Sponsored Thesis Project Competition on

“RE-IMAGINING URBAN RIVERS”

Season- 3

Project Title : Reviving ‘Poramboke’: A case of Pulicat Lagoon
Creator : M Divya B.arch

Community Welfare Centre for The Coastal Commons of Pulicat, Tamil Nadu

1. INTRODUCTION

1.1 Project Background

The drastic reduction of carbon sinks due to human-induced factors has led to a rise in global temperatures, causing climatic shifts. Climate volatility and an increase in water levels, directly impacting the coastal communities because of their geographical exposure. According to the United Nations, the most vulnerable are the communities belonging to the lower strata of the society, in the coastal regions of the developing nations, due to the lack of proper infrastructure, access to climate related information and their dependency on climate sensitive livelihoods like fishing and tourism. This necessitates external intervention for community so that they are economically, socially, and ecologically resilient.

The thesis is an inquiry into the interdependence of the community and the wetlands. Through community engagement and literature review, we try to recognize the community's aspirations and their socio-ecological vulnerabilities i.e., the social exclusion of the inhabitants from the basic facilities and several other economic and livelihood threats posed on them and their ecosystem due to its secluded geography and lack of sensitive resource management. intending to design and strategize how the built environment may intervene to enable the communities to coexist with the environment.

The project's goal is to intervene through an architectural design for the community that embraces local traditions while conceptualizing a new design that uplifts the communities and rethink how we perceive the wetland and their inhabitants.

1.2 Project Brief

The goal is to establish a built form to promote local art and artisans, offer skills for alternate sustainable sources of income, and uplift communities while rethinking the perspective of the wetlands and their inhabitants. The project envisions a built form that is sensitive to the landscape and fulfills the aspiration of the communities by intervening through an architectural design that facilitates, heritage of Pulicat, small-scale industries

and capacity building for a more sustainable source of income, in a manner to coexist

with natural biodiversity.

Table1.1 - Proposed Areas

Spaces	**Proposed Built area**
Craft Education Centre	7000 sqm
Food Court+ Restaurant	2000 sqm
Fish Market	500sqm
Total	**9500 sqm + Landscape**

1.3 Rationale

The existing art of palm leaf weaving in the community has the potential to thrive with the right support and exposure. However, there is currently a lack of infrastructure for training and capacity building in this area. The proposed community welfare center can address this issue by providing a dedicated space for artists to exhibit their work and providing opportunities for capacity building and training. The center can also help promote other local art forms, such as woodwork, shell art, and reed work, which can help diversify the community's sources of income.

One of the challenges that the community faces is the lack of space for promoting their art and other cultural activities. Therefore, the design of the community welfare center should prioritize creating a space that is flexible and adaptable to accommodate a range of activities. This will help blur the boundaries between communities and promote social cohesion.

Furthermore, the proposed fish market can become a landmark in the area if designed in a way that unifies with the sensitive surroundings. As the fish market is located in a CRZ 1 zone, it is crucial to ensure that the design is environmentally sustainable and does not harm the natural surroundings. The design should prioritize waste management and provide adequate space for sellers and buyers to operate safely.

In summary, the proposed community welfare center at Pulicat aims to address the challenges faced by the community due to the impact of climate change and rapid urbanization. The design can support the community in finding alternate sources of

income, promote local art and culture, and provide a safe marketplace for fresh seafood. The design should prioritize environmental sustainability, social cohesion, and flexibility to accommodate a range of activities.

1.4 Aim

To design an community welfare center for the coastal commons of Pulicat, Tamil Nadu to enhance resilience and blur the boundaries due to caste based or gender based deprivation.

1.5 Objectives

- To identify the needs and aspirations of the coastal commons of Pulicat. ● To analyze the existing infrastructure of Pulicat and derive the spatial requirement for the community.
- To study vernacular architecture of Pulicat and coastal areas to derive a sensitive design approach to livelihood-based communities.
- To Identify the relation between ecology, spatial design and livelihood. ● To Design for resilience to improve standard of living and the future of the community.

1.6 Scope and Limitations

Due to CRZ guidelines. The thesis limits its design to fish market expansion. There have been negotiations made owing to several factors such as cyclone resistance, tsunami resistance, eco sensitivity of site and the rurban character.

2. LITERATURE STUDY

2.1 Geography

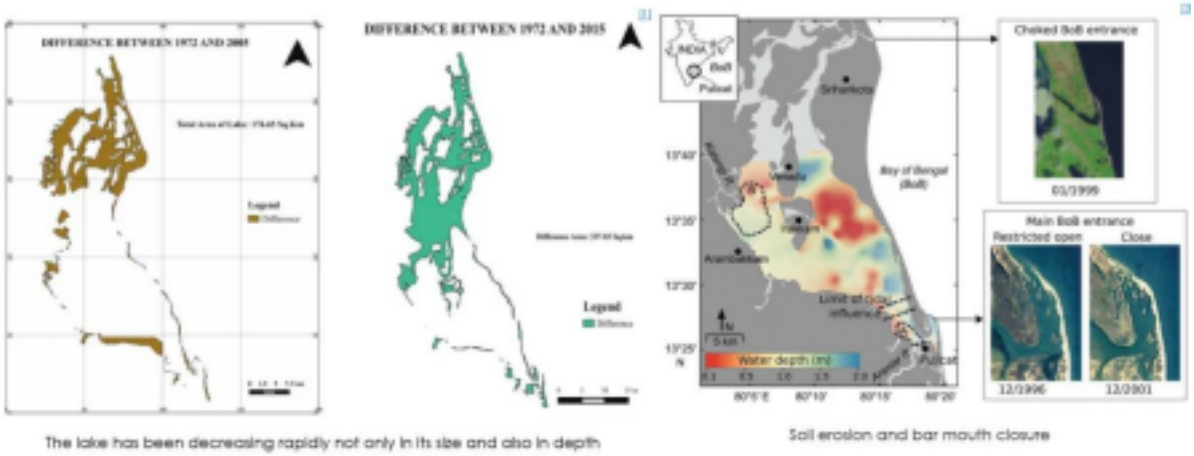
(Fig 2.1: Comparison of maps)

(Source: Web Archives)

