest proportion of Enterobacter species were noticed in the samples collected from Kaluthankadavu Bridge and Karaparamba sites (zone 2). The survey of the sites, found that sewage disposal practices in the area was very poor. Kaluthankadavu bridge site, a slum area is seen to have very poor municipal drainage facilities. Low bacterial counts were observed in the samples collected from Kaipuarhupalam and Erajikkal area (zone 5) where well established municipal drainage system waspresent. Majority of the sampling stations under zone 3 which were observed, have more of coliform bacteria than other pathogenic strains.

This may be due to the controlled release of municipal waste water.

Inflow of water to Canoli Canal

The depth of the canal ranges from 1.5m to 2m, (Hamno and Pettersson, 2005). Ground water seeps into the canal in varying quantities through the length of the canal depending on the water table depth at individual locations. The flow is observed maximum at Perunthuruthi wetlands and Kottuli wetlands and where the water table is at its highest (0.21m during monsoon months). The flow of water to Canoli Canal is from Kottuli wetland and Mangala River and opens at Kallayi River.

During high tide and monsoon water level in the Kallayi river increases and the water level increases than in the Canoli Canal, this leads to blocking of outflow of water from Canal and increases the inflow of water from the Kallayi River as well as from Kotulli wetland and Mangala river. As water level increases in Canoli Canal, a backflow of water from Canoli Canal to the drain outlets are observed. This can be listed as a main reason of water logging of Mavoor Road during Monsoon.

The outflow from the canal is more through the Kallayippuzha mouth. This could be explained by 2 factors:

1.The flow of water from the Kottuli wetlands and secondary tributaries of Kallayi River into the canal

2. Ground water flow into the canal through the entire length of the canal

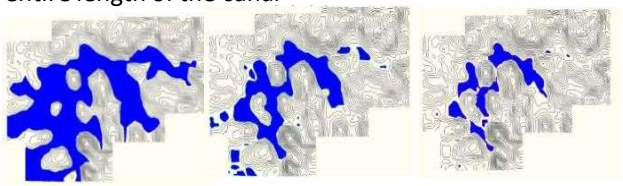

Figure 4 Prediction Model of Kotuli wetland assuming 2m deepening of Canoli Canal during 1848, 2018 and 2035 (Source: Impact of Colonial Navigation Canals on Wetland Systems in India.)

URBAN DEVELOPMENT ISSUES

Zone 3 & 4 were reported with more pathogenic bacteria, the reason can be attributed to the presence of hospitals and slaughter houses. The canal receives the waste water from the near by establishments. The data also revealedthat, the highest proportion of Enterobacter species were noticed in the samples collected from Kaluthankadavu Bridge and Karaparamba sites (zone 2). The survey of the sites, found that sewage disposal practices in the area was very poor. Kaluthankadavu bridge site, a slum area is seen to have very poor municipal drainage facilities. Low bacterial counts were observed in the samples collected from Kaipuarhupalam and Erajikkal area (zone 5) where well established municipal drainage system was present. Majority of the sampling stations under zone 3 which were observed, have more of coliform bacteria than other pathogenic strains.

a)Informal Development in Fringe Area. Areas like Olavanna, Cheruvannur Nallalam, Kunnamangalam, Beypore and Feroke are under pressure for further urban growth but do not have the level of infrastructure and development control. Poor control has resulted in the conversion of prime agricultural land and infilling of water bodies for urban use.

b)Dearth of Infrastructure. In Kozhikode, significant areas of land for housing were subdivided and sold but are lying vacant. As a result, the condition of infrastructure provided in the area has deteriorated.

c)Shelter. There is a shortage of affordable housing in most of the planning area. The urban poor find it difficult to get developed sites for house construction at affordable prices because of high land cost. This has resulted in the growth of slums and Economically Weaker Section (EWS) colonies. The Development Plan (2001) has identified present deficiencies in the housing stock and future requirements but it has not indicated how shelter and land for housing for the urban poor should be provided. It is essential to estimate the actual housing needs of the populace (including affordability), particularly for those Below Poverty Line.

d) **Poor Management of Water Bodies/Tanks**. Water quality as affected in Conoly Canal and other water bodies due to discharge of untreated domestic and industrial effluents. Water bodies and low-lying marshy areas are reclaimed due to demand for land for development, weak regulations and non-enforcement of environmental regulations that exist to safeguard water bodies. Ground water is the primary source for domestic consumption in newly developed areas but over extraction has resulted in brackish water, especially along the coastal belt. Thus, for any future use, ground water exploitation should be effectively monitored and controlled.

e) Lack of Co-ordination in Planning. Industrial, residential and infrastructure investment decisions are coordinated particularly in the fringe areas where pressures for urban expansion are increasing and it's becoming increasingly difficult to monitor and control development.[5]

PRIVATE WATER ARTIFACTS

There is a lack of clarity over departmental responsibilities for land use planning, development, maintenance and enforcement. This has resulted in ineffective and uncoordinated decision making processes and actions.

MASTER PLAN

FLOOD PRONE AREAS – SITE SELECTION

There is a lack of clarity over departmental responsibilities for land use planning, development, maintenance and enforcement. This has resulted in ineffective and uncoordinated decision making processes and actions.

Based on the flood prone areas developed by Town Planning Department, Flood map generated from DEM file, Land Use Map of Kozhikode and Primary study, suitable site for study is selected. From the maps generated it is analysed that stretch of Mavoor road between KSRTC Bus Stand and Arayadathupalam bridge observe frequent water logging issues. Reasons can be listed as unscientific drainage system, lack of inspection of waste disposal from commercial and residential buildings, lack of pervious areas etc. From the DEM file obtained from USGS, flood prone areas are generated. It is observed that main flood affecting areas are Kottuli Wetlands, banks of Canoli Canal, Jaffar Khan Colony and Mavoor Road. These are the major low lying areas in the corporation boundary. In the previous land use plans these are marked under wetland category, but in the present condition Jaffarkhan Colony and Mavoor Road are having several constructions.

DELINEATION OF SUB CATCHMENT AREA

The contour map shows that slope from the four sides of the site area is converging to one single point. In the road map its visible that the converging point is Mavoor Road and then to Canoli Canal. From the Contour map and road network a sub- catchment map is generated for the study area. Road network plays a vital role in delineating sub catchments, considering the water shed in urban areas. Water from built areas are opened to the road for run off. Sub-catchment delineated in map shows the flow direction of the entire catchment. A well planed drainage system have to be developed according to sub catchments and road network. Runoff rainwater amount is calculated according to the permeable and impermeable areas in the subcatchment area.

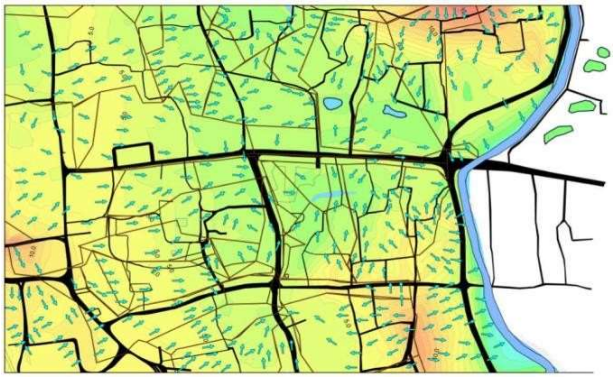

Figure 5 Sub-Catchment map overlayed with Road network and Contour map

STORM WATER RUNOFF POTENTIAL

Building typology map is generated to identify types of commercial, residential and hotels alongside surface typologies to understand the storm water runoff potential of the study area. Total site area is sub divided according to paved area, semi paved, sloping roof, flat roof, vegetation cover and road network. Total area are calculated with the help of

Arc GIS, the data is used for calculating total runoff calculation of the study area and drainage development plan.

RECOMMENDATION

The overlaid maps of delineated Sub catchments, Contour, Build Blocks and Road Network helps to find out the Best Management practice for the study area. Collective management in road system helps to collect the excess water from the designated basins. parcels and empty lands to the destination stream.

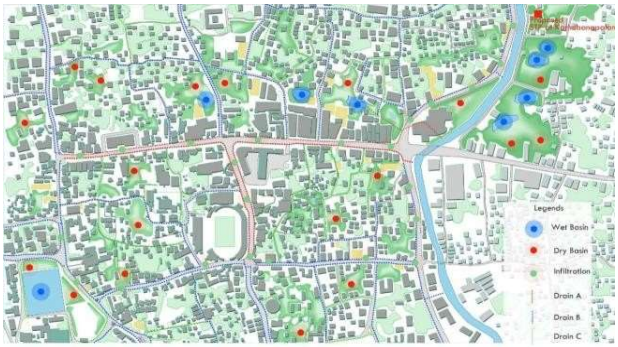

Figure 6 Proposed development plan for flood prone areas

PHASE I – IMMEDIATE MEASURES

Provision of Sluice Gate – Introduction of sluice gate at the opening of Kallayi River can reduce the inflow of water from Kallayi river to Canoli canal during monsoon and high tide thus avoiding blockage of storm water drains opening to Canoli canal. Parapet wall and fencing – Introduction of fencing or parapet wall along Canoli canal from Arayidathupalam to Karaparamba can reduce risk of throwing of garbage into canal. Desilting of Canoli canal – Sewage waste from the city and Silt from the Perunthiruthi and Kotuli wetland are deposited in the Canoli canal. Periodical desilting of Canoli canal can reduce the silt formation and blocking of drain outlet. Expansion of drainage at Arabian sea – The drains opening west to Arabian sea are always affected by high tides. Expansion of drain minimum to 200m to Arabian sea is suggested.

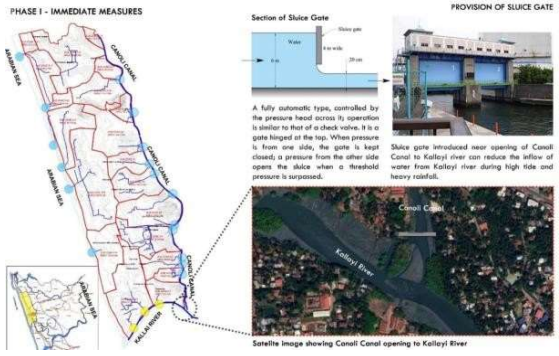

Figure 7 Proposed sluice gate to prevent inflow of water from Kallayi river.

6.2. PHASE II – DEVELOPMENTS AND PUBLIC PARTICIPATION

Solid waste management – The practice of solid waste management has been found to be inefficient in the city. Proper waste segregation, collection and disposal measures are to be taken. Control measures for sewage disposal – Proper inspection in the commercial buildings, hospitals, and residential buildings. Control and regulatory measures taken for prevention of sewage into storm water drain. Illegal drains should be dismantled. Development of drainages – Identification of existing drainage channels and preparation of master plan. Development of new channels to connect sub catchment areas to main drain channel. New construction of channels, silt chambers and culvert for connectivity.

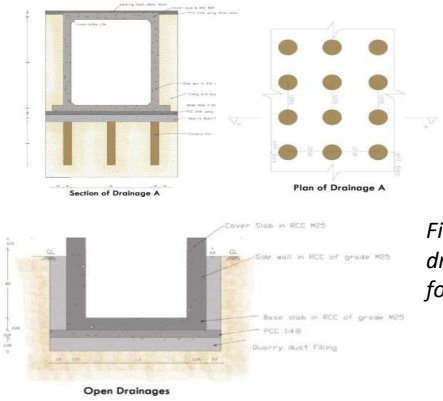

Figure 8 Proposed drainage drawings for the study area.

PHASE III – LARGE SCALE SOLUTIONS

Proposal of green network and infiltration basin – Green spaces including that of parks and other recreational areas to be proposed as to act as detention basins. Infiltration basins given at specific points help seep the water underground. Proposal of STP – Sewage treatment plants to operate the wastes of the approximately 3 million populations and the other miscellaneous wastes to be in action effectively. Separated sewerage system – Separated system to carry off the sewage need to be implemented so that it does not get mixed with the storm water and necessary treatments or ways of disposal can be carried out. Proposed road typology for Mavoor road – Improved roadways with pervious pavement and storm water inlet should be introduced.

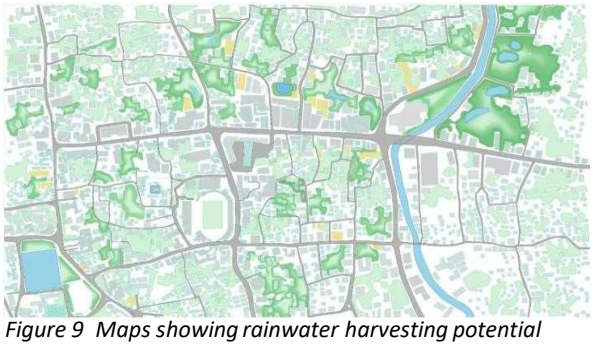

Figure 9 Maps showing rainwater harvesting potential

Figure 10 Proposed Road typology for Mavoor Road

CONCLUSION

The conventional method of storm water management practiced in the c major cities of Kerala are to collect the wastewater and storm water into a single channel or to a main water body like river or sea, same has happened in the Calicut corporation too. Even though proposals of Sewage Treatment Plans are proposed the implementation of integrated storm water management is not done well. Proposed STPs are not completed and more over waste from commercial land uses especially hotels and hospitals are open to the major drains and water bodies; thus leads to serious water degradation problems and health issues. In this study major water logging areas and storm water problems are identified and solutions are provided. The solutions are listed as in three phases according to the seriousness and possibility of solutions. Storm water outlet to the Arabian sea, garbage disposal in the drains and Canoli Canal, river water intrusion to Canoli Canal are given the first priority. Solid waste management and Proper drainage plan are mentioned in the second phase of development. Introduction of Green belt, separate drainage system, Artificial recharging through infiltration basin and retention system and improvement of road section are provided in the final phase. It is recommended that at least 20 percent of the total area should be kept as open space which consists of both recreational and greenery spaces. This practice could increase the time of travel of surface water to the channel and thus increase infiltration. Wherever possible, storm water drains should be aligned along the natural flow routes with a sufficient slope to effectively drain off the runoff. Governments should ensure that the determined natural flow routes are marked on the ground both in urban and rural areas. Rain water harvesting systems should be practised, in an effective manner, as per law. Plants with high affinity to water can be planted in such areas.

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COLONIAL TOWN ALONG THE COASTAL EDGE: A COMPARATIVE ANALYSIS OF PORTUGAL TOWN AND GOA TOWN

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ABSTRACT

Along the western coast of India, on a narrow strip of land lies the state of Goa which has a certain character which makes it different from the rest. Th place has strong footprints of the Portuguese rule and the same has also given them a unique lifestyle and the place an individuality of its own. There seems to be a remarkable influence of Portuguese planning on Goa which has been adopted where the former developed towns at the mouth of the waterbody. The Portuguese influence has given Goa and specially the Old Quarter a distinct identity. The research attempts to trace the similarities and highlights in the planning employed by the then rulers in 2 distinct areas in different parts of the world and a comparison of the same with reference to various parameters. The area taken for the study in Goa is one of the most frequented places; Old Quarter due to the distinct character lent by the Portuguese influence; hence becomes a good example to study the different influences on the same and how the same has stood the test of time.

KEYWORDS

Colonial, heritage town, Portuguese influence

INTRODUCTION

Goa; is the smallest state of India and a major tourist hub; boasting of several world heritage architectural sites. It is well renowned for its rich cultural legacy, historical significance and vivid customs and traditions. Its heritage value is multifaceted and encompasses various aspects viz religious heritage, colonial architecture, cultural festivals, palaces, churches and fortresses, traditional dance, music, art and crafts and culinary heritage. Under the urban renewal scheme of the Jawaharlal Nehru National Urban Renewal Mission (JNNURM), Goa has been officially designated as a Heritage City (Shankar, 2012). With several heritage structures in its fold, Goa houses the Old Quarter area which has been declared as one of the 5 conservation zones under the Outline Development Plan 2011 (Mohta, 2016).

The state in its formative years was under various rulers; of which the Portuguese ruled for more than 450 years. The Portuguese had a major influence on them w.r.t planning and the distinct character specially bestowed to the area of Old Quarter. Though the Portuguese era in Goa left a lasting impact, it's important to note that Goan culture is a unique blend of various influences, and the local population has contributed to shaping the distinct identity of the region over the years.

The research thus tries to understand the planning principles adopted by the Portuguese which was first implemented in the old Portugal towns and how it shaped Goa and certain quarters of Goa. These areas still show maximum tourist influx and hence becomes a very interesting area to study the planning and the architectural influence.

METHODOLOGY

The purpose of this study was to study the evolution of the coastal town at Portugal and evaluate and analyse the same w.r.t Goa and its heritage town of the Old Quarter.

OBJECTIVES

- To understand the evolution of Goa and the various political influences on it.
- To identify the similarities in planning between old Portugal towns and Goa.
- To analyse the influences on the settlement.

RESEARCH METHODOLOGY

The methodology adopted for the study was majorly descriptive and an exploratory one; which will be conducted through stages vide elaborate literature review relating to the history and evolution of Goa; the development under the Portuguese influence and the planning principles employed then by the rulers and its striking resemblance to other Portuguese towns. The descriptive method of research shall help to gather information about the past as well as the present existing condition and the emphasis shall be more on the details. The secondary research shall investigate all the studies and works carried out by experts in the field, NGO's etc. in the Old Quarter area. The primary study will also take into consideration and case study of the Old Quarter; Goa and see the reflection of the Portuguese planning principles which has led to the growth and development of the place.

INTRODUCTION

History of Goa

According to the tradition of Dashavatar; Goa is said to be born out of Parshuram's arrow and was firstly addressed as Gove, Govapuri, Gomantak and Gomant and was harbourage city near the mouth of the Mandovi River (Sinha, July-2021). Over the period of time Goa, has

has being ruled by Mauryans, Chalukyans and followed by Muslim rule under Adil Shah. It was during the reign of the Muslim rule that the Portuguese first discovered Goa through their discoverer – Vasco Da Gama. The Portuguese seized the occasion to exploit India and snappily captured Goa from the Muslim rule. The name Goa was conferred by the Portuguese who used Goa for all their trade in Asia for the coming 450 years.

Resemblance of Goa to Lisbon and other Portugal towns

The Portuguese settlements were instruments of global strategy of domination over the sea and generally followed 3 main categories of – the factory, fort and the city and these types were not tightly fixed, but they evolved from each other (Teixeira, 1990). The main objective of the settlement and its location close to the water locations were to either service or secure sea passages and tap more commercial gains. The Portuguese defensive tactics: Castrensian tradition which dates back to the Pre-Roman Era was employed in the construction of the Indo-Portuguese villages on high ground. The settlements were so designed to accommodate the geography of surrounding area with the aim to protect and keep the possession of land.

The settlement was developed in 2 layers; the government, university properties along with the housing was developed along the higher level whereas the business activities and dockyards were developed at lower level along water source. The connection between the two layers was established through a relatively straight road that ascended the primary hill, eventually evolving into the main street or road, constituting the primary structural unit. Small, winding pathways and narrow alleys were established to facilitate entry to a closely-knit community home, promoting shared shading that considered the prevailing weather conditions. At the convergence of the uptown and downtown layers, strategically located squares or churches served as key landmarks.

Fig 01: Map of Lisbon. Source: https://www.re-thinkingthefuture.com/designing-for-typologies/a6176-an-overview-of-portuguese-colonial-architecture-in-india/

Goa, swiftly emerged as the commercial, political, and religious hub of the Portuguese in Asia, and adhered to a layout where elevated and prominent hill areas were reserved for public structures such as palaces, town halls, churches, convents, etc. This arrangement not only imparted a communal ambience to the city but also played a pivotal role in organizing urban space. (Chavan, 2018). The commercial activities took place along the harbour, thus making Goa the clearest example of Portuguese colonial city. Goa earned the moniker "Lisbon of the Orient" due to its remarkable similarity to the Portuguese capital. Positioned along the left bank of a river in a location strikingly reminiscent of Lisbon's, Goa exhibited an irregular semicircular layout (Teixeira, 1990). Lisbon; stationed at the mouth of the river Tagus; was under the Portuguese influence from the 15th to the 16th Century and followed organic and irregular development.

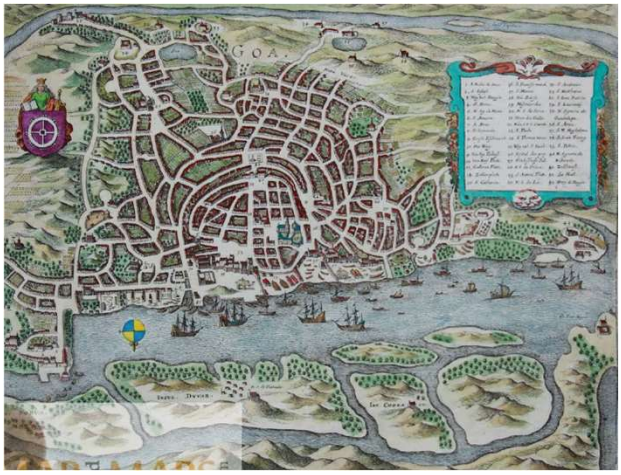

Fig 02: Map of Goa 1665.
Source:https://theworldofinfo.com/goa/history/

The Old Quarter has been declared as one of the 5 conservation zones under the Outline Development Plan 2011 of Panaji (Mohta, 2016). In the 2011 Outline Development Plan for Panaji, five regions have been designated as "Conservation Zones," namely: (1) Campal, (2) Mandovi river fronts (3) Fontainhas & Portais, (4) Altinho and (5) Fonduvem, Ribandar (Shankar, 2012).

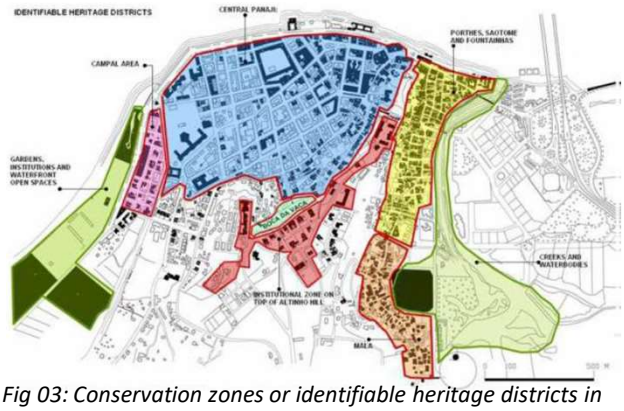

Fig 03: Conservation zones or identifiable heritage districts in Goa Source: https://archtallulahdsilva.blogspot.com/2010/08/jnnurm-focus-city-panjim.html

About the Old Quarter

The Old Quarter, a unique locale, preserves memories of Portugal's rule in India. It is a linear settlement, enclosed by the Ourem Creek to the East, the Altinho hill to the West, and the Mandovi River to the North. It consists of the 4 wards of Sao Tome, Fontainhas, Mala and Portais which are the oldest neighbourhoods in Panji.

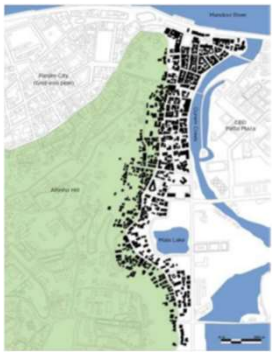

Fig 04: The Old Quarter nestled between the Ourem creek and Mandovi River (Source: Chapter "Project site" for detailed country and city level location maps)

Fig 05: The 4 wards of the Old Quarter Source: (Mohta, 2016)

The origin of the Latin quarters in 1770's is attributed to an Indian gentleman Antonio Joao de Sequeira, popularly known as "Mosmikar" because of the fortune he amassed in the Portuguese colony of Mozambique in East Africa before coming to Goa. Antonio Joao de Sequeira; used the land between the Altinho hill and Ourem creek (neglected parcel of land known as Taleigao village at that time in Tal. Tiswadi) and converted it into a coconut grove. The inhabitants predominantly comprised sailors, traders, blacksmiths, fishermen, and local individuals involved in the extraction of oil. The organic settlement established; was close to the Church of Immaculate Conception and soon the people started building houses on this patch of reclaimed land. The aristocratic Portuguese ruled from Old Goa then.

Following the demise of Antonio Joao de Sequeira, the land was transferred to the Convent of Our Lady of Carmo in Chimbel (Mohta, 2016). The deadly plague in Old Goa, in the early 19th century acted as a catalyst and the Portuguese shifted the capital to Panjim. The land was taken over from the Convent and the Portuguese converted it into residential quarter for the rulers and their administrators, since 1840's and the area thrive till date.

About the Old Quarter

As one of the oldest residential areas in Panjim, influenced by the Portuguese reign, this locality possesses a distinct yet modest character that reflects a blend of Portuguese, Art Deco, British colonial, and local Goan architectural styles. The Old District or "Latin Quarter," nestled adjacent the banks of the Ancient Ourem creek, distinguishes itself with a Mediterranean charm, narrow pathways, and balconies that gracefully hang over. Its atmosphere sets it apart from the main city (Shankar, 2012). The four wards have a minor difference in their built character; their usage and demographics but together they unite to form a common expression representing the Portuguese era.

Fig 06: The 4 wards of the Old Quarter along the Ourem creek, Mandovi river with Mala Lake. Source: (Mohta, 2016)

Sao Tome – The area is home to many historic buildings; including the Sao Tome Chapel and Old Post Office and has a mixed character; housing commercial on the ground floor and the residences on the top; with red tile roofs and colourful facades.

Fontainhas - The settlement derives its name as it is located at the foot of the Altinho Hills and is bounded on the west by the hills with natural spring from which its name derives. (Fonte Phoenix or Fountain of Phoenix). Mostly occupied by Catholic families; it is the face amongst all the 4 wards.

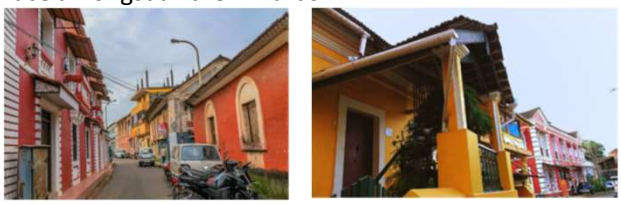

Fig 07: The varying streets and alleys of Fontainhas flanked by houses with Portuguese influence. Source: (Mohta, 2016)

Malas – The Mala houses located on the slopes are smaller and predominantly occupied by the Hindus marked by Maruti temple, and the urban poor and many as tenant outsiders; and has quiet lanes and inward-looking houses. Thus, Mala is predominantly residential neighbourhood.

Portais – The area includes a mix of Catholic, Hindu and Muslim houses which is evident from the ornamentation done along the entrance of each house. Houses belonging to different religious communities can be readily distinguished by specific symbols at their entrances—a tulsi plant signifies a Hindu household, while a cross indicates a Christian residence.

The main road / spine which connects the 4 wards is the Rua 31 de Janerio which starts from Sao Tome and extends till the Fontainhas and becomes Ramachandra Naik Road as it enters the Mala area and later Nanu Tarkar Pednekar Road as it moves through Portais. The spine stretches and narrows organically through the settlement adding element of surprise with the houses opening on to them. Some houses open onto the alleys which are a hub of activity during evenings and when the weather is not too hot. Thus, these alleys or streets not meant for vehicles; serve as an extended area for the people whose world extend beyond the walls of the house and some terminate into an open space which now act as a parking area; as it is a scarcity in the present scenario.

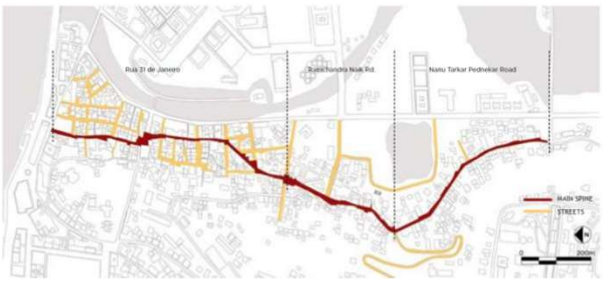

Fig 08: The main spine running the Old Quarter and the varying streets and alleys. Source: (Mohta, 2016)

The streets not only function as travel ways but also an open space for the community along with niches of open space along the streets which includes wells, chapels, temples, fountains etc. These spaces act as nodes for different activities, symbolic or religious significance, landmarks, meeting points or areas used for certain common celebrations.

Fig 09: Open spaces and places of symbolic significance at Old Quarter. Source: (Mohta, 2016)

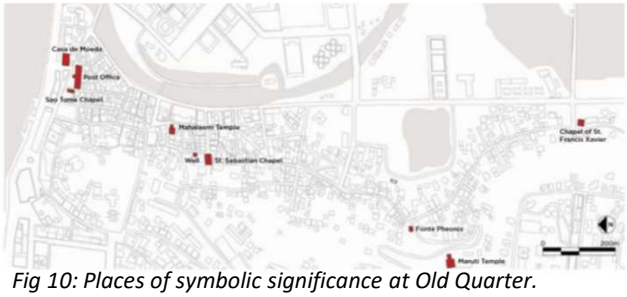

Fig 10: Places of symbolic significance at Old Quarter. Source: (Mohta, 2016)

ANALYSIS & INFERENCE:

Thus, it can inferred that Goa has been planned on basis of Castrensian tradition and Portuguese influence and has evolved over the period of time. The primary roads, streets, and alleys, particularly in the Old Quarter, adorned with clusters of charming old houses, remain untouched. This is primarily because the organic nature of the area, coupled with its location on a slope and the narrow width of the roads, restricts the possibility of extensive development (Shankar, 2012). Thus, the Old Quarter area is still reminiscent of the Portuguese with adaption to vibrant colours and features like pilasters, cornices, mouldings etc. opening on to the streets vide verandahs, balconies or even windows. With the development there are problems arising on account of the old planning like devoid of parking spaces, open spaces, traffic congestion, restricted human movements etc. yet the Old Quarter has retained its old charm.

CONCLUSION

Goa, situated along the western coast of India, possesses a unique character that sets it apart from other regions. The strong imprint of Portuguese rule has not only shaped a distinctive lifestyle but has also conferred upon the state an individuality of its own. The influence of Portuguese planning is particularly noteworthy, with the development of towns at the waterbody's mouth showcasing a remarkable impact. The Old Quarter, imbued with Portuguese influence, stands out as a prime example, and its distinct identity becomes a focal point for this research. However, the ongoing urbanization and the increasing demand for housing pose a potential threat to the Old Quarter's integrity. Flouting heritage guidelines for the sake of additional housing, addressing parking needs, or easing traffic congestion could lead to irreversible damage. To preserve the charming essence of Old Portugal, it is imperative to implement the existing Heritage Conservation regulations effectively and thoughtfully. In conclusion, safeguarding the unique heritage of the Old Quarter requires a balanced approach that accommodates development while respecting and preserving its historical and architectural significance. The insights gained from this study contribute to a deeper appreciation of how historical influences continue to shape and define urban spaces, offering valuable lessons to promote sustainable urban development.

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RELATIONSHIP OF WATER, HISTORY AND ARCHITECTURE IN THE CITY OF BHOPAL: HERITAGE, WATER AND ARCHITECTURE

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ABSTRACT

Water plays an important role in architecture. Understanding its features like flow, visibility and its consequences on its surrounding built form is necessary. The relation between water and architecture is best understood with Bhopal (CITY OF LAKES) as an example. Bhopal has 18 major lakes making up to 25% of the total area. The city lies between Vindhya and Singarcholi mountains and has many water bodies including the two main lakes upper lake and the lower lake. The upper lake or more famously known as Bada Talab is a manmade lake built by Raja Bhoj, there by its name BHOJTAL LAKE. The terrain of the land was intelligently exploited to suffice the demand of water. The city saw the organic development of settlements around the Lake which include Gond and Bhil tribal communities. The creation of lakes had positive impacts on the city of Bhopal which demonstrates the relation between man, water and built form. Over the years, development around the lakes led to the formation of the city. The city which once started as a settlement in 11 centuries developed over the years unveiling several layers of history. During the rule of the Hindu kings to Muslim dynasties there were several monuments like Moti masjid, Taj ul masjid, Taj mahal palace, Gohr Mahal built around the lake for various reason like vision, accessibility, aesthetic, utilitarian purposes, navigation to name a few. Many kings also patronized stepwells, dams, embankments, lakes, reservoirs for utilitarian, military, recreational and other reasons. The urban image of the city was carved by architectural sites, heritage precincts and water elements which unified involuntarily. For instance, even today the upper lake and the Bhoj dam anchor the city as it transcends as an amalgamation of both old and modern styles of architecture developed through centuries from the nomadic kingdoms to Hindu kingdom, Islamic dynasties, colonial era and period after post-Independence The gas tragedy of Bhopal in the year 1984 earmarks the ugly phase of urbanization. Post independence many cities followed the pattern of rapid urbanization abandoning the care of nature, including Bhopal. The swift growth of Bhopal has underlying consequences for nature. The city which was once known for environmental management and planning strategies which stood test of time is now a series of fragmented precincts of which many are dilapidated, mismanaged, ruined and in unattended state. To have a holistic vision for the future of Bhopal it is necessary to re look into the past and revoke the interlaced layers between the heritage, people and architecture. This study aims at understanding the relationship between built heritage, people and how it has evolved around the water over the centuries

KEYWORDS

man-made lake, heritage precincts, built heritage, rapid urbanization, terrain, organic development

INTRODUCTION

Bhopal is a capital city of Madhya Pradesh and is the administrative capital. The city has evolved around the water bodies and water sources it has relied on. The rapid industrialization and urbanization, led to city of Bhopal in the process of becoming into an Indian metropolis. Bhopal city has distinct characteristics and the same can be seen as old city and new city which have again evolved around upper lake and lower lake. Old city was developed in the reign of Raja Bhoj and even before when the Bhil and Gond Tribal communities settled around the tributaries of Betwa and Narmada River. The old city as it is seen today is also due to the contributions during the Islamic rule. In the later stage post-independence Bhopal was declared as capital of Madhya Pradesh and the new city has developed after that. Newly developed settlements, industries, amenities, commercial complexes, malls etc can be seen in this part of the city. Like many other cities Bhopal has developed into an urban metropolis as we see it today. The development of the city in this stage was mainly governed by reckless urbanization and modernization. This on the other hand has led to decreasing of the vital resources such as water and more. One can see changing relationships and evolution of the relationship between the existing water bodies, people and heritage structures.

RESEARCH METHODOLOGY

"Water links us to our neighbour in a way more profound and complex than the other"- John Thorson. Water sources, water bodies play a crucial role in evolution of civilization, cities, pattern of human settlements. The same is tried to be understood in two ways one is the development of the city around the water bodies for majorly utilitarian and other aspects and the second one is how the relationship with these water bodies and human beings changed over a period of time. The organic development of the city starting from the time the Bhil and Gond tribes migrated to the present day the evolution of the city around the water

bodies for majorly utilitarian and other aspects and the second one is how the relationship with these water bodies and human beings changed over a period of time. The organic development of the city starting from the time the Bhil and Gond tribes migrated to the present day the evolution of the city around the water bodies, establishment of heritage precincts, modernization and its effects on the water bodies is studied through the significant fragments along the historic timeline:

- Nomadic settlements by tribes
- During the 11 Century - Raja Bhoj Era
- Reign of Muslim dynasties
- Pre independence Era
- Post Independence Era
- Globalization phase till the smart city project phase (till now)

The aforementioned classification just sheds information on how the water bodies changed during the relevant era. Each of these phases have carved the Bhopal city as we see it today. There have been implications on urban morphology, some which are favourable and some which have led to congestion, encroachments, urbanization around heritage precincts and poor services.

NOMADIC SETTLEMENT OF TRIBES

The Gond communities which happen to be one of the oldest tribes and one of the largest Adivasi communities settled in the forested areas of Vindhya ranges in Madhya Pradesh. The 'Bhil' or the 'Bhilua' community literally means bow and the Bhil community are the ones which have mastered in archery, along with the skills of archery Bhil tribes are experts in skills like pottery, painting and weaving. The mention of the Bhil tribes can be found in Ramayana and Mahabharata. The Bhil tribes majorly stayed in the western part of India Rajasthan and seemed to have moved to comparatively greener areas of Vindhyas Mountain. When the tribes migrated to the central part of India they settled around the major rivers and their tributaries. Traces of their settlements can be found can be found around Kolan, Betuwa, Kerwa, Segru, Bansi, Bangna etc. There are many earthen embankments, dams, sluices, weirs which are functional even today and date back to this period.

DURING 11 CENTUARY - RAJA BHOJ ERA

Raja Bhoj was a legendary ruler who was very knowledgeable king of Parmars. The capital of the Parmar kingdom was Dhar. The king patronized several development projects including water bodies around city is always curated with a Folklore and a justification of its existence. The king of the Parmars, ruled the Malwa region and constructed Bhojtal when he was ruling Malwa (Reign:1005–1055). In order to fortify the eastern boundary of his province and give solution to water needs of the people in dry spells, he created Bhojtal in the Vindhya valley, the major feeder for which was Betwa river. He is also credited with founding the city presently known as Bhopal, which is named after Bhoj Tal . Another legend which has substantial physical and literary evidence narrates that King Bhoj once had a skin condition for which no Vaidya (English for doctor) could find a treatment. Then, one day, a saint begged the king to construct a pond that would connect all 365 of its tributaries, so that people may wash in it to heal skin ailments. Bhoj ordered his engineers to construct a massive tank across several streams and in the landlocked by hills creating a natural valley in the depression. But as the project advanced, they found that tank was fed by 359 streams which was 6 streams short of the original requirement. At this stage the commander of Gond tribes who had a sound understanding of the terrain suggested to divert the Kaliasot river to 90 degrees which had 8 streams. The massive tank which spanned 65000 Ha was the largest man-made lake of those times with several dams and islands. There were as many as 7 islands including the Mandi dweep island. Mandi dweep is a culmination of two words, mandi which means market and dweep which means islands meaning market island. Downstream to Mandi dweep was an oldest township existed near Bhojpur. Mandi dweep as we see today is surrounded by barely few streams contrary to its name and is an industrial hub few kilometres away from Bhopal.

The lake was an engineering marvel was created by damming Betwa river to feed the reservoir and another dam was created to divert Kaliasot river to Betwa river. The redirected kaliosat dam which is 1Km long and built with boulders of limestone with interlocking techniques and with no binding material can be seen today. This dam which is functional even today is undoubtedly oldest dams of the world. Subjects in the period benefited from the large sheet of water and in the later stage Raja Bhoj decided to build a Shiva temple which was located in such a way to reep physical vicinity and visual potential of the vast expanse of water.

Fig:1 Upper Lake and Manideep, Source: Google earth imagery

The temple was not completely constructed as Honshang Shah the appointed sultan of Malwa disrupted the massive hydraulic system when he invaded the province in 1400's. He destroyed all the major dams to drain the water of Bhojtal. There are folklore that say that it took several months to drain the lake. The remains of this is what we see as Upper lake today. It is located 32 kilometres from the Betwa River. The Bhojtal is located at the centre of the city. Its size of 31 km2, and its catchment area is 361 km2. The

majority of the upper lake's catchment is rural, while there are some urbanized districts around its eastern end. This era led to the formation of a water body, lake that would impact the city of Bhopal and the lives that evolved around it.

REIGN OF MUSLIM DYNASTIES

Gond dynasty is one of the celebrated dynasties that ruled the city of Bhopal among many. Rani kamlapati who was the ruler of a small Gond kingdom took military help from Dost Mohommad Khan who was the Pastun from Tirah and had joined Mughal army. He was given the Bhopal region as reward after winning the battle. Dost Mohommad Khan decided to fortify the city and made the decision to establish his capital at Bhopal in 1722 following the invasion. After the few Nawabs it was rule of Begums which started with Gohar Begum Qudsia, Sikandar Jahan Begum, Shah Jahan Begum and Sultan Jahan Begum. During the Islamic rule Pulphukta dam was constructed by Chote Khan Wazir who was minister of Nawab Hayat Muhammad Khan Bahadur of Bhopal. This led to the formation of Chota Talab or the Lower Lake. The lower lake is to the eastern part of the upper lake and is at a lower level than the upper lake. The surface runoff of the upper lake is collected in the lower lake. Upper lake and lower lake are separated by an earthen dam. The lower lake is 1.29Sq Km and has a catchment area of 9.6 Sq Km. The lower lake drains to Patra rivulet which connects to Halali river.

During the reign of Muslim dynasties many begums came into power and commissioned various architectural monuments in conjunction with water bodies which created historic precincts like Gauhar Mahal precinct, Motia talab precinct, Jamia Masjid precinct and market places like Paribazzar, schools to empower women. Gauhar Mahal was the first palace to be built during the time of by Quadsia Begum in 1820. The Gauhar Mahal has ghats connecting to the lake in three fragments. The section of the Ghats which were closest to the entrance might have been for royal family and the other two ghats might be for public usage. During the rule of Shan Jahan Begum, the first water pump was erected, and the "Zie-up-Abser" garden was created. She also built "Noor-us-Sabah," a brand-new palace.

MOTIA TALAB PRECINCT

Motia talab was fresh water reservoir built in 1899 by Shah Jahan Begam in Shehjanabad. The Talab which spans 230m x230m along with two other lakes create cascading network of lakes. Motia Talab is created at the highest level, Noor mahal talab is at the intermediate level spanning 175m x 230 m and at the lowest level is Munshi Hussaini talab which spans 115m X230m. The network of three lake along with Taj-Ul-Masjid to the south , Taj Mahal palace to the North and Benazir palace to northwest have created Motia Talab precinct. There were many streams which ran through

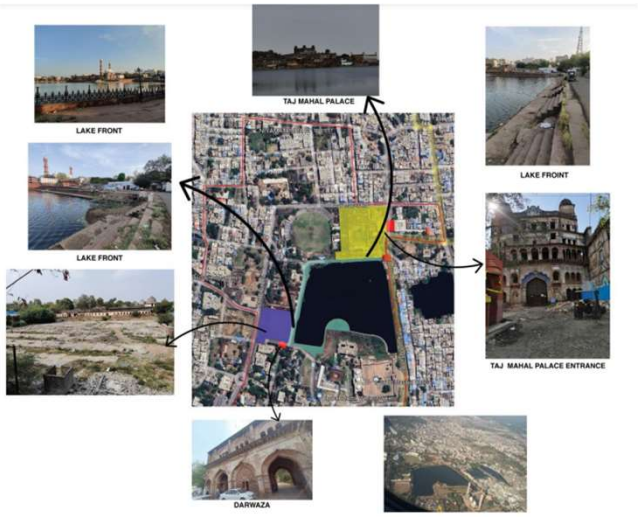


Fig:2 Motia Talab precinct, Source: Author

the cascading network of lakes before the surface rain water was collected in the lakes. Many of these streams even ran through the buildings as ornate channels, fountains, pools, chaddars, and Charbagh. There were many stepwells constructed in this region which are patronized by eminent people and kings as they understood the importance of rain water harvesting. Step wells are called as baolis in this region. Bara bagh Baoli is an excellent example which is a two-storey structure carved in red sandstone. The descending steps are flanked by ornate stone walls and there are functional spaces above the water level which were built for visitors as resting places.

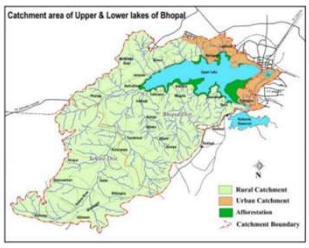
POST INDEPENDENCE ERA

Bhopal has emerged as administrative capital after being declared as capital city of Madhya Pradesh. There have been developments like dams, multi-storied buildings and many government buildings, educational institutions are constructed in this period. Bhopal being called as city of lakes continued the tradition. There are many lakes like Shahpur lake which is a man-made lake built for irrigation purposes under a government scheme to irritate field of ChunaBhati village. But due to urbanization around the lake it is no more used for irrigation. There are recreational facilities and waterfront for residents and visitors. In later stage there have been encroachments, sewage effluent, industrial waste that are left to the lake. This unsought urbanization has led to clogging of streams near Ekant Park and oxidation tanks are also not working properly leaving the lake stagnated with eutrophication at the fringes.

Bhopal Gas Tragedy - The Bhopal disaster, also known as the Bhopal gas tragedy, was a chemical accident that occurred at the Union Carbide India Limited (UCIL) pesticide facility in Bhopal, Madhya Pradesh, India, on the evening of December 2-3, 1984. Over 500,000 residents of the tiny communities surrounding the facility were exposed to the extremely poisonous

chemical methyl isocyanate, which is regarded as the world's greatest industrial disaster. (MIC) This tragedy had adverse effect on the lake, leading to ground water contamination. Many lakes of the Bhopal are also polluted for the very same reason. Bhopal even today faces consequences of the accident which happened in 1984

Bhoj wetland- Upper Lake and lower lake are part of the Bhoj wetland. “Two basic relationship between man and nature, I thou and I it ” E A Gutkind. The words said by E A Gutkind hold apt in reference with Bhopal lake. In the first phase during the Reign of Raja Bhoj the lake was constructed to use natural resources for human needs which is the “I Thou”stage which means mutual adaption (alteration and modification)between man and nature. Both alteration and adaptation can be seen between 11 century and during the Islamic rule. Until the post independence era lake was used as fresh source of water, without any treatment and the lake supported an diverse population of birds like Eurasian spoon bill, painted stork, barheaded goose, black necked stork etc and many other species like reptiles, amphibians and special varieties of tortoise. Where as in the consecutive years the lake was recklessly used by more than 15, 000 people for day today activities like bathing, washing, cleaning animals , vehicles, and discharge of industrial waste, sewage effluents. The upper lake has a catchment area of 361 SQ Km and the lower lake has a catchment area of 9.6 SQ Km. The catchment of the upper lake constitutes residential colonies, Van Vihar park and agricultural fields, scrub land, plantations. It demonstrates a variety of land use around the lake. Over a period of time there have been several encroachments, industrial suburbs around the fringe areas of lake, discharge of sewage and agricultural run off which is mainly harmful pesticides and human activities. These activities have led to the deterioration of the lake, the surface area of the lake has shrunk over a period of time, there are problems like eutrophication in fringe areas, siltation, degraded soil around the lake, clogged streams in the catchment area leading to urban floods and contaminated runoff, habitat loss for the rich flora and fauna. The upper lake had reduced to 8 Sq Km from 31 Sq Km during 2009. The lower lake is mostly surrounded by urban areas. There is encroachment in this area which had reduced the extent of the lake considerably to 2 SQ kM from 9.6 Sq Km. The main source of water for lower lake is upper lake. The inlet stream is through a sluice gate located upstream near the upper lake but this is not opened periodically and also the outlet streams are clogged which have made the water in the lower lake stagnant. Ministry of environment and forests in the year 1998 declared the upper lake and lower lake areas along with their catchment areas as Bhoj wetland and few conservation measures were taken which include demarcation of eco sensitive zone around the lake as buffer zone, desilting, soil conservation activities along with a few afforestation programs which included conservation of the Van Vihar. This phase clearly marks the “I It ” stage where human recklessly exploited the nature.