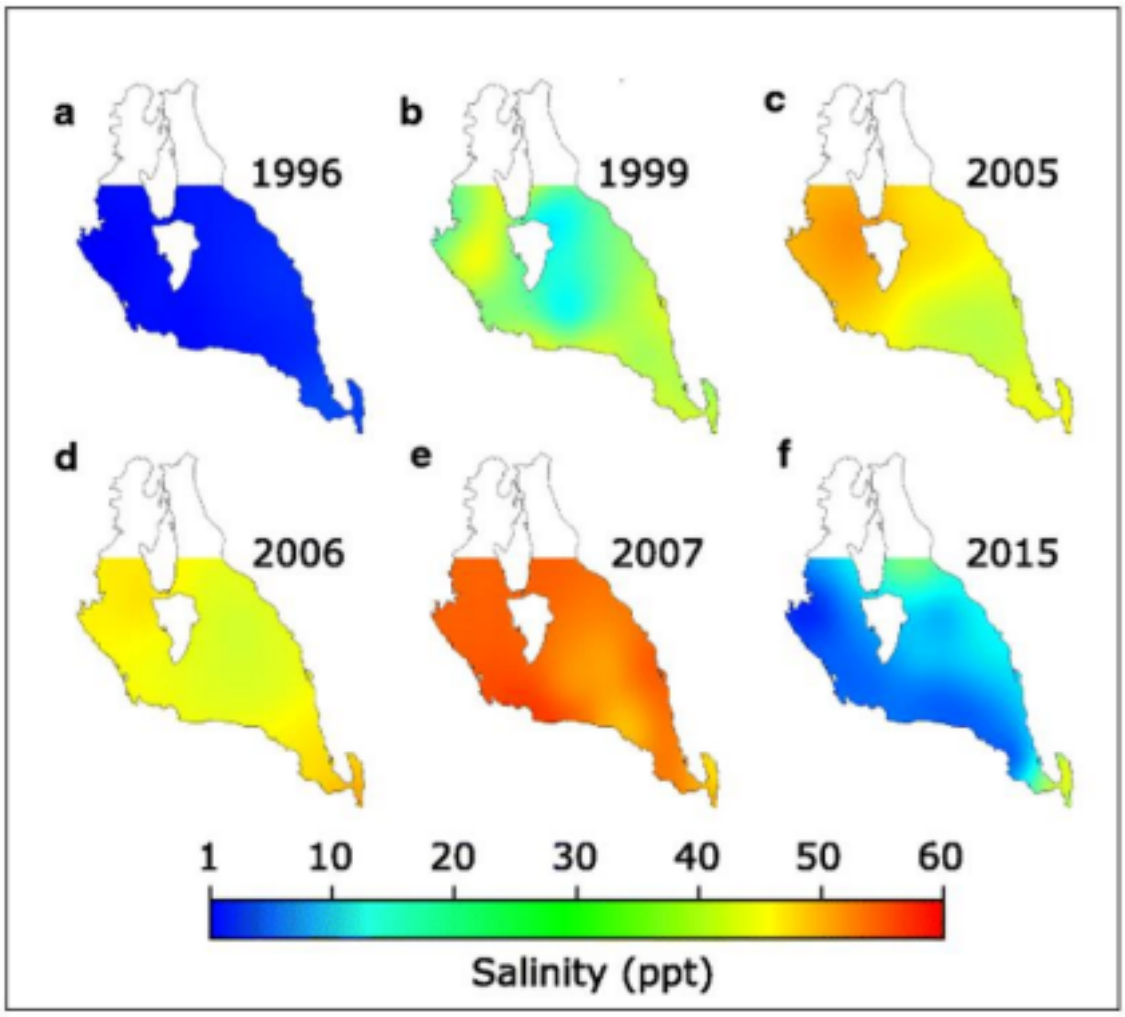
A comparison of an old map with a satellite map reveals the presence of two artificial water bodies known as E and F, which can be still observed today. However, a significant difference is that a river estuary has been transformed into a lake. This is due to the fact that the route and size of the Kalangi River have altered drastically over time. As a result, a brand-new lake, today known as Pulicat Lake, was born.

Today, The Pulicat lake is the second largest brackish water lagoon, located at the center of the Coromandel Coast in India. The upper 80% of the region lies in the state of Andhra Pradesh and the remaining 20% in Tamil Nadu.

(Fig 2.1: Image showing location of Pulicat Town) (Source: Author)



source: pulicat lake: a fragile ecosystem under threat (r. saraswathy, pitchai kasinatha pandian): Short-term desalination of Pulicat lagoon (Southeast India) due to the 2015 extreme flood event: insights from Land-Ocean Interactions in Coastal Zone (LOICZ) models (Harini Santhanam & Thulasiraman Natarajan): Spatial and temporal analyses of salinity changes in Pulicat lagoon, a transitional ecosystem, during 1996–2015 (Harini Santhanam & Amal Raj)



Salinity increase

[1] source: pulicat lake: a fragile ecosystem under threat (r. saraswathy, pitchai kasinatha pandian)

Threats

The lagoon was once three meters deep and shell dredging was done regularly, which was used for making lime and poultry fodder. The lagoon has now become shallow and non navigable following the ban on dredging for seashells, which came after the enactment of the Wildlife Act of India in 1972. The deposited layers of shells have hardened a few parts of the lagoon, which directly impacts its marine life. During the rainy season, the lake receives fresh water from four rivers: the Araniar, Kalangi, Royyola Kalava, and Swaranamukhi (Muttiah 2008). It has a wide range of natural resources, including aquatic and terrestrial animals and vegetation. However, The badly

treated industrial effluents

from the Ennore Creek and Buckingham Canal, including those from two coal-fired power stations and petrochemical companies, eventually reach Pulicat Lake eventually adding stress over the natural resources and the livelihood of the communities depending on them.

2.2 Settlements

The region is a great location in the state for fisheries and related commercial activity. Almost a quarter of the fishing villages are involved in both inland and marine fisheries, as well as, more recently, aquaculture. For more than a millennium, the lagoon's ecology has influenced the economics of coastal settlements, as evidenced by language, cuisine, trade, commerce, and construction technology (Jeyaseela 1997). The livelihoods and sustainability of the logoon settlements that rely primarily on this water body have become a major concern (Benedict 2018).

2.2 Ecology

The wetland is the second largest brackish water habitat in India and a national bird sanctuary. From October through April, hundreds of thousands of migrating waterfowl congregate around the lake, including enormous concentrations of Greater and Lesser Flamingos (Jacobsen and Raj 2009). Along with housing roughly 12 species of prawns, 19 species of crabs, 168 species of finfish, and other endemic, endangered, and keystone species, the Pulicat brackish water lake is renowned for its vast biodiversity of aquatic species. This renders it a remarkable ecosystem in the world.

It is interesting to note that many towns along the Coromandel Coast were named after their geographic features. In the case of Pulicat there are records of several different names that signify the rich ecology that may have existed once.

No	Place Names	Period	Kingdom	Source	Reference
1	Payym Kottam (INTACH) Paliyur Kottam as in No 315 Mandalam, Kottam,Nadu	11th Century	Chola	Thiruppalaivanam (Tiruppalaivanam) Temple inscription	INTACH * No. 315 (ARE 1929)
2.	Pular Kottam No 322	11th	Chola (sola)	-DO-	No 322 (ARE 1929)
3.	Puliym Kottam (Intach spelling) Pulal Kottam alias Vikramasola-Valanadu No. 323	11th	Chola	-DO-	No 323 (ARE 1929)
4	Pralaya Kaveri	1572 AD	Thirumalai Nayak	Wall Inscription in Adhinarayana Swami Temple –Pulicat	INTACH Nagaswamy (1978)
5	Mamalla Pattinam	6th century? ? AD	Pallavan?	Wall Inscription in Adhinarayana Swami Temple –Pulicat	Nagaswamy (1978)
6	**Anandarayan Pattinam**	1400 to 1521	Krishnadeva Maha Raya period (AD 1521)	SII	Vol. **XVII of SII: SII No 679 pp 368. Ref. ASI 1964).**
7	Palaverkadu	1521-todate	No Information		
8	**Pavazha Mangar** The city of Pearls	1600s		Thesis	(Munnuswamy 2003)
9	(Palaiyaverkadu the old jungle of mimosa trees	1600s		Report Book	Cotton (1946) Arulappa (1986).
10	Pavalaikkadu the jungle of coral)	1600s		Report Book	Cotton (1946) or by Arulappa (1986).
11	Pallia Catta Palliacatta	1620/1650 to 1777	Dutch	SII	Cotton (1946)
12	Pallia Catta is spelt as Paliacat and as Palicatt	Oct 1679	Dutch-British	Official Records	Madras Government

(Fig 2.1: Names over different periods) (Source: Web Archives)

It's worth noting that several settlements around the Coromandel Coast were named after geographical characteristics. In the case of Pulicat, there are records of multiple distinct names, indicating the once-rich environment. Pavazha Mangar's place name for Pulicat, translates to "Pearl City or city of coral stones " in English. The Tamil names "Palaiyaverkadu" (ancient jungle of Mimosa tree) and "Pavahvalakkadu" (jungle of corals) have also been used.

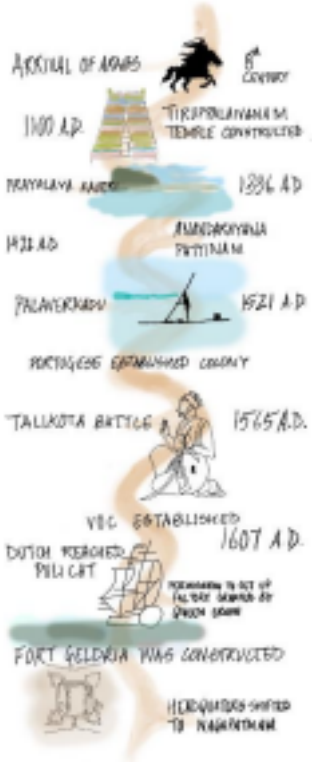
Buckingham canal

The Buckingham Canal, which stretches from Marakkanam to Mahabalipuram and the Pulicat Lake from its southern end, enters Sriharikota Island and runs up to Masulipattam in Andhra Pradesh. The Canal was established to enable the transit of supplies such as firewood during the construction of the now-historic edifice in Chennai. The Buckingham Canal, together with the Pulicat Lake, acts as a significant buffer for the city of Chennai and has proven critical in times of hydro hazards. As road and rail networks grew, the canal's importance faded, resulting in neglect and pollution. However, new initiatives to revitalise and repair the Buckingham Canal have been made, seeing its potential as a cultural asset and recreational space. Several restoration efforts have been launched in order to improve its natural value and encourage tourism, with the goal of conserving this ancient river for future generations.

2.3 History and Trade

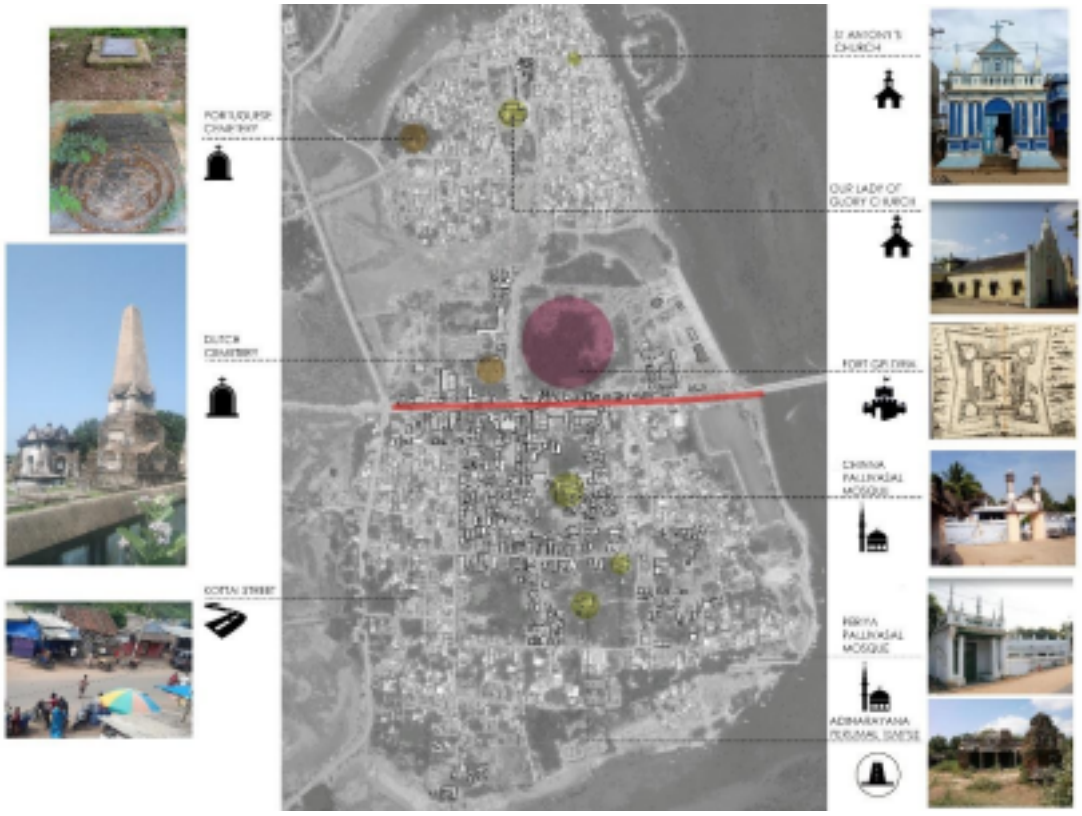
During the Cholas' Golden Age in the 10th century AD, Pulicat was an active commerce port. The presence of a Chola period Samayeswarar temple in Pulicat, as well as another Chola temple in Tiruppalaivanam, 6 Kilometers from Pulicat, demonstrates this. The oldest historical mention of Pulicat is found in the inscriptions of the Tiruppalaivanam temple. Pulicat appears in these inscriptions under several different names, including Payyar Kottam, Puliyur Kottam, and Pular Kottam. Pulicat was described as the most active and prosperous port on the Coromandel Coast and had a fort guarded by 90 people. It produced its own pagodas (coins) (Ramachandran 1980), supplied Eastern nations with gun powder, and was one of the major textile producers, for the seven decades that it served as the capital from 1613 AD to 1689 AD. Pulicat was a significant city for as long as it served as the Coromandel Coast's administrative centre. It lost its significance when

Pulicat was reduced to the status of a simple principality in 1689 AD, and Nagapattinam became the Coromandel Coast's administrative centre.



(Fig 2.2: Historic timeline of Pulicat) (Credits: Author)

Pulicat has the distinction of being ruled by at least 8 different rulers of Indian and foreign kingdoms. Each of these rulers has left behind some historical relics, which speak volumes about its past glory.