BHOJ WETLAND		
PARAMETERS	UPPRER LAKE	LOWER LAKE
Surface Area	31 Km2	1.29 Km2
Catchment Area	361 Km2 [139 sq mi]	9.6 Km2 [3.7 sq mi]
Source Of Water	Kolans River	Seepage from upper lake and drainage from 28 sewage-filled nallhas
Avg. Dep	Varies from 4 to 11.7 M	6. 2 M
Type of Dam	Earthen Dam	Earthen Dam
Type of Lake	Man made Lake	Man made lake

Table:1

Fig:3 Bhoj wetland, Source: Conservation and management of Bhoj Wetlands, India

GLOBALIZATION PHASE TILL THE SMART CITY PROJECT PHASE

The proposal of new master plan of Bhopal 2031 suggests construction activities in the catchment are This may lead to further deterioration of the lake and reverse the conservation efforts that have been carried out between 1995 to 2005 under the integrated lake conservation program. Bhoj wetland was declared as RAMSAR site owing to the ecological value in 2002. Several conservation measure like designated washing areas, idol immersion areas, soil conservation, desilting, clearing of encroachments were proposed. However, in the year 2005 the lake was deteriorated to the lowest and also faced dry spells due to which the lake went completely dry. This situation was used as an opportunity to clear encroachments around the lake bed area. Eco farming with organic pesticides was advocated in the catchment area, nature based solutions like afforestation in Bhoj wetland area by Borvan forest which has nearly 1,25,977 trees, increasing the extent of the lake by soil digging, deweeding along the lake edges, soil conservation by introducing check dams , gully plugs, stone pitching and vegetation around the lake. The city now has more than 10 lakes which help to maintain the microclimate of the place. Some of the major lakes including the upper lake and lower lake are Shahpura Lake, Motia Talab, Nawab Siddique Hasan Khan Talab, Lendiya Talab, Sarangaria Lake, Manit Lake, Mullah Sarovar, Munshi Hussain Khan Talab, Bordi kalan, Jawahar Baal Udhyaan Lake, Preet Nagar Lake, Nariyalkheda Golf course Lake which are built from the time of Raja Bhoj till recent past. Several attractive lake front promenades, places of tourist attraction, boating activities can be seen around these ecological precincts. They are home for nearly 150 bird species which include resident and migratory birds. Raja Bhoj Setu which is built recently establishes connect between old and new Bhopal. This 300 m cable bridge helps to decongest traffic on Kamala park - VIP road is a new landmark of the city. The demerits of this massive concrete construction is that it completely cuts the human connect with the lake edge from the eastern side. The natural edge along highway stretch is lost which was once habitat for numerous species. The VIP

road many Ghats are removed and some which are remaining have either lost connect or have become dumping grounds. Even Ghats near Motia Talab towards the Benazir palace which was once probably a vibrant water and human interaction space is now a dumping ground. The lake edge in Front of the Taj Mahal Palace is weed infested and lacks sense of safety.

CONCLUSION

The city has evolved from imperial capital to administrative capital of the largest state situated in centre of land. It has developed as industrial hub with major industries like BHEL, Mandidweep industrial hub. The city has infrastructure and good connectivity with Raja Bhoj airport, railway network and road network. Bhopal recently is chosen as the first 20 smart city mission which has major projects along the upper lake like solar city project, biomethanization plant, rejuvenation of the heritage core areas etc. Development and environment degradation are two faces of the same coin. The development strategies and plans should be executed in a way that it does not harm the limited natural resources we need to conserve and does not disrupt the age-old living traditions, built heritage in an iconic city

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THE FUTURE OF SURFACE WATER BODIES: ASSESSING A CASE OF OORANI IN POOLANKURICHI, CHETTINAD REGION

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ABSTRACT

Background: Due to the Insufficiency of land availability, people tend to occupy the water Surfaces which leads to water scarcity and groundwater depletion. It's not a modern science that will give a solution to our water crisis but our heritage will do. It is necessary to understand traditional water conservation techniques created by our ancestors for future needs that help to store rainwater and recharge groundwater and act as the primary source of life for economically backward people.

Purpose: The surface water bodies vary in size and purpose of usage. One such Surface water body found in the Inland and coastal areas of Tamil Nadu is called as Oorani, a 2000-year-old Indigenous water structure. Which are embedded with several Cultural Association and Sacredness depending on location and purpose. To assess and understand the Oorani's Significance in the Chettinadu region and its relationship between the Architecture and people's custom.

Methodology: To understand Oorani's and its relationship between the Built Environment to harvest rainwater and also People's belief and custom associated with the Water bodies will be studied through site visits of Chettinadu village. In order to understand the knowledge gap several literature studies are referred related to Oorani. To identify the issues and challenges faced by the people to access and save water for the future an assessment was done with the help of inventory.

Results & Conclusion: The studies will help to evaluate the lost values of the Living heritage of Oorani. By assessing the Existing Oorani's values and Significance and compared it to literature references through Inventory . So, By Inventorying more no. of Oorani's , helps to identify the issues in transferring knowledge and reviving the traditional water conservation techniques .

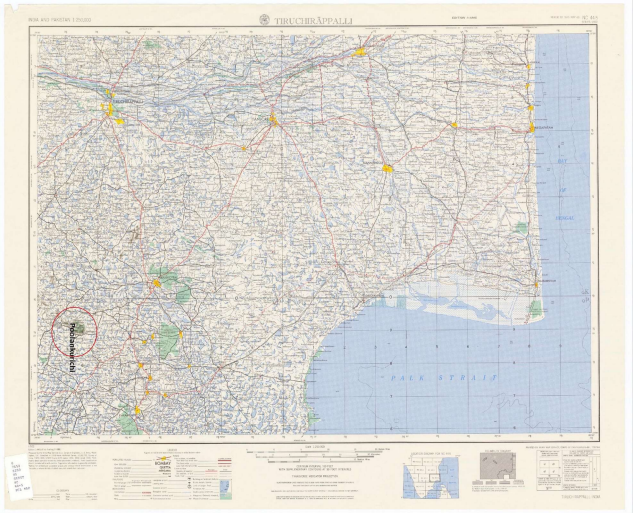
KEYWORDS

Oorani, Surface water body, Chettinad Region, Traditional Water conservation, Assessment Manual.

INTRODUCTION

Water, defined as H2O - a combination of Oxygen and Hydrogen. But it is a finite natural resource, which is essential for life, death, and birth. It is a symbol of Purity and Wisdom. Depending on the location and context water acts as a bridge which links past dynamic waterscape as a sacred landscape by combining the ancestors' memories, through its several layers like History, Culture and its Ecosystem for the future generations to Engage, Conserve, and manage the water bodies. Water is a fundamental architectural component and a landscape element as its own. Because of its multi-dimensional qualities, it has the ability to change the physical and spatial characteristics. It often comes under the discipline of social, cultural, arts and science, and also architectural studies as a landscape element interlinking the Built and Natural Environment. (Morrison, 2015) Surface water bodies vary in different sizes and shapes, it's either a natural depression or man–made structures. The surface water bodies not only help in groundwater recharge; it is also a key element in water cycle management. But at same time it also caters to socio–economic development. Surface water bodies are temporal in nature, the spatial capacity changes according to seasonal change. The challenge lies in saving the water for the future and to harvest the rainwater wisely. (Yao Liu, 2023)

India is rich in traditional water harvesting systems because of its various types of structures and techniques used in different parts of India to harvest, store and conserve surface runoff and rain water harvesting from generation to generation. The surface water harvesting techniques varies by its names, location ,Climate, geology and water availability in the semi-arid region of India (Paridhi Rustogi, 2018).For Example, the Surface Water body is called as Dongs in the Brahmaputra Valley of Assam; Nadis, Kunds, Talab, Tankas in the desert region of Western India and Cherravu in Andhra Pradesh (Bhattacharya,2015). Generally, in Tamil Nadu, surface water tanks are not only used for irrigation purposes but also serve social, economic, ecological, administrative, and political views (Global Cities and climate change studio, Spring 2016) In Tamil literature, nearly 45 names are their of the surface water bodies based on the size and usage . (Kuha, 2012) The semi-arid region in between Eastern Ghats and Bay of Bengal and the south eastern part below Cauvery Delta and has a greater concentration of surface water tanks than other parts of Tamil nadu (Ref. Map 1)(GCCCS, Spring 2016). Nearly 15900 to 39000 tanks date back to 200 BC servicing about 65000 to 15000 villages in the eastern part of TN. (Olivia Aubriot, 2011) About 3 to 4 tanks per village are there with different shapes and sizes. Among them two broader classification as follows: the one an earthen open air storage basin called Eri, Kulam , Kuttai , Kanmoi used for livestock and Irrigation supply.



Map 1: Map shows Density of water bodies in the East coast of Tamil Nadu - Shows the Poolankurichi Source: (Tiruchirappalli - Army Map service, 1953)

They are mostly a network of water bodies interconnected with channels from river or resovoirs. The second one is Oorani used for drinking and household needs. It is rain fed and a natural spring well will be present at the center of Square or rectangular basin are the major source. (Jessica Canfield, 2011) Mostly man–made water bodies will be created and maintained by wealthy people like the King, Kings Family, Ministers, landlords because of the expenses and sometimes the Needy people also do. In south East of TN, a merchant community called Chettiyars lived in the Sivagangai and Pudukkottai district for more than 200 yrs. are well known for management of surface water bodies and Oorani of that region. In this paper an Oorani called Shanmuganathi oorani is located in the Chettiyar village of Pullankurichi in Sivagangai district will be assessed in the paper.

AIM

This research aims to assess and understand tangible and intangible aspects related to Oorani developed in the Poolankurichi Village (Sivagangai District) of Chettinad region, especially to identify the Knowledge gap in their traditional knowledge system. This paper will address the following Sub-themes: People, Water, and Architecture.

PURPOSE

Water scarcity or crisis or drought refers to the demand for fresh water which leads to several water disputes among society. More than a billion people are suffering from water crisis and lacking the safe drinking water, by 2025 it will reach up to two – third of the world population. Sometimes, the old ways hold the key to a better future by incorporating a sustainable approach used in ancient times to harvest rain water (Vasileios A. Tzanakakis, 2020). The south eastern part of TN is mostly depends on the rain for freshwater because of salinity in the ground water. Surface water tank will serve them for their domestic needs. (Urban Ooranis, 2019) Those areas are facing a rise in the salinity level in the ground water because of land encroachment and development in the coastal areas which makes the water non-potable for the communities and also disappearing of traditional knowledge and wisdom in the fast machine depending era (Paridhi Rustogi, March 2018). The purpose of this paper is to understand the indigenous knowledge associated with Oorani's significance and its gaps in the Chettinadu region and also its relationship between the Architecture and people's custom. The Poolankurichi Chinna Oorani water is still used directly for drinking pupose by several people of the village in the modern times of cleanliness.

RESEARCH METHODOLOGY

The research was conducted in three stages:
Literature studies - To understand the Traditional Water harvesting techniques of India & Tamil Nadu (Chettinadu region - Oorani) various literature and research papers were referred. Which also Helps to understand and gives insight about the various parameters and assessing tools for water bodies. Site visit - The well maintained and functioning Oorani was identified to assess by making inventory. On site discussion about the history of village, Oorani and traditional knowledge with village people of Poolankurichi. The sample of Oorani water was also collected for the Quality Check.
Output - Comparing and assessing the collected data with literature studies, to know at what extent the traditional system is inbuilt with the society and still in practice. The ways to review the indigenous knowledge and technique back to functioning of many other Oorani in a sustainable manner. In this paper only one functioning Oorani is assessed because of limited time.

Image 1 : Interviewing the village people Source: Author

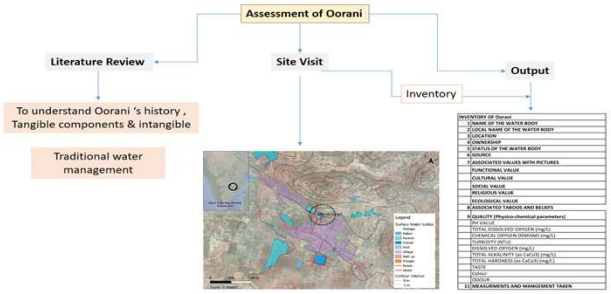


Figure 1: Methodological Chart Source: Author

FINDINGS/ ANALYSIS &INFERENCE

Overview of water management of Surface Water Bodies (SWB) in Tamil Literature:

The Thirukural by Thiruvalluvar belongs to the 4th century BCE - 5th century CE mentions the usage of Oorani as a drinking water pond.

ஊருணி நீர்நிறைந் தற்றே உலகவாம்
பேரறி வாளன் திரு. - குறள் 215

The wealth of men who love the 'fitting way,' the truly wise, Is as when water fills the **pond** that village needs supplies. – ***Kural 215***

Image 2: Thirukural mentioning about Oorani

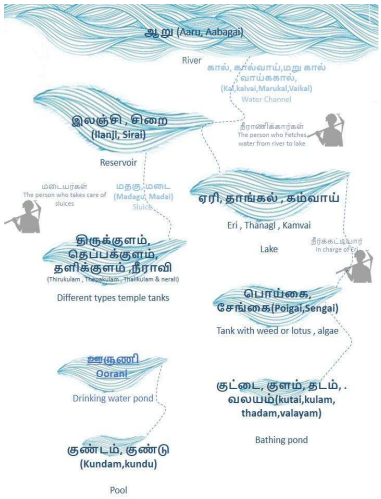


Figure 2 : Traditional water Management system of Tamilnadu Source: Author based on the Literature Studies

The Sangam literature Purananuru (1th century BCE - 5th century CE) refers to the term kulam. From 7th - 8th century CE the term Eri and construction of anicut for irrigation with replacing the bunds with stones like granite and laterite, sluices, wells and troughs. (Sengupta) According to ancient literature Sivagasinthamani (9th century CE) the water Ecosystem varies only by its names from region to region but not by the purposes. There are five geographical regions classified by the early Tamil civilizations called Thinai's. The geographical regions according to the literature 'Tholkappiyam' and its specific Thinai landscape has its own indigenous structures to harvest surface and subsurface water as follows: In Kurinji (Mountains) - Aruvi (Water fall), Mulla (Forest, pasture) -Kanyaru (forest Stream), Marutham (Agricultural areas, plain or valley) - Aaru (River), Poygai (small pond), Neithal (Coast) - Manalkinaur (sand well) and Palai(Parched wasteland) -Kuuval,Sunai (well , natural spring). The most common critical water resources found on all regions are Oorani, ponds and dug wells. (Springs , 2019) Graphical representation in Fig 2 illustrates the literature understanding about the classification types of surface water bodies, providing a visual depiction of their diverse characteristics and water manager & Tank caretaker's community assigned to maintain them. For example those who Fetching water from river to lake - Neeranikargal, Incharge of Eri (Lake) and irrigating water field from Lake - Neerkattiyar, Fetching water from river to Tank (Kulam) and also protects, manage the water bodies - Kulathu Pallarkal, kulathu Kapalarkal , the one who Fetching Water from kulam to fields - Neerpaychi - Small water body (Madagu,madai,kumizh,thumbu) take carers madrigal (S.Shobana, 2019)

INVENTORY OF THE STUDY AREA

Poolankurichi is a village located in Thirupathur block of Sivangangai district. Poo Alangara Kurichi is verbally changed over time as Poolankurichi, Where kurichi refers to Kurinji means hilly region. There are several Inscriptions are found in the slope of Hill rock belongs to 5th Century CE shows light about Jainism, Buddhism and kalabharas dynasties . Several names are there for this place as Pacherich / Pacherichill / Bhulangurichi. The nearest town is Ponnamaravathy. The village consist of several bodies includes Kammai, Kulam for agriculture and domestic purposes and Two Oorani's and palankenni (spring well) for drinking water source.

Map 2 : South India Maps shows the location of Pooalangara Village

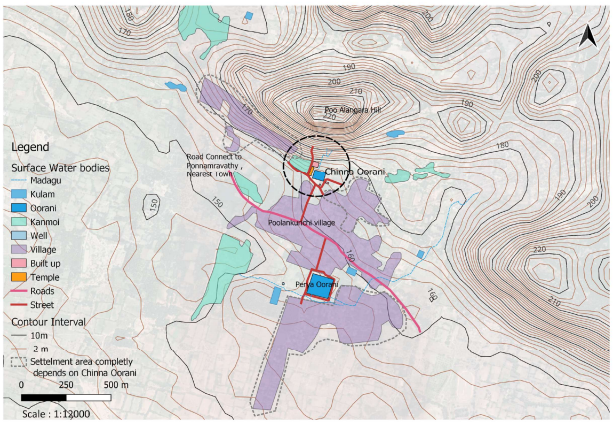
Image 3: The View of Perya Oorani with full of lotus Source: Author

Both the Oorani is intertwined with various customs and practices aimed at its preservation. Presently, the Periya Oorani is not utilized for the drinking water purpose while the Chinna Oorani remains in use by the village people. The Map 3 illustrates that the periya Oorani's inlet receives surface runoff from the hills through a Madagu (channel), due to distance between the Oorani and source and development the Madagu is contaminated with waste and the Oorani is adorned with lotus plants .Despite its pollution, the SWB is equipped with sluices using filtering techniques to separate waste , making the water suitable for domestic activities. The respect for the SWB persists. The Chinna Oorani, adorned with biological growth and deposits like lotus and banyan branches, is either disconnected or not linked to any channel .Nevertheless, the entire village on it, leading to the exclusive survey of China Oorani for assessment purposes. The Chinna Oorani is called as Shanmuga Nathi Oorani located at the Latitude and longitude of 10.272098 N, 78.589775 E in Poolankurichi, Thirupathur, Sivagangai, TN.

ETYMOLOGY AND DESCRIPTION OF OORANI:

Generally Oorani means Oor Unum Keni – water facility that is consumed for drinking & cooking purposes.

As per observation and collected information, Mostly Oorani's are constructed near / above a natural spring (Contact Spring) into Keni (a well) with a pond is Oorani used for drinking purpose. The sub surface water is springs up in dugout ponds with the sand filters below the ground surface. They have high earth bunds all



Map 3 : Village of Poolankurichi showing the water bodies Source: Author, Base: Google Earth

around it. This also used to collect the rain water. (Urban Ooranis, 2019) Shanmuga Nathi is the Name of the China Oorani next to Vinayagar temple. The Shanmuga represent the God Murugan and Nathi means River.

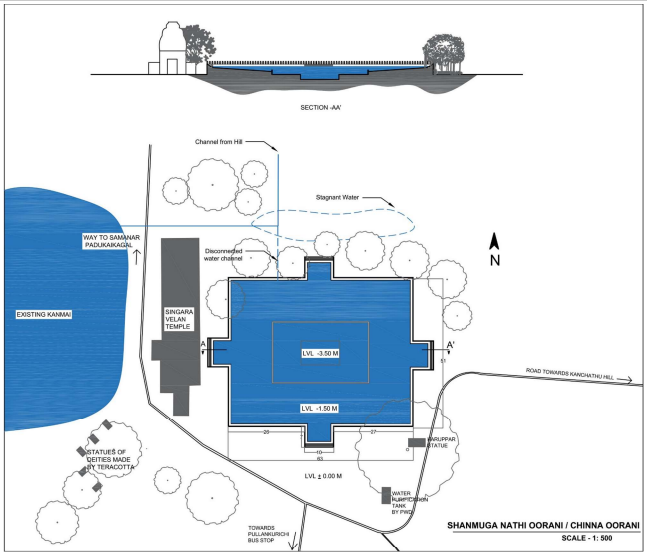
Image 4 : The Panoramic View of Chinna Oorani and the Surroundings (Poo alangara Kurichi Hill, Shanmuga Vinayagar temple). Source: Author

GEOLOGICAL CONDITION

Oorani's prove to be particularly effective in areas where vadose zone is whether or not there's an unconfined aquifer, and when a solid bedrock underlines the sandy overburden. (Paridhi Rustogi, 2018)

The topographical condition of Poolankurichi fall within the Tirupathur soil series , characterized by dark yellowish brown, calcareous and very deep soil . These are heavy clay soils contain deep and wide crocks, very deep, Entic chromusterts, and are situated over soft weathered gneiss underlain by laterite. (Organization, 1998)

Image 5 : Aerial View of Poolankurichi's Chinna Oorani Source: (Poolankurichi, 2023)



Map 4 : Documentation of Oorani and its Surroundings Source: Author

COMPONENTS OF OORANI

Structural description: Oorani's are typically excavated in a rectangular or square base, the china Oorani is 63 m by 51 m in area with 3-4m (mostly Oorani's are 2-5 m) and featuring steps on all four sides for accessibility sometimes has consolidated soil ramps instead of Ghats. (Urban Ooranis, 2019) The structure has three concentric rectangles as we seen from top view the first rectangular structure is completely laid with stone all around includes steps on four sides, the second one is earthen surface and third one is the well. There is an Inner path all around the pond to access and walls have niches in regular intervals. There is a well at the centre of the pond. The whole Pond is fenced and all the gates are there at all sides.

Inlet and Outlet of the Oorani: The Oorani either has an inlet feeder channel and outlet channel with traditional filter systems or lack of feeder channels, opting for high walls that directly collect rainwater. (Urban Ooranis, 2019) In the northern side of Chinna Oorani, there is a channel collects surface run off water from the hill near Oorani is disconnected from it but connects to the Kammai located on the other side. Parallel to the channel a hostel and Mandapa building is located which is completely polluted.

Image 6 : Inlet of Kammai Source: Author

Image 7: Local residents came to collect water from oorani in pots Source: Author

Image 8 : Woman fetching water in pot for drinking in Chinna Oorani Source :Author

Water capacity (Quantity): The Oorani's depth, length and breadth is designed based on the calculations of avg. rainfall of the region, domestic needs of the people who depend on it. (kuha,2012)

Functional description: The water management system of Oorani during water scarcity is interesting .The dug out well inside the Oorani is used in dried up periods due to monsoon failure. The practice of Oorani desalination during dry spells is also a conservation approach but due to change in the community practice. (kuha,2012) Currently, the village people relying on the government for desalination. If it is not done regularly leads to growth of lotus plant.

Water knowledge: The prohibition of wearing footwear inside the Oorani, as well as the restriction on washing vessel in the water, reflects a deep sense of respect for this vital source of drinking water. It highlights the cultural significance attached to the Oorani and emphasizes the importance of maintaining its purity. In steps a trench was created, there are evident in the placement of lime water or Caco3 as disinfectant. Such practices not only contribute to the physical cleanliness of the water but also symbolize a valuable collective commitment to preserving and honouring a valuable communal resources. (Urban Ooranis, 2019)

VALUES ASSOCIATED WITH CHINNA OORANI

a. FUNCTIONAL VALUE: The presence of Kammani next to Oorani serves as a source of water for all needy people. Oorani for Drinking and cooking purposes and Kammai for bathing and other activities.

b. CULTURAL VALUE: The Nagarathar community of this region offered (food) kattu soru to the Oorani during a marriage occasion. A tradition also there earlier the lamps are lighted on the niches in the parapet wall of the waterbody.

b. SOCIAL VALUE: The water body and its surroundings has several village deities linked with different communities. Banyan tree branches that have fallen inside the Oorani are considered sacred and not cutted down because a deity called Karupanswami or karuppar is worshiped as clan deity of particular community on the east side of the Chinna Oorani. A cluster of Terracota deity has been worshiped by potters and other arts work related community once but now they are dilapated condition and not worshiping right now.The Shanmyga vinayagar temple is reconstructed in larger scale on 2001 only .

Image 9 : Woman fetching water in pot for drinking in Chinna Oorani Source: Author

Image 10 : Karupar Statue under Banyan trees on the eastern side of Oorani Source: Author

Image 11 : VInayagar Statue on the Western side of Oorani Source: Author

Image 12: On South west side terracotta statues Source: Author

d. **ECOLOGICAL VALUE**: Fishing is banned; the food will be offered to fish based on the Religious custom. Daily Neithvethiyam and Purnima Anabeshagam food will be offered to fish in the Oorani.

e. **RELIGIOUS VALUE:** The water body is still in use because of the Several Cultural association (Temples). Along with circumbalotary niches inside the Oorani, Relief of Lord Ganesh & Muruga are carved near steps on two sides

Image 13 : Offering Neithvethiyam to the Oorani fishes Source :Author

WATER & HEALTH

The Oorani water is murky, so use Strychnos potatorum (Thethankottai). The water stored in the earthen pot is scrubbed with a handful of seeds.

The pot is scrubbed with these seeds for a good 20 minutes, after which the water is clear and drinkable. The seed sedimentation process works well, and is commonly used by the locals. Nagarathar Community is the one who took the water body management. As per information gather on site renovations like constructing fences all around the Oorani to prevent animal contamination , desalination , bund construction , stone laying on the steps and slopes of the oorani are done mostly done maintain mostly by Nagarathars. A chettiayar named Abiramiramanudhan done last renovation in 2007-2008. After that Panchayat has undertaken the work desalination and cleaning the lotus once in a year. The water from Oorani is purified and tank was established by the panchayat charge 5 Rs. for it.

Image 14 : Government 5 rs. Water facility from Oorani water Source : Author

Image 15 : Branches of Banyan tree falling in the Oorani Source : Author

In 2009, V.S.S College of Arts College in poolankurichi samples waters are taken three surface water sources include Perya Oorani (S3), Palankenni(S2), Open pond (S4) near College are satisfied as per standards and used for Drinking Purpose.

Table 2: Physico-chemical parameters of water samples at four selected places in Pulankurichi, with the standard values for comparison.

S.No.	Parameters	BIS (1998)		S1	S2	S3	S4
		P	E				
1.	pH	6.5	9.2	8.1	7.1	7.3	8.3
2.	E.C.	-	1400	705	191	345	599
3.	Sulphate	200	400	15	8	33	9
4.	Chloride	250	1000	48	22	42	20
5.	BOD	-	5	3.2	12	13	9
6.	TDS	500	1000	480	120	235	360
7.	Total hardness	300	600	242	35	96	210
8.	Total alkalinity	200	600	251	52	66	253
9.	DO	-	-	7.2	15.5	15.3	13.1
10.	Turbidity	5	25	3.6	1.8	3.1	0.2
11.	Colour	-	-	Colourless	Colourless	Colourless	Colourless
12.	Odour	-	-	Odourless	Odourless	Odourless	Odourless
13.	Taste	-	-	Tasteless	Tasteless	Tasteless	Tasteless

P-Permissible limit, E-Excessive limit. All parameters are in mg/L except pH, colour (Hazen units) and electrical conductivity (µmhos/cm).

It is not included the Chinna Oorani. (G. Subramanian, 2009). The water sample was taken from Oorani and test was conducted to check the quality of water whether it is suitable for drinking or not as per standards.

QUALITY (Physical-chemical parameters)	CONCENTRATION VALUES		
PH VALUE	7.28		
BIS (1998) standards	Permissible limit	Excessive limit	
TOTAL DISSOLVED OXYGEN (mg/L)	500	1000	104
CHEMICAL OXYGEN DEMAND (mg/L)			60
TURBIDITY (NTU)	5	25	10.5
DISSOLVED OXYGEN (mg/L)			3.8
TOTAL ALKALINITY (as CaCo3) (mg/L)	200	600	124
TOTAL HARDNESS (as CaCo3)mg/L)	300	600	500
TASTE	Tasteless		
Colour	Colourless		
ODOUR	Odourless		

Table 2: Water Test Report Outcome Source: TCE Laboratory, Civil Department

CONCLUSION

The Assessment report clearly indicates that Oorani water is in drinkable condition. Still people use it, but because of their knowledge gap in certain things are not maintained properly. The Oorani water is for all, but the developed people depends on RO and ignores the maintenance of Periya Oorani but most of the rural settlement are located near Periya Oorani and Chinna Oorani is the main reason for its function. The other is reason is for functioning of Chinna Oorani is there is a nearby kammai for other domestic purposes like bathing, washing etc. The surface water runoff from the hill are connected it directly. So, Oorani is only used for Drinking. Even Though the people are developed and adapted to this modern technology world. People from Economically weaker sections in rural India depend on the natural resources and traditional way of life. But current Urbanization and development affect the lifestyle of the people to blindly believe the system and forget the Knowledge behind it. The things are ignored by the people, even they completely depend on nature. They don't have rights to change or degrade the environment because of the economic situation. Necessary decision needs to be taken as soon as possible like PPP with the Government, (Dominated wealthy community of the region) Nagarathar and Rural people to preserve, conserve and maintain the Rainwater harvesting Properly. Because it is easy to revive them back because there is a need.

So, By Inventorying more no. of Oorani's, helps to identify the issues in transferring knowledge gap and reviving the traditional water conservation techniques. Although many studies talk about the current scenario or traditional water management technique, but there is always gap to study all of the existing and find a solution to Existing water crisis and demand.

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CHENNAI CHOOSES

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ABSTRACT
Chennai, primarily freckled with agrarian settlements, used to possess an intimate relation among water, nature, and people. This was heavily disrupted in the process of its transformation into one of the largest metropolitan cities of India. As a consequence, Chennai hits the headlines yearly for regular flood and drought-like circumstances. During the 2015 flood, however, a technological marvel occurred in Chennai: people of India saw its first crowd-sourced flood map that took information from people and marked inundated roads and nearby shelters. Since then IIT-Madras has enabled a crowdsourcing method to track waterlogging in Chennai through social media. But the potential of people's participation in city decision making still remains an unchartered territory. The purpose of this paper is to propose a crowd-sourced platform where people will actively participate in the inception and execution of inter-scalar and intra-scalar strategic approaches. To achieve the aim, this paper employs qualitative methodology and proposes several participatory strategies. The data collection relies on secondary resources and narrative analysis method is used for analyzing qualitative data. Booming IT background of Chennai is linked with the future execution of the proposal. The study takes note from Chennai's past, and proposes a crowd sourced manual for city development where each Chennaiet can be engaged in customizing, adapting and humanizing scalable and replicable solutions. This platform will ensure inclusive and transparent engagement among all stakeholders in shaping Chennai's future vision, a future where Chennai will choose to be resilient.

KEYWORDS
urban flood, urban resilience, crowd-sourcing, participatory, landscape-oriented development

INTRODUCTION

Chennai, a metropolis with almost 3600 bodies of water, is located at the mouth of the Cooum River on a coastal plain that spans from southeast India to Bangladesh (Water As Leverage, 2018). The city's three rivers- the Cooum river, the Adyar River in the south and the Kosasthalaiyar River in the north- are all fed by the monsoons (Gopalakrishnan, 2014). Using the water flowing in the rivers to its maximum potential before it reaches the sea, the clever "Erys" system was developed several hundred years ago. It directed the river water into tanks through earthen channels that were carved out (Chennai Resilience Centre, 2020). People back then had a close relationship with water and kept careful watch over the water system (Gopalakrishnan, 2014).

However, due to the quick pace of development, Chennai has seen ongoing degradation and a decrease in the number of water bodies over the past few decades (Banu, et al., 2021). The traditional "Erys" system has become dysfunctional as a result of unplanned rapid urbanization, overexploitation of natural wetlands, and industrial pollution (Gopalakrishnan, 2014). Because of this, the city is already at risk from erosion brought on by rising sea levels, rising temperatures, intense precipitation events, urban flooding, drought, and several other climate change-related hazards that will probably make the problems with the current water system worse (Chennai Resilience Centre, 2020). Although Chennai has had significant floods in 1903, 1943, 1978, 1985, 2002, and 2005, the flood of 2015 rendered the whole city immobile (Holthaus, 2015). The catastrophic flood of 2015 demonstrated the effectiveness of public involvement when volunteers and disaster management stakeholders used social media to link those in need and those who volunteered to help (Yadav and Raman, 2016). This unique Chennai flood map created by Mapbox helped to depict this collaborative effort (Ganesh, 2015).

By combining the local expertise of thousands of users, the map allowed ordinary individuals to add their knowledge to the program and was able to provide a real-time flood status for the entire city (Venkatraman, 2016). There has been a steady increase in the rise of citizen movements since this unique phenomenon (Raju, 2018). But to harness the people's power properly their participation needs to be ensured in the decision-making process of various scale of urban intervention strategies.

This paper tries to learn from Chennai's past relationship with water and incorporate ancient wisdom with modern needs. The proposed crowdsourced manual for city development has been developed to reflect citizens' aspirations that may hold the potential for nurturing the city back to health. The inter-scalar strategic approaches narrated in the proposal are envisaged as seeds of change that can guide the development of Chennai towards a resilient future planted by the citizens of Chennai.

PURPOSE

The purpose of this paper is to propose a crowd-sourced platform for Chennai city, where people can actively participate in the inception and execution of inter-scalar and intra-scalar strategic approaches for landscape oriented urban development.

RESEARCH METHODOLOGY

The authors used a qualitative approach to accomplish their goal. First of all, secondary resources were used in the data collection. The writers examined publications from reliable, peer-reviewed sources, including books, journal articles, scientific papers, city reports, newspaper stories, and volunteer handbooks. Information about Chennai's historic water systems, the predominate human-nature relationship in the past, the city's transformation and the forces behind this rapid change, the city's vulnerabilities and threats, the best examples of citizen participation in city decision-making, and the potential for citizen participation in the development of a resilient Chennai were the main points of emphasis. The findings were analysed using the narrative analysis method and the proposal took shape based on the analysis. The proposal acknowledged Chennai's history, listed the risks the city is currently facing, and suggested several citizen-driven solutions for a resilient future. The initiative aims to address Chennai's impending vulnerabilities by harnessing the active engagement of its people on three separate scales: the household, the community, and the city. This type of interscalar strategy is necessary because to achieve resilience the city needs integrated models that take into account not only space but also systems. The severed connection between the water and the people can be mended through scalable, replicable, and adaptable solutions hatched in even the veranda of one's home. The following section will narrate in detail the proposal designed following this methodology.

FINDINGS:

An analysis of Chennai's past revealed that the city's past ingenious water system was kept in good condition through the participation of community members (VijayKumar, 2022). A feeling of common ownership ensured the water bodies' survival. However, all these waterbodies are being treated as a backside of the city at present. The IT boom at the turn of the millennium caused massive encroachment of natural resources to accommodate offices in the southern areas of the town (Chaitanya, 2021). One of the few remaining wetlands in the city, Pallikaranai Marsh, has lost around 90% of its area due to urbanization (Jose, et al., 2016). The authors noted the findings and recognized the potential for a citizen-driven solution utilizing the cause of the problem- Chennai's IT expertise. Encouraging common people to share their local knowledge can lead to a revolutionary solution, as demonstrated by the 2015 flood map discussed in the previous section. The proposal is based on the building blocks of Chennai's current technology infrastructure, its historical water system management, and the citizens' desire for revolutionary change. The three main concerns addressed in the project are water management, encroachment, and managing waste cited by multiple sources as major contributors to Chennai's diminishing natural resources (Water As Leverage, 2018 and Resilient Chennai, 2018). The road to recovery is developed by having citizens participate in different decision-making processes, beginning at home. Involvement in community decision-making is also considered, as this will influence urban development holistically. "Chennai Chooses", reinterprets the conventions governing discourse between the city and the actual urban environment. Promoting individual decision-making can lead to more responsive, participatory, and networked public places where people can re-establish ownership and belongingness.

THE PROPOSAL: CHENNAI CHOOSES

The authors believe that an individual holds the power to bring about massive change in their community. Even if an isolated resilient lifestyle might not seem like much in the grand scheme of things, a few community-wide behavioral shifts can lead to better things in the future. For this reason, the authors have chosen a community individual as their resilient unit. The plan conceives of an online public forum where a person can actively engage in the process of shaping his community. The proposed digital platform called, "Chennai Chooses", will help residents of Chennai become more resilient by encouraging them to participate in and share their expertise on sustainable community development.

To start the journey, citizens will need to register on the site and provide basic details like name, age, address, employment, and number of family members. The platform will create specifications for various resilience criteria using this information. After registering, a user will see the home page with three simple icons, signifying the three distinct scales an individual can impact—home, community, and city (Figure 1).

Home: By selecting the "Home" button, users can investigate three crucial areas to strengthen the resilience of their living units: disposing of waste, collecting rainwater, and improving soakability. The platform will offer users a library of video lessons about healthy lifestyles in addition to analytical data about their families.

Figure 1: Homepage of the platform "Chennai Chooses"

Garbage: Domestic waste management is where efficient waste management should begin. Household garbage sorting can successfully minimize the total amount of Municipal Solid Waste (MSW) accumulated in a community. Sorting garbage and composting are the two distinct waste management issues covered on

the page accessed by clicking the "Garbage" icon on the platform. The user shall divide the household waste into two groups (Organic and Inorganic) and dispose of them in two distinct trash cans. It is suggested that the organic waste be sent to nearby proposed compost sheds so that it can be converted into compost for gardening. The user can reclaim these composts for their home gardening through online marketing via the platform. The physical entity of the platform will take the inorganic waste to proposed trash banks, where sorted waste can be exchanged for credit or cryptocurrency. The users can use this credit later for phone recharge, bill payment, online transactions etc. Another feature in this section titled, "Where does your garbage go?", will show the journey of the garbage from the households to the trash bank. The garbage will be recycled in these trash banks and the remainder will be sent to a Waste-To-Energy Plant that will incinerate the residue to create energy. The user shall divide the household waste into two groups (Organic and Inorganic) and dispose of them in two distinct trash cans. It is suggested that the organic waste be sent to nearby proposed compost sheds so that it can be converted into compost for gardening. The user can reclaim these composts for their home gardening through online marketing via the platform. The physical entity of the platform will take the inorganic waste to proposed trash banks, where sorted waste can be exchanged for credit or cryptocurrency. The users can use this credit later for phone recharge, bill payment, online transactions etc. Another feature in this section titled, "Where does your garbage go?", will show the journey of the garbage from the households to the trash bank. The garbage will be recycled in these trash banks and the remainder will be sent to a Waste-To-Energy Plant that will incinerate the residue to create energy.

Rainwater: Rainwater harvesting is a crucial component of resilience at the home level. It is not possible to use Chennai's groundwater for any domestic purpose due to its extreme contamination. As a result, installing rainwater tanks in homes can be a wise strategy to lessen reliance on groundwater. Furthermore, homes with rainwater tanks will aid in containing unexpected precipitation and averting urban flooding. The platform will generate the total daily consumption of the user's household from the number of family members and the utility bill. The platform will then generate the dimensions of an optimum rainwater tank for the household from this data and the size of the plot. After gathering data from the pump, the platform will display to users the percentage of groundwater they are extracting. The user will be credited on the site if they maintain their groundwater use within a specified minimal range.

Soakability: Soakablity can be increased in the user's house in different ways. The platform will analyze satellite imagery of the user's plot to suggest the scopes of gardening on the lawn and the rooftop. To improve soakability, vertical farming is an additional alternative. The user will get credit if their home incorporates and maintains a specific percentage of green space. A diagrammatic depiction of how the soakable regions in their home would help to absorb rainwater and subsequently replenish the groundwater is provided by the platform's "Is my home green enough?" function. Additionally, by reducing hard surfaces, this feature will lessen the impact of the urban heat island. These presumably minor adjustments made to community members' daily routines will guide their city toward a considerably more comprehensive development plan that is considerate of its natural resources.

Community: The three icons "Events", "Ongoing Projects", and "Become a contributor" can be found in the platform's "Community" section. By planning community events and posting films showcasing resilient practices, a user can contribute to the community platform. The forum will be used to post updates and a variety of social activities, such as "Canal Cleanup Day," "Earth Day," and "Weekly Meeting of Contributors," will be arranged to increase awareness and get people involved in community building. The users of the platform will be informed about current projects in their area and the project's future potential in the "Ongoing Projects" section. After that, users will have the option to vote for or against the projects. Additionally, the user will be able to choose from a variety of public amenities that they believe their community needs urgently. As a result, real-time data generated from crowds will be accessible to planners and designers in the communities. As a consequence, the development of vibrant public areas and hubs for social interaction will be facilitated through community participation.

Pallikaranai region is used as a model community for intervention proposals that can be displayed on the platform.

1. Edge of Canal: The first plan calls for softening the Buckingham Canal's edge in the area. The flood wall that now guards the canal border has been performing poorly in recent disasters. A more sensible strategy would be to phase the flood wall into a berm or a natural slope that can efficiently absorb floodwater. During the dry seasons, this will function as a thriving activity zone. The Buckingham Canal edge might encourage a variety of public activities. The platform will allow the design of spontaneous activity zones using data gathered from the crowd.

2. Dump Park: The establishment of a public park to preserve the Pallikaranai wetlands is the second intervention in this neighborhood. A continuous walking trail around the wetlands is proposed to transform it into a natural asset. This intervention will serve as a model for social integration points that can

be eventually replicated around Chennai, in addition to conserving the marshes and preventing encroachment The existing landfill in the Pallikaranai is suggested to be converted into a green park and a Waste-To-Energy plant is proposed in that place. The plant is designed to connect the walking trail on the other side of the highway. In addition, the highway is proposed to be elevated so that the park can flow uninterruptedly. The plant will have public access to a certain point and will accommodate public activities on the roof. Thus, this building will play a vital role in raising awareness within the communities about waste management as well as serve as an integration point. The landfill will be covered gradually with a liquid extraction and a gas collection layer. Next, a barrier layer, an impermeable layer, and a mineral drainage layer will be laid out. Then subsequently, it will be covered with soil layers and vegetation to turn it into a green park. Pallikaranai happens to be one of the most popular bird-watching spots in India. Many birds of exotic species visit this marshland around the year. Various decks will be provided along the trail to provide immersive vantage points for the bird watchers,

3. Sponge Park: The proposed sponge basin system is a modified version of the once-prevailing “Erys” system. The later population explosion in Chennai led to the disappearance of the tanks. However, rainwater still accumulates in the naturally low-lying areas. To handle this situation, sponge parks or sponge basin parks are proposed as an alternative solution where depressions will be created in the open green spaces so that they can work as retention basins. These parks can also accommodate public activities in the dry seasons.

4. Community Upgradation: In addition to these suggestions, certain interventions can be implemented in the surrounding areas to raise people's standards of living. Among these interventions are layers of vegetation and permeable pavement, which increase the permeability of the roadways. The street's runoff water will be gathered in interceptor channels using bioswales or filtration strips. The subterranean water system will be linked to the residential tanks.

Furthermore, it is suggested that open spaces in various land use types, such as school and institution grounds, skyscraper podiums and setbacks, etc., should be designed such that they can serve as retention basins in the event of a major downpour. As a result, the community will develop a water network that connects the water sources in the area to the smaller retention basins and house tanks.

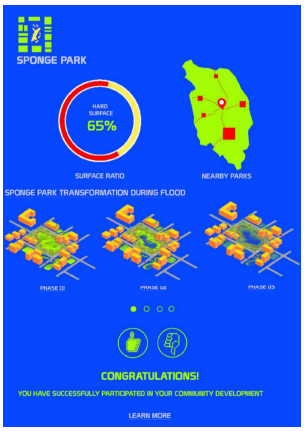

Figure 3: Participation in community scale through the platform

City: The interventions of Pallikaranai can be a design model to be replicated around different points in Chennai. Therefore, the city section of the platform will show the possible replication of proposed design interventions around the city on different scales. Firstly, the garbage network in the Pallikaranai area is proposed to be replicated and effectively applied in various other points across the city. Landfills will be replaced by Waste-To-Energy plants. In addition, compost sheds and trash banks will be provided at the neighborhood scale. Thus, the platform can aid in reducing the overall municipal solid waste generated by the city.

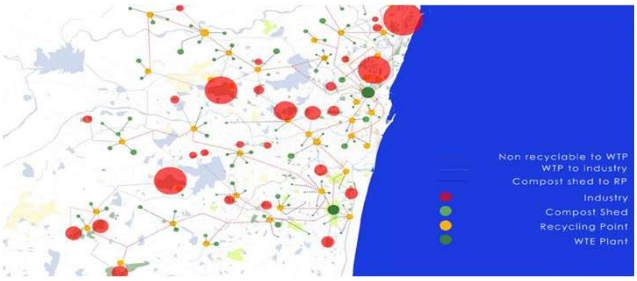

Figure 4: Proposed city wide waste disposal network

Secondly, depending on public preferences, the Buckingham Canal edge can be successively modified to allow various activity zones in different locations. Thirdly, the natural water retention points and rivers must be protected by soft edges with a plantation buffer, to make them more effective in rainwater absorption and during floods. Additionally, streets with permeable paving and plant strips, as well as neighbourhood-scale parks and green spaces, can be designed as a sponge network to help absorb and transport excess rainwater to neighbouring natural basins. As a result, the general problem of Chennai's water management can be resolved.

Finally, in the “Our vision" section of the platform, the overall synthesis of the smaller interventions will be portrayed- a landscape-oriented development. The overall growth and development of Chennai city is proposed to be guided along its natural assets, which will lead to an ultimate sustainable metropolis that takes nourishment from its resources

CONCLUSION

The numerous temple tanks that embody the spiritual significance of water bodies demonstrate how deeply

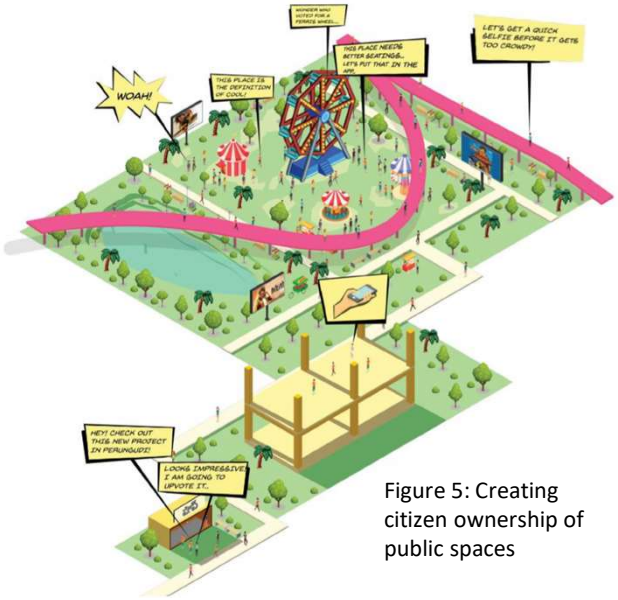

Figure 5: Creating citizen ownership of public spaces

entwined water and culture are in Chennai's daily lives, despite the current circumstances (Water As Leverage, 2018). Chennai is interwoven between complexity and intimacy. Public spaces can be designed to be more responsive, participatory, and networked if we encourage individuals to voice their decisions. The platform "Chennai Chooses" is a social tool that can voice the unheard call for help of the citizens of Chennai. The platform can also incorporate ongoing social projects in the city such as "City of 1000 Tanks", "Chennai Volunteer Network", "Citizen Buzz", "Resilient Chennai" and so on. If the citizens engage in conversation and become aware of their situation then through decisions taken via this platform, urban spaces will emerge as a social product and Chennaiets will be empowered in the production of it.

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FLOWING HERITAGE: A COMPARATIVE ANALYSIS OF MUGHAL WATER SYSTEMS AND THE LALBAGH FORT IN DHAKA

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ABSTRACT

One of the grandiose monuments constructed by the Mughal Empire in the seventeenth century is the Lalbagh Fort Complex was built to guard Bengal's capital city of Jahangirnagar (now Dhaka). This research paper delves into the intricate relationship between water systems and architectural design, focusing on a comparative analysis of the historical Mughal water system and its echoes in the architectural marvel of Lalbagh Fort in Dhaka. These parallels illuminate the lasting influence of Mughal design principles in the region. Through meticulous examination and analysis, this study unravels the multifaceted layers of design, architecture, and heritage embedded within these structures. This study elaborates the reciprocal relationship between water and architecture. Through a meticulous comparative analysis, this paper describes valuable insights about the integration of water systems in architectural design, emphasizing the need for sustainable and culturally informed approaches. This study encourages a holistic exploration of water-sensitive architectural design that bridges the gap between tradition and maintenance.

KEYWORDS

Heritage, water, architecture, sustainable, history.