(Fig 2.3: Heritage Mapping) (Credits: Author)

As British had established their first fort (St. George) in Madras (Chennai) in 1639; it thrived as the headquarters of the British East India Company, Pulicat slowly lost its importance forever. Communally held lands like wetlands that were once called '*poramboku*' were disregarded by the British powers and termed as wastelands. Post independence Pulicat was reduced to a fishing village and ever since, it has been serving as a backstage, despite outsourcing rich resources such as reeds, shells, etc to neighboring regions.

Pulicat as a Ramsar site

Pulicat Lake meets the criteria defined by the convention, which includes being an area of marsh, fen, peatland, or water, both natural and artificial, with diverse water conditions and salinities. The lake supports various indigenous fish sub-species, families, and other aquatic life forms. Additionally, Pulicat Lake serves as a habitat for migratory waterbirds

and plays a crucial role in their conservation. However, Pulicat lake is not listed as a Ramsar site yet.

Keeping this in mind. The thesis intends to establish a balance between ecology and livelihood and explore the possibility of decentralizing livelihood opportunity in order to reduce the stress over fisheries and providing them alternate livelihood opportunities by skill development with the natural resources and reviving thw lost art so as to keep them connected to their waterbody and heritage and eventually protecting the sanity of the lake. The revival of Buckingham canal would further encourage tourism to Pulicat which will give the visitor a holistic experience of Pulicat .

3 Social life of the community

Pulicat is predominantly a fishing village, with a few women practicing as basket weavers, palm leaf and handicrafts. The village has a history of boat makers, who now have left the profession. We see carpentry as another occupation practiced here. Daily wage workers and laborers are also seen in the area.

The fishermen of these villages practice a system locally called ‘padu’ to control the access to certain fishing grounds. The padu system, as practiced in Pulicat lake, is quite unique because of its caste-based nature and the distribution of access- rights with adequate attention paid to the unevenness in productivity of the fishing ground. This padu system may be defined as a traditional system of granting entitlements to eligible members of a particular community for undertaking specified fishing activities in certain designated fishing grounds of the lagoon. This eligibility criterion is determined by the marital status of fishermen belonging to the specified caste.

(Fig 3.2: padu system in Pulicat) (Source: Author)

Prior to the 1980s, there was little concern about demographic pressures and the conditions for becoming a padu fisherman were not very strict. However, from the 1980s onwards, only married fishermen from three specific villages are eligible to participate. Despite this measure, fishing grounds continue to be overburdened due to increased fishing operations and environmental factors. The pressure on the already fragile resource base has further intensified, highlighting the need to diversify livelihood options and explore alternative sources of income while maintaining the integrity of the water body. One such alternative is the palm leaf craft industry, which employs several women in the town and produces fine palm leaf articles that are exported through agencies. The Pulicat Women Palm Leaf Cane & Bamboo and Allied Products Workers Industrial Cooperative Society Ltd was established in 1959 and helped to promote the palm leaf craft of Pulicat. This cooperative, along with other similar crafts such as korai mat weaving, shell crafts, reviving lost wood works, kalamkari, and block print textiles, could provide sustainable livelihood options with the raw materials available in the region.

Present day front view of building of the palm leaf craft society

Present day side view of building of the palm leaf craft society

(Fig 3.3: Palm leaf craft in Pulicat) (Source: NIFT, Chennai)

3.2.3 Food

Rice is the staple diet of the residents and most of the small food stalls in Pulicat serve the meals on a giant banana leaf, which is considered as a healthy way to have food. There are few food stalls which sells food items like biryani, idli and dosa. There are various varieties of fishes available in Pulicat lake and In Pulicat, each fish is cooked in several tasty ways. Hence fresh fish must buy thing if You visit Pulicat.

3.2.4 Festivals

The major festival observed here is Eid, which holds significant cultural and religious importance for the local Muslim community. Another important festival celebrated by people of all faiths is Christmas, marking the birth of Jesus Christ. In the month of January, the vibrant festival of Thai Pongal is celebrated, rejoicing the harvest season. A notable festival in Pulicat is the Tamil New Year, which occurs in April and symbolizes the commencement of the Tamil calendar. During this time, special prayers are conducted in temples, and people partake in festive celebrations. It is worth mentioning that the region observes a unique practice during Diwali, as it is celebrated in a silent manner without bursting firecrackers. This conscious choice is made due to the area's ecological sensitivity, as it coincides with the nesting period of various species, thereby affecting the local fisheries. This thoughtful approach exemplifies the community's commitment to preserving the environment and its wildlife.

3.2.5. Occupation

Most of the people in Pulicat are fishermen, but there are some other sources of income for people living there. Other major observed occupations are as follows • Market - vendors and sellers.

• Carpenters

• Fishnet making

• Tailoring

• Kora mat weaving.

Most of the people in village are engaged in fishing and fishing related business. According to them, January to April is the best season for fishing in Pulicat. There are 15 types of fishes available in Pulicat and few most common ones are: Kenda, Medava

Kelangan, Oodan, Odupathi, Keluthi, Eral (prawn), Nandu (crab).

(Fig 3.4: Fish Retail Chain) (Source: Author)

Along with fishing business like boat making was once a major occupation for people here, but today boat making is hardly seen. But still people do fishnet weaving, merchandising the fishes.

(Fig 3.5: Fishnet mending) (Source: NIFT, Chennai)

Palm leaf craft is a traditional craft in Pulicat. Many people we interacted in Pulicat claimed that they know this craft since several centuries. It was practiced in every home. Rattles, storage boxes, mats, fishing equipments were common products. Everyone used to make these things for their own and relatives. According to many people in Pulicat, Tamil Muslim residents of Pulicat had taught this craft to Dutch people. Almost all area of today's kottai kuppam panchayat was practising this craft. There wasn't any need of commercializing this craft during those days. During British rule, fishing was only source of income left for these people. They started taking this craft seriously. Soon after Indian independence, a society was established for mutual support and growth in income of artisans in and around Pulicat. Today also this craft is sustaining so many families in and around Pulicat.

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(Fig 3.5: Palm Leaf in Pulicat) (Source: NIFT, Chennai)

4. SITE Selection

3.1 Location

Pulicat is a historic town located in the Tiruvallur district of Tamil Nadu state in India. It is situated on the east coast, about 60 km north of Chennai city. It is located at the confluence of three different types of waterbodies, The river Kosas Thalai, Bay of Bengal, and the Pulicat Lake. (Fig .2.2)

(Fig 2.2: Image showing location and the waterbodies) (Source: Author)

Owing to its strategic Location, The town was once an important center of trade and commerce, especially during the Dutch colonial period. Pulicat was a major port for exporting textiles, salt, and other goods to Europe and other parts of the world. Today, the town is a fishing village serving as backstage for resources to several other crafts and industries spread across the state.

The town is also known for its traditional handicrafts, including weaving and embroidery. One of the main attractions of Pulicat is the Pulicat Lake, which is a large brackish water lake that stretches across Tamil Nadu and Andhra Pradesh states. The lake is an important ecosystem that supports a wide variety of flora and fauna, including several species of migratory birds.

3.2 Context study

3.2.1 Public Facilities

Pulicat has basic facilities like school from pre-kg to highschools, a govt hospital and an informal bus stop. (fig 2.3)

Although Chennai has a 1msq open space per person it is surprising to see that Pulicat has fairly more open spaces (fig 2.3) however it is appalling to see that these open spaces are used as dump grounds and a few of them are around ruins.

Map 3.1 - Public Facilities in Pulicat (left) Open spaces in Pulicat

(Right)

it is also observed that the different religious communities in the town (Christians, Muslims, Hindus) have settled around their worship spaces over the years. The majority Christian population are on the northern part of the region whereas the Muslim and the Hindu community towards the south.

Map 3.2 - Public Facilities in Pulicat (left) Open spaces in Pulicat (Right) it is also observed that the different religious communities in the town (Christians,

Muslims, Hindus) have settled around their worship spaces over the years. The majority Christian population are on the northern part of the region whereas the Muslim and the Hindu community towards the south.

Map 3.2 – Settlements Pulicat (left) Open spaces in Pulicat (Right)

The various communities converge into the *kottai* street for their day to day needs which acts as the spine of the town.

5. Site Analysis

Map 3.3 - Site

Site area: 23 acres (67,000 sqm) out of which 7 acres lie in CRZ 1 zone

The selected site for the thesis lies along this kottai street at the heart of the town. It could help blur the boundaries between the various communities. the site lies along the two main streets of the town and bounded by the tidal confluence of the lagoon on the east.

The heart land, however, is being used as a wasteland for dumping waste. (Fig 3.1)

(Fig 3.6: Image showing activities on site) (Source: Author) 3.3.2 Site character

Map 3.3 - Site Character

3.3.3 Relief Map

Map 3.4 - Elevation Mapping

Map 3.5 - Slope Analysis

Map 3.5 - Stream Network

Fig 3.2 - Showing the stream in Historic Maps (source: Atlas of Mutual Heritage)

3.3.4 Bye Laws

For any Public/ Semi Public construction purpose, a minimum of 9m wide road is required. The setback remains to be 3m in all sides up to 18m wide access road. Tamil Nadu Town and Country Planning Department (DTCP) follows only the DCR specified by the CMDA. Rule 7 of the Tamil Nadu Municipalities Building Rules, 1972, states that buildings should be constructed with a 15m setback from the water body. The FAR is 1.5 and the ground coverage is 40% for any Public/ Semi Public construction in the district.

Mao 3.2 CRZ Map and site set Back (source: CRZ, Author)

3.3.5 Climate data and interpretation

Fig 3.7 – sun path and wind direction (source: author)

Fig 3.8 – Climate Data (source: Climate Consultant)

6. CASE STUDY And Inferences

4.1 Rationale

Fig 3.8 – Design Requirement and Case study rationale (source: Author)

4.2 Kalakshetra Craft education center

4.2.1 Rationale

This case study would help to understand the spatial planning and layout of modern Handicrafts center, climatic understanding, and spatial requirements of users related to the different activities in the craft.

Location: Thiruvanmayur, Chennai, India

Established Year: 1936

Site Area: 5.7 Acres

1.2 Kms from Thiruvanmiyur Bus Terminus

3.1 Kms from Thiruvanmiyur Railway Station

Map 4.1 : Context map

Map 4.2 – Kalakshetra Site plan

(source: Author)

4.2.3 Space Requirement

- Workshop space: 659 sqm
- College: 340 sqm
- Research lab: 100 sqm
- Ink storage: 64.4 sqm

• Canteen: 135 sqm • Washing:100sqm

• Pump room:40.8 sqm

• Firewood Storage: 50 sqm

• Admin+Storage: 220 sqm

Fig 4.4– Spaces in Kalakshetra (source: Author)

Fig 5.3 – Space Requirement for Korai Matt weaving based on literature study (source: Author)

4.2.3 Observations and inferences

The architectural design of the facility exhibits a consideration for hierarchical spaces, creating a functional layout that caters to specific needs. The building is intelligently oriented to maximize the utilization of natural elements such as wind and sunlight, enhancing the comfort and energy efficiency of the space.

The zig-zag layout is designed to accommodate a larger number of looms while optimizing the microclimate within the premises. However, there are some areas that could be improved.

Map 4.3 – plan (source: Author)

Despite its internal location being suitable for educational purposes, it fails to attract the attention of shoppers for exhibitions. The purchase store appears smaller and less prominent, potentially impacting its visibility and accessibility. Furthermore, the canteen is not connected to the workshop or accessible for visitors, which could disrupt the flow of activities. Another missed opportunity is the absence of a back exit in the workshop, which could have enhanced safety and convenience. Exploring the use of alternative building materials could have provided additional aesthetic and sustainable benefits. Lastly, the absence of a water-treatment system raises concerns about environmental impact.

Fig 4.4– Kalamkari process (source: LinkedIn)

4.3 Sargaalaya , Art and Crafts Village, Iringal, Kerala

4.2.1 Rationale

This case study would help to understand how promting arts and crafts helped in the urban regeneration of Iringal while being sensitive to the context It would further help

understand the spatial planning layout and requirements of modern Handicrafts centers.

Site Area : 20 Acres
Architect: R.K Ramesh
Established : 2011 An initiative of department of Tourism, Kerala

Fig 4.4– (source: Scribd)

4.2.3 Observations and inferences

The design of the academic block in this project has focused on creating a secluded and peaceful environment. The block has been strategically placed away from the main activity areas, allowing for a more focused and serene atmosphere conducive to learning. Courtyards have been thoughtfully integrated into the design, serving as gathering spaces and providing natural light and ventilation to the surrounding classrooms and corridors. The architecture showcases a blend of design languages, possibly due to the construction being carried out in different phases. One notable feature is the strategically placed cafeteria, catering to the needs of both visitors and workers within the campus. The incorporation of services into the overall aesthetics of the design ensures functionality without compromising on the visual appeal. Inspired by local architecture, the design incorporates elements such as laterite stone, terracotta, and welded rafters, lending a sense of regional identity to the campus. The emphasis on open parking promotes a more spacious and inviting environment. Waste management has been carefully addressed, ensuring sustainable practices within the campus. Additionally, the outdoor amphitheater

(OAT) offers a generous space of 650 square meters for various activities and events. The academic block, combined with accommodation facilities, occupies a total area of 3200 square meters, providing comfortable living spaces for students and staff. The cafeteria, spanning 360 square meters, offers a welcoming and functional dining experience. The choice of building materials, including the use of laterite stone, terracotta, and welded rafters, adds a distinctive touch to the architectural aesthetics.

4.3 Living & Learning Design Centre (LLDC), Bhuj.

4.2.1 Rationale

This case study would help understand the spatial requirement of different local crafts and the visitors. The project further addresses water management techniques at the site plan level. Since the thesis site is located in region with seasonal water scarcity. This case study would help address how water scarcity could be addressed in site plan and architecture.

Fig 4.4– Drawings (source: Indigo Architects)

4.2.3 Observations and inferences

Water harvesting features.

Stored rainwater cools the structure: Rainwater harvesting tanks were integrated in the design of the foundations to collect about 7 lac liters of rain annually. Construction of cost effective rainwater harvesting tanks was done using brick masonry and lime. Modular capsules such as the one shown, can harvest up to 33,000 liters of water.