INTRODUCTION

While various Mughal structures may be seen throughout the Indian subcontinent, Lalbagh fort is the only remnant of an encampment Mughal Garden architecture in Bengal's capital, Jahangirnagar (then Dhaka). In 1678 AD, Mughal prince Subahdar Muhammad Azam Shah, son of Emperor Aurangzeb, began construction of 'Fort Aurangabad' beside the Buriganga river. Later, because to the untimely death of his daughter and Prince Azam's fiancé Iran Dukht Rahmat Banu (named Bibi Pari), his successor Shaista Khan was unable to continue its development. As a result, the abandoned fort was given the name "Lalbagh." This location is now open to the public, and it is one of the few remaining green open spaces in that densely crowded neighbourhood. The complex water feature at its core signifies Mughal pragmatism and ingenuity integral to its creation (S. Farzana, 2019). This research is an attempt to examine and compare different opposing hypotheses regarding its architecture. The idea is to explore the water system of the building by analysing parallels with other Mughal structures in Bengal and outside. It would provide us further option to think and interpret the connections among the water feature, architecture with the historical context.

BACKGROUND

The Lalbagh Fort Complex portrays a quadrilateral garden with a hierarchical arrangement of buildings, enclosed by a fortress, resembling the Charbagh. The term 'Chahar Bagh' or 'Charbagh' originates from Farsi/Persian, defining a formal garden layout in architecture, derived from 'char' meaning 'four' and 'bagh' meaning 'garden'. A Charbagh garden usually divides into four sections via pathways or waterways intersecting at its centre, forming a symmetrical, geometric layout resembling a square or rectangle. (Ali 2011), Petruccioli 1998). Mughal emperors brought Persian garden style in the Indian subcontinent where Persian and Islamic concept of garden. was transformed into contextual realization. Derived from Persian and Islamic Garden design, Charbagh gardens, linked with Mughal architecture in the Indian subcontinent, aimed to craft visually striking and spiritually symbolic sanctuaries. The Lalbagh Fort Complex encompasses three structures spanning approximately 18 acres. The enclosed landscape mirrors the 'Charbagh' style, introduced by Mughal concepts into a contextual manifestation.

Fig 1: Aerial view of Lalbagh Fort (Source: Wikipedia)

AIM / PURPOSE

To reveal the enduring influences of Mughal water systems on Lalbagh Fort's architecture emphasizing the symbiotic relationship between water and heritage.

OBJECTIVES

1. To explore and document the historical significance of Mughal water systems, purpose, and cultural significance within the Mughal Empire.

2. To conduct a comprehensive comparative analysis between the Mughal water systems and the architectural design of Lalbagh Fort
3. To identify and highlight specific architectural elements and features within Lalbagh Fort that directly echo or draw inspiration from Mughal water systems

RESEARCH METHODOLOGY

Literature Review:

An extensive literature review was conducted by theoretical and evidence-based sources, site observation and secondary data. A systematic search was regulated based on journals, scholarly articles, books and papers. This study examines the symbiotic relationship between water and architecture.

CHARBAGH

The term 'Chahar Bagh' directly translates to 'four gardens.' According to the Quran, Islamic holy book, the garden of paradise is described as “Garden underneath which rivers flow”. The Quadrilateral setting of the garden originated from the concept of four flowing channels of water, honey, wine and milk mentioned in the Holy Quran. The arrangement and various components of these rugs mirror a distinctive Iranian garden style that has prevailed since . approximately 600 AD and remains evident in the region today. Interestingly, the roots of Chahar Bagh trace back to the mid-6th century BC, originating in Cyrus the Great's palace garden at Pasargadae.

Charbagh gardens, originating from the arid regions of present-day Iran, prioritized water and irrigation due to their climate. Exhibiting geographical elements, they boasted strong symmetry, featuring a central fountain or water source branching into four canals. These canals, designed at right angles, delineated the garden into four distinct beds symbolizing the elements of sky, earth, plants, and water.

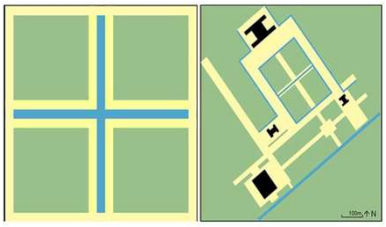

Fig 2: The Charbagh Pasargadae
Source: Charbagh four square garden (gardenvisit.com)

The "four square" layout of a Persian paradise garden is known as "Chahar Bagh'' (pronounced "Ch-haar-bah"). The Mughal and Iranian gardens are mentioned when using this phrase.

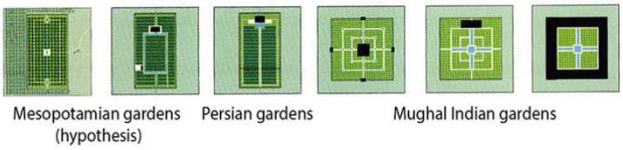

Fig 3: Evolution of the Charbagh Garden
Source: Charbagh four square garden (gardenvisit.com)

The diagrams show the evolutionary history of Islamic gardens, though the older styles were of course un-influenced by Islam. Famous examples of Charbagh gardens: Pasargadae , Bagh-e Fin , Humayun's Tomb.

WATER AS AN ELEMENT OF MUGHAL ARCHITECTURE

When Muslims began to arrive in India in the twelfth century AD, they brought with them their architectural skills from abroad. This resulted in the astonishing Indo-Islamic style. Water has a special value in Islam as well. According to Sura 55 (Al Quran), water running in the garden of heaven is a vital element in the eternal gardens of paradise.

The buildings were constructed to provide thermal comfort for the occupants because artificial control results in excessive energy consumption, which India was not prepared for. As a result, the opportunities to use naturally occurring energy led to creative solutions. The passive cooling techniques that the Muslims employed in their buildings were combined with local techniques to create new ways of coping with the harsh Indian climate (hot and dry).

Climatic Characteristics: Within the Mughal sphere of influence in northern India, two thirds of the year were hot and dry, with the remaining third experiencing humid conditions. The range of observed daily temperatures in the hot and dry season was 11–12 degrees Celsius, while in the cool and dry, it was only 3–6 degrees. During the wet season, the humidity level rose to 95%, and hot, dusty winds prevailed during the dry season.

Climatic Consideration: Changes in the microclimate outside the building were taken into consideration because they would regulate the interior temperature or heat gain. The external air was treated to enhance the microclimate of the area, and vegetation was added to improve the quality of the outdoor areas through evapotranspiration, which lowers the air’s temperature by adding water vapours and enhancing interior comfort. Because of this, water features—both still and moving—were added to palaces to increase humidity in hot, dry climates. The Mughals also improved the microclimate of the area by using water channels and their construction.

Water channels at Lalbagh Fort: The Lalbagh Fort Complex is a combination of three buildings (the mosque, the tomb of Bibi Pari and the Diwan-i-Aam), having two gateways and a portion of the partly damaged fortification wall and Chahar bagh style garden area covering about 18 acres. At the present condition, Lalbagh's waterways serve as a representation of history, even though nothing remains of the previous state as time goes on.

Roof garden with water features: A Quadrilateral Garden with hierarchy of buildings and surrounded by fortress as Charbagh was depicted in Lalbagh Fort

Complex. Roof Garden with water features and Islamic pattern was discovered recently which is an eccentric addition with Mughal garden style.

Diwan-I-Aam with water features: Diwan-I-Aam was used publicly and for the guests to spend time. So, it was designed with water features to enhance the ambience of the surroundings.

Fig 4: Mosque in Lalbagh (Source: Lalbagh Fort Dhaka - Bangladesh - Wikienfk5 (hfwu.de)

LALBAGH WATER SUPPLY SYSTEM

The notable highlight of Lalbagh Fort lies in its water supply system, strategically located near the Buriganga River.

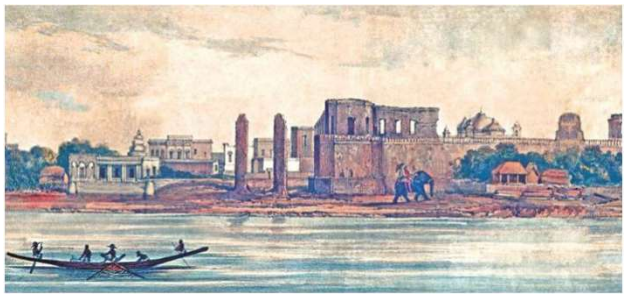

Fig 5: The ruins of the Fort and the Palace of the Nawabs of Dacca, called Lall Bag (Source: Panorama of the City of Dacca, 1847)

Hence, to facilitate the flow of water from the river into the fort, a water wheel known as the water tower, was erected near the bastion in the fort's southwest corner, likely operated manually by manpower. This mechanism transported water from the river to two primary channels within the fort: one leading towards the mosque and another running along the rooftop garden's fortification wall. Given Lalbagh Fort's extensive size, there's speculation regarding the existence of additional water towers along the wall. Following the Mughal Garden model, a hydraulic system was employed to circulate water throughout Lalbagh Fort's garden area. From the rooftop garden, water would cascade down to the ground level through a water sheet called a "chador." A large Water Reservoir acted as a Ballast Tank, collecting river water, which, when full, powered the fort's fountains under high pressure. An additional water wheel near the South Gate possibly sped up the reservoir filling process before the water returned to the river (Rashid, Md. M., 2011).

ANALYSIS & INFERENCE

The notable highlight of Lalbagh Fort lies in its water supply system, strategically located near the Buriganga River. Due to the huge demand of overpopulation, over time the water level is going down in the Lalbagh area of Dhaka. Due to the fall in the water level, the water in the pond located in the fort has dried up. As a result, it is now used as a sloping field in the fort complex. This pond in Lalbagh was one of the few surviving in the heart of Dhaka. It was important to preserve this pond as a Mughal heritage. However, a nearby river or tributary could be seen from which the entire complex was helped to maintain its water flow.

Fig 6: Depth of Groundwater Table in different areas of Dhaka City in different year (1980-2010) Source: Bangladesh Water Development Board, 2014

Year	Groundwater level
1995	19.78
2000	36.57
2010	44.77

It is believed that water flowed in the same way through the water line passing through the central spine of the Lalbagh fort built along the banks of the Buriganga. Which came out like a fountain through a narrow hole due to the pressure of the water height. As a result, a cold atmosphere was maintained throughout the entire fort complex. Which was suited to the climate and local context here.

CONCLUSION

The culmination of this study reveals a profound interconnection between Mughal water systems and the architectural marvel of Lalbagh Fort, spotlighting the enduring influence of Mughal design principles on the region's heritage. The meticulous amalgamation of water elements not only showcases remarkable engineering but also carries deep cultural and functional significance. Preserving these structures within their historical contexts emerges as a crucial imperative, advocating for sustainable and culturally sensitive approaches in architectural conservation and development.

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APPROACH OF LAKE CONSERVATION: NEED AND CHALLENGES

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ABSTRACT

Water sources including surface water bodies and aquifers are vulnerable in terms of pollution and exploitation. Hence it causes a great threat to the local and regional ecosystems, hydrological settings, public health, economy, social well-being. Lakes are surface water bodies surrounded by land from all the sides and one of the elements of local and regional hydrology. Also, they are the part of local/ regional/ continental ecosystems as well as carry ecosystem within. Ther are not only the part of ecosystem but also the water sources on which human is dependent on for his needs. These needs are domestic, irrigation, industrial, recreational purposes. In today's scenario many lakes are polluted due to anthropological interventions; waste water discharge, dumping of organic and inorganic waste, utilization of water as well as development in catchment area. Also, the over utilization of water for various purposes, disturbances in the flow of feeders of the lake, minimizing the green cover leads to drying of the lakes. This leads to adverse impact on aquifers as well. Hence some measures need to be taken to maintain and manage these lakes in terms of quality and quantity. The paper discusses conservation parameters of lakes and various measures need to be taken for lake conservation which leads to sustainability. The study will be carried out by gathering information from reliable sources, evaluating the related case examples etc. The conclusion will be based on evaluating iterative solutions based on various parameters.

KEYWORDS

Lake, Conservation, Pollution Abatement, Public Spaces.

INTRODUCTION

"A lake is a landscape's most beautiful and expressive feature. It is Earth's eye; looking into which the beholder measures the depth of his own nature." - Henry David Thoreau

Lakes are the distinct features of local and regional landscape. Lakes are fresh water resources on the surface and the part of local and regional hydrology system. These resources are closely associated with ground water level, surrounding ecosystems and societal needs. The societal needs refer to the consumption (domestic, agricultural, industrial purposes), fishing, recreation etc. Lakes are formed due to accumulation of water in a depression or basin on earth's surface. They are mostly the fresh water sources as well as contain salinity in exception. The lakes on the earth's surface are formed either due to natural causes or they are outcomes of anthropogenic activities. These stagnant water bodies surrounded by land from all the sides and often fed by rains, surface drains from surrounding higher terrains and aquifers.

On the earth's surface 97% of water is in oceans and seas and only 3% of water is fresh. Out of 3% of fresh water 79% is frozen in glaciers and ice caps, 20% is deposited underground and only 1% is accessible surface water. Again in 1% soil contains 38%, atmosphere contains 8% in the form of water vapors, rivers 1%, vegetation 1% and lakes contain 52% of water. That means lakes have highest fresh water reserves on the earth's surface.

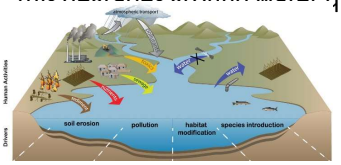
In 2015 United Nations (UN) declared seventeen Sustainable Development Goals (SDG 17) are to be achieved by 2030 across the world. These measures are to be taken by government level with inclusive, equitable and participatory approach through the various policies and programs. SDG 6, SDG 11 and SDG 13 can be accomplished by efforts covered for lake conservation.

SDG 6 - Ensure availability and sustainable management of water and sanitation for all	**The goal covers sustainable practices of water consumption sanitation, conservation and management of water resources and related ecosystems.**
SDG 11 - Make cities and human settlements inclusive, safe resilient and sustainable	The goal covers sustainable urban and regional planning approach aiming to societal well-being, preservation of cultural and natural heritage, prevention of natural adversities and resilience.
SDG 13 - Take urgent action to combat climate change and its impacts	The goal covers mitigation, adaptation of climate change impacts and strengthening resilience against climate related hazards, through public awareness, institutional capacities.

THE NEED OF LAKE CONSERVATION

Lakes are of varied capacity and easily accessible. Also, they have social, economic and cultural significance greatly and hence they are more vulnerable in terms of quality and quantity of water.

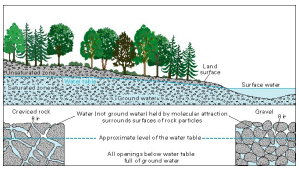
Qualitative degradation : The anthropogenic activities around the lakes and their catchment areas affect the water quality adversely by dumping of solid waste, discharging waste water, improper storm water management, deforestation in the catchment area. The practices of washing clothes and animals, bathing by the local communities add pollutants in the lake water. The feeders of the lake carry silt along with the flow and it is deposited on the lake floor. These are the pollutants enter into the lakes and degrades the quality of water.
The polluted water affects adversely on the public health and environmental quality of the local area. Also this degrades ground water quality.

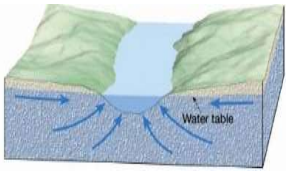


Quantitative Decrease: Unplanned development, in the catchment area causes obstruction to the feeders and reduces the capacity of the feeders. This cause flooding in the catchment area and disturbs the public life. Encroachment, land reclamation, around the lake leads to shrinkage of the lakes. Also overuse of lake water, evaporation are additional factors to reduce the water quantity in the lakes. The fig. below shows the shrinkage of Aral lake in 8 decades

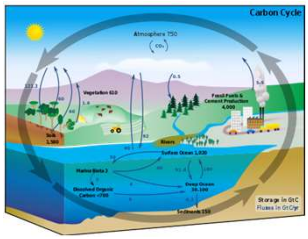
All these affects adversely on local and regional hydrological settings, geological characteristics and ecological balance which may question the sustainability in terms of social well-being, economic progress and environmental settings.

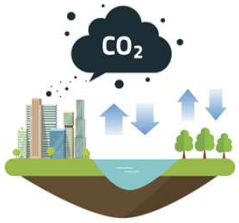
Supplementary action between Surface Water Bodies and Ground Water: Surface water bodies and Ground water are supplementary to each other. Ground water is presence of water in voids in sub-surface of the earth. These voids are saturated with water through percolation. Percolation rate is dependent on climatic conditions and geological characteristics of the region. Ground water has to two zones; unsaturated and saturated. Unsaturated zone is on the shallow level and saturated zone is deeper. Water table is a defining level of these two zones. Lakes/ surface water bodies help to maintain ground water table and ground water discharges water in the lake/ stream if the base of the water body is below ground water table. This is also called the baseflow. Fig. below shows ground water and supplementary action between GW and surface water





Role of Lakes as Carbon Sinks: Carbon sinks are the systems where they absorb more carbon from the atmosphere than they release in their natural processes or anthropogenic interventions. Carbon sinks perform an affirmative and major role in carbon cycle in the atmosphere. Forest, waterbodies and soil are the carbon sinks. The Lakes are surface water bodies and absorb carbon present in the atmosphere. The large number of lakes are present on the earth's surface.





Ecosystem Services of Lakes: Lakes provide ecosystem services. Those services regulate and balance environmental quality, social well-being and economic benefits.

Provisioning Services: Lakes provide fresh water, fishes, herbal food etc.

Regulatory Services: It maintains air quality in terms of temperature, humidity. During the rainy season the lakes hold water and manage water runoff. The banking around the lake prevents erosion from the edge of the lake.

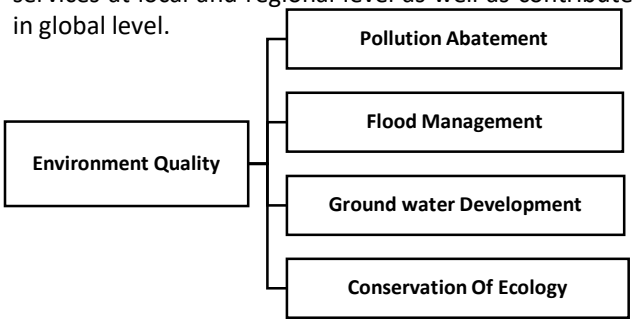
The lakes are resilient to natural hazards such as flooding, draught etc.

Supporting Services: Lakes are active elements in water cycle. The silt deposited in lake contains nutrition and is fertile.

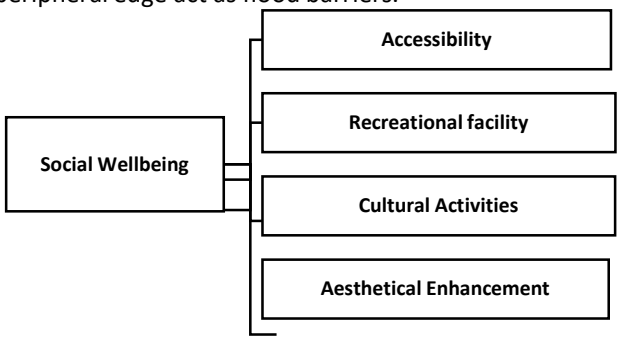
Cultural Services: Lakes have a close association with social integrity, recreational facilities, cultural trends etc.

OBJECTIVES OF LAKE CONSERVATION

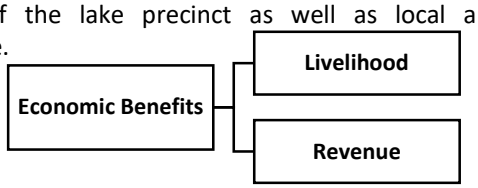
Lake conservation has multiple objectives includes maintaining environmental quality, social well-being and economic returns as well. These provide ecosystems services at local and regional level as well as contribute in global level.



Pollution abatement is the prime objective of lake conservation. Lake water may contain pollutants in various forms. These pollutants impact adversely on human health and ecosystem in and around the lake. Pollution abatement can be achieved through various technologies as per the requirement. Lakes hold excess storm water which runs off through the storm water drains (natural and manmade). This help to manage floods on the surface area. Lakes also maintain the ground water table and holds water through base flow in dry seasons. Lakes have their own ecosystems in and around its peripheral area. The vegetation around the peripheral edge act as flood barriers.



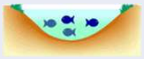
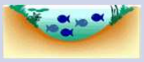
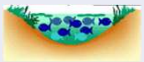
Accessibility to the lakes establishes the physical connection between the lakes and community. The lakes have close association with societal well-being in terms of their recreational needs and cultural trends. The lakes can be developed as public spaces. The architectural interventions such as landscape design around the lake attract people and enhances aesthetical quality of the lake precinct as well as local area landscape.



Lakes provide livelihood opportunities to the local communities and generate revenue to the local governing bodies. The livelihood activities for the local communities are fishing, vending the goods, boating, aquatic sports etc. The local governing body (Municipality/ Gram panchayat) has a responsibility of maintenance of the lake. This responsibility includes maintenance of water quality, maintenance of ecosystem, maintenance of public areas created around the lake etc. To incur the cost of operation and maintenance of the responsibility local government may incur the revenue by leasing out the spaces to the vendors, levying the tax/ charges (parking, other facilities) etc. This approach is beneficial to all the stake holders.

Trophic State Index of the lakes: Trophic State Index (TSI) of the lake determines the sustenance of biomass due to presence of nutrients in the lake water. More the biomass lesser the concentration of oxygen in the lake water. Presence of nutrients in the water indicates the pollution level and biological growth in the lakes.

The table below shows the Trophic State Index chart and its attributes.

TSI	Trophic State	Attributes
0-40	Oligotrophic 	Oligo – Lack of nutrition Clear water • Oxygen at the bottom • Few Aquatic plants and Fish • Sandy Bottom
40-50	Mesotrophic 	Meso – Medium nutrition • Moderately clear water • Moderate amount of aquatic life • Oxygen may present at the bottom of shallow lakes
50-80	Eutrophic 	Eu – Abundant nutrition • Lots of aquatic plants and clear water or • Few aquatic plants and less clear water • Potential to support lot of aquatic life
80-100	Hypereutrophic 	Hyper – Over abundant nutrition • Very low water clarity • Higher degree of aquatic plants, fishes, and wild life

CLASSIFICATION OF LAKES

Lakes can be classified in two categories

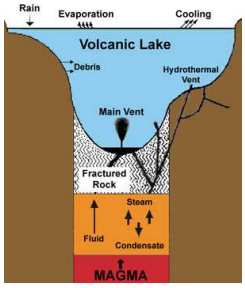
Saline Lakes and Fresh Water lakes

Saline Lakes: Saline lakes or salt lakes are found where the rock contains high amount of sodium chloride and other minerals and rate of evaporation is significantly than that of recharge/ refilling of the lake. These lakes house no aquatic life.

Fresh Water Lakes: Fresh water lakes are commonly found on earth's surface and may be suitable for human and animal consumption. They are majorly refilled by rains as well as fed by rivers, streams. Also the ground water/ aquifers act significantly to maintain quantity of water in the lake. These lakes are conducive to develop rich ecosystems in and around the lake.

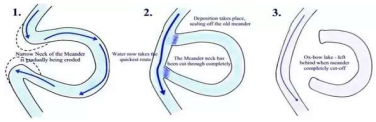
TYPES OF LAKES

Volcanic Lakes: Volcanic lakes are formed in the craters, the bowl-shaped depressions formed due to volcanic eruptions. Once the eruptions cease these craters eventually get filled with water and form lakes.



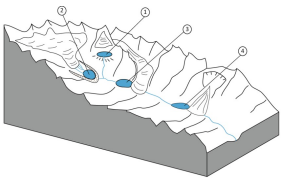
The fig. below shows Volcanic Lakes

Oxbow Lakes: Oxbow lakes are formed due to cut off of river course at the meander loop and the river course separates from the loop. The fig. below shows Oxbow lakes formation

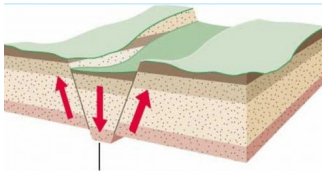


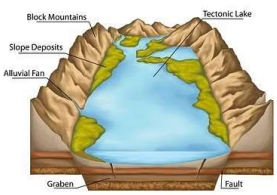
Glacial Lakes: Glacial lakes are found in the snowy mountain regions and fed by the glaciers and snow. In winter season they are in frozen state and in summer they are in liquid state.

The fig. Below shows Glacial Lakes formation

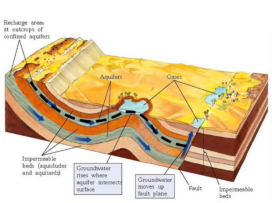


Tectonic Lakes: Tectonic lakes are formed as a result of lateral and vertical movement of earth's crust. Due to these movements the earth plates are morphed and cause land deformation. These movements can be faulting, tilting, folding and warping of the crust. The fig. below shows Tectonic lakes formation

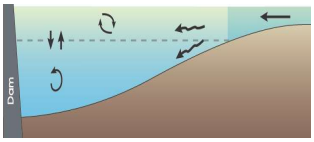




Oasis: Oasis are lakes in sandy desert areas. These are natural or manmade. These are formed as depressions formed due to sand erosion and landslides. These depressions go deeper and reach to the ground water table then they are naturally filled by ground water. Around the oasis the vegetation can grow and ecosystem can be developed. The fig. below shows Oasis Lakes



Artificial Lakes: Artificial lakes are formed for various purposes as per the social, environmental, economic need of the area. These are formed by excavating the ground surface and creating the depressions to collect and accumulate the water. They are formed at the strategic locations considering the topography and geology. Holding ponds, percolation dams are the example of artificial lakes. The fig. below shows a dam on artificial lakes.



COMPONENTS OF LAKE CONSERVATION

- **Pollution prevention and abatement measures:**

Several point and non-point sources degrade the water quality in the lakes and make adverse impact on the ecosystem in and around the lake, degrades ground water quality and human health. Pollution prevention and abatement measures need to be taken by all the stake holders in inclusive and participatory approach.

- **Cleaning of lake with appropriate technology:**

Lake Cleaning, desilting of the lakes. Lake may contain solid waste, silt and other pollutants which degrade the quality of water. These pollutants are organic and inorganic. These pollutants need to be removed in the consultation of expertise and with the help of appropriate technologies.

- **Catchment area management:** Catchment area management is foremost and the most challenging measure in the lake conservation projects. This is a planning level measure and to be worked out in a strategic way. This deals with overall governance, landuse planning, infrastructure planning, environmental planning, social awareness etc. Sewerage, stormwater drainage, solid waste management are the primary sectors in catchment area management.
- **Lake front development for public access:**

Lake front developments are the public spaces. These developments allow and attract local people and tourists for recreational activities, cultural practices, social gatherings etc. This creates positive impact on social integrity, economic gains, environment consciousness etc.

- Public awareness and Public Participation
- Capacity building
- Location specific requirements
- Study of Trophic State
- Aesthetic Enhancement

HOLISTIC APPROACH FOR LAKE CONSERVATION

Lake conservation is an exercise of planning and design at regional and local level. Qualitative and quantitative data analysis is required by various survey methods. Data need to be gathered by primary, secondary and tertiary means. The holistic approach is all needed for success of lake conservation program. The data analysis and inferences of catchment area of the lake

Catchment area Study

- Identification and delineation of catchment area
- Topography profile of the Catchment Area
- Geological characteristics of the catchment area
- Indigenous ecological settings and species of flora fauna
- Population growth analysis
- Socio-economic status
- Study of development pattern
- Provision of Sewerage system in entire catchment area

Lake Specific Study

- Physical data of the lakes in terms of Area, perimeter, depth
- Inflow of storm water drains in terms of Quality, quantity and locations
- Development of facilities for swimming, washing clothes, vehicles animals on downstream of the lake.
- Degrading / desilting of sediments in the lake and its disposal
- Aeration of water for proliferation of healthy aquatic life
- Demarcation and fencing of lake boundary
- Solid waste management within the lake premise
- Need for community awareness and Public Participation activities
- Development of recreational activities

CHALLENGES FOR LAKE CONSERVATION

- Public Awareness
- Political will
- Institutional capacity
- Funding Means

Lake conservation is a participatory program of all stakeholders. The stake holders include Governing bodies (Central, state, local, regional), expertise (environmentalists, engineers, architects, sociologists etc.), NGOs, CBOs, Local communities etc. Inclusive and participatory approach is required in the efforts of lake conservation.

Institutional Drive

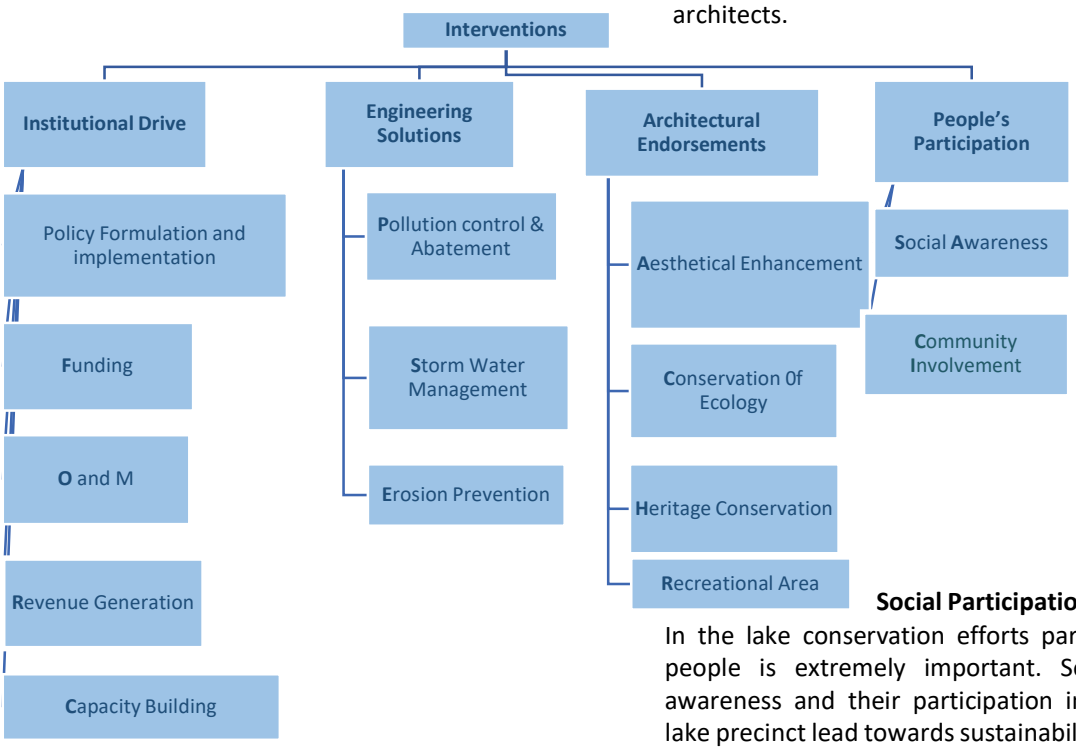
Government institutions play the key roles in lake conservation. Central Government, State Government and local governments are the driving agencies in lake conservation. Their role starts from policy formulation and implementation strategy, provision of funding, Operation and Maintenance of the lakes, revenue generation and capacity building of all the stake holders related to the lake.

Engineering Solutions

Pollution control and abatement of lake water need engineering solutions in terms of water quality and quantity. Appropriate technologies need to be deployed to maintain the water quality as per the standard prescribed by Central Pollution Control Board (CPCB) and State Pollution Control Board (SPCB). Design of Storm water Drainage, banking of rivers require technical expertise.

Architectural Endorsement:

Lakes are the public spaces. They should be accessible to public for cultural, recreational, economic needs. architects.



Landscape design around the lake enhance the aesthetical quality of the lake as well as the city. Also the Heritage Conservation is also the part of the lake development wherever necessary and in the scope of

Social Participation:

In the lake conservation efforts participation of local people is extremely important. Social/ community awareness and their participation in maintaining the lake precinct lead towards sustainability.

CASE EXAMPLES

Case example 1 – Rankala lake, Kolhapur Maharashtra

Rankala Lake is located at Western side of Kolhapur city and one of the prominent features of the city fabric. The social and cultural significance and environmental importance of the lake is greatly established over the period. The serenity, heritage structures and recreational facilities around the lake attract people of all age groups. Currently the lake is under threat of pollution and causes adverse impact on public health, local hydrology and ecosystem within and around the lake. This needs serious attention of all stakeholders of the city.

Contextual Reference: Rankala is located west of Mahalaksmi temple and at the distance of 500 meters. Shalini palace is situated in the North-West corner of the lake. There are five more smaller quarries are located in the South West corner of the lake. The entire lake is abutted by the road which makes the road accessible from all the sides.

The perimeter of the lake is 4.3 km and Area is 1.12 Sq. Km (112 Hectors) and maximum depth is 15m

Catchment area of the lake is nearly 7 sq. km.

History: Originally Rankala lake was a stone quarry dated back to 8th century. This stone was quarried to build temples in the nearby areas. In the 9th century an earthquake caused the disruption of geological setting and ground water started rising the in the quarry. This started filling up the quarry and eventually formed the lake.

The Lake Rankala is named after the Hindu deity Rankbhairav. There is a Lord Shiva temple with Nandi (A bull – Lord Shiva's vehicle) situated beneath the lake. The temple is known as Sandhya Math and has a distinct architectural character.

Social and Cultural Significance: There is lake front development around the lake which make the lake accessible to the people. The recreational spaces are well carved along the peripheral areas of the lake. The lake front was developed by the King of Kolhapur Chhatrapati Shahu Maharaj in the last century. The place is well popular in the city as a public place. The lake precinct has a significant heritage value and bears distinct architectural character.

Ecosystems: The lake has fishes and algae's which attract the birds. An island beneath the lake has a local vegetation.

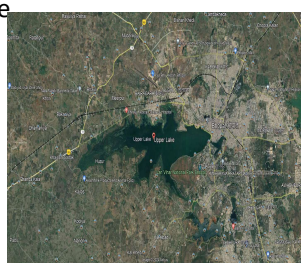
Images below show the ambience , satellite imagery and elevation profile of the lake Rankala

Case Example 2 - Bhojtal Lake, Bhopal Madhya Pradesh

The lake is located in the Western part of Bhopal City and built by Raja Bhoj in 11th century. The area of lake is 31 Sq. km. and catchment area 361 sq. km.The lake has a great significance of social, cultural and economic significance to the local people. Recreational facilities are developed around the lake. Washing clothes, fishing, cultivation of chestnut in the lake are major livelihood activities are being performed. The lake supports local ecosystems. It's a notabl habitat for Saras, the largest bird of India.

Currently the lake needs urgent attention against degradation of water quality and shrinkage.

The images below show the satellite imagery and lake ambience of Bhojtal Lakelake



Case Example 3 - Gadisar Lake, Jaisalmer, Rajasthan

Gadisar lake is a manmade lake located South East side of the city of Jisalmer in Rajasthan. The lake is built by the King Rawal Jaisal in 1156 AD and rebuit by Gadsi Singh Bhati around 1367. The lake front development attract local people and tourists. It was built for the purpose of rain water harvesting in the arid region. This was the main water source of the city.

The images below show the satellite imagery and waterfront development of Gadisar lake

THE WAY FORWARD

Lake conservation is a need of time considering the current water challenges in terms of scarcity and quality, climatic change, ecological importance, hydrological settings, public economic, recreational needs and overall development of the city/ town/ village. This creates a great impact on the social wellbeing, environmental balance as well as government organizations at every level; local, regional as well as national.

Inclusive and participatory approach in lake conservation leads to sustainable solution and

beneficial to all stakeholders. This can be achieved by social awareness, capacity building interms of newer technologies for pollution abatement, maintaining water mass, funding mechanism etc.

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THE ROLE OF WATER FEATURES IN INTERIOR SPACES FOR WELFARE OF HUMAN RESIDENT

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ABSTRACT

One of the most important design elements that helps people feel good about themselves physiologically, behaviourally, and mentally is water. The main motive of this research is to study the importance of waterscape in interior spaces with respect to its benefits and the human psychological behaviour of residents. Every type of waterscaping requires proper maintenance along with the proper planning and designing that makes it efficient. To assist designers in selecting and implementing an appropriate interior architectural design, an overview of important factors can be useful. Drawing on landscape principles, practices, maintenance, and psychological advantages, this design strikes a balance between the psychological demands of building occupants and sound architecture and interior design. The paper focuses on the study of environmental design, and psychological aspects and summarizes physical and aesthetic properties of various waterscape elements by exploring the applications of various types of waterscapes. The analytical study highlights the role of waterscaping in indoor spaces as a design element with its symbolic, visual, and auditory features; relaxing effect is studied in this research. The secondary data is collected using references from various research papers, articles about indoor waterscapes, and some internet sites, and analytical studies are done. The study found that different internal waterscape components provide varying benefits, with residents valuing them in visual, psychological, behavioural, and physical aspects, as well as functioning criteria evaluated in relation to internal values.

KEYWORDS

Human psychological response, interior waterscape, human resident welfare, interior design

INTRODUCTION

Indoor waterscape design is a fascinating concept that takes into account all of our senses when designing a space. It helps us gain a better understanding of our interiors and our role in creating a better living environment. That's an interesting approach used by designers like interior designers and others. It seems like they aim to create spaces that not only look good but also promote a sense of calmness and relaxation. It is fascinating to know that spaces can be design for multiple purposes. For instance, indoor water features can be designed to be accessible and enjoyable for people with disabilities as well as those without disabilities. This universal design approach is important for creating inclusive environments that cater to everyone's needs. Open places are especially significant when there is water present. The use of water in landscaping is distinct. It is a dominant trait in many environments. Water has an enchanting and enchanting beauty. It is a crucial element in landscape design in terms of its malleability, movements and reflection. Water generously presents its aesthetic beauty to humans. For this reason, it is frequently used in designs. Water is not only beautiful to look at, but it also makes spaces feel better. Through its symbolic, figurative and reflective qualities, it refreshes, accommodates animals, masks noise pollution, soothes, offers visual richness and mediation and generates a sensation of immensity, light, luminosity and mystery. It can attract attention, create a visual and auditory landmark, reduce mental fatigue, etc. The interior design of the water landscape has an impact on the psychological attitude of the individual from several points of view. In addition to Differences in personal experience, physical and psychological distinctions also contribute to the unique ways in which each individual receives, perceives, and responds. Resident demands are shaped by a variety of characteristics with specific interests, including culture, fitness, age, education level, gender, socioeconomic status, and ambition. The relationship between the psychological condition and the interior waterscape takes into account both the indoor waterscape's humanitarian features and design philosophy. Human mental and psychological responses to elements of the waterscape have been study from the earliest shelters to the most recent architecture. A key component of an interior waterscape is the designer's ability to articulate a holistic vision, recognize factors to consider, and consider the psychological effects of each design element.

AIM / PURPOSE

To study the importance of waterscape in interior spaces with respect to its benefits and human phycology.

RESEARCH METHODOLOGY

The data collection was carried out primarily on research papers, site visits were the author visited some ordinary indoor water features such as Shaniwar Wada, Vishrambaugh Wada where it was found that those indoor water features not being water features while designing still gives comfortable, pleasing, relax feeling. The further research paper is based on identifying what types of water features, materials, psychological impact, designing method of indoor

water features, its design principles, daily maintenance should be used to stimulate the sensual experience i.e. vison, auditory, touch, hearing and feeling to make indoor water features through study of research papers.

LITERATURE REVIEW

1. Indoor waterscaping:-

Indoor waterscapes come in a wide range of designs and styles, from classic to modern, and from simple to extremely elaborated. Although indoor water features are similar to outdoor water features in terms of circulating water in a controlled and contained manner for decorative purposes, they offer unique benefits for interior spaces. The movement and sound of water can create a calming and relaxing atmosphere, while also adding a visual element that can enhance the overall design of the space. It is no wonder that more and more people are incorporating indoor water features into their homes and businesses.

2. The indoor waterscape pattern's design:-

a. Static Water:- A person can feel calm and peaceful next to still water, the water is pure and transparent after filling. At the same time, calm water can reflect the surrounding environment, expanding the space and creating higher levels.

b. Flowing Water: Flowing water adds more life and beauty, and when combined with contemporary lighting, music and sculptures, can create a colourful and enticing indoor environment. In addition to serving as interior landscaping, circulation of internal drains, jet fountains, waterfalls, and the like also serve to divide interior spaces.

3. The design of an indoor waterscape:-

3.1. The Curtain drops: - The shape of a waterfall drop can classified into various types such as slide type, ladder type, curtain, strip, etc. The height of the waterfall also plays a crucial role in determining its overall design and function. Because of different water will produce different visual, auditory effect, Therefore, control of water mouth water flow and water height becomes a key parameter design, the residential area of artificial waterfall should be below 1m.

3.2. A Leisure Swimming Pool:- The swimming pool is design for recreation and an aquatic landscape, with blue geometric patterns and visual effects adapted to the site rules. The fish pool features geometric patterns, while the beach pool with charcoal grey or brown decoration and natural courtyard style looks harmonious. The purpose of the swimming pool goes beyond building water for recreation.

3.3. The cascade:

A fountain shaped like water, can wet the air, reduce dust and lower the temperature by discharging water through a nozzle sprayer. Its small drops can produce negative oxygen ions by colliding with air molecules, improving garden appearance and human health by reducing dust and temperature.

3.4. Spring and fall wall:

Wall springs and drop springs typically classified into three types, namely wall type, rock type, and plant type. It is interesting to note that statues of spitting water with various shapes such as fish, baby, dragon, animal, or human face with hookahs in their mouths were commonly placed in local courtyards. The drip water from the saliva into the wall fountains can be turned on and off, creating a ding-ding sound effect. Additionally, natural Rock Springs can be attached to walls, making them resistant to Yin dampness. Natural rock arches can also be attached to natural rocks, and stone plantings can be placed in the shade of moist herbs, creating a unique and serene environment.

3.5. Aquarium: Aquariums are containers for breeding aquatic animals and plants, divided into fresh and brackish water, tropical or low-temperature, depending on the conditions of their feeding. They are necessary for interior decoration and should be reinstalled when their position, size and style are more visible. Avoid direct sunlight in the local position of the aquarium, as this can hinder the growth and reproduction of fish and algae. Plant growth exhibits phototropism and direct sunlight can cause water inclination during growth and ornamental effects in shade.

4. Benefits Of indoor waterscaping:-

Provides psychological benefits of feeling healthy, more alert, reduced depression, increased social behaviour, more mental energy, better sleep), helps maintain internal microclimate, making it effectively cooler or warmer as required, reduces air temperature, helps in relaxation and increases concentration levels, causes relaxation, increases humidity, better interior design, releases ions minus.

5. Psychological impact on human being: -

Psychological impact refers to the influence of psychology on human thoughts, emotions, and behaviours, arising from various sources like stressful experiences, stressors, relationships, or personal achievements. Understanding this influence is crucial for promoting mental health and well-being, enabling the creation of effective interventions and support systems.

5. 1 Improve the appearance of the surroundings:-

Waterscape design is a captivating concept that combines moving water with still objects, expanding human senses and providing rich scenery and visual effects. This combination of water and standing elements with different forms and cultural meanings brings happiness and pleasure to people, making the landscape appear solid without water.

5.2 Modify the local ecological environment: -

Water plays a very important role in the ecological cycle system by absorbing solar radiation and acting as a temperature regulator. During the summer months, water evaporates, resulting in high humidity in the air above and next to it. At the same time, it absorbs pollutants, dust in the air, and emits beneficial anions for the human body. The water surface also absorbs

dust and contributes to the overall health of the ecosystem.

5.3 Change our mental emotions: - Water plays a very important role in the ecological cycle system by absorbing solar radiation and acting as a temperature regulator. During the summer months, water evaporates, resulting in high humidity in the air above and next to it. At the same time, it absorbs pollutants, dust in the air, and emits beneficial anions for the human body. The water surface also absorbs dust and contributes to the overall health of the ecosystem.

6. Waterscape design principles based on healing garden theory:-

6.1 the concept of function: -

Healing garden design aims to create a comfortable and tranquil environment for users to relax and rejuvenate. Residential waterscapes must respond to different demands by combining various elements such as play, observation, water texture and grandeur. These designs should be quiet yet lively, allowing users to adjust their mood and pressure. Combining different design styles, waterscapes can meet the needs of different people and provide a relaxing and invigorating experience.

6.2 The concept of security:-

The safety of waterscapes in indoor environments is crucial. Hydrophilic designs should consider age groups and physical health. For example, children should enter swimming pools or streams with a depth of 0.2 to 0.3 m, non-slip bottom materials and clean water. For swimming pools or lakes without access, safety measures such as railings and coverings should be introduce.

6.3 The Comfortable Principle:-

Waterscapes can be design to suit human size, slope, height and dimensions, ensuring comfort and market appeal. This includes hydrophilic environments, including walking, running, sitting, lying down, and touching water. Attention should paid to the elderly, children and people with disabilities, providing appropriate amenities to make them feel comfortable and happy.

6.4 The concept of ecological harmony: -

The healing garden design draws on the natural setting to enhance residents' physical recovery as well as visual, olfactory and tactile experiences. Residential water landscape design needs to be in harmony with the location and surrounding ecological environment, ensuring the water landscape is consistent with the structure's layout and function with the living environment. By arranging the water landscape properly, it can blend with the surrounding environment, creating an external space that intertwines and interacts with each other. Attention should be paid to the integration between humans and nature and functional adaptation.

7. Design and build residential waterscape guided by healing garden theory:

Healing garden theory enhances users' sensory experiences and expands the use of the landscape. Residential indoor water landscaping expected to enhance sensual excitement and the transition from one-dimensional visual experiences to multi-dimensional experiences, thereby improving the use value of the water area and transforming the landscape from a visual experience to a tactile experience.

7.1 Visualization:-

Vision is an important human sense, allowing humans to perceive visible shapes, colours, sizes, and spaces. A residential waterscape can display these features by incorporating aquatic plants and mountain rocks. Good design can enhance beauty, reduce fatigue, regulate mood and improve body functions, while reducing irritation and promoting overall health.

TABLE I. THE FUNCTION OF COLORS AND USING SUGGESTIONS

Color names	Meanings	Functions	Using suggestions
Green	Natural, grow, harmonious	Calm the mood, and relax the nerves	Suitable for all the landscape designs
Blue	Calm, slow, cool	Relieve the intensity of the muscle, relax the nerves, and lower the blood pressure	Suitable for the embellish spots in the landscape edge
Yellow	Vital, bright, warm	Excite the nerve system, and improve the brain function.	Suitable for the desolate and dark corners
Purple	Quiet, confidence, mystery	Relax the nerves and relieve the pains	Suitable for the special groups like Alzheimer's disease patients
Red	Enthusiasm, desire, bold	Stimulate the circulation of the blood, and revive the spirit	Suitable to embellish; not suitable for a large scale decoration
Orange	Optimism, likeness, relieve	Stimulate the circulation of the blood, improve the function of the digestive system, active the mind and excite the mood	Suitable to use with other colors

(Source: - Residential Waterscape Design Based on Traditional Healing Garden Theory Research Paper)

Harmonious colours can make people active, comfortable and cheerful, while disharmonious colours can make them depressed, passive and tired. Green, most suitable for the human optic nerve, is the bright colour of grass that gives people strong vitality and excites them. Colour coordination in landscapes involves contrasting, similar, and similar colours, as well as knowledge of hue, purity, brightness, temperature changes, and colour psychology. Table 1 illustrates the meanings and functions of different colours in the landscape and suggests their suggested uses.

7.2 Touch:-

Touch is a basic human sense that allows us to connect with objects, understanding their texture, material, hardness, volume and shape. It allows us to experience the world more deeply, convey emotions and have active healing functions. Residential waterscape design should reduce the barrier between people and the landscape by allowing people to touch and play in the water. The design should be close to the water and friendly, and aim to provide privacy and security. While the natural transitions and simple decorations at the water's edge may attract people to touch, the pleasant size of the stream is especially appealing to children. This approach can also attract people to spontaneous activities.