The project incorporated radiant cooling pipes, which circulated stored water from the foundation to the terraces and other slabs. This system facilitated the continuous removal of heat, resulting in stable temperatures ranging from 30 to 34 degrees Celsius throughout the year. Additionally, the

project implemented a decentralized wastewater treatment system (DEWATS) to manage all the wastewater generated on-site, including the process effluents from the printing and dyeing workshops and toilets. This system ensured the proper treatment of wastewater before its discharge.
Furthermore, water management on the site was achieved through the implementation of percolation wells and trenches. These features helped retain water along the perimeter of the compound wall section, contributing to effective water management and conservation efforts.
Local vegetation with low water consumption but dense canopywere planted on the site to reduce water demand

Fig 4.4– Drawings (source: Indigo Architects)

4.4 Shrujan Kutch

4.2.1 Rationale

This case study would help address how water scarcity could be addressed in site plan and architecture. Further it would also help understand the spatial requirement for crafts that address the needs of both communities and visitors.

Fig 4.4– Drawings (source: Indigo Architects)

The project incorporated water harvesting features to promote sustainable water management. A three-chambered rainwater harvesting tank was constructed in the main courtyard, with a capacity to store up to 100,000 liters of rainwater. A well-designed system was put in place to channel rainwater into the tank, allowing for its efficient

collection and storage. Additionally, the tank was connected to another reservoir that stored water from a bore well, ensuring a supplementary water source. To prevent runoff and enhance groundwater recharge, recharge wells were strategically located in the parking area and lower courtyard. These measures aimed to maximize water conservation and minimize wastage, promoting sustainable water practices within the project.

Fig 4.4– Drawings (source: Indigo Architects)

The Klong Pho Hak Floating Market

4.2.1 Rationale

This case study would help explore how the revival buckhingham canal in Chennai would be beneficial for the economic growth and facelift of pulicat.

The Klong Pho Hak Floating Market is a vibrant and culturally significant market located in Bangkok, Thailand. This case study explores the unique design and features of the floating market, highlighting its historical background, architectural aspects, and its role in promoting local commerce and tourism.

Background:

The Klong Pho Hak Floating Market has a long history, dating back to the time when

Bangkok was known as the "Venice of the East." Traditionally, communities along the canals relied on waterways for transportation and trade. Over time, these canals transformed into vibrant marketplaces where locals and tourists could buy and sell various goods and food items.
Design and Architecture:

4.2.3 Observations and inferences

Floating Stalls: The market features numerous small boats and floating stalls where vendors sell a wide range of products, including fresh produce, local delicacies, handicrafts, and souvenirs. These floating stalls are an integral part of the market's design, creating a unique and picturesque setting.

Canal Infrastructure: The canals and waterways of Klong Pho Hak serve as the main thoroughfares for the floating market. The design includes accessible water channels that

allow boats to navigate through the market easily. Bridges and walkways provide convenient access for visitors to explore the market and interact with vendors.

Traditional Architecture: The surrounding structures and buildings near the market often showcase traditional Thai architecture, adding to the cultural ambiance. These structures may include wooden houses, temples, and other traditional buildings that reflect the local heritage and architectural style.
Operational Aspects:
Commerce and Trade: The Klong Pho Hak Floating Market serves as a hub for local commerce, connecting producers and vendors with customers. It offers an opportunity for local artisans, farmers, and small-scale businesses to showcase and sell their products directly to the visitors, contributing to the local economy.
Cultural Experience: The market provides a unique cultural experience for both locals and tourists. Visitors can witness traditional Thai customs and practices, taste authentic local dishes, and engage with the friendly vendors, fostering a deeper understanding of Thai culture and way of life.
Tourism Attraction: The Klong Pho Hak Floating Market has become a popular tourist destination, attracting visitors from around the world. Its picturesque setting, vibrant atmosphere, and diverse offerings make it an appealing place for tourists to immerse themselves in the local culture and take-home unique souvenirs.
Preservation of Heritage: The market plays a vital role in preserving and promoting the cultural heritage of the region. By showcasing traditional trading practices and local craftsmanship, the market helps keep traditional skills and customs alive, contributing to the cultural identity of Bangkok.

4.5 Sanya Mangrove Park, Sanya, China,

4.2.1 Rationale

This case study would help understand how landscape architecture could be incorporated in order to chanellize the water draining into the lagoon, reduce the urban storm water

run off, reduce soil erosion in the site and how dynamic water levels could be incorporated in the design., it further also addresses the connect between community and the environment.

The Sanya River is located on the southern tip of Hainan Island. It is crucial for the ecological relationships between the sea and the inland coast, where the daily tides meet with the river's fresh water. Initially the site was choked with urban debri's.

Source: https://divisare.com/projects/433738-turenscape-sanya-mangrove-park

The objectives of the design

were to restore the wasteland and establish a mangroves park. The project encountered various challenges, including the protection of young mangroves from being washed away by storm surge and monsoon-driven floods originating upstream, as well as shielding sensitive mangrove seedlings from polluted urban runoff. Furthermore, it was necessary to ensure that the restored habitat was accessible to the public.

Design strategies implemented:

Onsite recycling of materials involved concrete from the demolition of the flood wall and other urban debri's. Cut-and-fill was employed to build a gradient of interlocked finger design that would host diverse riparian habitats which helps guide ocean tides into the waterways. Hence. mitigating the impact of storm surge and flash floods originating from the urban and upland area.

Source: https://divisare.com/projects/433738-turenscape-sanya-mangrove-park

4.2.3 Observations and inferences

This design approach also maximized habitat diversity, promoting an increased interface between plants and water, and enhancing ecological processes such as water nutrient

removal. The water depth within the park varies from 0 m to 1.5 m, creating a dynamic environment that follows the natural rise and fall of tides, thus providing essential daily water-level fluctuations required for the survival of several aquatic species. The Terraces were supplemented with bio-swales to capture and filter urban stormwater runoff. Additionally, these terraces serve as recreational spaces for the public. (truenscape,2019)
Top of Form

Source: https://divisare.com/projects/433738-turenscape-sanya-mangrove-park

The park's ability to engage and educate the public about the importance of mangrove ecosystems and environmental conservation is explored, along with the positive impact on the local community.
The lessons learned from this case study can be applied to future projects aiming to create a balance between architecture and nature, promoting ecological resilience and fostering a deeper connection between people and the environment.

Proposed crafts:
Korai matt weaving
Block printing

Kalamkari
Palm leaf weaving
Pith art
Art from reeds/ shells/ wooden carving

The total population of pazhaverkadu is about 17,000 out of which about 5,000 live In kottai kuppam and are traditional fishermen, and the rest are predominantly tribal fishermen, farmers and a few boatbuilders who have shifting to other means of work. The thesis primarily focuses on diversifying the sources of income by providing a crafts center and additionally facilitating and promoting local cuisine and fisheries. The thesis also intends to accommodate a formal bus stop for the community. To facilitate connectivity to Chennai.