7.3 Hearing:-

Indoor waterscape design, based on the healing garden theory, can provide a comfortable environment and create a suitable acoustic environment for users to recover. Acoustic elements, including natural and handmade voices, are important in garden landscapes. Chord sounds, violin and piano sounds, and flute sounds can all have calming effects, such as lowering blood pressure in hypertensive patients. In residential

waterscapes, captivating sounds of gurgling water or soothing music can used to help users relax.

RESULTS/DISCUSSION:

a. Graphical View of Waterscapes: -

To create liveable places, designers must consider human needs and psychological effects. Dead sites are those that do not respond to users' wishes and preferences. Water, for example, is an attractive element because of its varied and continuous movements, which can impress, calm and entertain. Water is highly valued for its aesthetic value, emotional stimulation, social function and psychological benefits in urban areas. Its characteristics include calm, agitation, sameness, continuity, change and renewal, making it an attractive and equitable environment. It is therefore crucial to consider these factors when designing residential developments.

b. Everyday maintenance of interior Waterscape:-

1. Anti-leakage:-

Water leaks can cause significant losses and serious consequences due to their inability to penetrate the natural ground. Effective anti-leak measures are therefore crucial. In complex water networks near underground structures, the design of an artificial waterproofing layer can limit the harmful effects of water leaks. Two main methods are to prevent leaks with anti-leak films and to use waterproof coatings, depending on the specific circumstances.

2. To avoid floating and waterfalls:-

To prevent visitors from falling and drowning, indoor water should be shallow and general measures against falling water, such as handrails and guardrails, should be implemented.

3. The protection of revetment rocks:-

The rockery, consisting of safety rocks and solitary caves, serves as a solid base, with stone backfill to save investment capital, underwater and containing mud and rubble.

4. Shock absorbent: -

Aquatic lighting fixtures in indoor waterscapes can pose serious safety risks for visitors. However, the use of modern photoelectric separation technology, which utilizes optical fibres for lighting, is a safe and reliable solution that improves the aesthetic appeal while ensuring visitor safety.

5. Protect the water clean:-

Indoor landscape water is often contaminated with plants, animals and other nutrients, causing water pollution and deterioration of water quality. The decomposition of aquatic animal proteins in water creates a vicious cycle that causes the water to smell bad. The design of these water sources is not scientifically sound, causing dead water to deteriorate over time. Pollutants accumulate in the corners, becoming an artificial source of water pollution. Blue-green algae, which can spread rapidly and consume dissolved oxygen, is a major cause of landscape water degradation. Purification methods include water diversion, water filtration, chemical addition, and ecological restoration technology. These methods are aimed at solving the problem and protecting aquatic plants from the harmful effects of pollution.

CONCLUSION

Water is one of the design elements that improves the visual quality of the space. Vast bodies of water have a relaxing and calming effect on people. The use of architectural elements with water and the flow of water over these architectural elements creates a feeling of excitement and calm. An indoor waterscape can effectively improve the environment and promote people's health. Designing a waterscape that meets citizen demand from the user perspective requires active research by aquatic designers. We still need to discuss and research how to build an ecological, beautiful, convenient and healthy indoor waterscape based on the healing garden theory. However, recent observations show that the key to designing indoor water features is to offer sensory experiences to the user in terms of emotion, sound, touch, hearing, through different water feature ideas using different materials and techniques and special elements for added effect. Accessibility, daily maintenance and safety are two main factors that play an important role in designing indoor water features. Rather than the design of the indoor water feature being an aesthetic asset, it is more important to create opportunities for sensory experience.

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REVIVAL OF INDIGENOUS AHAR-PYNE SYSTEM FOR IRRIGATION AND RAINWATER HARVESTING IN BIHAR

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ABSTRACT

Background: Over the past few years, there has been a growing emphasis on local management of natural resources and public property, especially irrigation systems controlled by farmers. Indigenous irrigation systems have been studied for years to acquire management concepts. The discovery of iron and its widespread application sped up the development of these systems. On the other hand, speedier groundwater extraction technologies are gradually replacing more conventional ones, such as the "AharPyne" system.

Result: Neglecting basic maintenance has led to a continuous deterioration of the AharPyne system, a crucial source of irrigation for farmers. In South Bihar, the AharPyne system was more significant, irrigating roughly 35% of the 2.5 mha of arable land during the first two decades of the 1900s. Nevertheless, the region that receives irrigation from this native source has consistently decreased, with 20,000 structures still in use today.

Conclusion: The AharPyne system is beset with issues such as energy waste, higher farming costs, greater farmer insecurity, decreased rainfall, and concerning declines in the groundwater level. India can raise its population's standard of living and increase food grain output by tackling these problems.

KEYWORDS

Ahar-Pyne, irrigation, agriculture, water management, rainwater harvesting

INTRODUCTION

Local management of public land or natural resources has garnered increasing attention in recent years, and farmer-managed irrigation systems have been recognized for their potential. To acquire management principles, several indigenous irrigation systems are being investigated, as they offer excellent examples of farmland management. Behind the existing indigenous irrigation systems, there are thousands of years of our tradition. The development of irrigation systems received a great impetus after the discovery of iron and extensive use of it. However, these traditional water management systems are increasingly being replaced by other faster means of groundwater extraction systems, which are less labor intensive for the farmers in the shorter run. But, if the long-term sustainability of water as well as providing water at crunch times for irrigation has to be looked upon, the traditional systems do far better than the modern systems of irrigation (Koul, Singh, Neelam, & Shukla, 2012). There is maybe even greater relevance today for the traditional water collection technique that was in place in some Indian states decades ago. India is accustomed to natural disasters such as hurricanes, landslides, droughts, famines, and floods, therefore it would be wise to take a lesson from the age-old yet reliable knowledge of ancient water harvesting practices. To increase food grain output and raise living standards for Indians, both qualitative and quantitative irrigation is required in several agricultural sectors. The "AharPyne" system is one example of a traditional water gathering structure. It served as a significant irrigation source for farmers. An Ahar is a catchment basin embanked on three sides, the 'fourth' side being the natural gradient of the land itself. Ahar beds were also used to grow a rabi [winter] crop after draining out the excess water that remained after kharif [summer] cultivation (Patel, 2021). Pynes are artificial channels constructed to utilize river water in agricultural fields. Starting from the river, pines meander through fields to end up in an Ahar. Pynes are artificial channels constructed to divert river water for irrigation purposes. The AharPyne system has been extremely effective one pyne can irrigate up to 400 acres; cumulatively, these structures supported crop production in 0.53 million hectares (Koul, Singh, Neelam, & Shukla, 2012). However, due to a lack of proper maintenance, this traditional water harvesting structure- AharPyne has witnessed a steady decline and has degraded, resulting in unpredictable droughts and floods in the catchment area. The Ahar-Pyne system of irrigation was overwhelmingly more important in South Bihar, where it was irrigating about 35% of 2.5 mha of cropped land during the first two decades of the twentieth century. Compared to it, the irrigation in North Bihar was a mere 3% of the 3 mha cropped area(Pant, 1998). The area irrigated by this indigenous source has witnessed a constant decline. The extent of decline can be gauged by the fact from 0.94 mha in the 1930s in South Bihar, the area declined to 0.64 mha in 1971 and to 0.55 mha by 1975-76. As per the Government figures, the area irrigated by the Ahar-Pyne system in the whole of Bihar came down to about 0.53 mha constituting about 12% of all irrigated sources in. the year 1997 compared to about 18% in South and North Bihar alone during the first two decades of twentieth Century. (Koul, Singh, Neelam, & Shukla, 2012). Twenty thousand such structures exist. of which three thousand are defunct today (Singh S., 2020).

DESCRIPTION OF PROBLEM:

I) Bihar relies on deep tube wells for irrigation, with

63.1% of irrigated land serviced by tube wells (Singh S., 2020). This leads to the wastage of energy due to energy consumed in the process of irrigation of crops.

II) The usage of bore wells also indicates an increased cost of farming making the process reliant on farmers with financial resources.

III) The increased insecurity in farmers and threat to livelihood due to the high cost of farming.

IV) Reducing the amount of rainfall and on-time rainfall also hurts the farming sector. It is seen that even if the family goes for irrigation through a pump the benefit-cost ratio (BCR) reduces.

V) It is concerning to note that groundwater accounts for 75.9% of the ultimate irrigation potential in Bihar. The groundwater table decrease is at alarming rates due to this (Koul, Singh, Neelam, & Shukla, 2012).

VI) In 1949. a Flood Advisory Committee investigating continuous floods in Bihar's Gaya district concluded that "the fundamental reason for the recurrence of floods was the destruction of the old irrigational system in the district." (Sahoo, 2020).

Review of work already done:

a) Mahesh Kant and Sarita of the Institute of Research and Action (IRA), a Patna based NGO, revolutionized the villagers' life by reviving an age-old water harvesting system - Ahar and Pyne. They united the villagers from different castes, religions, and communities, in this Naxalite-dominated region and then imparted lessons on water conservation.

b) Project Jal Sanchay, a water conservation model adopted successfully by the authorities in Nalanda district of south-central Bihar, has been selected for the national Award for Excellence in the Mahatma Gandhi National Rural Employment Guarantee Programme (MGNREGP) by the Union Ministry of rural development. Under the project, more than 1,000 km of traditional Ahar Pyne irrigation system were dug up and traditional water bodies were de-silted and renovated, accompanied by campaigns to create awareness about rainwater harvesting. The outcome resulted in Community sensitization and participation in water harvesting (NITI Aayog, 2017).

c) Some villages in Bihar have taken up the initiative to rebuild and reuse the system. One such village is Dihra. it is a small village 28 km Southwest of Patna city. In 1995, some village youths realized that they could impound the waters of the Pachuhuan (a seasonal stream passing through the village that falls into the nearby river Punpun) and use its bed as a reservoir to meet the village's irrigation needs. Essentially, this meant creating an AharPyne system. After many doubts, the village powers that be gave the go-ahead. Money was collected and work began in May 1995. After a month of Ramadan (voluntary labor), the villagers completed their work in mid-June. Their efforts have borne fruit. By 2000 AD, the air was irrigating 80 ha of land (Singh, Dey, Jain, & Majumdar, 2020). The returns from the sale of what they produce are good and the village is no longer a poor one. It had a successful outcome; farms were able to produce good crops, with the community now able to grow two cereal crops and one crop of vegetables every year. (KouI, Singh, Neelam, & Shukla, 2012)

AIM / PURPOSE

I) Bihar is a densely populated state of India. Most people are directly dependent on agriculture. and sustain their life on agricultural products. This depends on the availability of natural resources like fertile soil type and natural harvesting systems to recharge our groundwater.

II) One of the key initiatives for the security of a livelihood may be the revival of this old irrigation infrastructure. Reviving this system and making sure it is properly maintained through community activity should be a key component of watershed initiatives in South Bihar, according to a report by the Ministry of Rural Development.

III) The unavailability of locally managed irrigation systems and dependence on paid infrastructure to support farming activities have made the small and marginal families highly vulnerable and they are not financially sound enough to overcome the issue which side effects in terms of migration, reducing cropping intensity, increasing crop production cost, reduction in cropping area and decrease in livestock due to unavailability of surface water has been noticed. The project could aid the farmers and strengthen their livelihood.

IV) In contrast to Bihar, where agricultural productivity and production grew much more slowly, agriculture in eastern India experienced a dramatic turnaround due to the rapid development of groundwater. The project could help with the agricultural production and livelihood security of the farmer

V) Small-scale irrigation and feeder system management, both privately and collectively, has worked well in places where the community has been able to organize and take the benefits. Although deep tube wells have seen significant private investment. A constraint is the inadequate quality of the electrical supply and the high price of diesel. In light of this, AharPyne—despite its current state of disrepair—qualifies as an inexpensive irrigation supply with a broad network.

The current Ahar-Pyne restoration attempts are not based on a knowledge of the variety of Ahar-Pyne designs or technical details such as keeping the Pyne's "slight meander" to avoid sand deposition.

VI) Additionally, the transition in the broader context of agriculture's commercialization and diversification has not been taken into account in the restoration efforts. The system, which was originally intended to be used with paddy, pulses, and oilseeds in Rabi, has undergone significant changes in comparison to the paddy-wheat combination currently in use (Satoh, 2020). The project

might go into great detail.

Relevance to State priorities:

a) JAL-JEEVAN-HARIYALI Mission (JJHM) has been established to kick off time-bound and mission mode accelerated implementation of 11 target interventions that involve identification and rejuvenation of all public conventional water storage structures, construction of check dams and other water harvesting structures in small rivers/drains and water storage in the hilly area, Creation of new water sources and taking/delivering of water from the surplus river area to water deficit areas, Construction of Rain Water Harvesting Structures in the buildings, Creation of nurseries and dense plantation of trees, Promoting the usage of Alternative Cropping, Drip Irrigation, Organic Farming and other new techniques along with the Promotion of the usage of solar energy and encouraging conservation of renewable energy. JAL JEEVAN-HARIYALI Mission offers a great opportunity for citizens of India to recommit and strive to our path towards a more sustainable future, as promised by its logo: Water, Life, and Greenery, only then will be Prosperity. For targeted and time-bound delivery and monitoring of specific outcomes.

b) Agriculture is the main source of Bihar and it is also the liability of the state to improve the irrigation system to grow sustainably.

c) The agricultural activity depends on the type of traditional irrigation system water and government policy.

d) If nature like Ahar- Pynes gate is identified and regerminated the burden of water scarcity for the farmer and government agency may be minimized.

e) The revival of Ahar-Pynes is directly linked to our agency production and helping in the water harvesting system.

FINDINGS/ ANALYSIS &INFERENCE

Strengths

i)Evidence of Ahar-Pynes in the Bihar region will increase agricultural production as it is aided by fertile soil.

ii)The system helps in the preservation of the groundwater table.

iii)Apart from irrigation, another useful purpose served by the Ahar-Pyne system is to minimize floods.

iv)The cost of Ahar-Pyne maintenance is quite low compared to canal maintenance which comes to about Rs. 5000 per ha. In the case of Ahar-Pyne, it varies between Rs. 500 to Rs. 1000/ ha, depending on the extent to which games are utilized (Koul, Singh, Neelam, & Shukla, 2012).

v)Quality of construction is quite good because those who get engaged in the repairs are themselves the beneficiaries. Further, in some of the repairs the material used is the one which is locally and easily available.

vi)if the indigenous system of Ahar-Pyne is properly integrated with the recent canal irrigation schemes, the efficiency of both irrigation systems will enhance manifold.

vii)It mainly involves the mobilization of local material and manpower resources with very little financial requirement. This is especially important at present times when the financial crunch surrounds most states from all sides.

viii) It can also converge beneficiaries/manpower from MGNREGA.

Weaknesses

i) Huge land acquisition is required.

ii) Insufficient administrative and technical personnel to carry out the plan.

iii) Inadequate knowledge and evaluation of Ahar-Pynes.

iv) Farmers were unaware of the resurgence of Ahar-Pynes.

CONCLUSION

The problems faced by the Ahar Pyne system include energy wastage, increased costs of farming, increased insecurity for farmers, reduced rainfall, and alarming groundwater table decreases. By addressing these issues, Both the food grain output and the standard of living in India can be increased.

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MUMBAI GROUNDWATER: A FORGOTTEN LAYER OF THE CITY

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ABSTRACT

Mumbai once utilized springs and shallow wells as its principal water resources, but with rapid urbanization, these sources became contaminated and water reached individual homes, the city started depending on municipal supplied piped waters. Wells, after losing its importance due to changing lifestyle, increasing density, space crunch, etc were buried by subsequent construction or covered intentionally for health and safety reasons. This resulted in depletion of the groundwater table, contamination, rise in salinity, Spring flow dying, etc making groundwater unfit for habitable use in most of the cases. and the interrelationship between the current state of wells and the pattern of urbanization in Mumbai is studied. The same has been studied and analyzed using Research methodology – Qualitative research based on combination interviews, case studies, and focus groups. However, the shallow hydrogeological system still operates under the city's concrete jungle of roads, parking lots, parks, and buildings. This buried geology and hydrology should be considered in the city's development plan, building guidelines, and regulations. Thus, it lays the foundation for the new era of self-sufficiency in water management and integration of these urban springs with development regulation and reestablishes the lost connections with these networks. This paper focuses on the urban groundwater network in Mumbai, as an alternative water source during emergencies and secondary purposes. Thus resulting in underutilized underneath the hidden layer shows its importance in ecological systems needs to be aligned with the population distribution and integral part of the development plan for the city.

KEYWORDS

Groundwater recharge, environmental policy, water management urban element.

INTRODUCTION

With the rapid rate of urbanization and shifting urban accumulation across the globe with the current growth, it is expected that by 2050 more than 50% of the population will be residing in urban areas. (United Nations, 2014) To cater to the increasing demand of urbanized areas, land use patterns, infrastructure development, and access to basic services such as clean drinking water, sanitation, etc. While the cities and regions undergo different stages of economic growth it faces different kinds of environmental problems which are dynamic and evolve along with the development of the city. (John M. Sharp, 2013). Many researchers have argued that there is a considerable adverse impact on the urban ecology especially on the surface and underground water. With the increase in urban sprawl, there is contamination of endogenous water resources and more dependency on exogenous water resources, which leads to high pressure on existing public infrastructure for water supply and demands for more public infrastructure (Souza, 2020). In the process of Urbanization, there was a huge dependency on the surface underground water, as it acts as an invisible link in the urbanization process. Underground water networks have been completely ignored by the inhabitants and governing authorities. Various research has established a relationship between urbanization and declining groundwater quality and disturbing water balance (Tandon, 2016 -18)(Hasse, 2009) There are also close socio-cultural relationships between typology or urban settlements and transformation in groundwater extraction.

In Mumbai, development disregards the underground pattern of groundwater in the process of urbanization and has been undervalued by the state authorities (John M. Sharp, 2013). There is a huge gap in understanding urban form, groundwater use, urban aquifers, their characteristics, the significance of their service value, and a comprehensive understanding of competition and conflicts associated with them. (Shah & Kulkarni, 2015).

Considering the growing need for services and utilities like water resources, groundwater is completely underutilized and unacknowledged in Mumbai both in policy and in practice. This belief is further reinstated by the argument from the Central Ground Water Board which acknowledges the fact that there is not sufficient data available about the types and extent of aquifers in the city (Gupta, 2010). Considering the current state of underground water networks, it's high time that urban planners and governing authorities realize and understand the dependence and role of groundwater in the city of Mumbai.

To meet the desired aim of the research we aim to explore the following answers.

(i) Current State of wells in urban areas
(ii) Pattern of consumption of Groundwater

AIM / PURPOSE:

Urbanization is a conclusive global phenomenon that demands innovative solutions to cater to the increasing demand of the growing population. Water

management has been always a critical issue in cities and has created immense pressure on the existing infrastructure to meet the increasing demand for portable water supply. As more people gravitate towards urban areas, it's high time that we should have alternative sources of water in place. Mumbai Metropolitan Region MMR is geographically blessed with water ecology through Underground aquifers and water networks. Ancient communities like every other place have evolved around water springs be it Shallow Wells, Bore wells, or Lakes. For thousands of years, communities grew around springs based on socio-economic patterns. Depending upon geological structure, some have individual wells, few have grouped and owned a well and there are large community wells. This research paper aims to study the interrelationship between springs and the urbanization process. Wells in its current context has lost its importance as some has been buried, closed, contaminated, etc

This research paper embarks on a journey to scrutinize the pattern of evolution of wells, taking a fresh perspective on reuse and re-establish the lost connections with wells and explores the relevance of this concept within the urban landscape and development regulation.

RESEARCH METHODOLOGY

The methodology used is the combination of Qualitative research with case studies and focus groups used to research a specific phenomenon of urbanization and the exclusion of wells from regulation.

Focus groups survey involves asking questions and discussions among a group of people such as the local community, housing complex, commercial buildings, goathons, etc to generate conclusions from the same.

Qualitative research methodologies are used to examine individuals' behaviors, opinions, and experiences through methods of examination, surveys, documentation of settings and neighborhoods, etc.

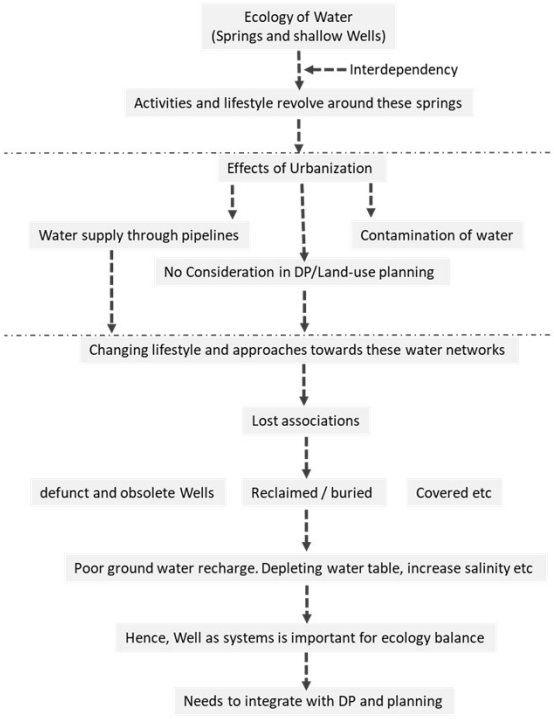
LITERATURE REVIEW

(Souza, 2020) studies the context of groundwater vulnerability in an urban context to investigate research to identify urban-area springs to generate an Index of Environmental Impact of Springs (IIAN). The project Ribeirao do Lajeado watershed, in Sorocaba, Brazil; is an urban area with springs and is classified according to type, physical characteristics, and vegetation surrounding the spring to support the evaluation of spring conservation. The Macroscopic diagnosis at each spring location was conducted to analyze the samples, to highlight that all spring sites are impacted negatively by urbanization—with the quantity of garbage, protection of the spring area and proximity to urban structures highlighted as key issues. (Tandon, 2016 -18) carried out a study to assess the patterns of consumption and quantification of groundwater extraction in urban settlements in M-ward, Mumbai. His findings witnessed that there is reduced dependency on shallow aquifers for consumptive purposes, and the dependency on groundwater networks has shifted to borewells and piped water systems from dug wells.

The piped water provided by the local authority which can be attributed to various factors such as the suitability of groundwater, deterioration of water quality, accessibility, and encroachment. It also states that due to a Lack of information and guidelines from authorities on bore wells and groundwater extraction states that there is a lack of acknowledgment of groundwater during the planning of a large, centralized water infrastructure.

(Parimala renganayaki, 05 July 2013) has carried out a study to assess the suitability of groundwater and to understand the impact of water stored in a check dam on groundwater quality near Chennai, Tamil Nadu, India. The Bureau of Indian Standards and the World Health Organizations provides guidelines on ways to assess groundwater suitability for drinking. The suitability of water for irrigation was determined based on the EC, SAR, US Salinity Laboratory diagram, percentage sodium, Wilcox's diagram, Kelly's index, and Doneen's permeability index. The study confirms that the check dam in this area improves the groundwater quality in its surroundings.

Conceptual Framework: The conceptual framework for this paper revolves around the mapping of the current state of Shallow wells and its relationship with the community. We consider the present state of wells, the changing surrounding context, influence of urbanization on it. Additionally, we explore the challenges and opportunities associated with reusing these urban springs in Mumbai and advocate for a more holistic perspective that views them as ecosystems for urban development.



CASE STUDIES

One of the largest and densified cities in the world, Mumbai has dynamic evolution and has witnessed various stages of development to support its incrementally growing population over the years. To understand the process of urban evolution it is imperative to start around the springs.

Mumbai receives water through its centralized system taking water from reservoirs and supplying it to the households. There are various large and small water reservoirs which are in surrounding districts on major rivers in the western ghats. These rivers are Ulhas, Vitarna, Patalganga and Amba.The groundwater is not suitable for drinking purposes, and to mitigate the risk of the epidemic, Brihanmumbai Municipal Corporation (BMC) and the Government of Maharashtra (GoM) have banned the use of water from wells and ponds for domestic use. The report also mentions that since the water demand is very high and there is a mismatch between the supply and demand of water, groundwater is used as a supplementary source for all purposes except domestic purposes in certain urban villages.

Looking into the existing groundwater infrastructure in Mumbai it is observed that historically there has been usage of groundwater. The remains of large dug wells in the habitat indicate that the communities were dependent on these dug wells for their primary water supply. GSI conducted survey that mentions about presence of dug wells and bore wells in various parts of Mumbai.

Patterns of utilization of wells are studied in the following parameters.

a.Ownership
b.Depth and Discharge of Water
c.Usage pattern
d.Modification
e.Quality

Thane is the city with lots of wells. In ancient times Springs were considered as a lifeline for the settlement of the community, but today lies a dead hole in Mumbai. The mapping of wells in the thana and mumbai suburbs are done. The Chendani Koliwada documentation of wells has help in understanding how the city must have evolved. The mapping of wells is categorized according to its size, location, number of people or houses it catering etc

Fig 1 showing Individual Well condition

Individual Well owner Chendani Koliwada(East)

Most of the Chendani Koliwada at Thane East are most of individual Well owners. Sometimes a well caters to one or two houses. It has observed that these wells are usually have shorter diameter openings, and in most of the cases openings are altered due to space crunch. The water of these wells is used for the secondary and tertiary purposes.

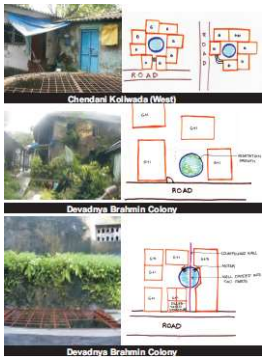


Fig 2 – showing Small Group well owner

Small Group Owner : Most of the Chendani Koliwada at Thane East, Wells catering to smaller household groups are of 3 - 6 houses. Every small group of houses had their wells. Some of these wells are yet active and are used for secondary and tertiary use of water.

Public Wells : Most of the Chendani Koliwada at Thane East, Wells used to cater to big household groups of 12-20 houses. These wells usually have larger diameter openings. These spaces have good potential to be community or interaction spaces.

Fig 3 – showing state of Public Wells

Physical Alteration of wells: Over the years the physical form of the wells has been modified and alternated according to the need and change in context. All possible dimensions have been explored to use It and its surroundings in the best possible way.

Fig 4 showing condition of wells in goathans

Building level: Context around wells has been changed but many a times the physical form still exists. Many alterations has been done to its form, some are also used as storage but many are lying in bad condition with vegetation growth and garbage dumps. Some well water is used for flushing purposes.

Fig 5 showing condition of groundwater in cow sheds

The wells which cater to the cowshed are still very active. water from these wells is used for drinking and washing cattle. Many well's physical forms have been altered and some are lying in bad condition with vegetation growth and garbage dumps.

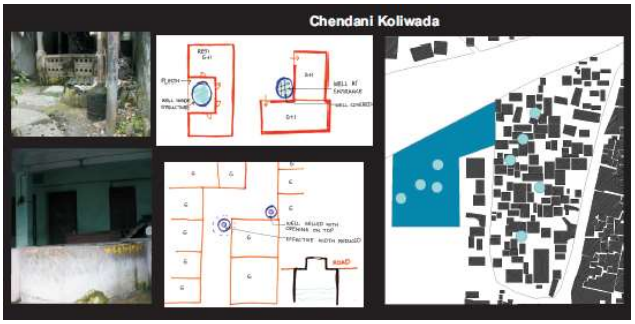


Fig 6 showing alteration of wells

Evolution Pattern: The community settlement must have evolved near the creek and their major occupation was fishing and farming. Based on their financial capacity, some houses have individual well's still exist while others have been buried. Some are used as secondary sources of water.

Economy: This settlement must be a high-income group as many wells are catering to individual houses.

Social: Wells that serve the community acts as a platform to interact and social space. Many of them are now modified by covering them with grill mesh, pumps connected to individual houses, etc to taping system.

Present Condition: At present water from wells is only used during the time of crisis and for tertiary use. Water has been polluted with garbage dumping. It is also used as storage. Many well's physical form have been altered to use the maximum space.

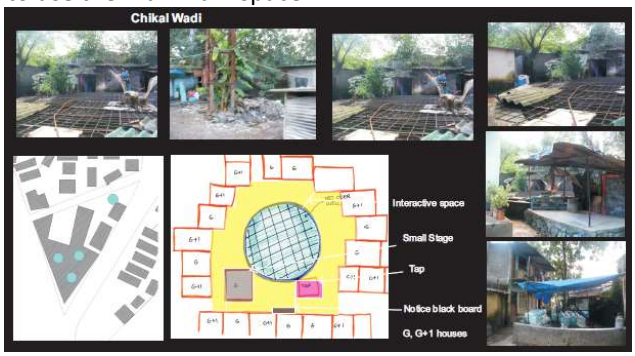


Fig 7 showing condition of community wells

Evolution Pattern: The settlement must have come with and around the well. 4 Wells used to cater to the entire chikal-wadi. some parts of this settlement along with wells have been washed away with the arrival of the Eastern Express Highway.

Economy: This settlement must not be for high-income groups as there are no individual wells. many public wells cater to groups of 6-20 houses.

Social: Wells acts as a good social and interaction space. As these spaces are more interactive, stages, public notice boards, etc have come up around the well.

Present Condition: Well water is only used during the time of crisis and for tertiary use. Also, well water has got polluted with garbage dumping. It is also used as storage.

Fig 8 showing condition of wells in goathans

In the context, chikal wadi where the well is 12m Dia, located at the heart of many houses, by providing functions like a washing platform, perforated paved blocks, providing more interaction spaces, etc will

encourage people to use more well water. Also, the above space has the potential to be a good public square for the localists.

Reusing the existing wells, and buried wells, and proposing new wells can make that district or Goathon self-sufficient in terms of water supply. These districts together as a whole will make the entire city self-sufficient and independent.

To encourage people to use more well water certain competitions (on self-sufficient water) or less consumption of TMC water etc could be arranged. To Encourage more and more people to use well water, certain incentive should be given in the bill of TMC water. Also, sustainable competitions in the neighborhood should be arranged. Also, the sustainable rating and star system should be followed. Also, new guidelines for new upcoming buildings of water sustainability should be followed.

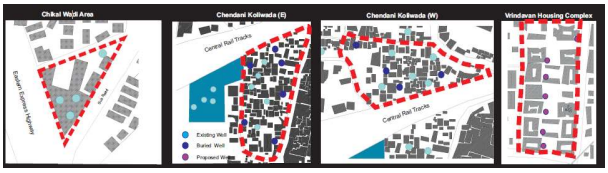


Fig 9 showing evolution of housing along wells

Rainwater harvesting can be done by different techniques is possible in different parts of the city. The city is occupied by basaltic lava flows, alluvium, marshy swamps, and mud plains. The rainwater could be collected in the tank, cleaned, and then could be used for flushing propose. This Practice could be applied to all buildings, and complexes such as Saket, etc. which could conserve water.

Impacts of enclosing wells: An SUV fell into a 43-bottom-deep well in Ghatkopar on Sunday morning, The spot where the Car had been parked was once the mouth of the 200 year old well that was recently covered. Due to unexpected heavy rainfall over many days and, presumably,

the weight of the vehicle, the concrete portion caved in. (Times of India 4 aug 2021). Shallow Wells has always been an integral part of the ecological system. It keeps the groundwater recharging. So, the wells should be kept active. Considering the rapid urbanization and present context, the wells could be reused by following the guidelines:

Fig 10 showing impact of buried wells

Fig 11 showing revamp of existing community wells

Bhandari family owned the well is in the oldest part of the koliwada; stands as an important landmark in the tehsildar's residence. Wells has always been an integral part of the Koli culture. This well is in the backyard of the Bhandari family's residence and was once the only source of water for the Bhandari chawl and its tenants. Well water is used for washing and the locals worship the well water regularly. Place-making intervention to turn the Bhandari well into a community space where people can come, sit, interact, and not just pass by (mid-day 31 July 2021).

Well as an Urban element:

The physical form of the Wells could be an urban element if restored and reused. Many of these systems spread across the city are conserved. Wells in between roads have been conserved as traffic islands, whereas some as in landscape elements etc. A 200-year-old well located in I.C. colony, Borivali, Mumbai has been revived, restored, and beautified in 2017. This well has not only helped in recharging groundwater but is also used as a secondary source of water.

FINDINGS/ ANALYSIS &INFERENCE

CONCLUSION

From the findings it was observed that there is reduced dependency on shallow aquifers i.e groundwater for consumptive purposes, groundwater

Fig 12 showing revamp of existing community wells

dependency has shifted from dug wells to municipal piped water supply schemes at every household. The increase in population and the need for the availability of round-the-year reliable potable quality led to the shift from groundwater use to reservoir-sourced surface water supply. With the availability of piped water supply the need to use groundwater through dug wells reduced drastically. The deteriorating quality of groundwater in the city has been a key determinant in reduced dependence on dug wells over time. Improper disposal of sewerage or inappropriate construction of sanitation systems like pit latrines, etc. The inability of the wells to meet the needs in a developing metropolis with lifestyles demanding more water poses huge demands for public water supply. Thus, negligence and dependence go together with the current state of natural resources like groundwater. The gap between supply and demand has been constantly increasing.

This research tried to investigate the gap between the planning process and the practice at the micro-scale. The research and surveys conducted to understand various patterns of groundwater usage exposed us to some interesting insights that are crucial for water resource management. Mitigation of Nonconsumptive usage of water through secondary sources: According to the research most of the residential society are using groundwater from bore wells for nonconsumptive purposes. There is also a need to revive and have an appropriate recharging mechanism for these shallow wells to ensure better quality water for nonconsumptive water usage. Regulatory bodies have never given importance to integrating groundwater systems with bylaws and building regulations. Building bylaws and development plans needs to guide development towards utilization of groundwater, its recharging mechanics, conservation of wells, and recharging ground aquifers. Considering its importance to the systems and mankind building bylaws needs to incorporate and integrate these hidden underground layers.

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FROM WELLS TO PUBLIC REALM: TRACING SOCIO-CULTURAL AND TIMELESS ARCHITECTURAL HERITAGE OF WATER BODIES OF JODHPUR

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ABSTRACT

Step-wells were the life support for the people in deserts and reflected community ownership and responsibility (Brahi, 2013). However, the introduction of piped water and bore wells led to the disuse and disrepair of this unique architecture. it is popular for its water engineering and architectural perfection, which also posed as a space of social and cultural significance as they provided a cool and pleasant atmosphere for the community interaction, especially for women and were also used as places of worship (Krishna, 2014). Water is an important aspect of life which binds the living being to the nature. Jodhpur also called blue city is famous for its intricate water bodies with a network of talabs, tanks, wells and stepwells which adorns the beauty of this place is basked in the limelight of historical heritage opulence, cultural dynamism is a tourism hotspot. . Throughout the history these water bodies have played a significant role within the day to day and socio-cultural activities which is engrossed within the rich heritage of the city. The marvellous architecture of the stepwells are representation of beautiful design fulfilling the need of people, but due to urbanisation and piped supply these bodies are in a state of neglect resulting in a decay of these once vibrant spaces of social interaction and loss of heritage and identity of Jodhpur. The research paper aims to identify and map the different types of water bodies understanding the historical heritage and interface along these water bodies within jodhpur. Through analysing the present condition of water bodies and understanding the reason of negligence of these water bodies the paper tries to provide an overview on revitalizing them as a place for social interaction and vibrancy to preserve the heritage and identity of the city

KEYWORDS

Heritage, revival, stepwells, socio-cultural spaces, water network, place centric.

INTRODUCTION

The city of Jodhpur nestled in the arid region of the Thar desert is a magnificent place of urban tapestry and rich cultural and historical heritage. The relevance of architecture and its history has been felt throughout history through its representation of society, its values, successes, and eventual downfall of its civilizations over time. At its roots, architecture is more than just the built environment, it is a part of our culture, and it epitomizes the values, beliefs, traditions, and aspirations of a specific community.

(Emmons, et al., 2012) The name Blue City was given as the Brahmins living in the Brahmpuri area used to paint their houses blue to devote themselves to the lord Shiva and also represent their higher social status. Amidst the scorching heat and dry temperatures, the city remains resilient due to an intricate system of water bodies in the heart of the city. These water bodies remain part of the day-to-day life of the residents and act as celebratory spaces embedded in rich cultural and heritage history. The water bodies in the walled city are constant in the ever-changing urban form within the continuously evolving old core, transforming from a place of residence to a place of tourism. The semblance of architecture in stepwells is the most exclusive structure since early Indian history. (Amirthalingam, 2015) The research paper endeavours to unfurl the pages of Jodhpur's hydrological history meticulously navigating through the city's stepwells, reservoirs and age-old water management system. Scale, shape, form, and usefulness were the primary design characteristics observed in the stepwells. The majority of stepwells in India, ranging in size from little to enormous constructions, contain remarkable architectural details and distinct utilitarian qualities.

The stepwells' features and construction were entirely determined by the ruler's commission and the location's suitability in terms of geography and topography. (Chandra, 2015) Stepwell designs were not representative of any one national architectural style. Despite being built as water sources and reservoirs, they are also examples of architectural achievement and cultural features that have persisted throughout history. (Jain- Neubauer, 1981) While some of these heritage water bodies are being utilized and preserved with conscious efforts many of them are still deteriorating due to negligence and also lack of connectivity is not helping the situation. Such an example is Toor Ji ka Jhalara a squared step well that is still an active place where its function changed from being a water source for daily needs to now being a recreational space surrounded by commerce with restaurants and hotels providing a great view to the traditional stepwell.

This transition from being a place of necessity to now a recreational space within the commercial and tourism circuit helps such a place to survive whereas another stepwell called Mahila bagh ka jhalara is now in a position of decay as the area around it is not developed in the same manner. This is one of many comparative examples to understand how external

factors can have a dramatic impact on a space of the public realm in which both spaces were once serving a similar purpose but had a drastic change in outcomes. Through interdisciplinary approaches, we embark on the journey to understand the cultural historical and environmental tapestry that Jodhpur's water heritage and the present scenario of these marvellous pieces of architecture and engineering.

RESEARCH METHODOLOGY:

BACKGROUND

The historic evolution of water bodies is intertwined with the city being built by Rao Jodha, a Rajput warrior of the Mewar region in 1459 on a sterile land covered with high sand hills (Britanica, 2023). Water has been an important component for a city to grow and develop. Jodhpur receiving minimal rainfall water conservation becomes a necessity. To tackle the water shortage various rulers built different water bodies over their time of rule. These water bodies have quenched the thirst of thousands of people over the years and a prominent part of the history and culture of jodhpur embedding into the cityscape.Various systems of water bodies served differentpurposes from lakes to wells and stepwells each of these water bodies followed a system of network and served different purposes. The Balsamand lake is the oldest lake in the city and one of the most beautiful lake built by Balak Rao Parihar in 1159 AD which was later adorned by Balsamand palace built by Mahraj Sur Singh for his entertainment time close the lake. The city was originally built as a walled city for the defence purpose when the king shifted from Mandore to jodhpur and built Meharangarh fort on a higher elevation.

METHODOLOGY

A mixed-method research design, combining both qualitative and quantitative research approaches, is utilized for the comprehensive investigation of site reading and research. This involves understanding the physical, social, and political forces that have played a pivotal role in shaping the watershed. The research delves into the manipulated topography and hydrology of the region, examining the intricate
relationship between urban development and the transformation of waterscapes, particularly focusing on stepwells. The study encompasses the evolving usage, associations, and diverse land uses within the watershed area. It scrutinizes the physical, social, and political factors contributing to the formation of community identity and explores the significant role of stepwells in defining place and behaviours within the community.

Furthermore, the research investigates how landscapes, including enigmatic places, contribute to supporting play and imagination in the community. This mixed-method approach ensures a comprehensive exploration of both qualitative nuances and quantitative data, providing a holistic understanding of the complex interplay of factors shaping the watershed area.

Preliminary Mapping Investigations: The primary focus of the research lies in the comprehensive and directed preliminary mapping investigations. These investigations are intended to be refined and aimed at informing about the transformation brought about by the information derived from the analysis of documented responses. The research is conceived as a holistic and circular, iterative process. It encompasses a continuous cycle of research inquiry in a region abundant with traditions, water harvesting customs, rituals, and practices. These aspects are inherently agrarian, shaped by the geography that sculpts the land and the wisdom of the residents who not only shape but also survive within this environment.

Transforming Responses: The responses obtained from this rich cultural tapestry serve as both the foundation and the catalyst or transformation. The research celebrates and acknowledges the symbiotic relationship between the cultural landscape and the iterative process of analysis. It is through these responses that the cultural landscape is not only informed but actively transformed.

WATER NETWORK OF JODHPUR

The water bodies seemingly isolated is intricately woven in the tapestry of the city with a network is found dotting the landscape into a system through sub terrain and surface movement (Arya, n.d.). There are water structures which are independent as well as one which are systematically connected to a network. One physical link between the different scale of water ranging from reservoirs to jahlras and the well is through the subterranean and surface water movement. Other connection is the network of water bodies and their relationship of people with the environment and their immediacy to the society.

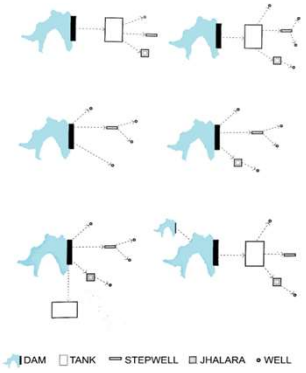

Figure 1 Network of water bodies, Source Spatial ecology of water

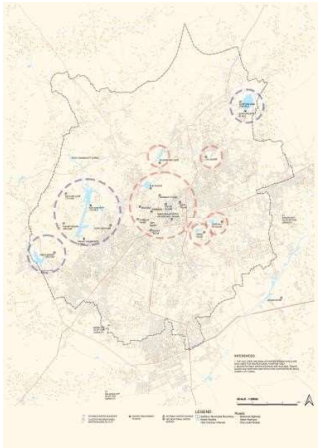

Figure 2 Water Bodies in jodhpur (Source: Author)

WATER BODIES OF JODHPUR AND THE SOCIO CULTURAL INTERFACE AND EVOLUTION IN URBANSCAPE

To understand the socio cultural aspects of the wells and other water bodies it is necessary to have a knowledge about the various types of water bodies which are present in the city and how the network these water bodies are placed within the urban tapestry of the city. The water bodies can be classified in to broader categories of Lakes and Reservoirs, tanks, stepwell and traditional wells which serve different purposes to different class of society.

Lake and Reservoirs:

The Bal Samand lake being the oldest manmade lake in Mandore near the outskirts of jodhpur. The Bal Samand Lake Palace is a private Hotel owned by the king adjoins the lake thus making the lake private to the residents of the Palace. The lakeside accessible to local people is occupied by quarrying sites thus making it more private.

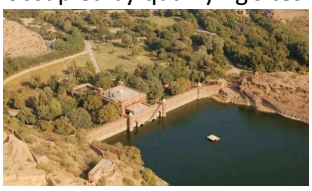

Figure 3 Bal Samand Lake

The Kaylana lake is the biggest lake of jodhpur which is used to fulfil the present water demands of the city. It is also an artificial lake which is outside the city and an attraction point for nature lovers.

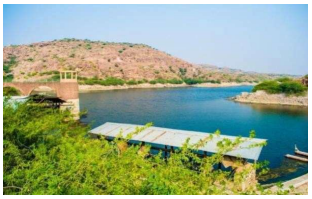

Figure 4 Kaylana Lake

The Takhat Sagar Lake named after Raja Takhat Sagar is south of Kaylana Lake. It is famous for its fantastic view and Shri Siddhnath Shiv Temple making it a destination for local people to follow their ritual and traditions. The Ranisar and Padamsar lakes near Mehrangarh Fort are still utilised, although their role has changed from a place of daily usage to more recreational and leisure activity. The Ranisar lake was made on the order of queen Jasmade Hadi, spouse of the founder of Jodhpur Rao Jodha. The Padamsar lake was created by the order of queen Padmini, daughter of Rana Sanga from Mewar. These two lakes are the perfect instance of water upkeep in historical instances. (Rajwadacab, 2022) The Ranisar has one of the most complex embankments seen in the reservoirs of Jodhpur with a series of criss-crossing steps leading to the water. The embankment was fortified, has multiple levels and a large entrance gateway; it was made for the use of the palace.

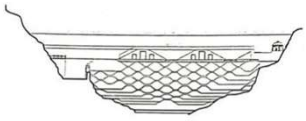

Figure 5 Section of Ranisar Lake

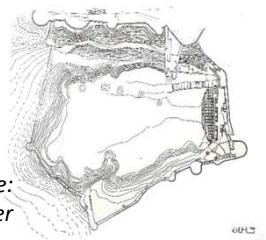

Figure 6 Ranisar Lake, Source: Spatial ecology of water

Figure 7 Ranisar Lake

Figure 8 Ranisar Lake

Tanks and Ponds:

Gulab Sagar is a tank near the sardar market which was constructed by Gulab Rai. The purpose of tanks was to transport water. With the shift of piped water these water bodies are being ignored and deteriorating due to negligence of locals and administration. The interface is a major influential factor for the condition as the surrounding environment is not interacting with the water body. The open spaces are used as parking spaces and nearby buildings are neglecting the edge of the water body.

Figure 9 Gulab Sagar

Fateh Sagar was constructed in 1778 by Maharaja Vijay Singh. There is a renowned Ramanuj Kot temple made in 1866, that belongs to the Ramanuj Cult of Vaishnavas. The fateh sagar lake is also suffering the similar fate as gulab sagar as the surrounding buildings are also neglecting the water body. Garbage and waste disposal by nearby residential building has destroyed the serene beauty of the tank. The open space are present but due the overall deterioration of the image of the lake the lakefront is inactive throughout the day.

Figure 10 Fateh Sagar

Wells and Stepwells: (Beras, Bawdi and Jhalaras) Bawdies and Jhalaras were traditional stepwells which were used for day to day activities and located near a temple thus becoming places of community interaction. The bawdies functioned as a source of drinking water and Jhalaras were built for public function such as bathing and washing clothes. Jaita Bera Between Fateh Pol and Kotawali is Jaita Bera (well). Mutha Jeta built it during the reign of Rao Jodha Ji. Rajkiya bera (Royal Well) is another name for Jaita bera. This well's water has long been thought to have medicinal powers. As a result, water collection from here was directly supervised by Mehrangarh Fort via its kiledar (fort's head guard) or kotwal (district police officer). With the approval of the kiledar, every anyone who sought to utilise the water for any medicinal or religious reason was given the necessary amount of water. With the necessity of this water in mind, a soldier was always on duty to guard water collecting.

Chand Bawdi constructed by Rao Jodha ji's queen Chand Kanwar is a small constructed during the time of construction of fort and used to have a temple on

Figure 11 Jaita Bera

the plinth. Over the time the usage of bawdis are no existent and these once historic and architectural feats are becoming neglected structures in the urbanscape.

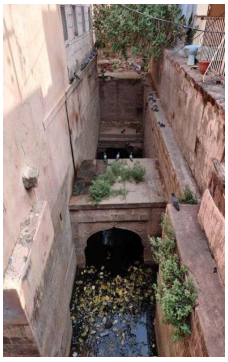

Figure 12 Chand Bawdi

Toor ji ka Jhalara is one of the major attraction and the features a symmetrical series of steps leading down to the water level. The exquisite carvings, intricate lattice work, and ornate balconies surrounding the well create a stunning visual spectacle.

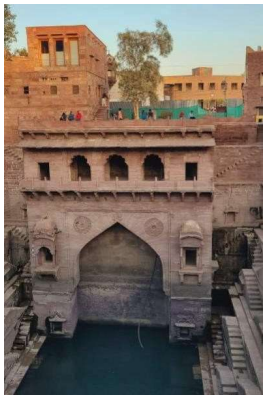

Figure 13 Toor ji ka Jhalara

Mahila Baug ka Jhalara is also a stepwell which is located near the Gulab Sagar lake is also an architectural marvel but the built environment neglected its importance and the stepwell once an importance feature has become and ubran void. Garbage disposal of the adjacent buildings has completely destroyed the image of the stepwell. Restoration of the edge and activating the water body can still provide a hope for preservation of mahila baug ka jhalara.

Figure 14 Mahila Baug ka Jhalara

Stepwell as a celebratory Place

Toor ji ka jhalara is one of the most celebrated spaces within the city the architectural features of the symmetrical steps, ornate carving, niches and balconies and lattice work it poses as an important site for the tourists as well as local people in the dense fabric of the city. Beyond its utilitarian purpose, Toorji ka Jhalra has been a cultural hub for centuries. It served as a gathering place for the local community and witnessed various social and cultural events. The vibrant atmosphere surrounding the step well has made it a favourite spot for both locals and visitors. The step well has also become a focal point for community engagement and local events. Cultural festivals, art exhibitions, and heritage initiatives often find a backdrop in the vicinity of Toorji ka Jhalra, fostering a sense of pride and ownership among the local residents. The development of restaurants, cafes and hotels has helped in preserving the jhalara and a major factor for urban placemaking.

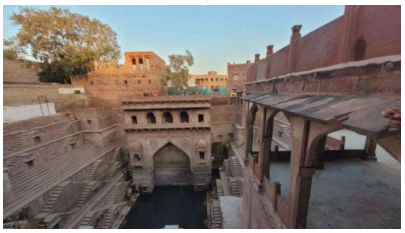

Figure 15 Toor ji ka jhalara

The place has been serving as a space for various activities throughout the history acting as a social and community gathering place where locals and visitors are frequently meeting for casual interactions. The steps of the stepwell provide a comfortable and picturesque setting for meeting place. The place also acts as a venue for photoshoots and cultural events where local artists, musicians and playback singers perform to entertain the locals and tourist and showcase their talent with this historic stepwell as a backdrop.

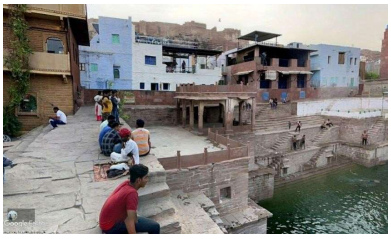

Figure 16 The stepwell as space for social interaction

Due to its cultural significance, Toorji ka Jhalara becomes a focal point for religious and ceremonial activities. Local festivals,religious rituals, and community celebrations may take place here, fostering a sense of shared identity. The serene environment, combined with the architectural beauty, offers a peaceful space for leisure activities and relaxation. The open design of Toorji ka Jhalara encourages spontaneous interactions among people. Whether for a leisurely stroll, a quiet moment of reflection, or a shared conversation, the stepwell fosters connectivity within the community.

Figure 17 Cafes nearby the stepwell

The presence of Hotels and restaurants and cafes has activated the place as space for leisure and recreation and provided a new image to the stepwell. The presence of Hotels and restaurants and cafes has activated the place as space for leisure and recreation and provided a new image to the stepwell. This showcase how the usage of stepwell has been changed from a water source but the essence of community and social and gathering space has been carried forward with the development by the surrounding built environment. Families and individuals often visit Toorji ka Jhalara for recreational purposes, with the nearby restaurants providing space for patrons to enjoy refreshments while appreciating the scenic views of the stepwell.

CONCLUSION

In tracing the water bodies of Jodhpur the research paper unravels that the urban interface is an important aspect for conservation and revival of a water body. The path from wells to public space reflects not only the city's historical adaptation to its arid climate, but also the community's continuing spirit. Water, in all its forms, has moulded the social fabric of Jodhpur, as we toured the architectural marvels of Toorji ka Jhalara, the tranquil beauty of Kaylana Lake, and the bustling places surrounding these water features. These bodies of water have socio-cultural importance that goes beyond their practical functions. They have witnessed hundreds of years of cultural events, communal gatherings, and shared periods of introspection. As indicated by their adaptability as community hubs, these venues' significance as cultural nodes remain critical in promoting a sense of belonging and shared heritage. The architectural tradition of Jodhpur's water constructions is shown in the elaborate carvings, symmetrical forms, and antique pavilions. The combination of form and function in step wells like Toorji ka Jhalara reflects the inventiveness of the city's forefathers who turned functional constructions into pieces of art. Jodhpur filled with water bodies which once quenched the thirst of local people has neglecting its rich water heritage as many wells, stepwells and other water bodies are in serious need of preservation. The challenges of urbanization and negligence to upkeep the waterbodies has lead them to despair. The need of conservation of these water bodies is to preserve rich historic value and architectural features and also sustain the cultural legacy embedded in their stones. Toor ji ka jhalara is a great example of how socio cultural aspects play a major role in keeping these water bodies active and a lively place for community gathering and social interaction. With the robust efforts of local people and administration the water heritage of jodhpur can be preserved and can be added as a major attraction for tourist and create a network of spaces for social interaction making the city more vibrant and tourist friendly. This will not only build the overall image of the city but also help in increasing the tourism economy of the city. Balancing current city demands with the preservation of these architectural treasures poses a unique challenge, and the success of such endeavours will decide the city's future connection with its aquatic legacy. In conclusion the exploration of jodhpurs water bodies from wells to public realms signifies the cultural continuum and interplay of urban environment in preserving a water source and changing a structure from utilitarian purpose to a place of social and cultural identity. As we commemorate the timeless heritage inherent in these bodies of water, we are reminded that their value extends beyond the physical boundaries of water management they represent the beating heart of a city that takes sustenance from its past in order to survive in the present and imagine a robust future.

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UNDERSTANDING PUBLIC PLACES: LAKEFRONT AND ITS ACTIVITIES WITH PUBLIC BEHAVIOR IN THE CHANGING URBAN FABRIC OF THE CITY : A CASE OF FUTALA LAKEFRONT, NAGPUR

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ABSTRACT

The urban form of a city is a dynamic entity, perpetually shaped by the changing associations and activities of its inhabitants. Waterfronts, in particular, play a pivotal role in defining the character and public behavior of a city, serving as vital pause and breathing spaces. This research delves into the evolving nature of waterfronts in Indian cities, emphasizing the need for cohesive public spaces as urban development rapidly transforms their fabric. A case in point is Futala Lake in Nagpur, which once provided a serene backdrop to public activities and engagements, offering breathtaking views of the city's skyline and sunset. Recent interventions along its shores, however, have drastically altered the waterfront's dynamics and the nature of activities within the area. A significant aspect to consider is the fundamental disparity between Western waterfront ideologies and those of Indian cities, stemming from factors like climate, activities, public associations, and behavior. The design of Indian waterfronts frequently defaults to imitation rather than interpretation of the public realm, leading to the failure of creating holistic public spaces. This research aims to investigate how the Indian public realm, its activities, and behavior differ from Western counterparts and explores the unique aspects that characterize public life on Indian lakefronts. It questions how Indian lakefronts can be envisioned to authentically reflect the character and form of Indian cities, as well as the diverse activities and public behavior that define them. Ultimately, this paper seeks to provide valuable insights into reimagining and designing waterfronts in India, offering a nuanced understanding of what it means to create vibrant and culturally resonant public spaces in a rapidly evolving urban landscape.

KEYWORDS

Public realm, lakefronts, public realm, urban form, public behaviour, activities.

AIM:

To understand public realm in Indian context, and how the activities and public behavior governs the urban form in the transforming cities.

OBJECTIVE:

1. To understand the public behavior and activities in the Indian public realm by taking the case of Futala Lakefront Nagpur.

This will include:

- Mapping of type of activities
- Mapping of different intervals and frequency of activities
- Mapping the public behavior through different studies and interviews
- Needs and expectations of the people with the place.

2. To study the differentiating aspects of westernized public realm and Indian public realm.

3. Impact of evolving urban form and activities on resultant public realm.

INTRODUCTION

"Public spaces are a window to the city's soul"- Sharon Zukin

Activities determining good urban places: Good urban places are understood as areas in the city where social interactions and economic exchanges taking place which gives birth to sense of community and commerce; where friends meet, strangers interact, kids play as well as people in need of places to live and also where political demonstrations, religious processions and cultural celebrations take place. these places are melting pot of various cultures and social fabric of the city which is open and accessible to all. Vibrant public spaces also interconnected to the fabric of the city, it adds to the vibrancy breaks the monotonous fabric and acts as an open breathing space. These become the landmarks of the city and are most identifiable as urban form of the city. (lynch, n.d.)

Many of our Indian public spaces are crowded, chaotic, dirty and unsafe yet they are beautifully alive – throbbing with vitality and dynamics. The apparent chaos and disorder, actually consists of several layers of order, all superimposed. These spaces celebrate their democratic and multifaceted nature and offer something of functional utility and value to everyone.

Historically, most cities started growing out of settlements, which were anchored along the shores of a river, sea or a large natural lake. Water attracts people, provides a focal point in the city for the day-to-day fundamentals of life as well as a backdrop for celebration and rituals, recreation, fishing, tourism, etc. Hence, we find the world's greatest cities, built around rivers, large lakes and along coastlines.

From a Western standpoint, successful waterfront public spaces would constitute of a visual access to the waterfront enhanced by multiple corridors and access points, accessibility of waterfront for pedestrians, physical linkages from the urban core areas and commercial hubs, retail promenades, tourism, recreation and cultural activities. Successful integration of the development and built form with the adjoining

waterfront creates vibrant public and safe spaces where the landscape forms a natural setting for the occupants and city dwellers to appreciate and enjoy.

In the Indian context, water is sacred, revered and has significant metaphysical importance within our socio-religious framework. For Hindus water is a purifier-considered to have spiritually cleansing powers, life-giver-dictating the cycle of life and death, and destroyer of evil. Most Hindu religious celebrations and rituals involving key life events from birth to death all revolve around water. Holy places are usually located on the banks of rivers, coasts, seashores and mountains and Hindus hold the rivers in great reverence. the rivers are generally female divinities, food and life bestowing mothers. As per Hindu beliefs, there are seven sacred rivers which are worshipped- Ganges, Yamuna, Godavari, Saraswati, Narmada, Sindhu, and Kaveri.

BACKGROUND:

Futala Lake in Nagpur is one of the most visited attractions in the city, and for good reason. This lake covers more than 60 acres of land and has a significant historical legacy. The man-made lake has two major interventions. In 2005, Deep roots Design was appointed as Designer for the Intervention of Lakefront and the street focusing on proper urban design approaches with sensitivity towards the context as well as Landscape. Now in 2022, The intervention of the renovation of Futala Lakefront and street was proposed in 2020 and was executed by Nagpur Smart City, NMRDA, NIT, and Nagpur Metro which focused on making the largest fountain show in India, as well as activities centered along it to increase footfall.

The changing urban form of the city is the result of changing of association what the city looks upon. People engaging in different activities also evolve with changing times. Thus, the resultant Public spaces and their public behavior change. Public places govern the activity and place-specific association of the city and are considered the pause and breathing spaces of the city. The demand and creation of more cohesive spaces are required within Indian cities as the development of the urban fabric is rapidly transforming.

This research provides a structured approach to studying public places and public behavior in the context of the changing urban fabric of Futala Lakefront in Nagpur. It encompasses the background, objectives, literature review, theoretical framework, methodology, case study analysis, and recommendations to contribute to the broader understanding of urban public spaces.

RESEARCH QUESTIONS:

Understanding the factors behind the changes in activities and growing urban form around the lakefront public realm. The city evolves with changing the urban fabric and so does it impacts the urban aspects like , infrastructure, networks, morphology. It also changes the way people interact in a Public Realm. Public realm changes according to the activities and nature of activities. With changing skyline of the city and more in the world of AI. How the public life is getting affected with the changing city fabric?

1. What are public places & its association with activities?
2. Documenting activities, public life, and the evolution of the public realm
3. What are the factors of activity depending on public space
4. Factors differentiating public places from South Asian countries to Western activities.
5. How are the needs to be looked upon to induce activities and develop a public realm in the growing urban fabric?

RESEARCH METHODOLOGY:

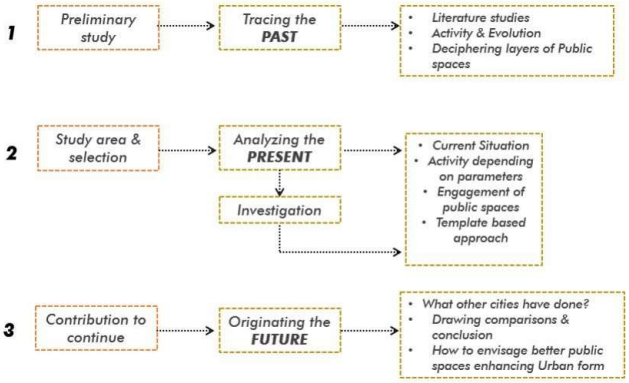


Figure 1 shows research methodology theoretical framework

LITERATURE READINGS:

To understand the parameters and aspects through readings

1. Social logic of small urban spaces - William Whyte
2. Celebrating public spaces of India- Archana and Anshuman Gupta

CASE STUDIES:

To compare and find newer ideations towards public realm

1. Kankaria Lake- Ahmedabad (Indian Context)
2. Jinji Lakefront, Suzhou, China

FUTALA LAKE, NAGPUR:

Figure 2 Observations during the virtual walk mapped by authors.

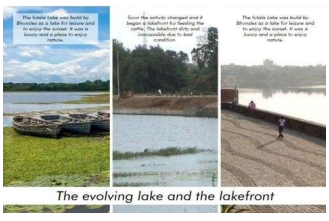


Figure 3. shows the evolution of Futala Lake with changing activities

Historical Significance: Futala Lake is believed to be over 200 years old and has played a significant role in the history and development of Nagpur. It was

originally built by the Bhonsle dynasty of the Marathas, who ruled the region.

British Influence: During the British colonial period, the lake underwent some renovations and improvements. It was a popular recreational spot for British officers and residents in Nagpur during the colonial era.

Prominent Features: The lake covers an area of about 60 acres and is known for its octagonal shape. It has a beautiful garden, an island with a musical fountain, and several walking paths. The lake is surrounded by lush greenery, which makes it a popular destination for picnics and leisurely walks.

Condition of Futala Lake: In 2012, The lake was quite an active public realm including the street within it. Visual connectivity was maintained with activated spaces such as restaurants, vendors, and boating activities along the lake. It was the anchoring point of the city. But in 2022, The intervention changed the interface of the Lake completely with concretization and a discontinuity with a visual of the lake and inactive edge due to restricting the public space. This lacks in public interaction and a wide gap is generated with what is envisioned through intervention doesn't meet the needs of the people. The newer intervention is an interpretation of westernized character inIndian context. It has hidden the lake view and instead had constructed it with a ticketed viewing plaza with world class fountains which hampers the simplicity of being just a viewpoint with more informal activities.

Figure 4 shows condition of Futala Lake in 2012 and 2023

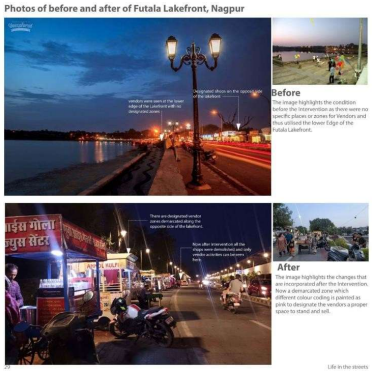


Figure 5 shows before and after images of Futala lakefront. Source: Living Streets by Urban Design Square

The photos of lake highlighting the different interventions and the before and after scenario which clearly emphasizes on the addition of urban form and how it is influencing the public life. The top image shows a visual connectivity of lake through the street whereas, in the bottom image its clearly difficult to identify the street and lake visual connectivity.

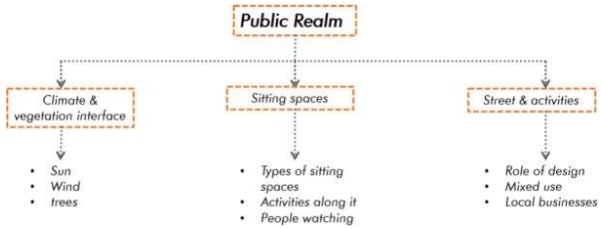
LITERATURE STUDY:

Social Logic of Small Urban Spaces- William Whyte

William H. Whyte's book, "The Social Life of Small Urban Spaces," explores the dynamics of human behavior in public spaces, particularly in the context of small urban areas. The book is based on Whyte's observational research conducted in various plazas and public spaces in New York City during the 1970s.

Here are key aspects and insights from the book:

- **Observational Approach:** Whyte's work is characterized by its empirical and observational approach. He and his research team spent countless hours studying how people use and interact in public spaces, relying on methods such as time-lapse photography and behavioral mapping to capture the nuances of human behavior.
- **Social Patterns and Behavior:** The book examines the social patterns that emerge in public spaces, including the ways people move, sit, talk, and interact. Whyte identifies recurring behaviors, such as the preference for certain types of seating arrangements and the impact of environmental factors on social dynamics.
- **Importance of Seating:** A central theme is the significance of seating in public spaces. Whyte emphasizes the value of movable chairs and benches that allow people to arrange seating according to their preferences. The ability to control one's environment by moving chairs contributes to the success of a space.
- **Triangulation Concept:** Whyte introduces the concept of "triangulation," which involves the creation of focal points or features within a space that attract people. These points of interest, such as water fountains or food vendors, serve as magnets that draw individuals and groups, fostering social interaction.
- **Unplanned Social Activities:** The book highlights the importance of unplanned and informal social activities in public spaces. Whyte found that successful spaces often accommodate a variety of spontaneous activities, from impromptu conversations to street performances, contributing to the vibrancy of the environment.
- **The Role of Design:** Whyte explores how design elements, such as the arrangement of seating, the presence of trees and greenery, and the overall layout of a space, influence social behavior. Well-designed spaces encourage social interaction and create a sense of place. (Whyte, 1980)



Temporal Patterns: The book delves into the impact of time on social behavior in public spaces. Different times of the day and week can attract different user groups, and understanding these temporal patterns is crucial for effective urban planning.

• **Ownership and Control:** Whyte discusses the concept of ownership and how a sense of ownership among the users of a space can positively influence its social dynamics. Spaces where people feel a sense of control and responsibility tend to be better-maintained and more welcoming.

• **Practical Implications for Urban Designing:** The book offers practical insights for urban planners, architects, and designers. It emphasizes the importance of incorporating human behavior into the design process and creating spaces that are responsive to the social needs of the community.

"The Social Life of Small Urban Spaces" has had a lasting impact on the fields of urban planning and design, influencing the way professionals approach the creation of public spaces to promote social interaction and community engagement.

FUTALA LAKEFRONT MAPPING:

Application of literature theory to the analysis on precinct:

Walkability
Views and vantage points along the lake
Movement of people
Different types of sitting spaces
Activity mapping according to different time interval

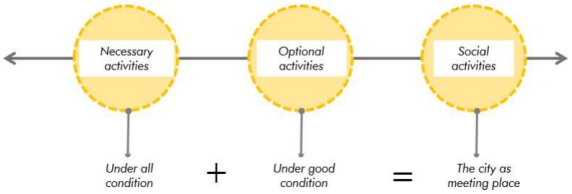


Figure 7 framework derived for mapping of activities in Futala Lakefront

The understanding and the parameters generated through the literature: The Social Logic of Small Urban Spaces by William Whyte focuses on understanding various parameters through layers of activity which can be done through mapping. This will help to analyze and understand the requirements of the people in waterfront spaces. And how the newer intervention is responding to the needs of users. The newer intervention at Futala lake now comprises of built mass with dedicated spaces for different activities but isn't accessible at all times and is a ticketed public place. And thus, major activities are happening on the street with no visual connectivity to the lake. Areas dedicatedly made for sitting, and vending activities.

Figure 8 framework derived for mapping of activities in Futala Lakefront

There are now designated zones of all the activity. The viewing plaza consists of auditorium fashioned seating to enjoy the fountain shows in the lakefront. And the street facing shops for eatery and formalizing the lakefront with more activities.

Mapping of intensity of activities on futala street:

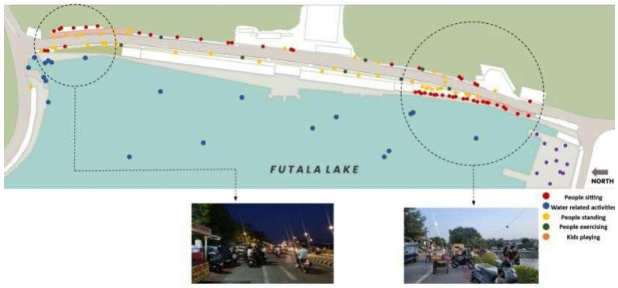


Figure 9 mapping of intensity of activities on Futala Street

The street is majorly activated in the evening with most of the crowd along the hawkers and vendors stalls. Apart from that many people are seen sitting along the edge of the lake to enjoy the views of sunset. Water related activities are only active before sunset. Majorly the intensity of people is only towards the eateries as the plaza seems to be closed and thus, has become a dead public space for temporary.

Mapping of different types of activity on the streets:

In the evening the street has different types of informal activities. More than the lakefront, the street gets activated due to spillover of vending activities can be witnessed on the street Which attracts more people along the street rather than the lake. The edge of the lake is mostly used for the parking which defeats the purpose of development the edge along the lakefront.

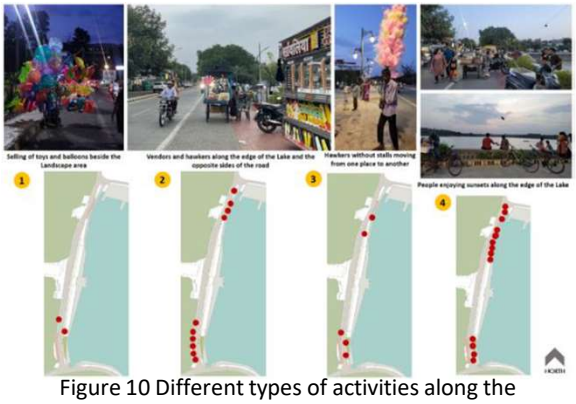


Figure 10 Different types of activities along the street in the evening

Figure 11. Mapping of informal vendors and hawkers along the street

MAPPING OF INFORMAL ACTIVITIES (HAWKERS AND VENDORS)

The mapping shows that the intensity of hawkers and vendors can be seen occupying the areas where there is access to visually connected lake. This highlights the behavior of the vendors as well they users since a connect with the place is important visually.

Mapping of where do people sit?

The analysis of Futala street was done to understand where do people prefer the most to sit. The reasons behind understanding this aspect are:

- How people behave in near public waterfront spaces
- Do designed places are the most preferable places to sit or places which connects the person to the lake is suitable to sit.
- There are any activities which directly or indirectly makes person sit at a particular place
- Does minimal design interventions are required rather than too much of design?

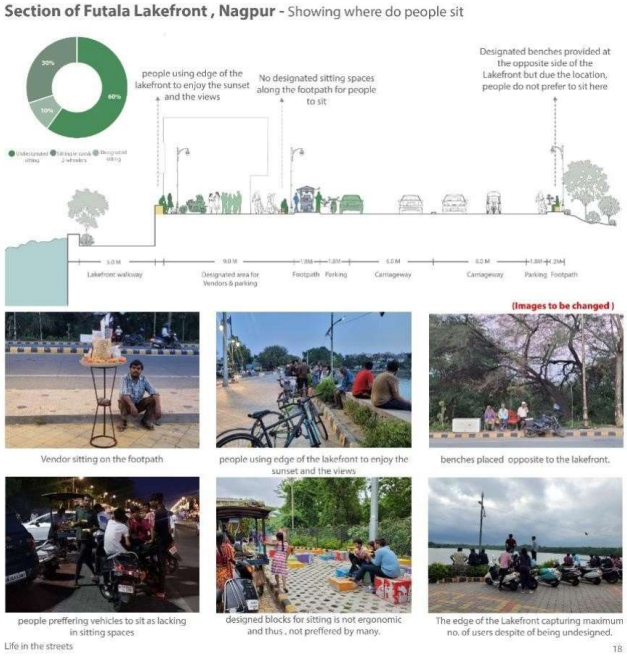


Figure 12. detail analysis of where do people sit Source: Urban Design Square

After the analysis, it is observed that the people mostly prefer to sit on the edge of the lakefront since it gives them a sense of belonging with visual connectivity to the lake. Despite of giving designated spaces there are no linkages to connect to and thus, the designated spaces are not much used. Also, people prefer to sit along the activity centric spots such as the informal vendor zone. But most importantly these places are not dedicated sitting areas , not ergonomic and climate also affects and thus many people prefer to enjoy in their car. Also, the above image highlights a pie chart survey that states 60% of people prefer siting on the edge of the lakefront with is not newly designed and is not designated place to sit. 30% of the people find it comfortable to sit in the car or 2 wheeler and remaining 10% of people choose to sit on the designated designed sitting spaces. This infers that people do not adopt the design changes which are not designed according to the Indian Context.

Overall activity and its timeline along the lakefront:

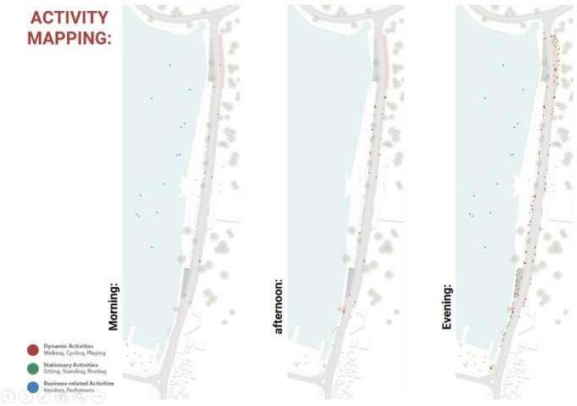


Figure 13. Activity mapping at different time intervals at futala lake

There are multiple activities in the lakefront which are occurring at various intervals of time. Considering from stationery activities like sitting, talking etc., moving or dynamic activities which are in motion like running, walking, moving cars etc. there are multiple business related activities like water related activities i.e. boating, fishing ,and informal vendors moving or stationery. Most of the activities are witnessed during the evening and the nighttime. Apart from it most of the lakefront is vacant in the morning as well as in the afternoon because of the climate. Since, Nagpur has extreme summers and generally the temperature in the daytime is high. It gets difficult for a user to go to open public places, especially to the lake front because of thermal discomfort.

Figure 14 highlights the sitting issues

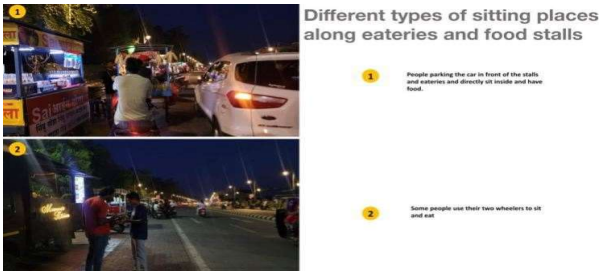


Figure 15 different types of sitting places and informal vendors

ISSUES:

1.No proper sitting places: there is clearly design not responding to the need of people in term of what people need. Users prefer to sit to view the lakefront and the
sunset.

2.No designated spaces for informal activities: there are no designated spaces for informal activities along the lakefront. Most of the activities are happening on the street which creates congestion along it.

3. No connect with the lakefront

CASESTUDY:

The intention of the case study is to understand the public behavior and perception of lakefront as public realm in the city. The examples used can help to generate further understanding towards better designing and according to the need of context. The studies can help to analyse new ideations and experiments done with the indian context to stop wasting quality of public spaces through bad decision.

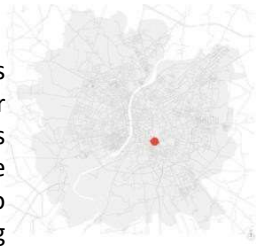


Figure 16 map of Ahmedabad highlighting kankaria lakefront

Kankaria Lakefront, Ahmedabad:

The historic Kankaria Lake has been a part of Ahmedabad since its foundation was laid by its then ruler Ahmed Shah in 1451. Originally planned as a green destination, it suffered due to heavy vehicular traffic encircling the lakeside road, unorganized and informal activities in the area as well as an unkempt environment.

Conditions before interventions:

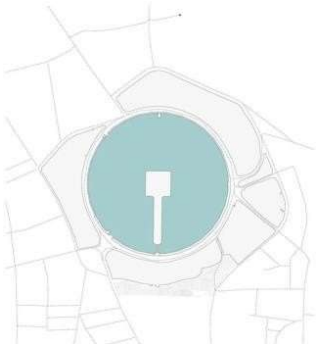


Figure 17 kankaria lake

Figure 19 Conditions around the lake

Figure 20 parking enchroachment along the lakefront

Figure 21 views and vistas from street to lake

Initiated by the Ahmedabad Municipal Corporation, the primary objective of the Kankaria Lakefront Development was to transform this city-scale public space with efficient and robust infrastructure. The strategies to implement this transformation included creating complete pedestrian zones encircling the lake's edge, developing an outer ring road by strengthening the existing road network, creating approximately 6 km of access streets as well as new access points to the lakefront, enhancing recreational potential by improving public facilities, preserving historic buildings and encouraging overall development within the precinct. (HCP, n.d.)

Figure 22 intervention plan of Kankaria Lakefront

Figure 23 shades trees and green

Figure 24 sitting places along lakefront

Figure 25 informal activities

Figure 26 user- centric entertaining activities

Changes in public life after interventions:

Learnings:

Indian cities have different aspects of looking at public life. With changing urban fabric there is a significant change in the approach towards lakefronts. With more designed activities along the lakefront to enjoy the lake view. People choose informal vendors along the lakefront rather than any fancy outlets. In addition, more user-centric activities are incorporated into the place. More concern towards the climate thus more trees and vegetation to enhance the microclimate and shading around the area creates the effect. More user-centric activities along the lakefront keeps it activated. All such activities improves the public life and the fabric around it significantly changes.

Jinji Lake:

Suzhou combines an ancient city with two distinct new areas the Suzhou New District (SND) and the Suzhou Industrial Park (SIP). In 2008, SIP was one of 3

eco-industrial park demonstration sites in China, containing two large lakes. Jinji Lake and Dushu Lake are both in the heart of SIP. The Jinji Lake Suzhou waterfront project can be seen as a modern-day city equivalent of the ancient city moat that surrounds the old city, that creates a waterfront public space that circles the old city. (Hoskyns, 2019)

Figure 26. Area around Jinki Lake

Figure 27. Jinji lakefront

For AECOM: "These parks and open spaces are open day and night all year round, changing in character and subtleties over the seasons. Safety and maintenance procedures have been implemented and maintained as envisioned in the design. As Chinese culture embraces the idea of public open space, the people's love of the land has been re-ignited. On the weekends the parks are flooded with crowds escaping the old city to the open landscapes and waterfront parks along the lake"

Figure 28 Deck around the Lake

Figure 30 walkways along the lake

The Jinji Lake project was completed in 2018 and like the ancient moat gives 24/7 access to the waterfront. The Jinji Lake development is a network of public spaces that combines pedestrian bridges, open public parkland, boat yards, art installations, children's playgrounds, wetland gardens, a fishing pier, and water side promenade and includes cultural activities and tourist destinations. The waterfront provides pedestrian. connections to some of SIP's major destinations: the restaurant area of LiGondi at the south of the lake, the Culture and Expo center, and the shopping district Times Square at the north of the lake. The newly built Suzhou Centre at the west of the lake. The new Ferris wheel at the east of the lake. The waterfront project allows the public to walk around the entire lake and is the site for Suzhou's annual half marathon. (AECOM, n.d.)

Learnings: Jinji Lake, stands not only as a picturesque water body but also as a dynamic center for diverse and vibrant public life. Encircled by lakeside promenades, green spaces, and recreational facilities, Jinji Lake fosters a rich tapestry of activities. Residents and visitors alike engage in activities such as walking, jogging, cycling, and boating along its scenic shores. The area hosts cultural events, festivals, and art installations, contributing to a lively cultural ambiance. With waterfront promenades, public parks, and entertainment zones featuring restaurants, cafes, and shopping areas, Jinji Lake emerges as a multifaceted destination that seamlessly integrates leisure, community engagement, and urban development. The lake not only serves as a natural retreat but also as a hub for social interaction, making it a symbol of Suzhou's dynamic and inclusive urban lifestyle.

HOW CAN WATERFRONT SPACES BE LOOKED UPON IN THE INDIAN CONTEXT?

Encouraging Engagement with the Urban Environment:

The park serves as a catalyst for spontaneous interactions. Many passersby exhibit a noticeable reaction, taking a second look, pausing briefly, and then, with a subtle increase in pace, continuing up the steps. Children, in particular, display more energetic responses, with young ones often pointing excitedly at the park, urging their mothers to enter, and older children sometimes breaking into a run just before reaching the steps, occasionally skipping a step or two.

Aspects of Urban Experience: Staircases Observing these patterns highlights the significance of staircases. The steps at Paley are designed to be low and easily navigable, creating an inviting pull. They introduce a pleasant ambiguity to one's movement – you might stand and observe, take a step or two, and then, almost unconsciously, find yourself within the park.

Emotional Impact: Musicians and entertainers have the power to bring people together, and the quality of the performance is not the sole determinant. What matters is the mere presence of such acts, forming bonds among individuals. Interestingly, even a subpar act can sometimes foster stronger connections than a superior one.

Qualities of an Ideal Plaza: A well-designed plaza begins at the street corner. In a bustling intersection, it becomes a hub of social activity. People aren't merely waiting for the traffic signal to change; some are engrossed in conversations, while others are in various stages of extended farewells. If there's a vendor at the corner, individuals tend to gather around, fostering significant two- way movement between the plaza and the street corner. Revitalizing the waterfront is an ideal opportunity to re- establish meaningful relationships with the waterfront parcels of land and Lake. Once thought of as almost quixotic, the waterfronts have shown how intervention on the urban scale can wholly transform a city. Waterfront spaces in the Indian context present a unique canvas for observing and influencing public behavior. Understanding how people interact with and utilize these spaces is crucial for effective urban planning and creating environments that enhance the quality of life for residents. Here are

considerations for examining public behavior in Indian waterfront spaces:

Cultural Practices and Traditions:

Religious Practices: Water bodies often hold cultural and religious significance in India. Observing how individuals engage in rituals, ceremonies, or religious activities near the waterfront can provide insights into the cultural fabric of the community.

Festivals and Celebrations: Waterfront spaces may serve as focal points for festivals and celebrations. Studying public behavior during such events can inform the design of spaces that accommodate diverse cultural practices.

Recreation and Leisure:

Family Activities: Families often visit waterfronts for leisure activities. Observing family dynamics, such as picnics, playtime, and other recreational pursuits, can guide the creation of family-friendly spaces.

Social Gatherings: Waterfronts may attract social gatherings, such as group outings or informal meet-ups. Analyzing these gatherings can inform the design of seating arrangements and communal spaces.

Economic Activities:

Informal Economy: Waterfront spaces may host informal economic activities, such as street vendors and artisans. Understanding how people engage with these economic opportunities contributes to a comprehensive understanding of public behavior.

Mobility and Connectivity:

Walking and Cycling Patterns: Waterfronts often serve as pedestrian-friendly zones. Studying walking and cycling patterns can help plan for adequate pathways and connectivity.

Water Transportation: In locations with navigable water bodies, observing how people engage with water-based transportation, such as ferries, can inform strategies for enhancing connectivity.

Health and Well-being:

Physical Activities: Waterfronts can attract individuals engaging in physical activities, such as jogging, yoga, or exercise routines. Examining these behaviors can inform the provision of fitness facilities and open spaces.

Mental Well-being: Waterfront spaces may offer tranquility and scenic views, contributing to mental well-being. Studying how individuals use these spaces for relaxation can guide efforts to enhance mental health aspects.

Community Engagement:

Public Events: Waterfronts often host public events, such as cultural performances, markets, or art installations. Analyzing public engagement during these events can offer insights into community participation.

Public Art and Installations: Waterfront spaces provide opportunities for public art. Understanding how people interact with and respond to art installations can inform strategies for enhancing cultural and aesthetic experiences.

Safety and Security:

User Perceptions: Studying public behavior can help gauge user perceptions of safety. Observing where people feel comfortable or uncomfortable can guide interventions to enhance security and comfort.

Temporal Patterns:

Day and Night Activities: Observing public behavior during different times of the day and night can provide insights into the temporal dynamics of waterfront spaces. Understanding when and how these spaces are utilized informs lighting, security, and programming considerations.

In summary, examining public behavior in Indian waterfront spaces requires a nuanced understanding of cultural practices, economic activities, recreation, and community engagement. By embracing this holistic perspective, urban planners and policymakers can create waterfront environments that cater to the diverse needs and behaviors of the public, fostering vibrant and inclusive spaces.

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WATER TRANSPORTATION AS THE MAINSTREAM OF COMMUTING BETWEEN MATHURA AND VRINDAVAN: A SUSTAINABLE APPROACH

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ABSTRACT

The waterways connecting Mathura and Vrindavan present a unique opportunity to reimagine commuting as a sustainable and culturally rich experience. This research Paper explores the potential of water transportation as the mainstream mode of commuting between these two historically significant cities. By delving into the environmental, economic, and cultural dimensions, this study advocates for the integration of water transport systems as a sustainable alternative. Known for their cultural and religious significance, the demand for sustainable transportation options has increased along with urbanization. The viability and benefits of using water transportation as the primary means of transit between Mathura and Vrindavan are examined in this study. The report includes a thorough examination of social, economic, and environmental factors, backed up by graphics and references. Drawing on existing research, interviews, and case studies this paper aims to contribute to the discourse on sustainable urban mobility.

KEYWORDS

Water Transportation, sustainable transportation, pilgrimage, river cities

INTRODUCTION

India is known as the 'Land of rivers' due to its vast network of river system. The extensive system of these rivers across the country has played a crucial role in laying foundations of Indian Culture and history. Most popular and principal rivers being Ganga, Indus, Brahmaputra, Yamuna, Godavari, Krishna, and Narmada. India for times unknown has thrived upon these rivers acquiring the status of an Agricultural country due to rich deposits of the rivers. The routes traversed by these rivers have promoted transportation along with serving as significant religious and cultural symbols.

Yamuna River is one of the most sacred rivers, revered and worshipped by numerous Indians for its association with Lord Krishna. Yamuna is the second largest tributary of the Largest River Ganga. It is also the longest tributary in India. (Yamuna River Basin Atlas by Ganga and NMCG)

India boasts a vast system of inland waterways, including creeks, rivers, backwaters, and canals. Compared to wealthy nations, the country significantly underutilized waterways for freight transportation. Inland and coastal waterways in India play a minor role in the country's hinterland connectivity, which is mostly provided by road and rail. Waterways are discovered to be an economical and ecologically sustainable mode of freight transportation. Inland Water Transport (IWT) in India can relieve the strain on the Nation's overworked railroads and clogged roads. ("INLAND WATER TRANSPORT")

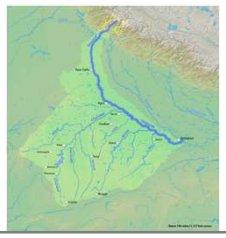


Fig 1 By Shannon - Background and river course data from http://www2.demis.nl/mapse ver/mapper.asp, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=9971222,

INLAND WATERWAYS AUTHORITY OF INDIA

(IWAI), division -Inland water Transport (IWT) points at underutilised routes in backwaters and rivers along many towns and cities.

The Mathura-Vrindavan corridor's ever increasing traffic jams and mounting environmental concerns highlight the need for creative and sustainable transportation solutions. This study argues for the revival of water transport as a practical alternative, acknowledging the historical relevance of the mode in the area. through an examination. Through an examination of the economic environmental and cultural aspects, the research seeks to clarify the viability and advantages of using water for transportation in this significant route.

OBJECTIVES

- To evaluate the feasibility of water transportation in the Mathura-Vrindavan region.
- To analyse the environmental impact of adopting water transport.
- To assess the economic viability of water transportation.
- To examine the social implications and benefits of promoting water commuting

The ambitious development plans for the Braj region, discussed in a recent meeting in Delhi, signal a transformative era for the area. The proposal outlines crucial connectivity initiatives, Proposal includes the construction of two 6-lane bridges across the Yamuna for improved accessibility.

- National highway to be connected to Govardhan via Hindustan College Goverdhan Drain's dual tracks
- Direct route from Agra to Goverdhan to reduce traffic in Mathura
- A light rail system to cover the 12 km rail line between Mathura and Vrindavan, with an estimated expenditure of one thousand crore rupees. ("Mathura

and Vrindavan to be soon connected via cruise service")

FEASIBILITY OF WATER TRANSPORTATION:

India boasts of many rivers, of which 9010 miles is navigable waterways. Uttar Pradesh alone owns 1010 miles of rich navigable waters. Thus, after railways and roadways, inland water transport is the next best way of transport, especially in Uttar Pradesh. (Bandyopadhyay and Deb #) exchange of ideas. India, and the United provinces in particular, are blessed with an abundance of permanent navigable rivers, such as the Ganges, Yamuna, Ghaghara, and others.

In India, river transportation has been a habit since ancient times. The epic Ramayana relates that at Prayag (Allahabad), Lord Rama, his spouse Sita, and brother Lakshman are being ferried over the Yamuna River by a village boatman named Nishad Raj. Throughout the 19th century, Indian ships maintained their unfair position. India's inland waterways were traversed by country boats carrying enormous loads of building supplies, feed stocks, wood, and cereals at essentially minimal expense. (Mehta #)

Water transportation has always been essential to the Mathura-Vrindavan area since it provides a quick and easy way to connect. Reintroducing water-based commuting into the transportation matrix is feasible given the historical background and contemporary advancements. A natural channel for sustainable transportation, the Yamuna River serves as a vital link for culture and spirituality (Dewan 1561-1574) India is a river-rich nation. It boasts almost 9010 miles of navigable rivers, the most of which is located in Uttar Pradesh, one of the former United Provinces (1010 miles). Therefore, inland water transport (IWT) may have emerged in India as a crucial mode of transportation after the development of the railways and roads a component of dialogue. In a region with numerous powerful navigable rivers, inland water transportation has traditionally been an essential means of transportation. (Bandyopadhyay and Deb #)

Tourism -

Due to their reputation as the birthplace of Lord Krishna, the twin cities of Mathura and Vrindavan draw a sizable influx of pilgrims and visitors each year. These twin cities are highly recommended for individuals who are eager to embark on a brief spiritual retreat. Additionally, one may see the majority of the sites in a single day because the locations of interest are not too far apart. Union Shipping Minister Sarbananda Sonowal recently stated that Mathura and Vrindavan will be connected with a cruise service, for which waterways on the Yamuna will be developed. This move comes in the wake of promoting religious tourism in the region. ("Mathura and Vrindavan to be soon connected via cruise service")

Tourism along the Yamuna River in Mathura has witnessed significant growth, raising concerns about its environmental impact. There lies an intricate relationship between tourism and development and environmental sustainability. The intersection of tourism and environmental sustainability presents a critical challenge in the context of the Yamuna river in Mathura.

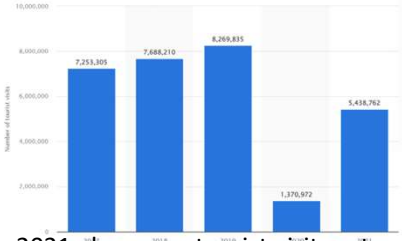


Fig 2. Graph of Tourist Influx 2017-2021, Source: Statista Research department

As per Statistics, Year 2021 alone saw tourist visit up to 5.3million. With Mathura-Vrindavan corridor now the next project under HRIDAY scheme is expected to attract double fold of pilgrim and visits. As per reports from Uttar Pradesh Brij Tirth Vikas Parishad, Mathura, the Braj regions annual pilgrim-tourist footfall is expected to multiply from the current level of 2.3 crore to six crore by 2041.

Vrindavan the ancient city of India is about 15 Km, away from Mathura. Vrindavan alone can draw pilgrims up to 50,000 a year. People throng these cities especially on festivals of Janamashtami, Holi, Bhai dooj. Many visit these shrines on weekend as getaway and religious tourism. (Dewan #)

The pilgrimage tradition has been the main source of evolution for religious tourism in India. The journey has tourism elements, but the goal, purpose, and substance are nonetheless religious. The organization and visitor numbers have undergone the most modifications of the travel and tourism sector (Shinde #)

The 1,376-Kilometer Yamuna River traverses Mathura. The Indian Government intends to offer two spacious cruises. The Indian Government intends to offer two spacious cruises that can accommodate up to one hundred passengers each. As per the proposal the PPP model will be used to operate the additional steamers. Current discussions are to run the steamers in radius of 22 km from Gokul to Vrindavan covering various ghats of Mathura, Vrindavan and Gokul as of now. With new DPR underway final route is to be established. (Mathura : यमुना में चलेंगे क्रूज स्टीमर, वृंदावन से गोकुल तक बनेगा जलमार्ग, 2022)

Mathura Vishram Ghat, Source: Author, Pic 1

ENVIRONMENTAL IMPACT OF ADOPTING WATER TRANSPORT.

Yamuna the sacred river has constantly been under Human-Induced pressure due to urbanisation and industrialisation. The additional transit and connectivity options have had a significant impact on the city's growing number of visitors. The city's carrying capacity has been exceeded, making it challenging for the authorities to manage the increasing number of motorized vehicles. (Kapoor, Mathur, & Sehgal, 2022)

Where using the power of water transport is sure to decrease this burden, it is evident to face other challenges with respect to environment. As per IWT, compared to other transport modes, water transport is more powerful in bringing down the carbon footprint. Mathura-Vrindavan is seeking to become a "net zero carbon emission" tourist destination by 2041, the Uttar Pradesh government just stated. This would be India's first such comprehensive plan for a tourism attraction that is carbon neutral. To achieve such carbon neutral status, measures must be undertaken to run carbon free vehicles, as in, to run on electricity. Major Announcements made to achieve the Target are:

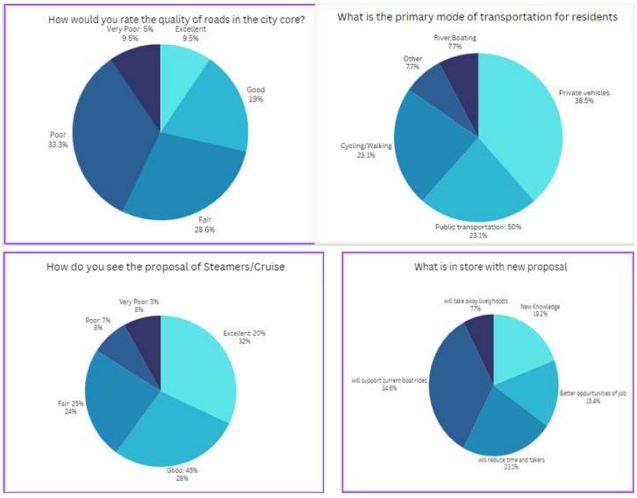
• Tourist vehicles will be banned from the entire Braj region, which includes famous pilgrim centres such as Vrindavan and Krishna Janmabhoomi.
• Only electric vehicles used for public transport will be allowed into the area.
• All 252 water bodies and 24 forests in the area will also be revived.