Area Program:

Percent distribution of areas

Area required for 5 bus bays (5 based on observation in site and confirming from MRTS data)

Proposed areas for facilitating tourism and fisheries.

7 Thesis Elective

Identifying an Architecture Vocabulary for Waterlogged Regions: A Case of Pulicat

Abstract:
The coastal commons in Pulicat face significant vulnerabilities to climate change impacts, including sea level rise, soil erosion, rapid urbanization, and water pollution. While ethnic social groupings in these areas possess customary wisdom that has enabled effective mitigation and adaptation to calamities, the physical socioeconomic conditions necessitate initiatives to enhance their adaptation capacity. In low-lying coastal areas. When building in these places is required, it is critical to prioritize the creation of resilience for an uncertain future. Furthermore, it is critical to choose construction methods and materials that do not disrupt the sensitive coastal habitats.

This study aims to identify the dwelling types in such regions. Through qualitative analysis of case studies that explore traditional knowledge alongside modern findings, the research seeks to develop effective adaptation strategies and resilience-building measures for the coastal communities.
A key focus of the study is on knowledge co-production, where traditional knowledge and contemporary scientific knowledge are integrated to generate comprehensive insights and practical solutions. By combining local wisdom with scientific expertise, the research aims to produce an architecture design toolkit for flood resilience specifically tailored to the context of Pulicat. The developed architecture design toolkit will provide valuable guidance for architects, and policymakers in designing resilient infrastructure and settlements in flood-prone areas.
By promoting community-based resilience-building approaches, the research offers practical insights for enhancing the adaptive capacity of coastal communities in Pulicat and similar contexts worldwide.

Background:
Climate change – the rise in global temperatures has caused climate volatility and

increased water levels, directly impacting the coastal communities because of their geographical exposure. According to the United Nations, the most vulnerable are the communities belonging to the lower strata of society, in the coastal regions of the developing nations, due to the lack of proper housing, infrastructure, access to climate related information, and their dependency on climate-sensitive livelihoods like fishing and tourism. This necessitates external intervention for building resilience to natural disasters in the community.

The coastal commons at Pulicat are one such community. Pulicat is a coastal village in Tamil Nadu at the center of the Coromandel coast Lying within the Very High-Risk Zone for cyclones, soil erosion, sea level rise, and water pollution. Due to this a fall in marine productivity and uncertainty has disrupted their economy. The project focuses on building resilience within the existing community fabric in the fishermen's village, focusing on community engagement with the water body, economic diversification, infrastructure, and community spaces.

Research Question:

How can architecture design intervene to help make the coastal commons of Pulicat more resilient to water logging?

Aim: To understand the vernacular architecture of Pulicat and devise an architectural vocabulary for flood resilience.

Objectives:

To Understand the indigenous architecture of Pulicat.
To Analyze case studies of architecture in low lying coastal regions and wetlands
To devise an architectural vocabulary for flood-resilient design in Pulicat.

Scope and Limitations:

The research examines examples of how buildings have adapted to hydro-hazards, with a

focus on floods and rising water levels. However, the study is restricted to low Tech solutions considering the site context. While the proposed model can provide a safe shelter at times of flood the same cannot be guaranteed for tsunami.

The study is limited to building form and properties of suitable material. The study will not include load calculations and settlement patterns of the individual case studies.

Methodology:

Literature review

Research conducted show the pressure on walls without a top constraint, and the deformations show the wall's horizontal out-of-plane displacement. The modeling shows that the safe(r)®'s wall head movement is substantially less than that of already built houses. Because the collapse of masonry walls is often triggered by the wall overturning owing to out-of-plane instability, smaller wall head deformations signal that the collapse threshold is at greater pressure. According to the current assumptions, the new design will withstand a wave five times greater than the original design. (tenzin Priyadarshi, prajnopaya foundation, 2008)

The roof cover is made of tin or tiles and provides cost-effective rain and sun protection. The roof structure is built with basic materials that adhere to vernacular construction practises, and bamboo partitions or heavy-weight collapsible partitions form a porous and ventilated skin that occupants may modify over time. The core pieces are comprised of concrete blocks, which provide increased resistance without inhibiting water flow in the case of a tsunami. A higher platform allows for better water drainage and healthier soil. The walls are composed of concrete blocks reinforced with rebars, while the roof is formed of typical timber parts covered with tiles or tin. Partitions are made from recyclable materials.

Maxims Of 'khona'

Due to the agricultural heritage, the people of Bangladesh have a strong sense of connection to the soil, which has encouraged the creation of amphibious homes that can withstand floods. With this design, the building can float on cresting floodwaters as opposed to being buried. The plan incorporates tethering, buoyancy blocks, and a sub frame to keep everything in place. Reduced wind loads, protection from floods, and the possibility for inhabitants to stay in their houses during floods are all advantages of amphibious architecture. Due to its accessibility, affordability, and durability, bamboo is

a frequently utilized material in traditional design, making it an excellent option for the building of amphibious homes. An example bamboo-built home is presented in detail. There are several benefits to amphibious building.
In coastal risk locations, the flood protection depth is calculated by considering the height of a breaking wave, which is anticipated to be around 78% of the design still water flood depth, with 70% of the wave occurring over the Stillwater flood depth. Eq. (1) should be used to compute the design flood protection depth in coastal flood hazard zones. ������_������������������ = ���� + 0.7(0.78����) + ����������������������

(Md. Obidul Haque, Nabeela Nushaira Rahman, & Zaman, 2019)

Building Material: bamboo, Thatch, EPS, Jars.

Sama Bajau Resettlement in Philippines

The Bajau community, over the centuries, has adapted to the various climatic phases. A community that has developed through closeness to the sea, they are sensitive to the slightest of shifts in sea conditions. The free wanderers, in recent times, due to the regulatory approach of countering climate change and citizenship movement, the community fonds themselves victims to national and international policies.

Derived from the form of traditional lepa-lepa and boggo-boggo boats of the Bajau community, is the spatial layout of Bajau housing. The housings are stilted over the water where the individual boats are docked. Their coastal dwellings consist of three primary sections – the bow area for fishing; the midsection for sleeping; and the stern area for storing food and cooking.

In Bajau culture they believe that the salty water washes away the impurities of their households. The houses were Built on stilts, they were placed 1.8 m above the slime

strewn sea water edge, surrounded by salt making fields ad mangrove swamps. The housing units were connected by wooden bridges, which often widened up at pockets forming informal marketplaces that boosted their microeconomy. The women were taught weaving and sewing to counter gender-based violence.

Money was invested in sari-sari stores and fish vending, among other economic ventures. There were support programs like housing, livelihood support, and education programs. into the mainstream and empowered. The materials used to build the Bajau Lout traditional house over water are the materials of wood found in their surroundings.

Source: Google Image

(Sahibil, 2019)

Location: Coastal edge
Settlement Pattern: Clustered, connected by wooden bridges over slime and water maintaining a primitive clustered pattern led to the proper social functioning of the community within the settlement.
Building Material: Permeable latticed bamboo walls and wooden stilts.