The plan divides the entire region into 4 clusters, each containing 2 of the 8 key cities
The idea is to form small circuits called 'Parikrama Paths' which the pilgrims can undertake either on foot or using electric vehicles. In case they want to travel from 1 destination to another they can avail electric minibuses. ("Mathura-Vrindavan Carbon Neutral Target | ENSURE IAS")
According to the International marine Organization (IMO), marine transportation contributes 2.89% of greenhouse gas emissions worldwide. Electric propulsion systems seem like a viable solution for cutting ship emissions, particularly for larger, more powerful ships. (Ammar, et al. #) Diesel generators generate the electricity, which then drives the electric engine. This moves the ship's propeller. This has many advantages: It saves between five and 20 percent of the fuel. The electrical machines also consist of fewer components, are less prone to faults, and have less wear and tear.
Traffic Surveys yielded back and forth movement in terms of vehicles to tune of 100s per day. Vehicles used were two wheelers and 4 wheelers. Heavy load vehicles transporting goods and material have increased significantly in last decade due to various construction projects undertaken by MVDA and Nagar Nigam Authorities. (DUBEY et al. #)
Current congestions on roads are contributing to maximum of carbon emission. River cruises shall be helpful in lessening the burden on roads and delays thus caused. Such that time of travel shall come significantly through cruises and mass transportation of 100s at a time shall have considerable effects on individual plying 2 wheelers along the routes.

ECONOMIC VIABILITY

It is imperative that the river cruise tourism industry be expanded as soon as possible by making. River and terminal infrastructure accessibility, multimodal connectivity, ease of conducting business with various agencies, availability of a safe and standardized fleet, simplicity of funding, and incentives through income taxes, challenges with GST and customs tariffs, standard operating methods for all river cruise systems, integration of tourism assets with state master plans, insurance and risk underwriting, and the availability of competent labour.(Ministry of Tourism, India) In order to make cruise tourism a significant socioeconomic driver, the Ministry of Tourism will work with all national and state public and private stakeholders to develop capacity, skill development, and efficiency through policy initiatives and advocacy for reforms that will further ease the doing business process.

Yugal Ghat: This ghat is currently used by Row boats for pilgrims to leisure rides and rituals. The boatmen are residents of eastern bank of Yamuna, popularly known as 'Palli paar'. A whole community of boatsmen reside on eastern banks, with their income sources relying on ferrying or boating. Refer Pic 4



Survey Results from existing Boatsmen, Survey by Author, Pic 5

Currently ferrying is limited only for leisure rides, or rituals along the riverbanks. A survey with the Boatmen on their perspectives to bring in water transport revealed great excitement and welcomed the announcements of Cruise travel. With great excitement and expectation, Mathura's boatmen are ready to welcome the idea of cruising the Yamuna River, one of the holiest rivers in India. These knowledgeable navigators, who have a strong respect for the area's cultural and historical value, are aware of the potential advantages that cruise travel may have for their community's economy and culture. With a lengthy history of negotiating the calm river currents, the boatmen are prepared to modify their knowledge and skills to suit and improve the cruise experience, offering a distinctive viewpoint on the enchanted scenery and holy locations along the Mathura-Vrindavan stretch. Their readiness to accept cruise ships is indicative of a

well-balanced fusion of history and modernity, showing a society eager to share the Yamuna River's splendour with a broader audience while contributing to the sustainable development of the region. The new transport system can bring better prospects of increased income sources.

CULTURAL RESONANCE: HERITAGE PRESERVATION AND PROMOTION

Yamuna river holds a significant religious and cultural significance for the people of Brij Bhoomi. It connects rituals and ceremonies to the life of people. It acts as a symbol of purification and Renewal. Various mythological stories, folk songs, and belief systems directly or indirectly of the Brij Bhumi are co related to the river. A water transport network connecting the sites between Mathura and Vrindavan will establish a strong connection between physical artifacts, traditions, customs, practices, and values with the tourist where they experience the journey along the route. (Dewan #)

The river cruise between Mathura and Vrindavan should be helpful to showcase the rich cultural heritage of the Yamuna River, showcasing the evolution of human settlements, religious practices, and the development of ghats and temples along the riverbanks

River cruises promote cultural preservation and heritage promotion, showcasing historical sites, folklore, and traditions associated with rivers like the Nile in Egypt and the Danube in Europe.

The water cruise industry, when managed effectively, can boost tourism and economic growth in regions like Vietnam and France, attracting tourists interested in cultural exploration.

The Yamuna River, with its ghats and temples, houses interconnected stories and legends, especially those related to Lord Krishna. River cruises, like those along the Mississippi, celebrate these stories.

River cruises in Myanmar foster community engagement by involving locals in cultural performances and craft displays, promoting mutual enrichment and participation in tourism.

Eco-friendly river cruises, like those on the Amazon River in South America, show the potential for responsible tourism practices along culturally significant water bodies.

Viable Route for Adoption

There are numerous ghats at Vrindavan along the Yamuna River's banks. The majority of the ghats are dry since they are no longer connected to the river due to the river's ever-changing course. (Kapoor et al. #) There are currently just twelve ghats, and the only one that is being used is the Kesi ghat.

Vishram Ghat, Mathura, Source: Author, Pic 2

Vrindavan Map with Kesi Ghat, Source: Google Earth, Fig 3

Vrindavan has numerous ghats and carries a religious story for each Ghat. It has more than 15 ghats of which Kesi Ghat is most popular and visited by pilgrims, Refer Fig 3

Mathura boasts of many Ghats, of which popular and important ghats with activities are namely: Bangali Ghat, Swami Ghat, Vishram Ghat, and Vasudev Ghat. Refer fig 4

Ghats of Mathura, Source: Google Maps, fig 4

The length of River between Vishram Ghat and Kesi Ghat is approximately 22 km. Since both these ghats are highly active with religious activities, facilities of port requirements are not viable. while studying ghats at Mathura, Bengali Ghat near the bridge, which forms the tail end of ghats at Mathura or Yugal ghat before Vishram ghat should be considered.

Bengali Ghat: The locality Bangali Ghat falls in Mathura district situated in Uttar Pradesh state, with a population 517. The male and female populations are 278 and 239 respectively. The size of the area is about 0.25 square kilometre,

Bangali Ghat is a well-known location in Mathura, situated on the banks of the Yamuna River in the centre of the city. Bangali Ghat, a sacred site, is teeming with culture and history. Residents in and surrounding this neighbourhood often attend Swaminarayan Mandir, Krishna Mandir, and Gita Temple. The Hathras, Mathura Road, which borders Bangali Ghat, facilitates convenient access to neighbouring areas. The closest station from this location is Mathura Cant Railway Station. Additionally, Mathura Junction is found not too far away. Among the numerous reputable educational

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institutions in the area are Government Inter College, Champa Agarwal College, and Kishori Raman College.

Yugal Ghat, Mathura, Source: Author, Pic 4

CASE STUDIES AND BEST PRACTICES

Venice, Italy: One famous example of a city that has successfully incorporated waterways into its transportation network is Venice, Italy, and its transit system, which is centered around the water. This unusual system, which mostly uses canals and boats, has been in use for centuries and is still a useful and important way to get around the city.

Venice's water-centric transportation system, primarily based on canals and boats, has been a practical and essential mode of transportation for centuries. However, the system faces challenges such as maintaining canals, preserving historic buildings, and requiring specialized vessels. A preliminary case study highlights the need for sustainable solutions amidst environmental concerns. (Water Transport Decarbonization: Preliminary Case Study in Venice, 2023)

Key Takeaways: Venice is embracing sustainable practices in its water-based transportation system, using electric or hybrid boats to minimize environmental impact. This aligns with global decarbonization efforts, reducing air and noise pollution. Boats provide efficient and accessible transportation for locals and tourists, preserving Venice's cultural and historical heritage. The water transport system also enhances the tourism experience, particularly the Grand Canal, offering a unique and memorable route for tourists. (Water Transport Decarbonization: Preliminary Case Study in Venice, 2023)

Kochi, India:

With the use of water transportation, the Water Metro project in Kochi seeks to improve connectivity and reduce traffic in the city. Under the management of Kochi Metro Rail Limited (KMRL), this project aims to incorporate waterways into the city's public transportation network, establishing an effective and sustainable form of transportation. The Water Metro project, which was introduced in 2019, aims to connect different islands and the mainland with a network of waterways, ports, and boats. (Kochi Metro Rail Limited)

The Water Metro project, a meticulous water-based transportation infrastructure, involves modern terminals, jetties, eco-friendly boats, and technology for ticketing and scheduling, enhancing commuter experience. The Water Metro project, led by KMRL, has successfully engaged local communities, ensuring efficient transportation, promoting tourism, and creating job opportunities, thereby uplifting local economies.

Key Takeaways: The Water Metro project combines water transport with existing metro and bus services, offering a comprehensive, interconnected transit system. It promotes sustainability through eco-friendly boats and waterways, aligning with global efforts to reduce carbon emissions.The project also stimulates economic development through community engagement and job creation and enhances urban planning by utilizing natural water resources.

CONCLUSION

In conclusion, the economic feasibility, environmental advantages, and compatibility with the local cultural legacy of water transportation highlight its potential to replace land-based transportation as the primary means of commuting between Mathura and Vrindavan. The case studies of Kochi and Venice offer important insights into how water-based commuting systems are successfully implemented. Urban regions are facing more and more environmental issues and traffic congestion, thus it's critical to embrace sustainable transportation options like rivers. To promote a more environmentally friendly and culturally diverse Mathura-Vrindavan corridor, this study advocates for additional research, design, and execution of water-based transportation systems.

CONCLUSION

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EXPLORING THE THRIVING RELATIONSHIP BETWEEN GHATS, MOHALLAS, AND ACTIVITIES ALONG RIVER GANGA'S STRETCH IN VARANASI : Discussing the Role of Statutory Bodies for Retrofitting Organic High-density Clusters with Strong

Ritu Deshmukh & Chaitanya Joshi

Abstract:

Built form as the element of urban fabric reflects the social, economic, cultural, and ecological aspects in the spatio-temporal frame. Therefore, the utmost significance is the qualitative assessment of built-form along riparian neighborhoods in understanding the relationship between the cities and respective rivers in an urban context. Lack of efforts to document and understand the nature of the riparian-built environment has led to challenges in achieving objectives for river restoration projects in various Indian cities. The study highlights the significance of understanding socioeconomic aspects by analyzing built-form to conceptualize river restoration projects in a brownfield context. The paper puts forth the argument using the case study of Varanasi (Benaras), considered as the oldest living city located along the banks of River Ganga. The objective was to delineate the parameters to document and analyze 7.2 km of land-water interface with ghats as thresholds, surrounded by neighborhoods. Following this, based on delineated parameters, the entire stretch of ghats was divided into 15 major parts to analyze the existing relationship of the river with existing riparian neighborhoods. Documentation of built forms and activities using a primary survey was the major tool used for qualitative assessment. The study indicates that the analysis of built-form along the land-water interface provides a variety of nuances which, if conducted, provides a humane and holistic way to deal with riparian buffers in a brownfield context. The paper calls for a transforming outlook of the river restoration process from a generic engineering-based approach to a local situation-based process resembling cohesion with the existing urban fabric and a more people-centric (bottom-totop) view towards restoring waterfronts.

KEYWORDS: water conservation, renewable source, rapid increase, rainwater, sustainable

BACKGROUND STUDY:

Considered the oldest living city on the Earth, multiple resources across various times have contributed to the vast repository of diverse subjects ranging from Sanskrit literature, philosophy, history, archeology, anthropology, cultural geography, art, and architecture. Each of the issues extensively mentions various aspects of the city. The historical records indicate there are multiple names based on the time and character of the city, among which Kashi or Kasi (means concentration of cosmic light) and Varanasi (the city along river Ganga settled along the confluence of River Varuna and River Assi) are the most common names. Some of the oldest records that mention the city include sacred scriptures of Atharva Veda and Kasi Rahasya (p.24, Singh, 2009).

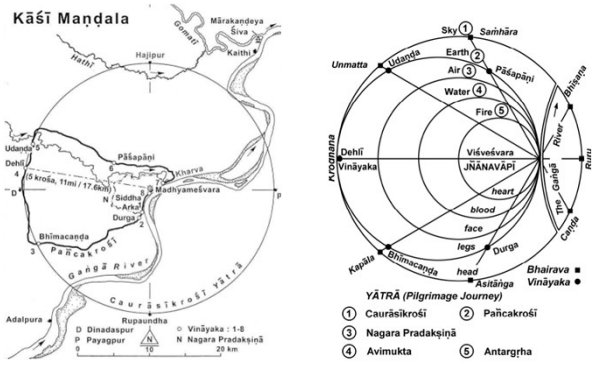

Figure 1 . Image illustrating the correlation of physical urban morphology and pilgrimage routes (left) and cosmic geometric (right) illustrated in sacred texts. Source: Singh Rana P.B., 2017

Having a religious and cultural significance, the city, owing to different immigrants who came to this city for solace, peace, and sacred merit (Sanskrit) education, and because of various invasions, Varanasi developed a diversified community structure while preserving its regional characteristics (p.31, Singh, 2009). The city, perceived as organically evolved away from the banks, is considered to have developed based on cosmic geometry, as per Kasi Khanda (Singh & Rana, 2016). Cultural landscape studies (Singh, 2012) mention the five sacred pilgrimages that mark the start and end of the Kasi, as mentioned in the holy texts, and provide evidence that the city developed around the Kasi Vishwanath Temple. This justifies the evolved urban form over the years using cultural landscape. Physical proof of the mythological texts, which indicate various versions of Kasi, from Lord Shiva's Trident to Lord Vishnu's Vocal Instrument (Shankh), provides evidence of a cosmic order that is looked at as an organically grown spatial form from aerial imagery. (Singh, 2017).

As a part of studies in built environment, significance is given to the study of ghats along the River Ganga. Ghats, as the public open space along the land-water interface, and the cultural landscape – public buildings, temples, and built forms- are some of the prominent features that contribute to the built heritage (Sinha,2014) is actively documented over the years. The establishment of ghats is based on historical, geographical, mythological, and cultural significance, which is widely seen along with diurnal transformations in using ghats as a public space throughout the stretch.

The mornings and evenings have different activities involving various age groups based on their likelihood. Apart from that, the nature of activities changes depending on the adjacent neighborhoods behind the ghats. Dashashwamedh Ghat, closest to the Kasi Vishwanath Temple, is a prominent ghat highly active during the evening. To another extent, Assi Ghat is used as a public open space for choirs. Both these aspects are essential parts of the urban general area to promote inclusivity and multipurpose usage of tangible built forms, allowing interactions of people with water bodies. Rising water during the monsoon protects the adjacent neighborhood, which could have been flooded without ghats as a built buffer where season variations can also be seen. The functional usage of ghats varies and depends on the communities in the adjacent mohallas, which is explained in the successive sections of the study.

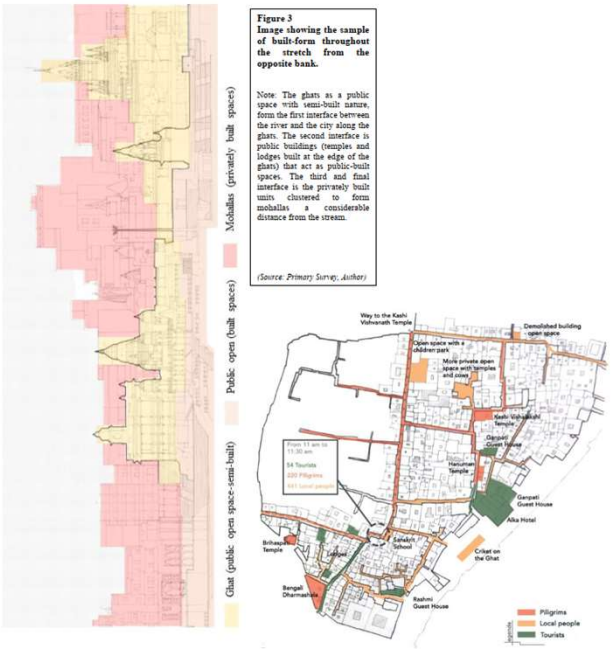

Figure 4. Map showing the major hotspot location of pilgrims, local people and tourists near Man Mandir Ghat.

The relationship between the riparian neighborhoods located adjacent to the ghats (built urban fabric that is semi-public/semi-private in nature) with the ghats (a built form which is public space) The transition of public to private is always a part of discussion in urban built environments as it is based on the human perception of public space. The neighborhoods adjacent to the ghats are characteristic-specific and reflect a similar sociocultural linkage with the history of the establishment of ghats. For example, the Scindia Ghat and Bhonsale Ghat have neighborhoods of the Maharashtrian community, while housing clusters along Kedar Ghat dominate the South Indian community. This ends up with significant variations in neighborhood character and residential typologies. As a result, a similar organization of inner spaces, semi-private areas, and architectural elements like atlas, thresholds, cornices, and façade resembles every household but varies significantly throughout the stretch.

Since the individual units cannot expand horizontally, the vertical incremental module is popular in neighborhoods. The boundaries of urban areas are perceived from the extent of the ghats, where the start and end of the ghat stretch along the river and open to the main street and further stream to subordinate streets. The main street emerging from the ghats intersects the arterial road, which runs parallel to the river, marking the boundary of riparian neighborhoods. The arterial highway is characterized by mixed-use built typologies where most structures have been noticed to have undergone multiple alterations. Most of the residential typologies are semi-detached and can be seen to have experienced various structural changes to accommodate growing needs as compared to the built typologies in the inner streets.

The relationship of riparian neighborhoods (tangible aspect) with the micro and medium-scale occupations and activities (an intangible part)

Apart from the increasing needs of the family, the other factor determining the transformation in the individual-built units is an increase in income per household. To qualitatively justify this, mapping activities conducted in the neighborhood were performed. Like the historical narrative related to the area's character, as mentioned, most of the activities shown in these mohallas have continued for the past three generations. Activities of boat making, weaving, washing clothes, jewelry making, dying, and various activities associated with the day-to-day routine of temples are prominent throughout the neighborhood. For example, Nishadraj Ghat has a mythological link to the Ramayana and mohallas adjacent to these ghats by the people of the boat-making community. Housing clusters near Manikarnika Ghat are traditionally dwelled by merchants who have shops near cremation grounds along the ghats. However, unlike streets, which divide the neighborhoods, the activities along major ghats indicate that there are linkages between the activities that are well organized in this organically developed neighborhood. Occupations associated with

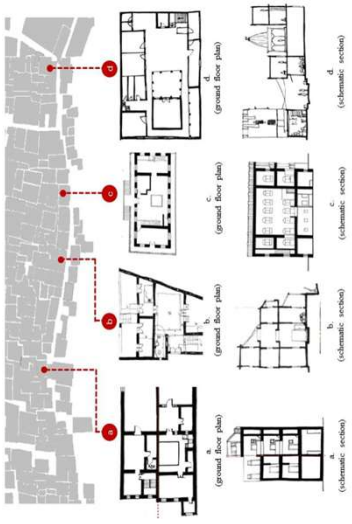

Illustration showing open space in the form of chauraha by intersection of streets. (Note: The intersection of the street's central point of interaction is where a source of water (handpump or well), temple, or tree is likely to be seen. Over the years, most owners' extension of the built space has resulted in indicated bottlenecks, which are significant problems that restrict the retrofitting of urban infrastructure in mohallas).

• The Case of the low-income community in the Mohallas adjacent to Gola Ghat -Jute bag weaving and basket weaving communities along Gola Ghat follow a specific pattern of vertical incremental increase of building space, which is affordable based on their economic condition. The weeds from the river are a source of raw material for basket weaving, which indicates that the community still has a linkage with the river for their livelihoods. (Fig. 7a & 7b).

• The case of jeweler-making occupation near Zaveri Bazaar (near Sankatha Ghat) –Informal metal workers working with precious metals like gold and silver initially has its workplaces within the neighborhood. All the backend work for jewelry making is organized in a similar informal market around- Zaveri bazaar in Varanasi. Over time, the workspaces started to shift away from the old city area as it took more work to expand the activity, especially in areas with poor infrastructure. This action can disturb the existing chain of labor markets and likely hamper the economy.

• The Case of Textile Workers Replacing the Clusters of Traditional Boatmaking Community along Pnachaganga Ghat Communities skilled in small-scale textile community, have replaced the settlements belonging to the boat-making manufacturing, identifies the opportunity; on the other hand, boat-making was not as profitable, so boatmen decided to migrate out, finding themselves a better chance.

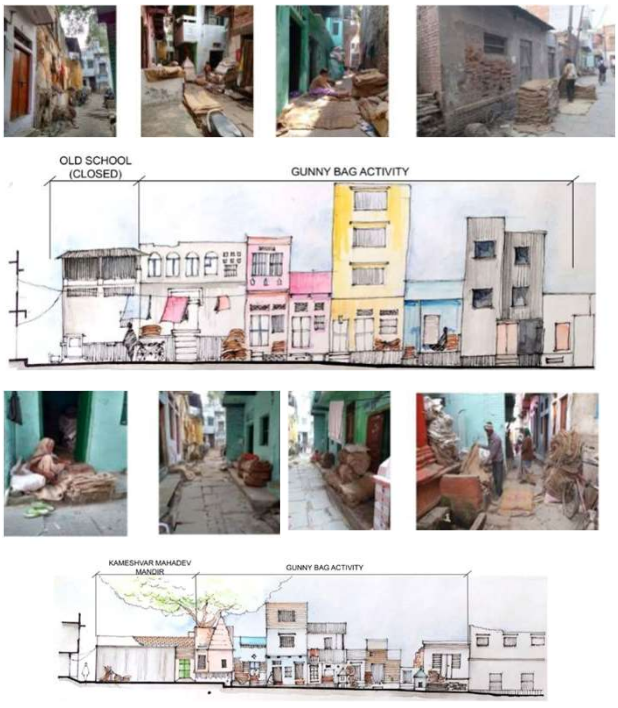

Figure 6a (top) & 6b (bottom) Comparison of inner 7a inner streets and outer streets 7b residential clusters of jute bag and basket weaving community in Gola Ghat with transformations (increasing floor) (Source: Primary Survey, Author) (Note: Due to poor daily wages, the community will likely choose vertical increments of residential units over the years. These high-density neighborhoods are preferred for living despite poor living conditions due to their proximity to the market areas nearby)

dying, knitting, and Zari work, which belong to the Muslim community. Since Zari's work is a famous artwork that suits the context, it

- The case of the washerman community losing their existing engagement with the ecosystem of activities due to government actions- Traditional washerman communities in mohallas along Panchaganga Ghat have been provided an alternative space for conducting daily business 4.0 km away from the ghats. The increasing tourism industry along Dashashwamedh Ghat and Manikarnika Ghat was a significant source of daily income for the community. The action is taken as a mitigative measure to reduce the impact of wastewater generated from dhobi's neighborhoods.

Apart from this, various examples reflect the positive and negative aspects of how the community-driven urban transformation is taking place dynamically in the mohallas. The mapping of the condition of built spaces in the mohallas conducted specifically to the prominent mohallas indicates that most structures have poor structural conditions and require immediate retrofitting. (Figure 9 (a) & 9(b)). The participatory changes and transitions indicate the positive tradeoffs, which are community-driven and depend on pros and cons based on the shifting trend and economies.

INFERENCES AND FINDINGS:

The study in a structured manner provides observations along ghats, neighborhoods adjacent to the ghats and, finally, understanding of various activities and occupations that are carried out by the people living in these mohallas. Apart from the multiple activities mapped and identified, the built form was observed to reflect the communities' socio-economic and sociocultural aspects. Though the city looks organically developed, the organization can be called orderly chaos driven by the free-market ideology established over the years of thriving micro-economy. The neighborhood along the ghats, where the city is gradually shifting from manufacturing dominant to the service sector, has a robust informal economy in the purview of the circular economy. The first two objectives indicate poor livability in the densely packed settlements. In contrast, the cases in the third objective justify why the communities prefer to live for generations even though there is poor livability compared to the other developing areas of the city

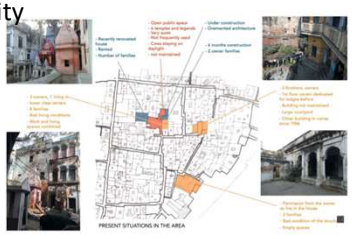

Figure 7 . Image showing the present condition in the area in the mohallas of Panchaganga Ghat (Note: The primary survey indicates that congestion and poor living conditions are likely reasons the communities prefer to move out. This situation is seen in the community, which does not directly relate to the circular economic chain in these mohallas).

On the other hand, the problem of gentrification is also observed to be widely replenishing the microcosm of the informal economy existing in the neighborhoods. In this case, gentrification is seen as a positive outlook if the communities are willing to rehabilitate outside the areas, whereas, on the other hand, it can be considered a forced rehabilitation when local authorities do not upgrade the basic amenities over time. For example, mohallas along Dashashwamedh Ghat are being converted into luxurious lodges, indicating a high demand for tourism. On the other hand, there are cases within the neighborhood where gentrification led to the enhancement of the place value of the area identified. This pattern was seen near the mohallas of Nishadraj Ghat, which was traditionally known for settlements of boatsmen (mentioned earlier) who decided to shift away from the river as the activity was not fetching enough livelihood. This indicates that the city is transforming naturally based on the changing economic patterns, which need to be acknowledged by the civic authorities, urbanists, and city professionals. The value chain of activities linked to each other existing in the mohallas may, therefore, get disrupted if forced transformation is based on projects-led top-to-bottom development agendas.

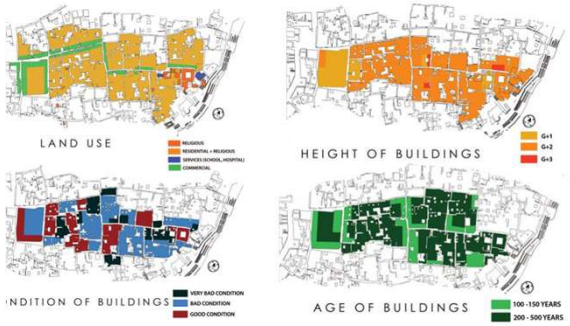

Figure 9 . Map showing land use , existing height of building, condition of buildings and age of the building for small section of neighbourhood along Sankatha Ghat. (Note: The above map indicates the existing scenario of one of the neighborhoods adjacent to the Sankatha Ghat supporting each other. This infers that the average height of a building is G+1 with an age of structure more than 50 years indicates that the immediate retrofitting is necessary and individual built units are in poor condition). (Source: Primary Survey, Author)

In the case of ghats along the river Ganga, it does not regulate the natural rising of stream water. It provides a perfect ground acting as a sponge-like riparian buffer using landscape plantation. Even the historical ghats have provided a threshold for encroachment for habitation. Since the buffer between the urban neighborhood adjacent to the ghats and the water body has already been established, the ghat as a public space can be transformed depending on usage. Therefore, in the case of urban river delineating, land as a buffer is a priority, which is essential to reduce direct encroachment of the banks. The city's ghats are a perfect example of how most cities can rethink their polluted rivers and brownfield contexts, where the priority will be to ensure facilitating public open space. Intervention may not be a riverfront development throughout the stretch, but by-laws to ensure the edges can be planned later.

The implications on health and the environment due to the use of primitive technologies in these activities, which is degrading the riverine ecosystem (Verma & Shrivastav, 2018), are not discussed in detail, but identifying the significance of communities in the existing informal economy, rehabilitating micro-scale industries, or forced shifting should be thought of with other technologically driven alternatives. Rehabilitation of dhobi's workplaces away from the economic value chain increased travel time for the community, where a similar problem could be solved in technocratic ways. The study also highlights that vertical incrementation of dwelling units and structural alterations are identified as more affordable options than shifting to alien city areas. Due to this, specific neighborhoods are undergoing retrofitting at a more rapid rate. This is commonly observed in various communities with rising family sizes, low income, and unwillingness to rehabilitate because of dependency on traditional skills. In such cases, restricting the development up to 200 meters from the High Flood Line (HFL) at 73.90 meters and Low Flood Line (LFL)at 58.22 meters at Raj Ghat along the River Ganga (Fig.21) (IWAI, 2018) renders no scope for retrofitting and structural modifications. Such litigations are observed as the severe cause of forced migration impacts the built heritage of the self-functioning neighborhoods. In such cases, a mild stand promoting limited alterations guidelines for using materials may lead to lesser environmental damage. It can be a possible way to rethink the future of mohallas along ghats. In most cases, illegal occupancy and encroachments on public and private land are also some of the concerns that widen the demand-supply gap between water and sanitation infrastructure.

This can also be the case as to why mohallas are treated as alienated areas of the city, which is not an appropriate solution as it will degrade the living conditions, acting as a cause of forced migration discussed earlier. Such situations must be tackled by providing land ownership and identifying the quantum of illegal clusters using various land management practices. The major challenge of local authorities is to ensure that the supply of land for urban utilities is available in neighborhood clusters, which can be used to improve the social infrastructure facilities and urban utilities which help community to thrive. Hence there is a need for sound retrofitting by identifying the impact of socio-economic likages that exists for people who still have their livelihood dependent on rivers, pilgrims, and tourism. The study, therefore, indicates the need to integrate the bottom-up approach with special concern towards bridging the gap between planning and policies.

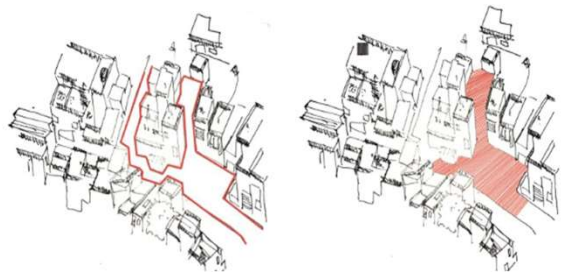

Illustration showing open space in the form of chauraha by intersection of streets. Note: The intersection of the streets is a central point of interaction where a source of water (handpump or well), a temple, or a tree is likely to be seen. Over the years, most owners' extension of the built space has resulted in bottlenecks, which are major problems restricting the retrofitting of urban infrastructure in mohallas. (Source: Primary Survey, Author)

Apart from this, the city of Varanasi experiences tourists and pilgrims throughout. The existing built environment must also be inclusive enough to support the facilities for tourists and pilgrims. Since a significant portion of tourists and pilgrims are concentrated primarily in specific areas of the ghats, separate provisions for developing ghats that experience a high influx of tourists can also be considered. Hence, in the case of Varanasi, projects like ghat development, restoration of built heritage, improving the experience of pilgrims, etc., should be contextual. Central-sponsored schemes and programs focus primarily on physical attributes when retrofitting infrastructure, while they do not consider the socio-economic implications. The issues at a ground level can be tacked only if there is cohesion between the vision of the programs sponsored by the central government and the local. Programs like HRIDAY and PRASAD for heritage rejuvenation and development of pilgrim destinations, respectively especially in cities like Varanasi, should be reflected in the statutory plans so that project implementation addresses the on-ground issues.

CONCLUSION

The study points out various aspects leading to noteworthy inferences where different angles to relook at the transformations and the existing relationship between built and unbuilt urban fabric are presented. The three-layered objectives highlight the interrelationship of traditional mohallas, activities on ghats, and activities in built typologies, justifying why Varanasi remains the oldest living city on Earth. With various examples, the study answers whether urban transformation is happening rapidly due to the shift of economic patterns where the rise in tourism is a significant factor at the city-wide level. This case study clearly shows that community-driven decisions that reflect bottom-to-top and democratic choices must be preferred and sets a clear perspective on the fundamental role of civic authorities. Examples of autocratic activities against socio-political agendas damaging the circular economy must be replaced with surveys and studies where the on-ground situation can be studied to understand a clear picture of the mohallas. The role of civic authorities at present lies in ensuring guidelines for safety and hazard mitigations, promoting alterations that will have lesser or no impact on the environment, using modern technology to reduce pollution, and providing essential amenities and social infrastructure facilities to upgrade the livability of mohallas. Therefore, forced rehabilitation should be the last outcome to ensure the functioning of neighborhoods along ghats in an economically sustainable manner. Understanding the existing ground reality to propose alternatives for any urban issue is paramount, and the qualitative study of socio-economic aspects is as essential as urban character.

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AQUATIC ARCHITECTURE: INTEGRATING WATER FEATURES INTO URBAN DESIGN

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ABSTRACT

Water is a very crucial part of life, it is important for both buildings because there are natural water features such as oceans, lakes rivers ponds, etc. Water is a crucial part of domestic, commercial, and industrial use. Water is a very important aspect of drinking to survive. It is used in bathrooms for bathing. It has a strong relationship with people as well as surrounding spaces. water is where civilization started across. It is also important for all types of species. For aquatic animals also mammals and reptiles. Water is a very unique feature in existence. There are both types of water In the presence of salty ocean water and pure drinking water. The proportion of drinking and salty water is very vast. The drinking water is very low as compared to ocean water which cannot be consumed by people. without proper treatment. Water once used needs to be disposed back into the larder water bodies or reused after being treated for landscaping purposes. this paper's emphasis is on points such as water to bring down the room temperature and provide comfort. It can also be used for heating the surroundings in cold regions and seasons. In urban spaces, water acts as an attractive element. Structures are to be designed on and underwater. The use of colorful lights with waterbodies can bring a relaxing effect. And improve emotional wellbeing. There is an immense amount of positive impact on cities that do not have seafronts. the use of water curtains in the design helps to provide a barrier to the spread of fire across the structure. The waste from water can be used in Producing and using methane gas to be used as fuel.

KEYWORDS

Aquatic,Water features, Sea, Waterbodies, Drinking.

AIM / PURPOSE

The paper aims to examine the various ways water contributes to the urban environment. Such as drinking, washing, planting also water used for aesthetic purposes such as fountains and reflecting pools. And maintenance of water. the given points lead to a better understanding of the use of water in urban design. Water is currently playing a very important role and also in future its importance will increase. This paper the importance of the able use of sea water for domestic purposes after treatment. Is crucial for meeting the needs of urban society.

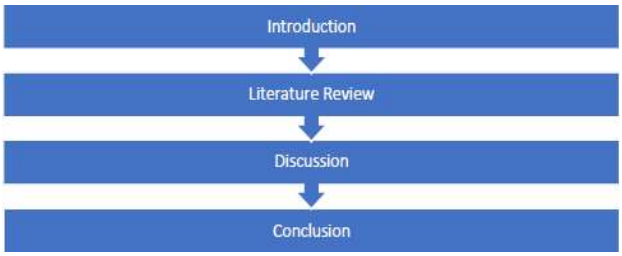

Figure 1 Research Methodology

INTRODUCTION

1. Background

Definition of Aquatic Architecture

Water architecture is a very important part of the built environment and living organisms. About one third of architecture is related to water and its impact on architecture which includes technical, material, environmental, and psychological aspects. There are also underwater structures. Underwater architecture is a very new area of architectural design with very futuristic concepts which are different from the current scenarios. Understanding underwater space is very different from surface space. Since there is lot of water pressure both vertically and horizontally.the Knowledge about building on the water, and under water must be developed enough constantly to make the design of structure more practical. The Tourism Industry and recreation industry are key reasons for building aquatic facilities like underwater structures and floating houses.

RESEARCH METHODOLOGY

Technical Aspects of Water Architecture include building on, and under the surface of the water to create structures like pools and floating houses. Designing this Requires a lot of knowledge about the behavior of water and its interaction with different materials and structures. For the endurance of these strcutures. the impact of water on the architecture must be considered crucially. this includes the use of water as an internal environment factor . therse is need of attention attention in order to the development construction techniques that avoid impractical concepts. Constructing on water often involves floating structures or platforms that can support buildings. Underwater construction may use sealed and pressurized environments for habitation of humans.The use of water as a decorative element includes fountains and water walls within the architecture. Techniques for regulating the internal environment might involve water-based heating or cooling systems. Water features can cool down a building by absorbing heat from the air or surfaces it comes into contact with. It can also be used in heating systems, where water is warmed up and then circulated to release heat into the environment. Water

features like fountains can add moisture to the air, which can help in regulating indoor (Bujniewicz 2020)

2. Significance of Water Features in Urban Design

The Water features in public spaces add value to the places aesthetically and functionally. The presence of water elements in public spaces is very important since they impact positively to the surroundings. Water elements increase the attractiveness of city spaces. It defines the identity of urban places. Fountains and watercourses add to the social and aesthetic value of a particular urban space. Different types of water features offer different experiences. Water Elements provide a visual focal point in urban spaces. Water features offer a cooling effect, especially during hot weather. The sound of water can create a relaxing atmosphere. They can serve as interactive elements, like pavement fountains Water elements can reflect the surrounding consisting of architectural and natural features (Langie, Rybak-Niedziolka, and Hubačíková 2022)

B. Objectives of the Research

1. Explore the Integration of Water Features

There is importance of focusing on water management of urban water runoff and other water-sensitive planning (WSP) in areas like flood protection and streams rehabilitation . WSP aims to integrates into both urban and regional planning from the start, requiring collaboration across various professional fields. Universal WSP implementation with specific rules and guidelines tailored to local conditions Carmon and Shamir 2010) (Brodaric, Hahmann, and Grüninger 2019)

2. Assess the Impact on Urban Aesthetics and Functionality

Urban areas are closely linked to the aesthetic qualities of spaces . A city is considered to be active if it provides some enjoyable places and interactive things for people

. importance includes visual beauty and the variety of activities in public spaces . The main goal of aesthetic urban design is to create spaces that people find pleasing.

C. Rationale for the Study

1. Addressing Urbanization Challenges

Quality growth is linked to transformation of urban spaces, which drives growth and determines its attributes .this Transformation is related to the changing resources and competitive advantages, requiring the industrial strategies and policies .Policies differ from country to country to achieve quality growth, consideration of their unique transformation paths . There is no standard model in any each country and they must develop their own strategies for transformation and quality growth of spaces. The complexity of the relationship between resources, transformation, and quality growth leads to further study. Some of the East Asian countries have successfully transformed their economies, but there is a renewed focus on economic transformation in Asia. Quality growth involves economic growth that is sustainable and beneficial for the society. It also includes improvements in the well-being of peoples lives and reduction of poverty. Quality growth should be inclusive, meaning it provides opportunities for all people. It also preserves the resources for future generations. Quality growth aims for efficiency, makes the best use of resources and technology. It should be enduring and able to withstand economic shocks and stresses. (Hosono 2022)

II. Literature Review

A. Historical Context of Water in Architecture

Water has been significantly influencing architectural thinking, both physically and intellectually. Understanding the relationship between water and architecture reveals the potential and risks of water in architectural terms . Studying how water has evolved in architectural thought can lead to new opportunities in modern architecture . (Heckenast, Ferencz, and Kertész 2021)

B. Theoretical Frameworks

Psychological and Physiological Effects of Water

Water and water structures havea lot of psychological benefits for the people living in urban areas. The presence of water in cities can improve the image and meaning of the urban environment for residents and tourists Designers play a crucial role in creating water structures that positively influence human psychology sensitive urban design techniques in place-making is also determined by their secondary functions (Carmon and Shamir 2010)

A. Architectural Elements

1. Fountains and Reflecting Pools

Mughal buildings in North India used passive cooling techniques suitable for the climate. These historical design elements can inspire modern sustainable building designs. Further research is needed to create guidelines for energy- efficient and sustainable buildings. Modern architecture can learn from the harmony between humans and nature seen in traditional solutions. Old buildings used natural cooling system, which can be applied to new buildings to save energy Researchers are looking at old designs to make rules for building energy-saving and eco-friendly modern buildings(Ali 2012)

2. Water Walls and Water Curtains

Water curtains can reduce heat from fires and protect nearby walls and materials. The water curtain was effective in preventing the spread of flames and sparks to adjacent areas. The effectiveness of the water curtain in reducing heat flux was less at longer distances. Also The water curtain helped to prevent

fire from moving upwards on a building's facade. The amount of water flow from the sprinklers did not significantly change the heat reduction after a certain point. Larger fires needed more water to reduce the heat to safe levels. The study's findings could help in setting safe distances between buildings with the use of water curtains. The study shows that water curtains can lower the heat from a fire, which can protect buildings close by By knowing how much heat a water curtain can block, we can figure out how far apart buildings should be to stay safe. water curtain reduced heat, which can be used to set these safe distances(Turco, Lhotsky, and Hadjisophocleous 2016)

B. Urban Planning Strategies

1. Incorporating Water in Public Spaces

High-quality of urban structures are increasingly valued, with nature and water playing key roles in their design . Water elements like fountains have historically served multiple functions, including practical, cultural, and decorative purposes . Water features bring in modern times, water elements are used to enhance the attractiveness and usability of public spaces, especially in revitalized areas . life and refreshment to urban spaces and are significant compositional elements . The ecological use of water in city public spaces is gaining attention, though its potential is not yet fully realized . Artistic and technical innovations continue to reveal new possibilities for incorporating water into urban spaces (Langie et al. 2022)

Sustainable Water Management

Anaerobic treatment processes are beneficial as they convert pollutants into methane, a source of energy, instead of consuming oxygen and producing carbon dioxide. Anaerobic treatment processes are beneficial as they convert pollutants into methane, a source of energy, instead of consuming oxygen and producing carbon dioxide. Anaerobic treatment processes are beneficial as they convert pollutants into methane, a source of energy, instead of consuming oxygen and producing carbon dioxide Anaerobic treatment processes are beneficial as they convert pollutants into methane, a source of energy, instead of consuming oxygen and producing carbon dioxide. Anaerobic treatment processes are beneficial as they convert pollutants into methane, a source of energy, instead of consuming oxygen and producing carbon dioxide.(Qian 2016)

Rainwater Harvesting Systems

Land Conservation Micro-catchment approaches are effective for water harvesting and soil conservation. The system is suitable for growing crops like maize and groundnuts that need a moderate amount of water. Micro Catchment Rainwater Harvesting (RWH) can be enhanced by using pits to capture litter, seeds, and protect seedlings Increase soil water storage by trapping rain where it falls. Design contour bunds with proper spacing and cross- section for alignment on undulating land. Use semi- circular bunds of various dimensions to collect water. Implementing micro-catchment systems for integrating conservation and production. Utilizing hillside sheet rill runoff for water collection. Harvest flood water within stream beds. Divert ephemeral streams to capture runoff. Combine Rain water harvesting with storage solutions (Bonniga 2020)

2. Use of Recycled Water in Features

Building water recycling systems save water, reduce environmental harm, and can save money. There are challenges with ensuring water quality, setting up separate pipes for recycled water, and following government rules. Government support, like money help or rules requiring water recycling, is important. New technologies for water recycling in buildings are being looked at, but they have their own strengths and weaknesses. It's important to keep improving these technologies to make them better and cheaper. Using smart systems can help manage water recycling more effectively. It's also important to make sure that recycled water is safe and that people understand its benefits. (Chen et al. 2024)

B. Functional Benefits

1. Cooling Effects in Urban Heat Islands

Water bodies like Suzhou Bay can lower daytime temperatures in urban areas The cooling effects of water bodies decrease with increasing distance from them Green spaces are more affected by the cooling effects of water bodies than impervious surfaces, especially within 200 meters The presence of water bodies can change the usual relationship between land cover types and urban land surface temperature (LST) Urban planners should consider the effects of water bodies on surrounding areas for sustainable urban and landscape planning(Ali 2012) sensitive urban design techniques in place-making is also determined by their secondary functions (Carmon and Shamir 2010)

A. Maintenance and Operational Challenges

1. Water Quality Maintenance

Attention is required for the problems of increased cost and quality deterioration in water systems due to infrastructure issues Pipes often have no maintenance, and once issues start, they happen more frequently . Collecting consistent and analyzable data is important for making repair or replacement decisions . Direct economics of repair do not always justify replacement; other factors like customer complaints and water regulations should be considered . The risk of severe damage from a pipe break should be evaluated to decide on the urgency of replacement . The water distribution system affects the quality and cost of water reaching consumers(Goodrich, Clark, and Jr 1987)

DISCUSSION

Water in general plays a very important role in urban areas. In many aspects for both domestic and industrial purpose i.e. on a small scale and a large scale. the findings are water features are used for cooling or heating in urban areas. Prevent fire from providing by providing features such as water walls. Creating aesthetically pleasing places by incorporating water features.

CONCLUSION

The paper concludes about building on and in water. the use of water features for cooling the microclimate is also a point which is emphasized. The sound of flowing water can create a relaxing atmosphere for all age groups since it is a natural phenomenon. water can serve as interactive elements, like pavement fountains Water elements can reflect the surrounding architecture and nature. water provides an enjoyable space for city and its people. water induces visual beauty and the variety of activities in public spaces . Different countries need unique policies to achieve quality growth, considering their specific transformation paths . There is no standard model to use water each country must develop its own strategies for transformation and quality growth .this paper also discusses the importance of how water has evolved in architectural thought can lead to new opportunities in modern architecture . Satisfaction of users is a key aesthetic need in designing successful public spaces . Social, economic, environmental, functional, and cultural vitality are the five dimensions of urban vitality. Urban designers should aim for a balance between these dimensions and aesthetic design . People's preferences for water structures are influenced by individual habits, experiences, and their living environment. In cities without a sea, the impact of water and water elements on people is more significant. the way Old buildings used natural cooling, can be applied to new buildings to save energy Researchers are looking at old designs to make rules for building energy- saving and eco-friendly modern buildings. The water curtain helped to prevent fire from moving upwards on a building's facade .

another use of water is Anaerobic treatment processes are beneficial as they convert pollutants into methane in areas The cooling effects of water bodies decrease with increasing distance from them Green spaces are more affected by the cooling effects of water bodies than impervious surfaces, especially within nearby areas. The presence of water bodies can change the usual relationship between land cover types and urban land surface temperature . Urban planners should consider the effects of water bodies on surrounding areas for sustainable urban and landscape planning. The risk of severe damage from a pipe break should be evaluated to decide on the urgency of replacement . The water distribution system affects the quality and cost of water reaching consumers. further research can be done on the technological part of water in architecture since this paper covers all major aspects of water in urban design.

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ANALYSIS AND ASSESSMENT OF FRESH WATER ECO SYSTEM WITH ITS REMEDIAL MEASURES - A REVIEW CASE OF GANGA RIVER

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ABSTRACT

To reduce pollution of river Ganga and its Ecosystem which has been disturbed by human interventions and anthropogenic activities, had led to the degradation of the water quality of freshwater ecosystem. GOI launched Ganga Action Plan in 1985 were at-tempts had been made to control, improve, and maintain ecological integrity of the ecosystem by physical, chemical, and biological methods. Rapid urbanization, industrialization besides agriculture using chemical fertilizers and pesticides, which is directly released in the basin, have degraded the water quality. The paper deals with the impact of technical interventions in the form of liquid and solid wastes, carried by the river are the issues and challenges for the ecosystem. Besides these, there are some suggestions and recommendations to minimize the ecological degradation of the river to restore its ecology. The measures include active as well as passive restoration techniques to bring back the sustainable ecosystem of River Ganga.

KEYWORDS

Species-diversity, Various Pollutants, Threats, Disturbances in Ecology, Conservation tools

INTRODUCTION

Ganga river basin is the freshwater ecosystem and is the largest of these. It originates from the ice caves at Gaumukh (N30º55´, E 79º7´) and traverses a distance of ≈2510 km from its source to its mouth (Ganga Sagar), draining eleven states of India. The river Ganga is home to a vast variety of living organisms from simple microscopic flora and fauna to a large assemblage of higher invertebrates and vertebrates .River quality is day by day deceased due to domestic and industrial effluents pollution threatens not only humans, but also more than 130 fish species, 83 amphibian species and the endangered Ganga river dolphin. Due to industrialization, the number of factories and population has increased rapidly. The riverine systems has be greatly infected with pollutants released from industrial, domestic, mining and agricultural effluents.

Common carp and Tilapia are are commercially exploited species in Ganga which are used to evaluate the health of aquatic ecosystems because pollutantsare buildingup in the food chainandare responsible for adverse effects and death in the freshwater ecosystems. The entire stretch of river Ganga (mainstream) can be viewed into three segments where each segment is further divided into 5 stretches. These three segments not only differ in their geomorphology, ecology and theology but are different in terms of issues that need to be addressed:

- Upper Ganga ≈ 294 km Gaumukh to Haridwar
- Middle Ganga ≈ 1082 km Haridwar to Varanasi (Kanpur to Bihar) stretch
- Lower Ganga ≈ 1134 km Varanasi to Ganga Sagar.

Figure 1 Represents critically polluted stretch, Source: Status paper on river Ganga

ORIGINALLY THE ECOLOGICAL SETUP OF RIVER GANGA

Ganga is a prime example of lotic ecosystem. It is referred as running water ecosystem, which has current were in, water is in motion. Before 30 years, the values of dissolved oxygen (DO) - exhibited a more or less stable pattern in Ganga. The average values ranged between 6.8-7.2 mg/l. The values were generally above 4.0 mg/l. Higher values were recorded in winters at Haridwar, Allahabad, Varanasi and Patna. There were only minor fluctuations. Biochemical oxygen demand (BOD) - depicts the pollution status of a stream and is measured as oxygen equivalent of organic matter. The values exhibited higher pollution level higher which was recorded at Kanpur downstream 15.5 mg/l, 14.15 mg/l, 16.39 mg/l and Coliform- the variation in total coliforms was 48333, 916667 and 835333 mpn/100 ml. The stretch from Kanpur – Varanasi- Bihar remains critical and needs focused attention Further, Ganga passes along 29 class-I cities and about 48 towns. Most of the cities had no Sewage Treatment Plants or even if the plants existed, they were not functional or needed augmentation. There were several polluted stretches along its course where Ganga was critically polluted at Middle Ganga stretch {Kanpur-Bihar} as shown in (Fig-1)

PRESENT SCENARIO

According to the latest update received by CPCB, the actual measured discharge of wastewater is 6087mld, which is much higher thanthe estimated discharge of wastewater in 2013. CPCB estimates shows that 64 industries in the mainstream of Ganga consume 1123mld of water and discharge 500mld of effluent.

STPS are ineffective because of factors like lack of electricity, lack of connectivity with drain etc. that contributes 90% of Ganga water pollution. 3000mld of domestic wastewater is discharged into the river, which is roughly half of its total load. (14). Among the pollutants, toxic metals are of serious concern because they accumulate through the food chain and create environmental problems. Higher concentrations of heavy metals such as Mercury, Cadmium, Nickel, Lead, Arsenic, Zinc, Copper, Chromium. From industries forms Harmful complex

Water Quality Data of Ganga River During 1986-2008

Sl No	Station/ Location	Distance in km	1986		1993		2002		2005		2008		Standard values	
			DO (mg/l)	BOD (mg/l)	DO (mg/l)	BOD (mg/l)	DO (mg/l)	BOD (mg/l)	DO (mg/l)	BOD (mg/l)	DO (mg/l)	BOD (mg/l)	DO (mg/l)	BOD (mg/l)
1	Rishikesh (0 km)	0	8.1	1.7	9.0	1.3	8.2	1.2	8.5	1.0	8.1	1.2	5.0	3.0
2	Haridwar D/s (30 km)	30	8.1	1.8	7.2	1.4	7.8	1.7	8.1	1.4	7.9	1.4	5.0	3.0
3	Garhmukteshwar (175 km)	175	7.8	2.2	8.5	1.6	7.5	2.1	7.8	2.0	7.8	1.9	5.0	3.0
4	Kannauj U/S (430 km)	430	7.2	5.5	7.2	2.3	7.7	1.2	8.5	1.7	6.5	2.9	5.0	3.0
5	Kannauj D/S (433 km)	433	6.5	5.1	8.4	2.5	6.5	4.2	7.6	4.5	6.2	3.1	5.0	3.0
6	Kanpur U/S (530 km)	530	7.2	7.2	7.5	1.9	6.3	3.8	6.2	4.3	4.9	3.4	5.0	3.0
7	Kanpur D/S (548 km)	548	6.7	8.6	5.2	24.5	6.7	4.9	4.7	5.4	6.0	4.1	5.0	3.0
8	Allahabad U/S (733 km)	733	6.4	11.4	6.9	1.8	13.0	8.0	8.5	5.5	8.4	4.8	5.0	3.0
9	Allahabad D/S (743 km)	743	6.6	15.5	7.2	1.9	8.2	3.8	8.4	3.1	7.7	3.2	5.0	3.0
10	Varanasi U/S (908 km)	908	5.6	10.1	8.2	0.8	10.8	3.0	8.6	2.0	7.5	2.2	5.0	3.0
11	Varanasi D/S (916 km)	916	5.9	10.6	7.6	1.0	7.5	2.5	8.3	2.3	7.3	3.0	5.0	3.0
12	Patna U/S (1188 km)	1188	8.4	2.0	8.2	1.2	7.1	1.9	7.4	2.0	6.0	1.7	5.0	3.0
13	Patna D/S (1198 km)	1198	8.1	2.2	8.0	1.5	7.1	2.0	8.0	2.2	5.9	2.4	5.0	3.0
14	Rajmahal (1508 km)	1508	7.8	1.8	8.5	0.7	7.9	1.5	7.4	1.8	6.2	2.0	5.0	3.0
15	Patna (2050 km)	2050	7.3	1.0	7.1	0.9	7.3	2.7	7.0	3.0	6.9	2.2	5.0	3.0
16	Ulberia (2500 km)	2500	5.8	1.1	6.1	0.9	5.4	1.9	5.4	2.6	5.3	3.6	5.0	3.0

Table 1: Represents water quality data of Ganga River during 1986- 2008 Source: Status paper on river Ganga

Year	2009	2013
SEWAGE GENERATION(MLD)	2638	2723
TREATMENT CAPACITY(MLD)	1174	1208
GAP (MLD)	1464	1514
% GAP	55	55

Table 2: CPCB estimates the domestic sewage load on river Ganga from 2009-2013. Source: Status paper on River Ganga

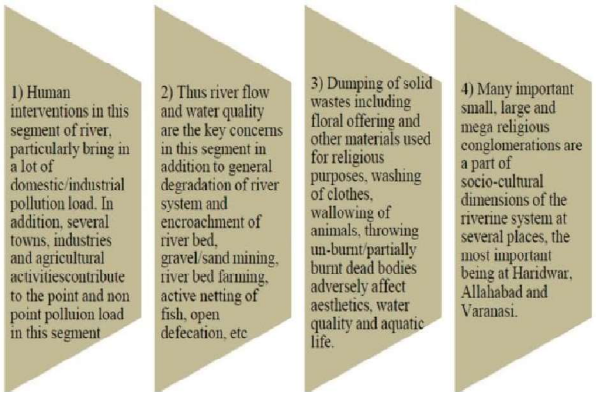


Fig 2: Represents factors causing pollution Source: Author

compounds, which critically effect different biological functions and are of potential risk to aquatic ecosystem, animal, and humans.

FOOD CHAIN IN FRESH WATER ECOSYSTEM (KANPUR-BIHAR STRETCH)

Fish population predominates depending upon grazing and detritus food chain. The next portion has Turtles, Crocodiles, Ghariyals and Gangetic Dolphin along with active breeding sites. Thus, there is one-way flow of energy through the biotic community

And recycling of nutrients between the biotic and abiotic components of the ecosystem. Thus, any ecosystem requires a continuous flow of energy to fuel life processes and to replace energy loss as heat.

Phytoplankton's (Algae, diatoms) – Zooplanktons - Small Fish - Carnivorous fish - Grass – Rabbit - Fox

The ultimate source of energy is Sun. The ultimate fate of energy in ecosystem is for it to be lost as heat, metabolism, reproduction, etc. energy and nutrients are passed from one organism to the another through the food chain as one eats another. Inorganic nutrients are cycled, Energy is not. Decomposers remove the last energy from the remains of organisms.

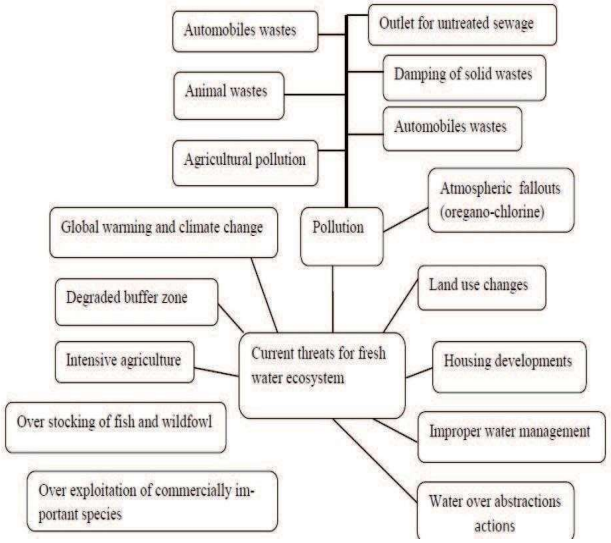


Fig 3: Represents summary of factors, which are threats for the sustainable functioning of River. Source: Author

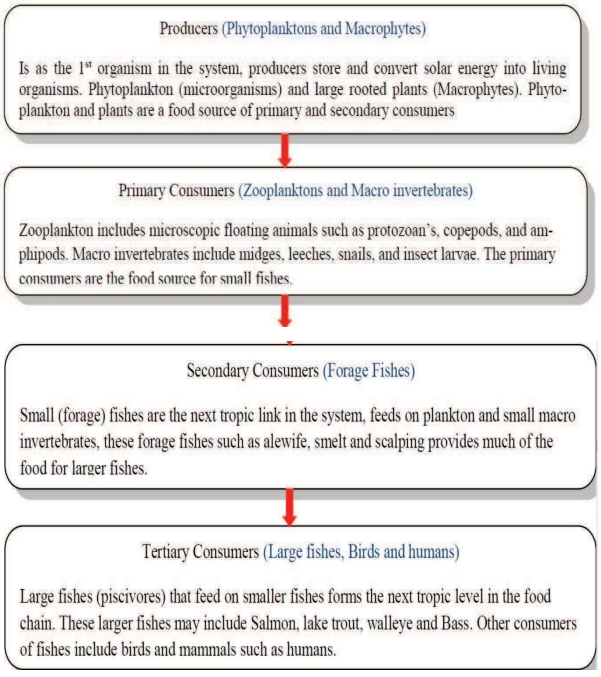
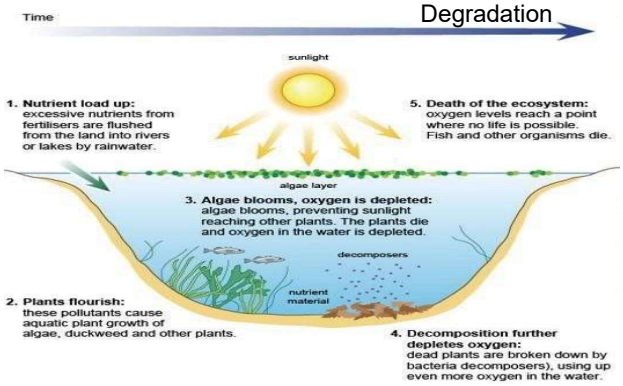


Fig 4: Represents the hierarchy of food chain in the eco-system Source: Author

How Water Pollution affects the Fresh water Ecosystem?

Wastewater and runoff carry micro plastics into waterways - Plastic objects are broken down into smaller pieces by sunlight and surf/detergent actions - Marine plastics are often mistaken for food - Persistent bio accumulative and toxic Compounds in freshwater ecosystem preferably sorbs to plastics. Bioaccumulation may be amplified by plastics shuttling pollutants into marine organisms - Potential plastic mediated- Bioaccumulation - At the same time, constituents of the plastic processes accumulate themselves such as additives leach into the tissues of the organisms that consume particles. Similarly compounds of heavy metals that are found in this stretch from industries and are toxic.



CHARACTERISTICS OF POLLUTANTS WHICH LEADS TO DISTURBANCES OF NATURAL PROCESSES

Algae are microscopic plants that usually aquatic, unicellular, and lack stems, roots and leaves. Nitrates and Phosphates enter the system (such as sewage, fertilizers from agricultural run-offs) increased nutrients causes surface plant growth and algal blooms. It occurs in freshwater environment when an algal species out competes other species and reproduces rapidly. It kills fish and other aquatic life by decreasing available sunlight to water and by using all the available oxygen in the water, due to which water becomes cloudy and turns green, yellow brown or red, which lead eutrophication. It occurs when nitrite leaches into the water body and causes severe reduction in species diversity and water quality. Which results into the disturbance of Nitrogen cycle and Carbon cycle of the river. In aquatic environments (like freshwater- river), blue-green algae is an important free-living nitrogen fixer. Bacteria (called Nitrogen-fixing bacteria) form symbiotic relationships with host plants. The bacteria live in nodules found in the roots of the legume family of aquatic plants.When an organism excretes waste or dies, the nitrogen in its tissues is in the form of organic nitrogen Various fungi and prokaryotes then decompose the tissue and release inorganic nitrogen back into the ecosystem as ammonia in the process known as ammonification (Fig-8).The ammonia then becomes available for uptake by plants and other microorganisms for growth. Further, as result disturbed Nitrogen cycle in surface water, extra nitrogen can lead to nutrient over-enrichment. This leads to fish-kills, harmful algal blooms, and species shifts in aquatic and land ecosystems. Some forms of nitrogen (like NO3- and NH4+) also enter the atmosphere to become smog-nitric oxide(NO), Greenhouse gas- nitrous oxide (N2O) and Acid Rain- (nitrogen oxides) thus degrades the climate.

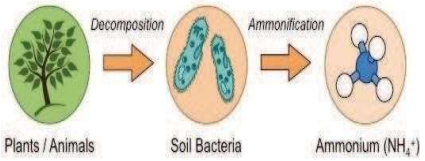


Fig-6: Represents Process of Ammonification Source: Nitrogen Cycle ppt.

In addition, Dissolved oxygen, also called DO, is vital to the health of aquatic ecosystem. Plants and animals need oxygen to survive. A low level of Dissolved oxygen in the rivers is affected by weather and temperature. It is important to monitor DO, since it can be used as an indicator of water quality. Algae produce oxygen during the day through photosynthesis but also quickly consume oxygen at night during respiration. Bacteria decompose the algae after the bloom dies, using a significant amount of oxygen in the process, which results in lack of available oxygen for other plants and animals Carbon dioxide, also called CO2, is found in water as a dissolved gas. It can dissolve in water 200 times more easily than oxygen. Aquatic plants depend on carbon dioxide for life and growth, just as fish depend on oxygen. Plants use carbon dioxide during the process of photosynthesis. Sometimes carbon dioxide levels in water become too high. Pollution causes too much carbon dioxide. Resulting into disturbance of CO2 cycle, which leads to the unhealthy state of ecosystem. In these conditions, fish have a hard time getting the oxygen they need from the water. Because of which they suffocate and die.

HOW POLLUTION AFFECTS ABIOTIC COMPONENT?

Cold water holds more oxygen than warm water because Salmon needs a high level of oxygen to survive; they live in fast-moving, coldstreams and rivers. Whereas warm-water fish such as bluegills, crappie, perch, walleye, catfish and carp can tolerate lower levels of dissolved oxygen in the water. Dissolved oxygen (DO) used as an indicator of water quality. Anoxia occurs when oxygen levels are low and often results when dry, hotweather causes waterto warm andevaporation increases. If these conditions are severe, large “fish kills” (floating dead fish) may result due to lack of oxygen Carbon dioxide, also called CO2, is found in wateras a dissolvedgas. Itcan dissolve in water 200 times more easily than oxygen. Aquatic plants depend on carbon dioxide for life and growth, just as fish depend on oxygen. Thus for a healthy and

sustainable ecosystem balance between Biotic and Abiotic has to be maintained.

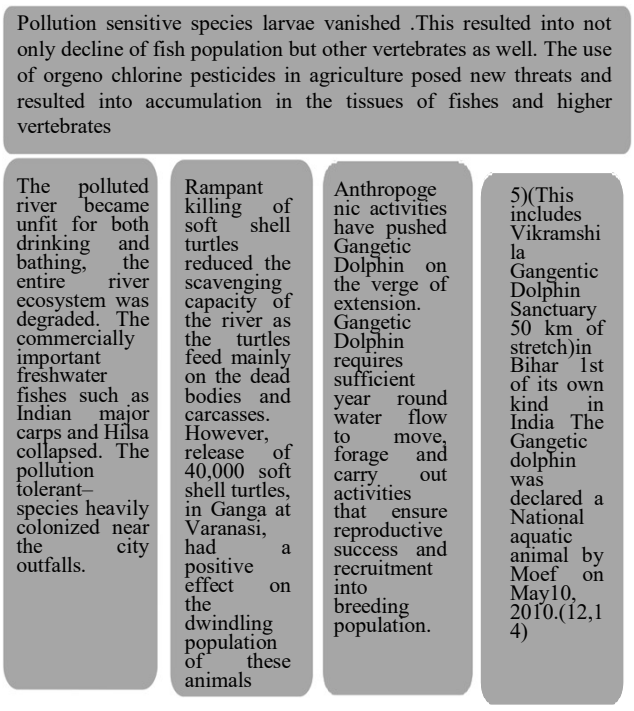


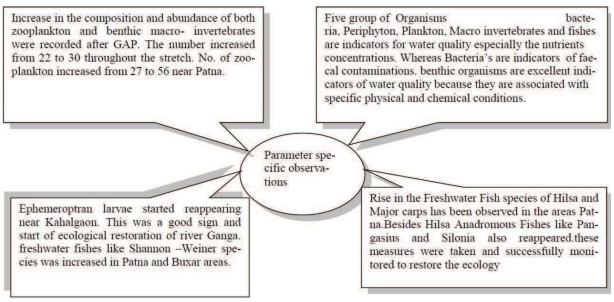
Fig7: represents observations made for the process of restoration Source: Author

The BOD levels were higher and maximum values were recorded at Kanpur (Fig-2).

OBSERVATIONS

Among five zones in the middle stretch of river Ganga, a total of 143 fish species belonging to 58 genera and 24 families were recorded. 29 species are threatened due to pollution in fresh water eco system. Schemes for Interception, diversion and Activated Sludge Process (ASP) and Oxidation Ponds were adopted for treatment of sewage, low cost sanitation, 28 electric crematoria and 5 Riverfront developments were successfully taken under Ganga Action Plan, phase I.

PARAMETER SPECIFIC OBSERVATIONS



RESTORATION MEASURES (TOOLS)

The following restoration measures seem inevitable in river ecosystem to bring river Ganga to sustainable, stable and healthy condition.

a. To provide enough space for endemic(prevalent) species of both flora and fauna for growth and migration through Environmental Flows (E-Flows) by maintaining the lateral, vertical and longitudinal connectivity in the entire stretch of Ganga system.

b. To provide connectivity with wetlands. Restoration of wetlands may be made point of focus to ensure breeding sites of fish and other aquatic animals.

c. From the above study, it is evident to identify all the species including zoo benthos, fishes and aquatic higher vertebrates, which come under rare, endangered and threatened category, should be conserved to maintain ecological integrity.

d. Breeding sites for fish and other higher aquatic vertebrates should be identified and con-served. Soft and hard-shelled turtles lay eggs in the flood plains during the post monsoon period.

e. To assess and monitor river health, primary data collection for all parameters including bio monitoring from selected stretches should be done by recognized and reputed research institutions
through empowering and involving local riverside communities.

f.Use of chemical fertilizers and pesticides in agricultural in flood plains and riparian zone be regulated and restricted.

CONCLUSION

The study indicates that the River Basin has started showing signs of recovery and physio- chemical conditions of the river has improved discernibly. Fish diversity and biomass has start- ed showing increasing trends inspite of many adverse factors, besides pollution invasion of exotic species is another big threat for the river biota. The river basin is one of the most thickly populatedareas of the world. It sustains thousands of aquatic species of flora and fauna including many endemic and charismatic mega-fauna like the Ganges dolphin, (12,14) Gavials etc. However, since 1950s the river is facing threats of erosion of its ecological integrity due to an- thropogenic pressures in the form of construction of dams, barrages andembankments; loss of forest cover in its catchment area leading to heavy siltation, pollution from industrial effluents and domestic sewage degrading the water quality to the extent that the river water is not fit for even bathing purpose. Nevertheless, the river harbours rich and abundant aquatic biodiversity. The ecological changes cannot be attributed entirely to GAP but definitely it played an important role(14,16).The Eco-Restoration of big river like Ganga is subsequent of this recovery, and re- quires constant efforts, monitoring time and patience.

RECOMMENDATIONS AND SUGGESTIONS

a. Large daily fluctuations in flow should be avoided. Equilibrium between sediment erosion and deposition is necessary to maintain essential habitat features.

b. Access to flood plains should be preserved to ensure natural spawning and rearing habitat for fishes, which are prey base of the dolphins. Enhancing the capacity and governance framework for Gangetic Dolphin conservation is needed.

c. Information on the pre development ecological conditions of a river is essential for evaluating migration efforts and to implement future development decisions. Post development empirical studies are needed to monitor the operational aspects as well as the effects on upstream and downstream populations of cetaceans and their habitat.

d. Effective construction of fish passage structure is necessary. Conventional fish ladders de-signed may not be successful because most fishes do not jump. In the middle stretch of the river Ganges (Allahabad), which used to form a good share in catches below Allahabad, has almost disappeared after inception of Farakka barrage despite fish ladders were installed. Steps should be taken to improve fish pass way so that the fishes may negotiate upstream areas.

e. Cumulative and synergistic impacts of multi development should be considered in assessment of environmental impact.

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INTERNATIONAL DESIGN COMPETITION 2023

Reclaiming Urban Waters

A story about urban aquaculture as a form of urban commoning ensuring a resilient chain of food supply in Slave Island, Colombo 02, Sri Lanka.

Sri Lanka is facing its worst economic crisis since its independence in 1948. As a consequence, a quarter of the population in Sri Lanka is now estimated to live below the poverty line, which compromises their ability to access sufficient, nutritious food (World Bank, 2022/23).

Amidst these unprecedented challenges, urban poor of Colombo have turned to urban farming as a coping mechanism to ensure food security in their households (Figure 01). However, despite its potential, urban farming encounters a critical limitation: the inability to ensure sufficient dietary diversity. Due to spatial constraints and other limitations, urban farming often allows for only a selective range of crops to be cultivated. This compromises the nutritional diversity which is crucial for fighting against food insecurity effectively.

As a solution to overcome these limitations, a Malay community in Slave Island, known for its rich culture and varieties of food, introduced urban fish farming in 'Beira Lake' Colombo to tackle food insecurity, all while promoting their cultural practices, social values, and environmental stewardship. **And this is their story!**

Figure 01

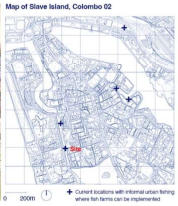


Figure 02

Fishing in the Beira Lake is no breaking news story. Not very long ago, fishing for what is popularly known as 'Beira Batto' was a leisure time activity or for personal consumption.But today, fishing in this polluted lake has become a lucrative business (Figure 02). Unfortunately, unhygienic waters and overfishing has made it an unsustainable trade because it has severely depleted the fish population making it hard for the ecosystem to sustain itself. Therefore, this intervention attempts to achieve broader ecological goals while creating a resilient chain of food supply.

The design introduces productive infrastructure into Beira Lake, revitalizing the current local fishing practices. Local ways of construction and usage of materials will be employed to allow for greater design flexibility while reducing assembly cost and also, it allows many locals to participate in the process of design and construction. The scheme operates across multiple scales, starting from the immediate household level it responds to, extending towards broader ecological goals on a larger urban scale.

Broader ecological goals

Water quality improvement
Floating Treatment Wetland (FTW) systems are being used to filter and purify water, enhancing the overall water quality in urban areas. Fish farming setups in multiples places with FTWs can collectively help in maintaining local water bodies.

Ecosystem restoration
Urban ecosystems will be restored by reintroducing native fish species to urban waters and by controlling the environment from invasive species.

Climate resilience
The farm can adapt to varying natural conditions, such as fluctuations in water levels during rainy seasons, ensuring continuity in fish production despite climatic variations. This will be achieved by employing local ways of construction that can respond to local conditions. The farm will be designed in a human scale that is easier to be monitored, so the locals can respond to what is happening.

Sustainable water use
Incorporating rainwater harvesting into fish farming practices promotes responsible and sustainable use of water.

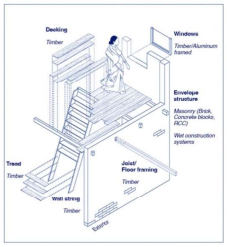
Educational and awareness
These farms will be used as a tool to raise awareness about aquatic ecosystems, sustainable food productions, rainwater harvesting, environmental stewardship and low-tech sustainable construction systems.

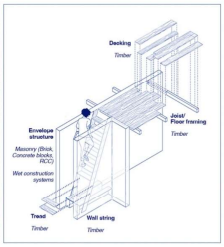
Understanding local ways of construction

The details of aesthetics and the structural logic of this scheme is shaped by the local ways of construction, materiality, and ways of occupying space as it supports to reduce construction and assembly cost while allowing for greater design flexibility. Implementing traditional and innovative local methods ensures better adaptation and durability in changing environmental contexts.

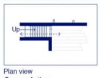
Existing building systems

Existing building systems in common single and multi-storey households and public buildings were studied to understand their existing knowledge on materiality and construction methodologies.

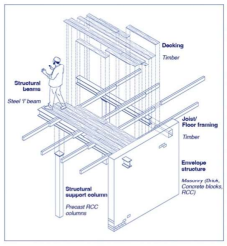




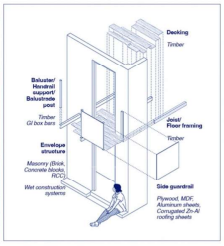
Isometric blow-up diagrams of common two-storey houses in Slave Island
Source: Author



Plan view
Source: Author

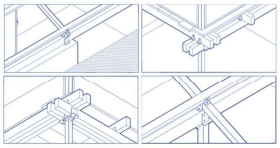


Isometric blow-up diagram of the two-storey Masjidul Jamiah Mosque in Slave Island
Source: Author



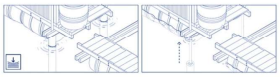
New building systems

New building systems have been derived for the interventions, building upon the existing materials and methodologies. The new modular systems allow for a wide range of interventions, ranging from small roadside eateries to large fish farms.



Interchangeable Modules
The components of these building systems are carefully designed to be interchangeable, meaning they can be easily replaced or modified without requiring significant alterations to the entire structure. This adaptability allows for quick repairs or upgrades in case of damage or evolving needs.

Enhanced Redundancy through Modularity
The modularity of these systems inherently builds redundancy. If one module fails or is affected by external factors (like extreme weather conditions), the redundancy ensures that there are alternative modules or mechanisms in place to maintain the overall integrity of the system.

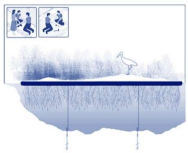


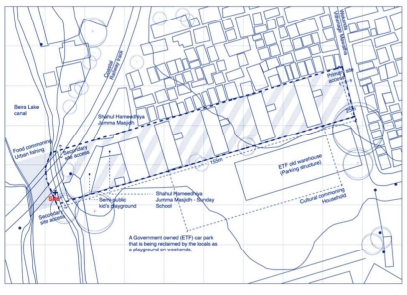
Floating mechanism
The structure sits on concrete filled PVC tilts when the lake is on its natural water level and will start floating with the rise of the water level with the help of buoyancy in the plastic barrels attached to the structure. The structure will rise along with the guiding steel bars that keep the structures in place.

Rainwater harvesting system
This system is comprised of a gutter that is detached from the building and can be removed and maintained regularly as per the regulations in Colombo.

Floating Treatment Wetland (FTW)

Locals of Slave Island will get together and make FTWs by planting plants such as Cannas, Savandara and Heliconia using PVC pipes, bamboo, and foam mattresses as floating supports. Plants in floating wetlands absorb excess nutrients carried in the water. This reduces the amount of algae in the water and purifies the water, eliminates odours, and maintains an ecological balance by providing habitat for water-dependent organisms.





Map of Site:
Wekanda Social Housing

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"Beira Batto"
Redbreast tilapia
Coptodon rendalli

Reclaiming Urban Waters: A short story

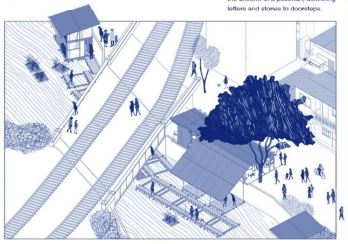
A story about urban aquaculture as a form of urban commoning ensuring a resilient chain of food supply in Slave Island, Colombo 02.

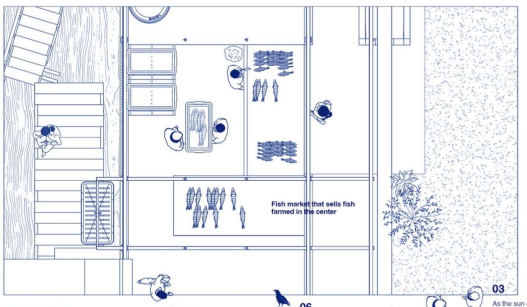
Latent scenario

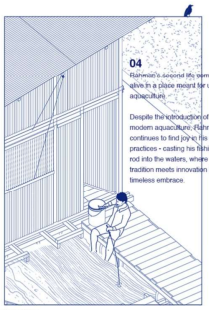
Material resource:	Material resource: Beira Lake canal
Commoners:	Local residents
Commoning:	Urban fishin (Food commoning)

01
In the heart of the bustling city, a forgotten water canal flowed silently beneath a railway bridge. But time and community's vision intertwined, and beneath that bridge, an urban fish farm emerged, turning the once neglected waters into a thriving source of sustenance for Slave Island.

02
There lived a man named **Rahman** who lives a life as dynamic as the city itself. By morning, he puts on the uniform of a postman, delivering letters and stories to doorsteps.

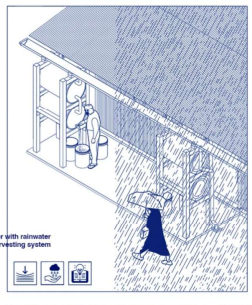






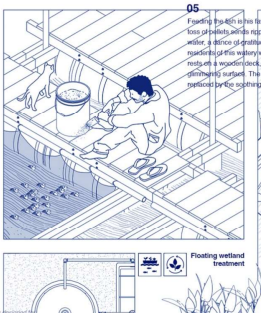
04
Rahman's second life comes alive in a place meant for urban aquaculture.

Despite the introduction of modern aquaculture, Rahman continues to find joy in his old practices - casting his fishing rod into the waters, where tradition meets innovation in a timeless embrace.



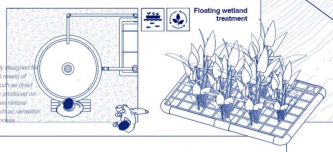
UDA of Colombo doesn't allow buildings in low-income settlements to have rainwater gutters as they pose a plausible threat towards the wellbeing of the locals because they are inaccessible and lacks maintenance resulting in growth of dengue mosquitos and other deadly illnesses.

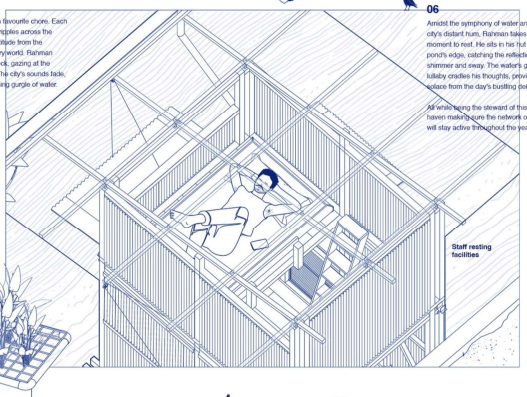
As a response, a gutter system with rainwater harvesting has been introduced that advocates regular maintenance and accessibility.



05
Feeding his fish is his favourite chore. Each toss of pellets sends ripples across the water, a dance of gratitude from the residents of this watery world. Rahman rests on a wooden deck, gazing at the shimmering surface. The city's sounds fade, replaced by the soothing gurgle of water.

Diets specially designed to meet the nutritional needs of farmed fish such as direct pellets will be produced on site and utilizes natural resources such as rainwater during the process.





06
Amidst the symphony of water and the city's distant hum, Rahman takes a moment to rest. He sits in his hut by the pond's edge, catching the reflections shimmer and sway. The water's gentle lullaby cradles his thoughts, providing solace from the day's bustling demands.

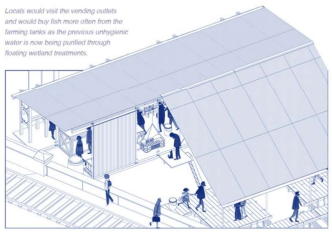
As while being the steward of this aquatic haven makes sure the network of food will stay active throughout the year.

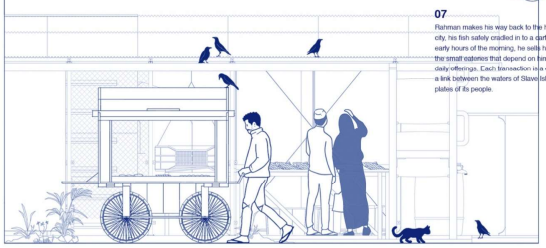
03
As the sun climbs higher, Rahman's path shifts. He makes his way to an urban aquaculture haven. In this oasis amidst the concrete jungle, Rahman became a fisherman.

Fishing in the Beira Lake is no breaking news story. Not very long ago, fishing for what is popularly known as 'Beira Batto' was a leisure time activity or for personal consumption. But today, fishing in this lake has become a lucrative business.

This is Rahman

Locals would visit the vending outlets and would buy fish more often from the farming tanks as the previous unhygienic water is now being purified through floating wetland treatments.





07
Rahman makes his way back to the heart of the city, his fish safely cradled in to a cart. In the early hours of the morning, he sells his catch to the small eateries that depend on him for their daily offerings. Each transaction is a connection, a link between the waters of Slave Island and the plates of its people.

08
And so, Rahman's life continues - postman by day, fisherman by night. His story, a testament to the beauty that thrives in the most unexpected corners of the city, reminds us that even amidst concrete and chaos, there are pockets of serenity and sustenance waiting to be discovered and his tale is a tribute to the intricate dance of life and the symbiotic relationship between the urban landscape and the natural world.

Rahman's story isn't just about fishing; it's about sustenance!

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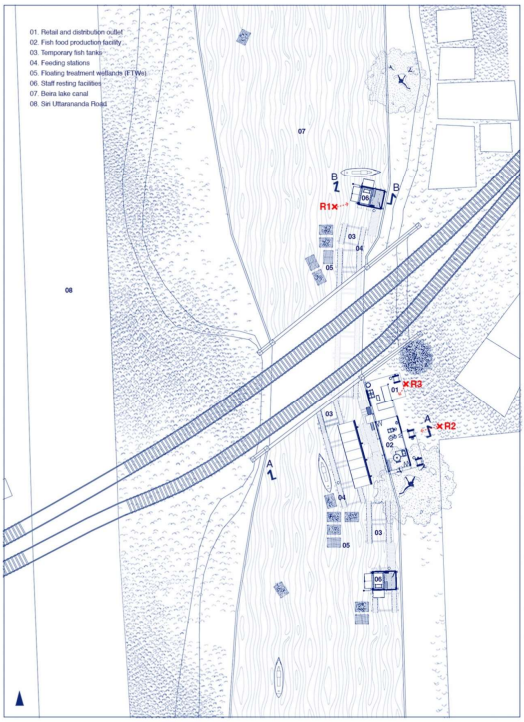
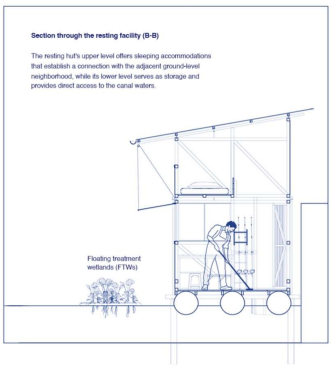


Rainwater harvesting system

This setup involves a design where gutters are not directly fixed onto the building but instead are mounted to an external timber structure. This timber structure not only supports the gutters but also functioning as a storage unit for the collected rainwater. This arrangement allows for easy access to the collected water directly from this external unit. With this setup, the gutters can be easily removed or accessed for maintenance without interfering with the operations of the farm.

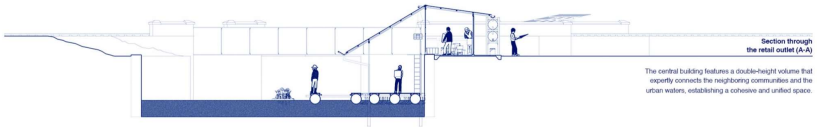
Section through the resting facility (B-B)

The resting hut's upper level offers sleeping accommodations that establish a connection with the adjacent ground-level neighborhood, while its lower level serves as storage and provides direct access to the canal waters.



Ground floor plan

The aquaculture center is strategically placed along the canal, integrated seamlessly into the landscape. This placement serves to harmoniously connect the local neighborhoods with the urban waters, resulting in a cohesive environment where these two domains unite.



Section through the retail outlet (A-A)

The central building features a double-height volume that expertly connects the neighboring communities and the urban waters, establishing a cohesive and unified space.

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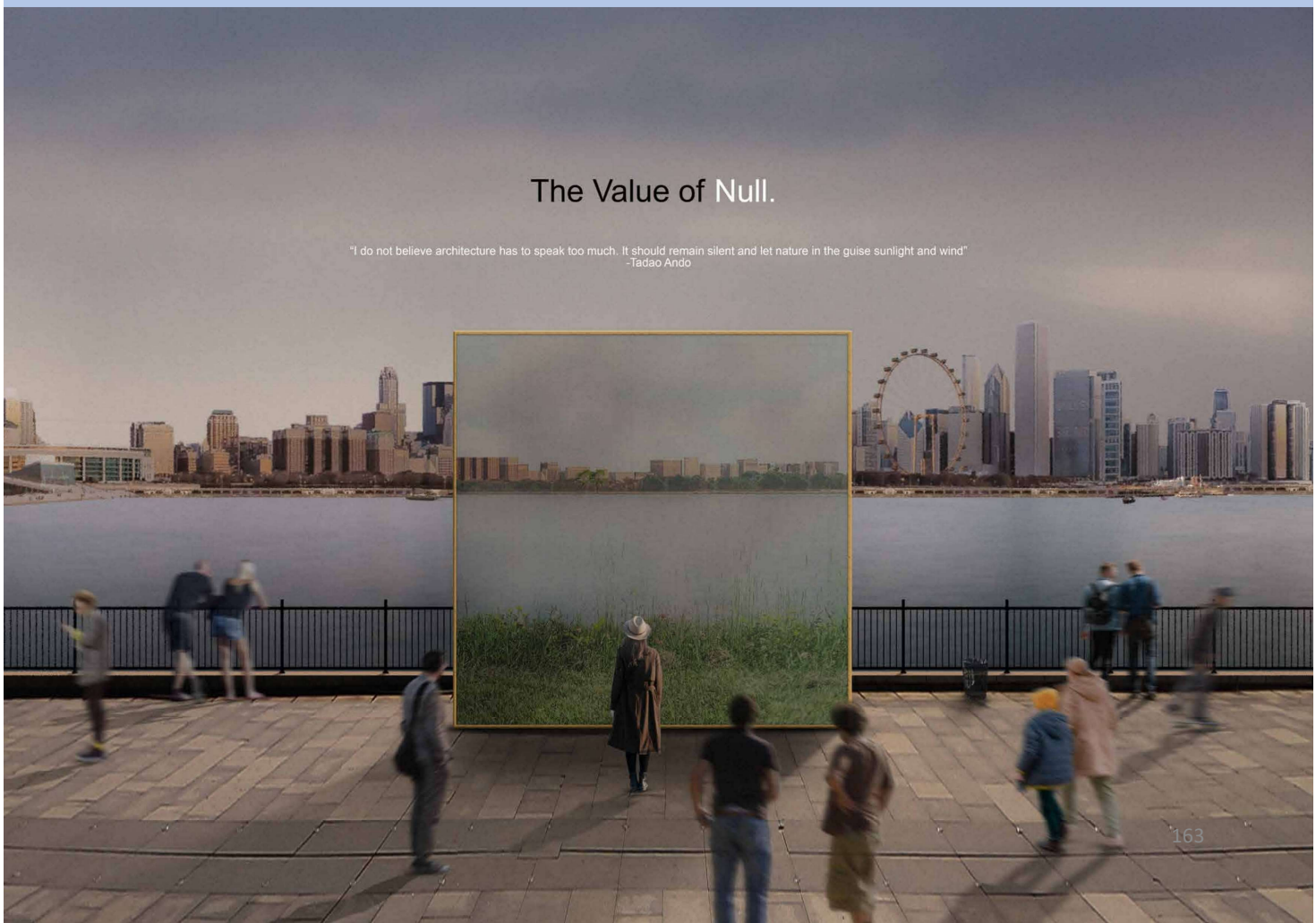
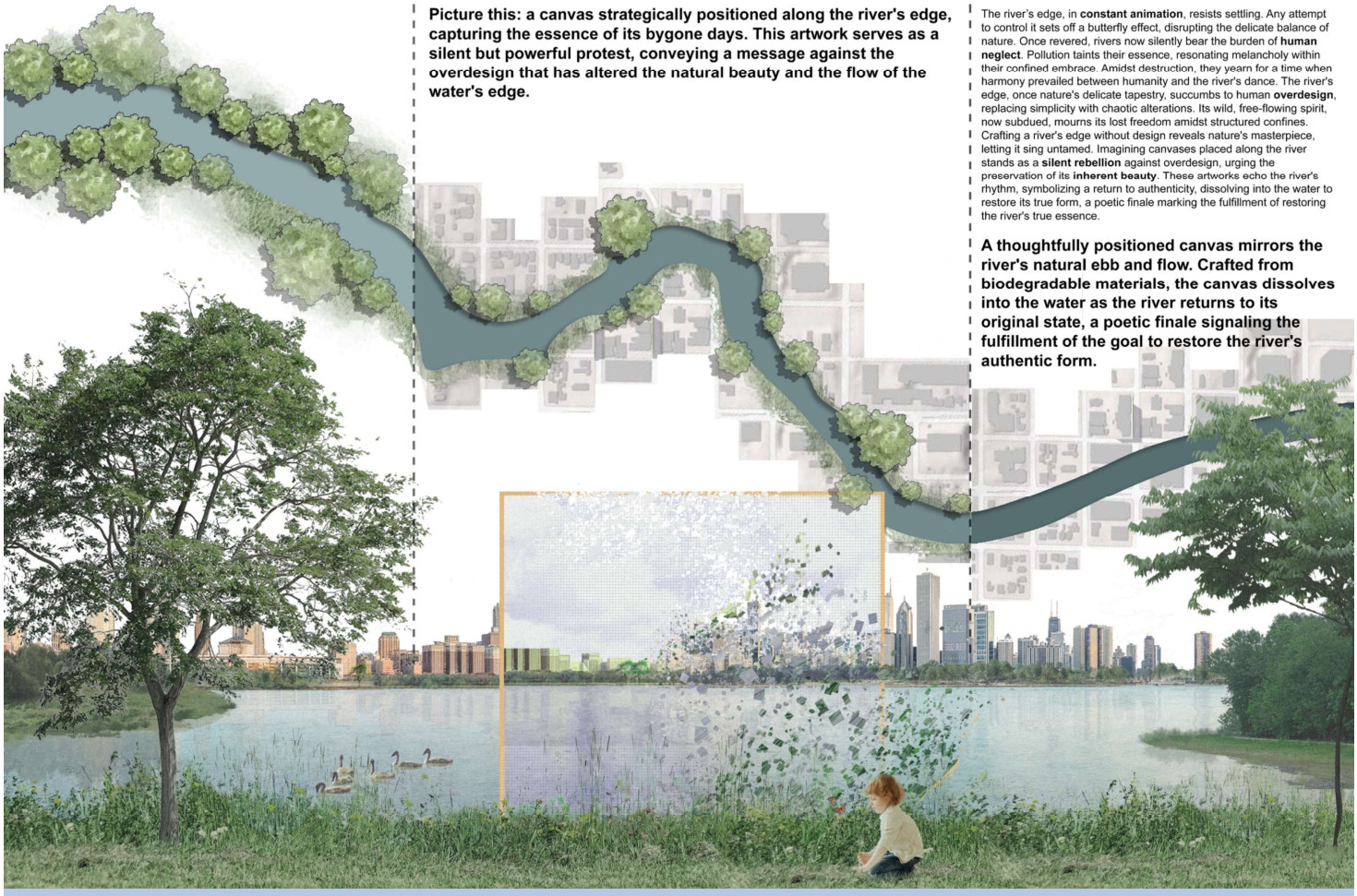
IDC WINNING ENTRIES – 2ND PRIZE

Julkarnain, Nafisa Anjum, Golam Ahammad Sunny





Picture this: a canvas strategically positioned along the river's edge, capturing the essence of its bygone days. This artwork serves as a silent but powerful protest, conveying a message against the overdesign that has altered the natural beauty and the flow of the water's edge.

The river's edge, in **constant animation**, resists settling. Any attempt to control it sets off a butterfly effect, disrupting the delicate balance of nature. Once revered, rivers now silently bear the burden of **human neglect**. Pollution taints their essence, resonating melancholy within their confined embrace. Amidst destruction, they yearn for a time when harmony prevailed between humanity and the river's dance. The river's edge, once nature's delicate tapestry, succumbs to human **overdesign**, replacing simplicity with chaotic alterations. Its wild, free-flowing spirit, now subdued, mourns its lost freedom amidst structured confines. Crafting a river's edge without design reveals nature's masterpiece, letting it sing untamed. Imagining canvases placed along the river stands as a **silent rebellion** against overdesign, urging the preservation of its **inherent beauty**. These artworks echo the river's rhythm, symbolizing a return to authenticity, dissolving into the water to restore its true form, a poetic finale marking the fulfillment of restoring the river's true essence.

A thoughtfully positioned canvas mirrors the river's natural ebb and flow. Crafted from biodegradable materials, the canvas dissolves into the water as the river returns to its original state, a poetic finale signaling the fulfillment of the goal to restore the river's authentic form.

IDC WINNING ENTRIES – 3RD PRIZE

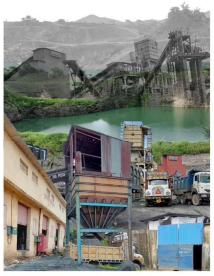
Jenil Sarvaiya

WaterQuarry: A Holistic Transformation of Neglected Landscapes

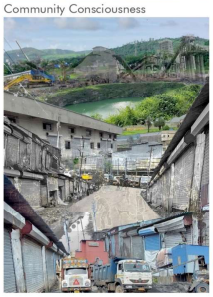
Project intent

The world is still rife with industrial wastelands, each one representing a stark rift in the contemporary landscape. It is within this challenging context that WaterQuarry emerges as a groundbreaking initiative, aiming to breathe new life into abandoned quarries. Rather than viewing these quarries as desolate spaces, WaterQuarry perceives them as untapped opportunities for transformative regeneration. This visionary project seeks to leverage the dynamic potential of water to create vibrant, sustainable spaces that harmonize both community life and the natural environment.

Why? preserve industrial heritage and altered landscapes



Community Consciousness

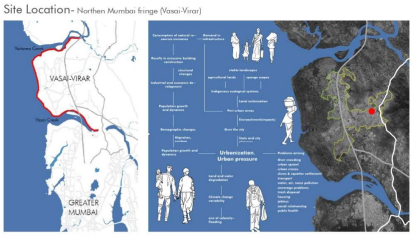


Post industrial landscape

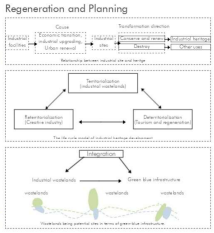
Satellite Image 2022

"Landscapes gives us an informative impression about the economic and technical development of a particular society; they are, in fact, more informative as they us a comprehensive, detailed and precise account of the state of the environment in a far better than any museum could better do"
-Walter Benjamin, Passagenwerk.

Site Location- Northern Mumbai fringe (Vasai-Virar)



Regeneration and Planning

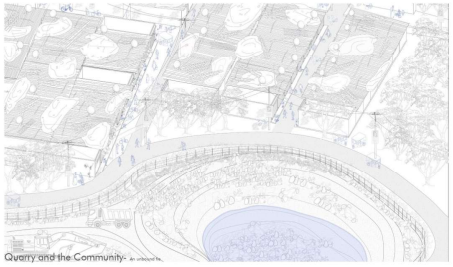


Basalt rock quarry lands

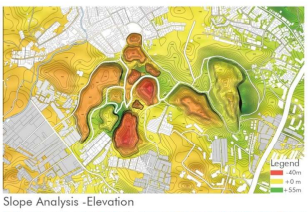
The quarry is located in Vasai taluka, Palghar district, Konkan division of Maharashtra. It lies along the Arabian sea coast north of Mumbai. Site is approachable from NH-48 at a distance of about 0.5km. The area over the region has exposures of Deccan trap basalt. This compact rock scales are quite strong. Before the quarry started, these lands were used for agriculture. Over several years, an industrial setting started to emerge around the quarry. Post-ubon, informal settlements started to form at the

Site Zones

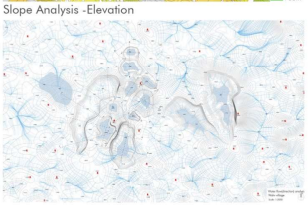
Site Photographs



Quarry and the Community- an unbound te...



Slope Analysis -Elevation

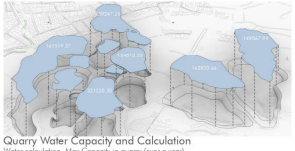


Water Flow, Ridge Valley Analysis

Taking in account the industrial part of the region, where sensitive ecology is being altered for years with no apparent results for these peri-urban areas, alteration of morphologies in a variety of ways can be seen. Many of these abandoned industrial wastelands in industrial zones are left with deteriorated negative spaces that once held significance. This thesis found its premise on the question of what happens to such desolate landscapes and how one may turn such spaces into positive ones since, as of yet, one has only gained poorly from the ugliness it creates. What emerges in these wastelands?

1. What has led to the divide between the waste land and the community? What's the possibility of reviving such spaces?

2. How does architecture tend to play its role or as a connecting bridge between the quarry as a waste land and community?

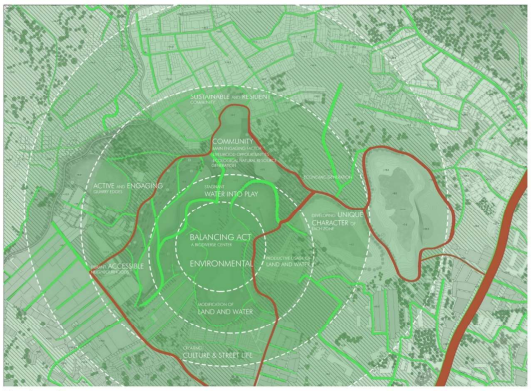


Quarry Water Capacity and Calculation

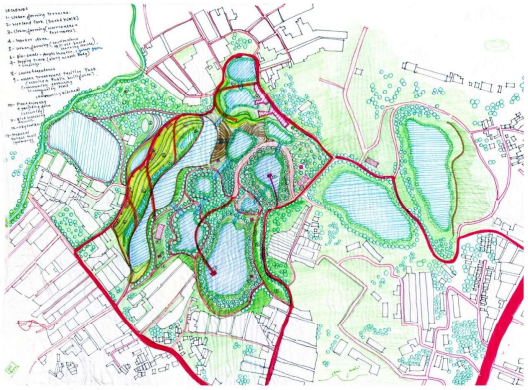
Water calculation- Max Capacity in quarry (over a year)
Total Volume - 1160297.4 cu.m
Litres - 1116,05,23,200 L

Water served per house- 135L -90 L from Muncipal co-operative
-45 L - Building complex manages from outside or borewell

Water filled in quarry (comes in 45L of section)
Total- 116,05,23,200 L per year
- 45 L per person x 365 days
No. of people served - 70,655
Water will be used for secondary purpose like Flushing, washing etc. Also in industrial activities.



Design Strategy



Concept Sketch

Summer Season Site Condition

Monsoon Season Site Condition

Site Analysis

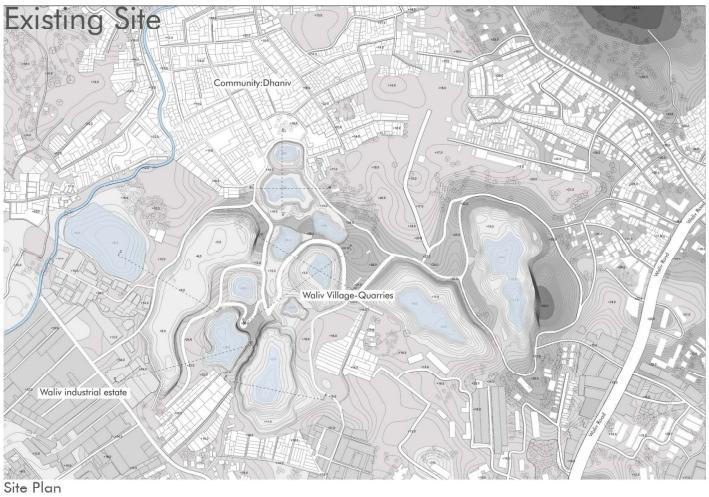
1.Enhancing local food sustainability and fostering community connections.

2. Promoting biodiversity and contributing to overall ecological balance.

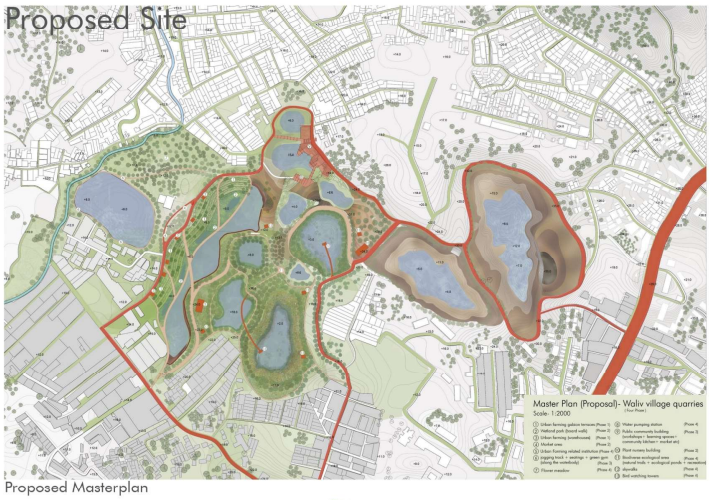
3. Establishing spaces where water unifies, encouraging social interactions and a sense of belonging.

4. Integrating markets and recreation areas with water features, fostering local economic growth while respecting nature.

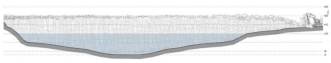
5. Create unique breathing spaces in the industrial region, departing from traditional processes to offer unconventional hubs for regeneration.



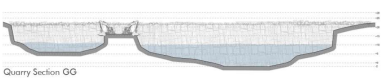
Site Plan



Proposed Masterplan



Quarry Section EE(AA)



Quarry Section GG

Building Section CC

Building Section DD

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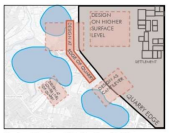
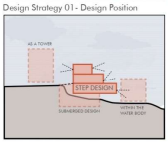
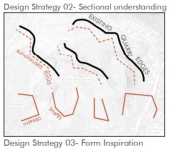


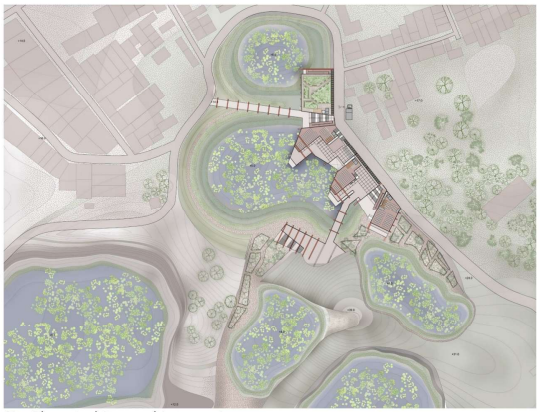
Design Strategy 01- Design Position



Design Strategy 02- Sectional understanding

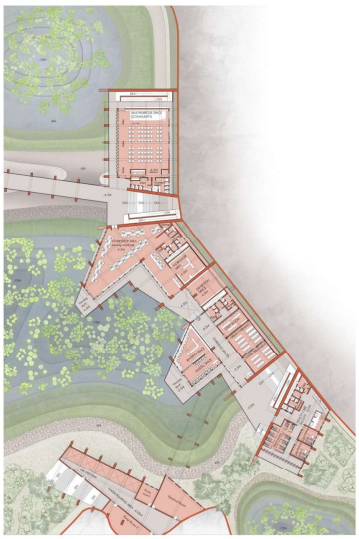


Design Strategy 03- Form Inspiration

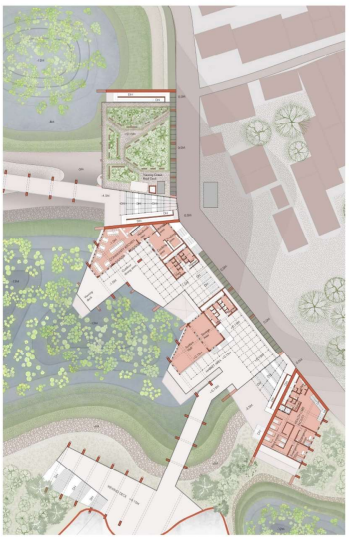


Site Plan- Architectural intervention

Exploded Axonometric View, Framing the Design, Quarry Greens and Water



Ground Floor Plan

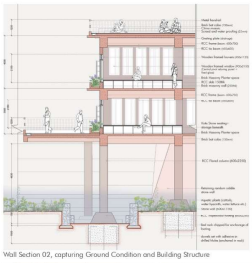


First Floor Plan

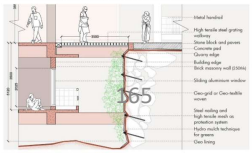
Section AA'

Elevation

Section BB'



Wall Section 02, capturing Ground Condition and Building Structure



Quarry Edge and Steel Deck Detail

Oishani Chowdhury

SMRITISUDHA | The Life of death

Thanatogical space and mnemonic ritualization study - an urban necropolis for the 'greater good'

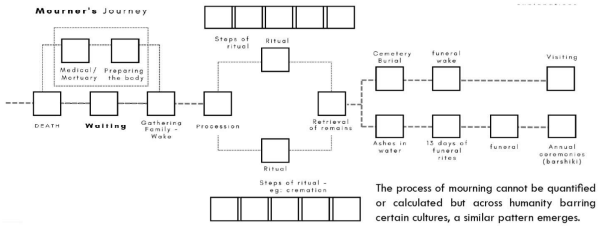
allegorical | necropolis | for the living

thanatology
the scientific study of death and the practices associated with it, including the study of the needs of the terminally ill and their families.

allegory
a story, poem, or picture that can be interpreted to reveal a hidden meaning, typically a moral or political one

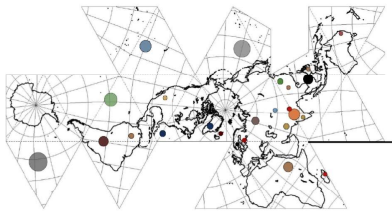
mnemonic ritual
looks at the uncomfortable subject of loss, mourning, and the remnants of what was. Too often the ritual passage of death and loss are shuffled along at a pace so quick, there is little time to reflect.

Necropolis - thanatological spaces interpreted to relive or represent the lives of the departed, hence **ALLEGORY**.

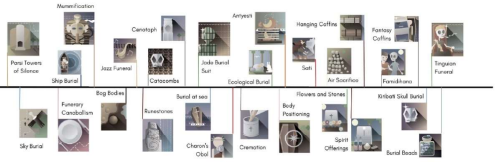


The process of mourning cannot be quantified or calculated but across humanity barring certain cultures, a similar pattern emerges.

memory | legacy | water | death | living ;



Mapping of funerary rituals or activities in the world

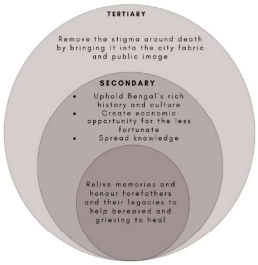


Contextualizing the Project

Theme development and concerns addressed

The central concern of "Smritisudha" is to create a thanatological space that transcends conventional notions of funerary and memorial architecture. This project aims to provide a sanctuary for individuals and communities to engage in the process of grieving, remembrance, and acceptance.

"Smritisudha" seeks to bridge the gap between the living and the departed, fostering an environment where memories are cherished, and legacies are honoured. The space is intended to remove the stigma surrounding death, bringing it back into societal discourse as a natural part of the human experience using the river landscape as an element of healing connecting .



INTENT DIAGRAM

NEED FOR THE PROJECT

In India, Funerary Architecture falls short in providing spaces for solace and reflection for those who are grieving.

A myriad of spiritual expressions coexist alongside a burgeoning population increasingly opting for non-religious identities

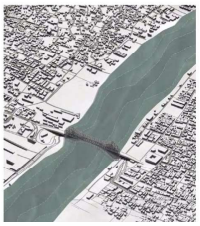
Death is still considered a taboo in modern society.

Contextualizing the Project

Site and Context

SITE CRITERIA

1. flowing water as a way of beginning and ending representing life,
2. urban population,
3. rooted in traditions and cultural memory,
4. proximity to death related spaces,
5. opportunity to bring death as a positive character into the city fabric



The selection of the Old Salt Golah on the banks of the river Hooghly, locally revered as the Ganga, is foundational to the projec- scenic site, steeped in history, offers profound connection to local identity.

To enhance the connection with the Howrah Bridge, the project will incorporate visual and symbolic elements that echo the bridge's iconic form. The interplay of light and shadow will be choreographed to emulate the dance of sunlight on the waters of the river.

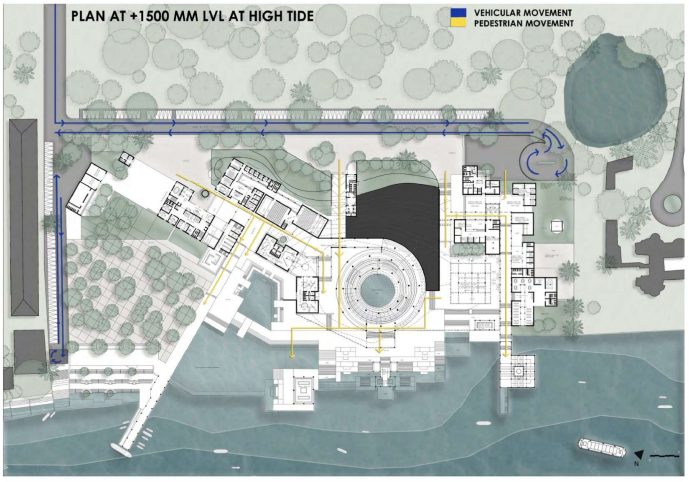
Additionally, elements such as arches and spans will be subtly integrated into the architecture, paying homage to the bridge and further strengthening the project's conceptual link to the idea

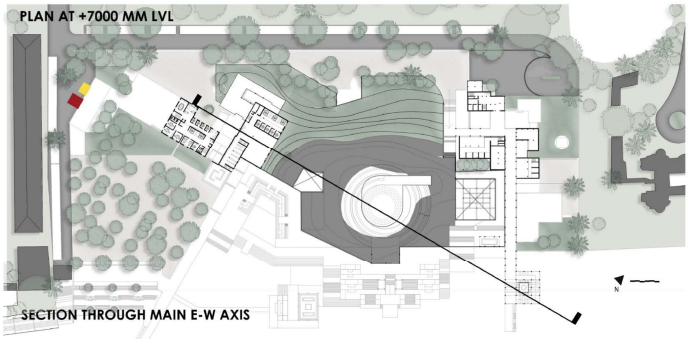
Proposed Intervention

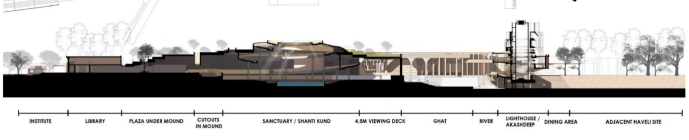
The plan follows the axis which when extended to the opposite ghat runs through Nimtala burning ghat forming a connection to a space of departure of the soul. The organisation of blocks follows the original grid of golahs rotated to align to the aforementioned axis.

LEGEND

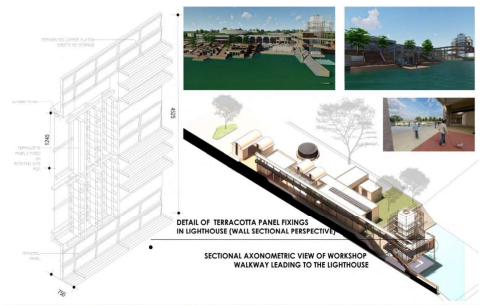
1.Front view from river at an angle of an approaching 'nouka' or boat (top)
garden of ashes
2.Front jetty ghat
3.View from boats of ghat and lighthouse
4. Plaza view between institute and office
5.Pushpanjali kund
6.Exhibition gallery

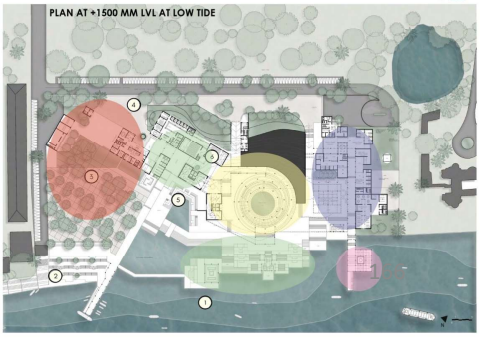


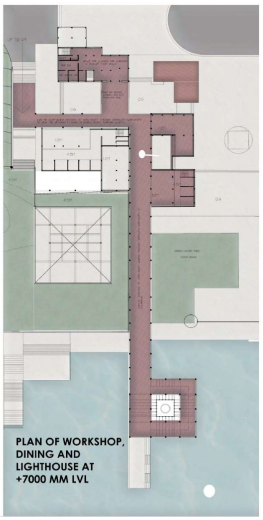


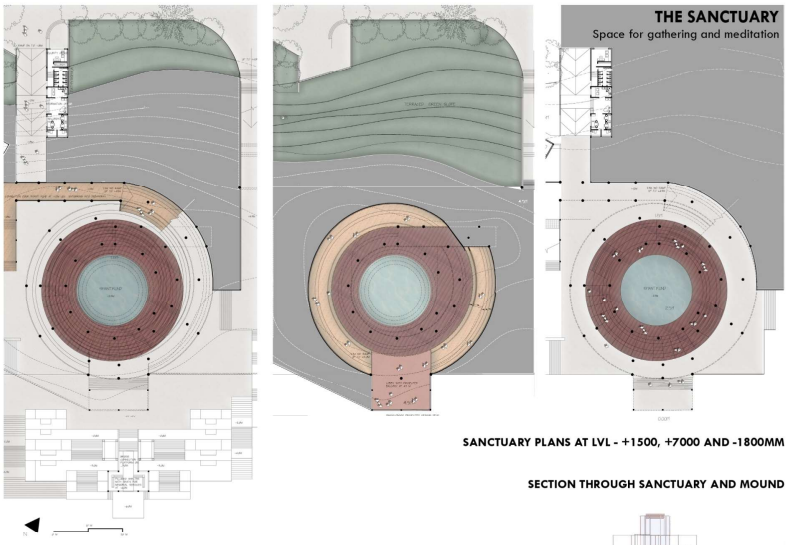


5 Archetypes of Shared Human Experience as Spatial Interpretation



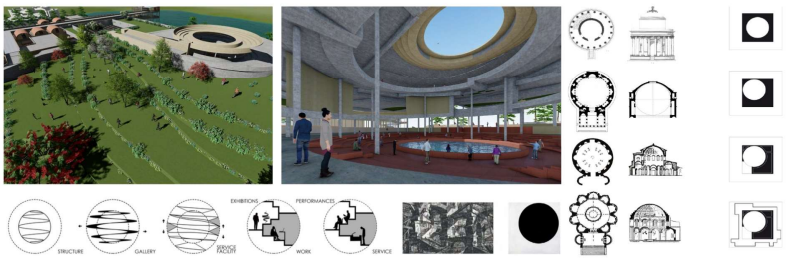






SANCTUARY PLANS AT LVL - +1500, +7000 AND -1800MM

SECTION THROUGH SANCTUARY AND MOUND



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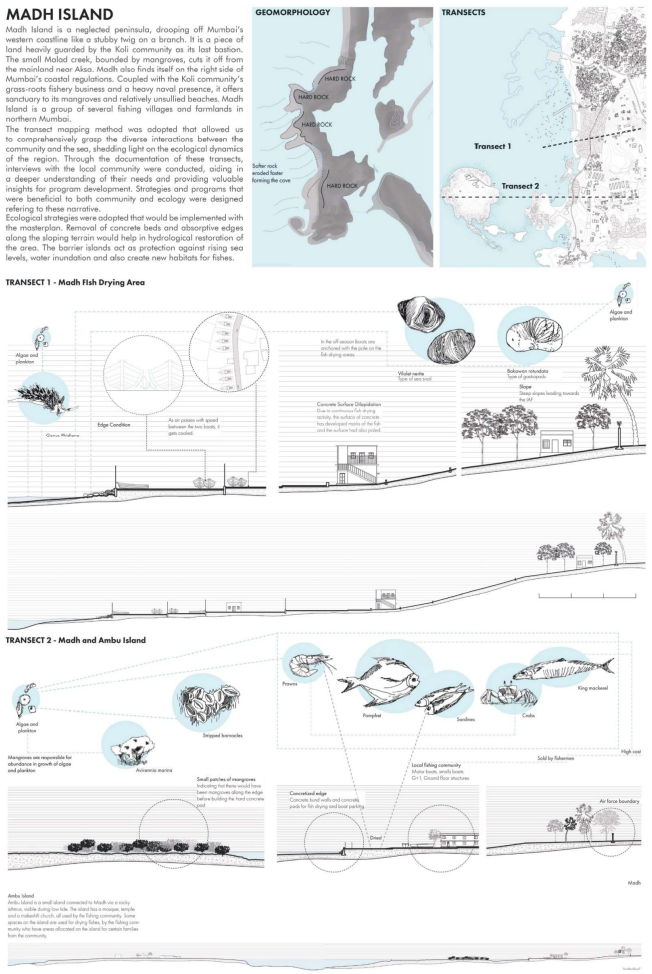
HONORABLE MENTIONS

Tejas Bilaya, Kshitij Churi




Silver Beach

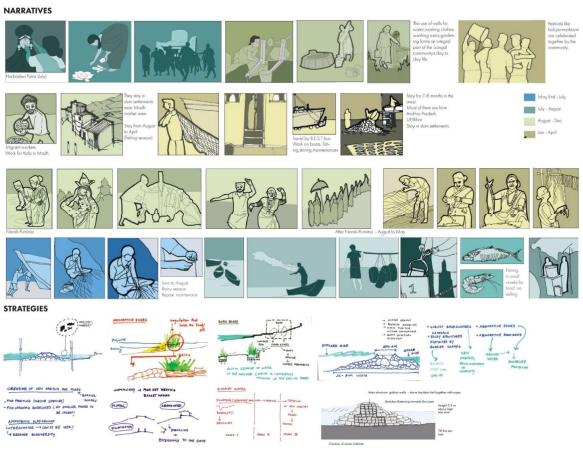

Silver Beach - Tourist area

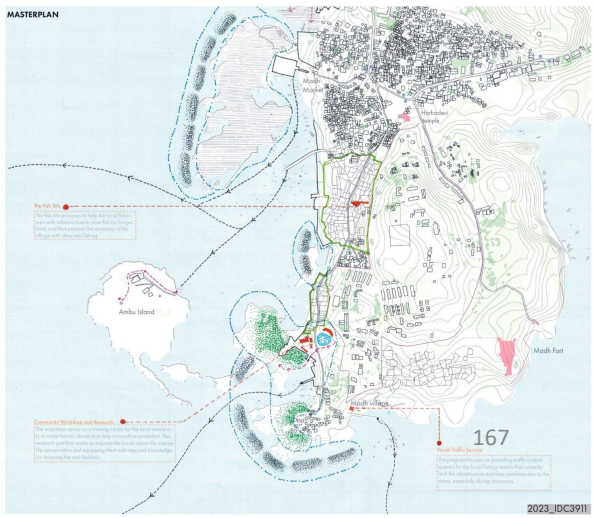

Madh Village - Rocky edge & concrete edge


Madh Village - Fish drying

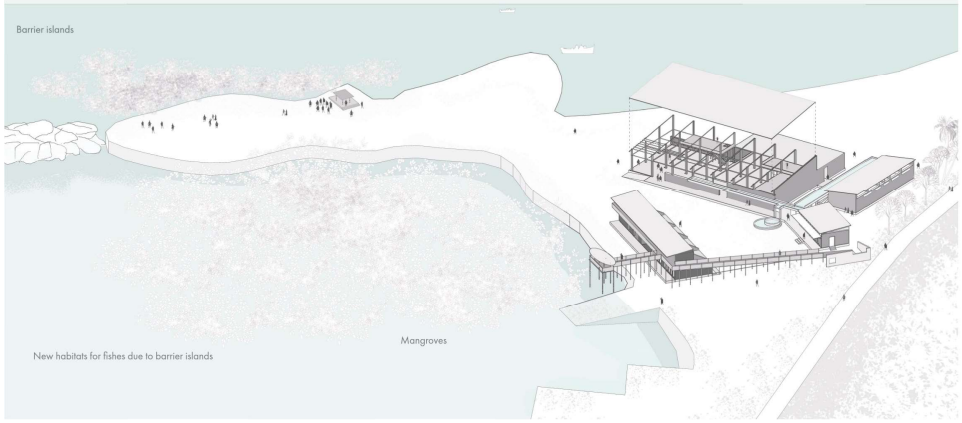

Madh Village - Rocky edge

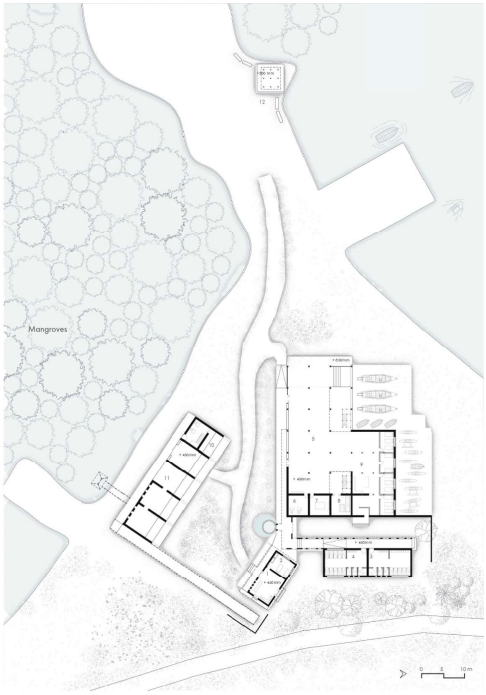

Madh Fort - Backside





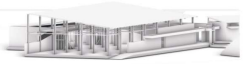
TRAINING CENTRE WITH WORKER'S PAVILION AND RESEARCH INSTITUTE

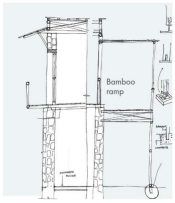




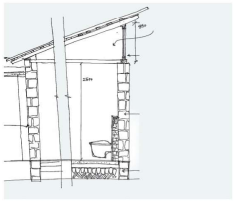
The community workshop operates as an eco-conscious training center empowering the local community to skillfully craft sustainable stone walls and gabion structures. These creations play a pivotal role in fortifying barrier islands, contributing to coastal protection, and fostering the development of new habitats. The research pavilion is dedicated to enlightening locals about marine life conservation, offering essential knowledge to nurture the emerging habitats. The exhibition spaces, watchtowers, and marine trails are strategically designed to encourage meaningful interactions among locals, researchers, and visitors, fostering a collaborative effort towards environmental awareness and preservation.

Massing iterations of the intervention

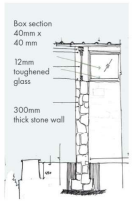




1 - Research Institute



2 - Washroom area details



3 - Worker's resting area

Materials that are contextual to the region are used. Joineries details of various materials like stone and timber are worked out.

1 - Research Institute

Stone walls on the ground floor support the bamboo flooring on the first floor

2 - Washroom area details

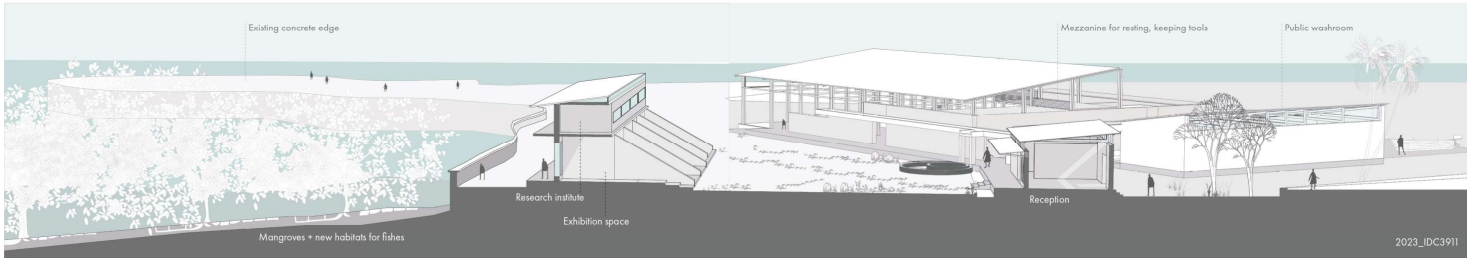
The design incorporates a sloping roof strategically oriented to maximize the influx of natural north light, enhancing the overall functionality and aesthetic appeal.

3 - Worker's resting area

Foundation details for stone walls was worked out.

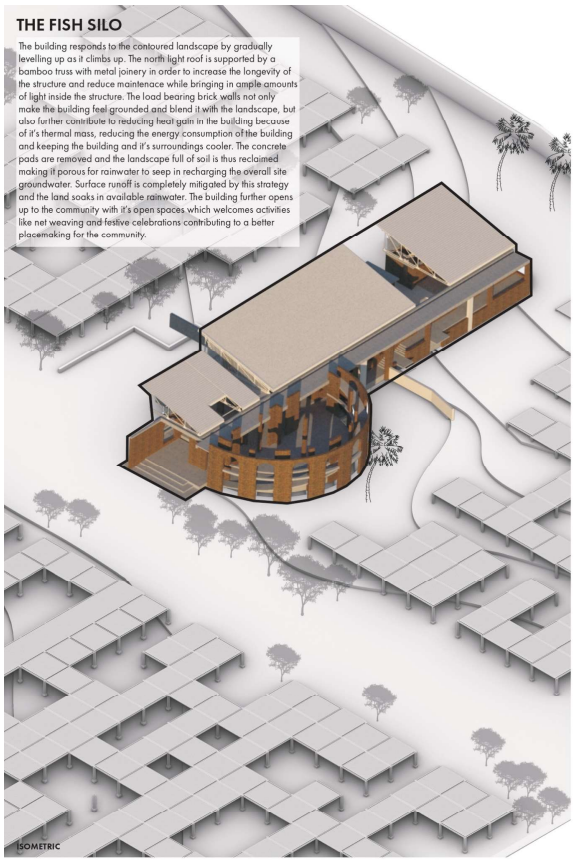
LEGEND

1 - Reception
2 - Resting area
3 - Public Washroom (M)
4 - Public Washroom (F)
5 - Workshop area
6 - Office
7 - Meeting room
8 - Storage
9 - Worker's resting area and canteen
10 - Research institute office
11 - Exhibition space
12 - Gathering space for workers



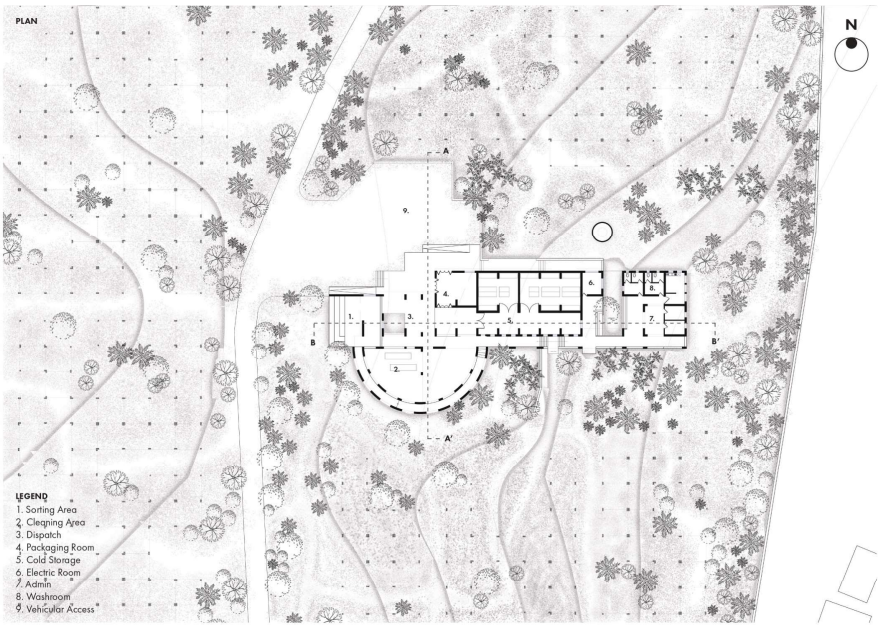
THE FISH SILO

The building responds to the contoured landscape by gradually levelling up as it climbs up. The north light roof is supported by a bamboo truss with metal joinery in order to increase the longevity of the structure and reduce maintenace while bringing in ample amounts of light inside the structure. The load bearing brick walls not only make the building feel grounded and blend it with the landscape, but also further constribute to reducing heat gain in the building because of it's thermal mass, reducing the energy consumption of the building and keeping the building and it's surroundings cooler. The concrete pads are removed and the landscape full of soil is thus reclaimed making it porous for rainwater to seep in recharging the overall site groundwater. Surface runoff is completely mitigated by this strategy and the land soaks in available rainwater. The building further opens up to the community with it's open spaces which welcomes activities like net weaving and festive celebrations contributing to a better placemaking for the community.



ISOMETRIC

PLAN



LEGEND
1. Sorting Area
2. Cleaning Area
3. Dispatch
4. Packaging Room
5. Cold Storage
6. Electric Room
7. Admin
8. Washroom
9. Vehicular Access

SECTION AA'

SECTION BB'

Bamboo Stilts
Bamboo stilts are used to raise the activity of fish drying above the ground and open the lower floor to activities and a more permeable landscape to help aid adequate percolation of rainwater.

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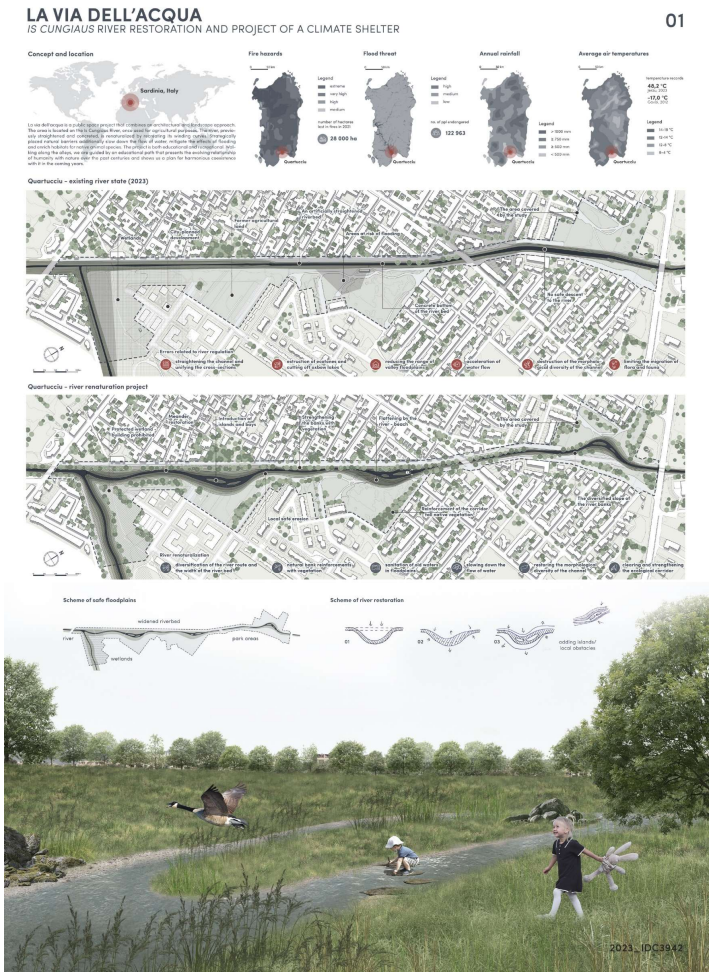
LA VIA DELL'ACQUA
IS CUNGIAUS RIVER RESTORATION AND PROJECT OF A CLIMATE SHELTER
01
Concept and location
Sardinia, Italy
Fire hazards
Flood threat
Annual rainfall
Average air temperatures
Quartucciu - existing river state (2023)
Quartucciu - river renaturation project
Scheme of safe floodplains
Scheme of river restoration
2023_IDC3942


LA VIA DELL'ACQUA
IS CUNGIAUS RIVER RESTORATION AND PROJECT OF A CLIMATE SHELTER
02
Function analysis
Exposition analysis
Form analysis
Land development project | scale 1:1 500
Composition scheme
Transportation scheme
Functional zones
Composition of greenery scheme
Local reduction of air temperature
Groundwater supply - fight against drought
Enhancement of the landscape with native vegetation
Wetland protection
Protection of fauna habitats in wetlands
Habitat elements
Safety zones/shelters
Stagnant/quiet flow zones
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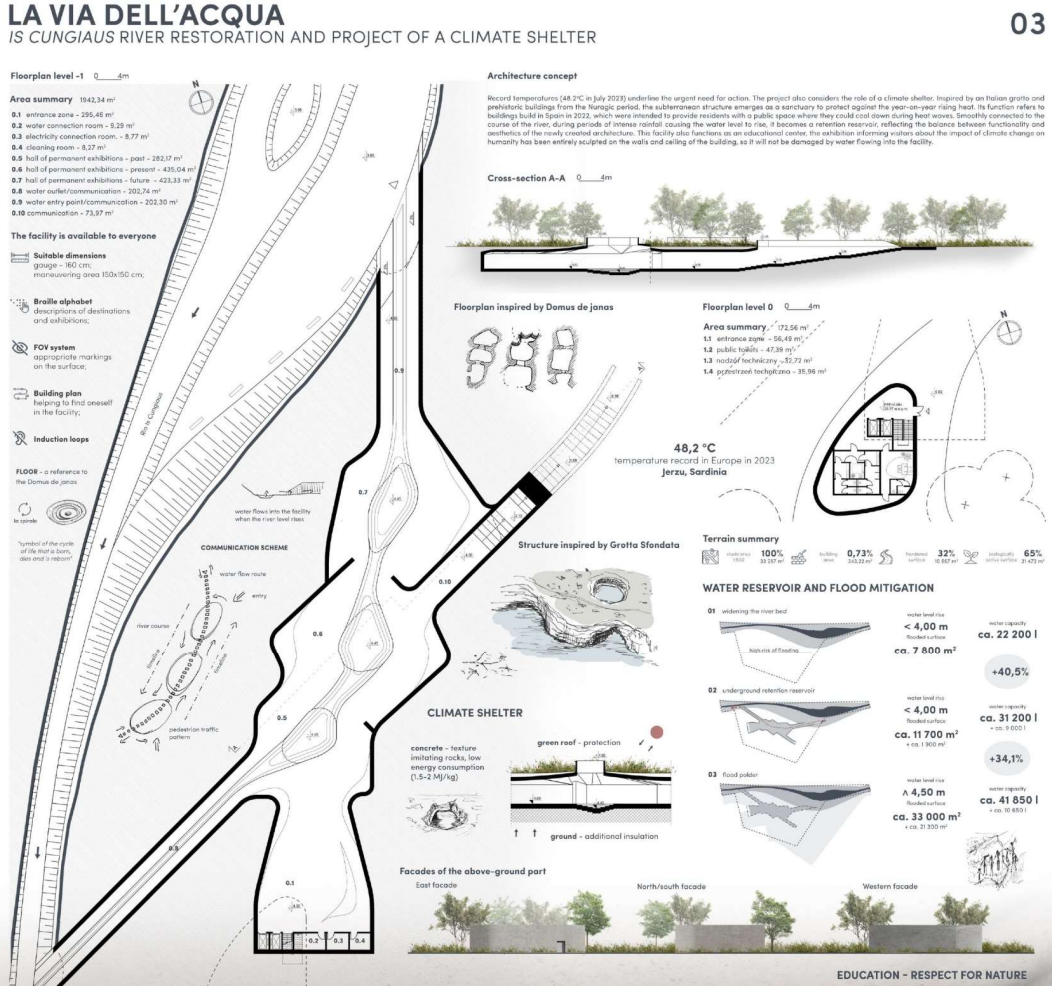
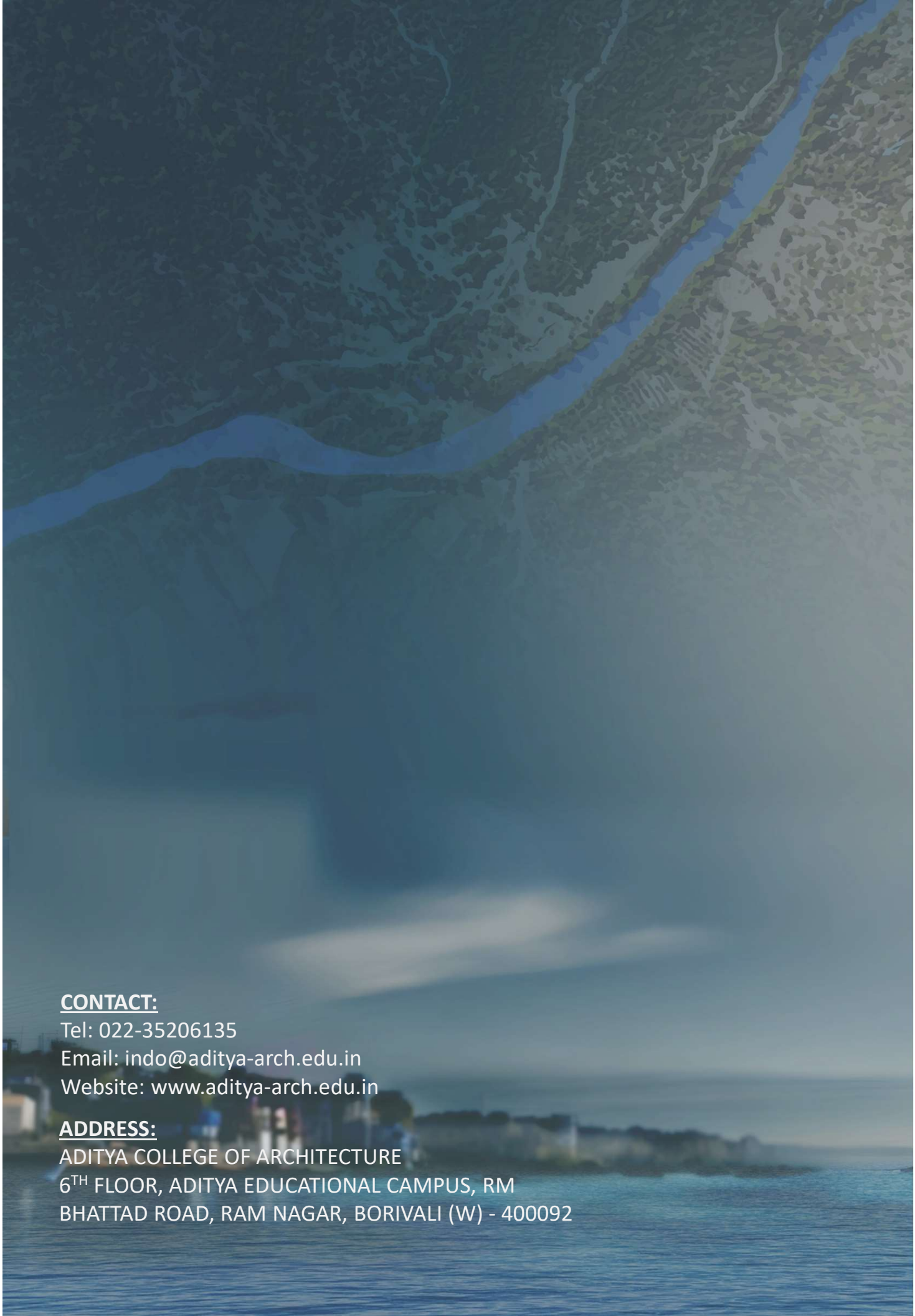

LA VIA DELL'ACQUA
IS CUNGIAUS RIVER RESTORATION AND PROJECT OF A CLIMATE SHELTER
03
Floorplan level -1
Area summary 1942,34 m²
0.1 entrance zone - 295,46 m²
0.2 water connection room - 9,29 m²
0.3 electricity connection room. - 8,77 m²
0.4 cleaning room - 8,27 m²
0.5 hall of permanent exhibitions - past - 282,17 m²
0.6 hall of permanent exhibitions - present - 435,04 m²
0.7 hall of permanent exhibitions - future - 423,33 m²
0.8 water outlet/communication - 202,74 m²
0.9 water entry point/communication - 202,30 m²
0.10 communication - 73,97 m²
The facility is available to everyone
Suitable dimensions
Braille alphabet
FOV system
Building plan
Induction loops
FLOOR - a reference to the Domus de janas
COMMUNICATION SCHEME
Architecture concept
Cross-section A-A
Floorplan inspired by Domus de janas
Floorplan level 0
Area summary 172,56 m²
1.1 entrance zone - 56,49 m²
1.2 public toilets - 47,39 m²
1.3 nodzaf techniczny - 52,72 m²
1.4 przestrzeń techniczna - 35,96 m²
48,2 °C
temperature record in Europe in 2023
Jerzu, Sardinia
Structure inspired by Grotta Sfondata
Terrain summary
WATER RESERVOIR AND FLOOD MITIGATION
CLIMATE SHELTER
concrete - texture imitating rocks, low energy consumption (1.5-2 MJ/kg)
green roof - protection
ground - additional insulation
Facades of the above-ground part
East facade
North/south facade
Western facade
EDUCATION - RESPECT FOR NATURE



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