The Last Kelongs in Southeast Asia

Kelongs are wooden structures built on stilts in shallow water offshore, mostly in Singapore, Malaysia, and Indonesia. Traditionally, rattan rope-tied poles made of the nibong palm tree are anchored six metres into the seabed and used to support timber floors. The supply of food and water is dependent on a shipment of filled jerry cans sent from the

mainland. A big, onboarded area is often left in the center of the building for the fishing net.
However, the kalongs is struggling with issues including unfavorable legislation, a declining fish supply, and rising natural resource prices. Although some kalongs are now involved in tourism, maintaining them is expensive. Non-tourism-reliant commercial fisherfolks are quitting.

(Lee, 2014)
Location: Coastal edge Traditional living environment inducing satisfaction and normalcy in living conditions.
Settlement Pattern: Crowded linear pattern of the settlement now disappearing. **Building Material:** palm tree, Wooden floorboards, rope, Thatch

Mumbai Artist Retreat / Architecture BRIO

In low lying coastal regions. when construction is necessary in these areas, it is crucial to prioritize the development of resilience for an uncertain future. Additionally, it is important to utilize construction methods and materials that minimize harm to the fragile coastal ecosystems.
The site for this project is a coconut palm plantation situated near a beach, characterized by a decline in groundwater levels and the presence of saline water during summer months. To address this issue, a water harvesting pond is implemented in the center of the site to replenish the groundwater with freshwater. The pond also attracts a diverse range

of fish and birdlife. The site is divided into three zones: a temporary residential zone, a

workspace zone, and a long-term residential zone. The proposal includes temporary structures to accommodate these activities.

Because of the site's limited soil carrying capacity and occasional floods, a lightweight and flexible steel framework is used to lift the building above the ground. Off-site manufacturing procedures are employed to minimize building site disruption, and nut and bolt connections are used to unite the steel components. Stone boulders acquired from a neighboring construction project support the columns, with a steel rod anchoring them into chiseled depressions in the basalt rocks. This construction method enables for the structure to be relocated to higher ground if needed.

The use of flexible design features prioritises resilience. Each modular bay of columns may be outfitted with movable wall panels, creating customizable rooms inside the workplace. As needed, these timber slat panels give rain and direct sunshine protection. Depending on the needs, the artist's workshop can be utilized as a single huge workshop, many simultaneous workshops, or even an exhibition space. The workshop is meant to be future-ready, with its adjustable spatial arrangement and flexible construction system, capable of handling the dynamic nature of creative programming as well as the uncertainties of the surrounding landscape. (Abdel, 2019)

Post tsunami housing- By Shigeru Ban

The goal was to use easily available and affordable materials that could be quickly constructed. The walls were made of compressed earth blocks (CEB) with uneven surface that were cement-bonded together making them sufficiently sturdy. These blocks are made from a clay and cement mixture that is abundantly available. The roof structure was composed of timber trusses and was topped with clay tiles. The central pillar that supports the roof trusses was made from coconut wood. This wood was chosen specifically for its seeming strength. (Arch Daily, n.d.)

Indigenous Architecture of Pulicat, Tamil Nadu- Live Case Study

Buildings are observed to be arranged in a grind iron form owing to the geographical location which makes the area vulnerable to tsunamis and floods. As observed in other

coasta hamlets in the Coromandel coast this arrangement is devised to reduce the effects of hydro-hazards. Sloped roofs with ridge parallel to the road to drain the rainwater. Four leafed wooden doors and windows are incorporated to maintain privacy. Madras roofs, Thinnai, and a few other Dutch influences like gabled roof are notable.

Building materials used are wood, mud, and country bricks (1”,3”,6”), lime plaster, Terracotta tiles.

Discussion

Buildings in marshy or waterlogged areas can be categorized by its foundations and their relationship to the water. These dwellings include static elevation, pile dwellings, amphibious dwellings. Some types have been used for centuries while others are relatively new, such as the amphibious house, however, each type has proven resilience in the event of rising water levels.

Since the site is in a ecologically sensitive area prefabricated materials were preferred. Locally observed architectural elements are re-interpreted to new one

Although there are several strategies to safeguard against rising sea levels amphibious buildings are a reliable flood security strategy that gives improved flood resilience and enhances its capacity to recover from disaster. When there is flooding, the structure rises vertically to keep itself safely above water and then falls back into position as the water goes down. All buildings will have the same heating, cooling, and ventilation systems as a building on the land, as well as the same municipal pipelines and electrical connections, which further guarantees comfort.

The following architectural elements has been compiled after understanding of the vernacular architecture of Pulicat and learning from other traditional modern techniques to identify a new architectural vocabulary for Pulicat that respects traditional knowledge while being more resilient to flooding.

Conclusion

Window

Wooden louvered windows to allow wind while maintaining privacy.

Source: Author

Foundation

Combination of stilt and amphibious structure with prefabricated steel

sections

Source: Author

At a height of at least 1.2m or above the mean sea level as the high tide level in the region is 1.1 m

Walls

Locally available burnt Bricks (*aachikal*) 1”,3”,6”

With groves, so they can be used as dry bricks causing less disruption to ecology.

Roof
Pitched roof, preferably with ridge running parallel to the street

Source: Author
Madras roof for a span of 3x3m

Source: Google images

Jack arch roof

Source: Google images
Wooden members could be replaced with steel hollow sections.

Spatial arrangement.
Building could be arranged along the street as it has been observed over the years in order to leave the central area to act as sponge for storm water.

Source: AARDE, Author

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8 Concept Development

Pulicat is a beautiful coastal town located in the state of Tamil Nadu, India, known for its rich cultural heritage, handicrafts, and fishing industry. The proposed mixed-use center aims to capitalize on these unique characteristics of the town by creating a space that celebrates its history, culture, and natural resources.

The center will be a hub for artisans and craftspeople from the surrounding areas to showcase and sell their wares. This will help to support local economies and promote traditional handicrafts, which are an integral part of the region's cultural identity. Additionally, the center will provide a platform for artists to exhibit their work, providing exposure and opportunities for artists to grow their careers.

Finally, the center will cater to the town's thriving fishing industry by providing a marketplace for fresh seafood and a space for fishermen to sell their catch. This will not only support the local economy but also give visitors the opportunity to experience the local culture and taste fresh, locally caught seafood.

In conclusion, the proposed mixed-use center in Pulicat will serve as a unique cultural and economic hub for the town and the surrounding areas. By promoting traditional handicrafts, providing a space for artists to exhibit their work, preserving local heritage, and supporting the fishing industry, the center will contribute to the town's growth and development while providing a rich and engaging experience for visitors.

The project aims to revive a wasteland with historical significance and transform it into a community hub that blurs social boundaries and promotes ecological resilience. The project intends to bring the "poramboku" to the forefront.

Fig. 7.1 Illustration showing revival of 'poramboku' (source: Author) The project seeks to address both the physical and social aspects of the site, and to incorporate sustainable design principles that consider the local ecology and community needs. The project seeks to integrate with the existing urban context and ecology to create a more resilient community that can adapt to changing circumstances. By involving the community in the design process and providing opportunities for them to engage with the

site, the project aims to create a sense of ownership and pride in the space, making it a true 'people's fort.'

Fig. 7.2 *Site Illustration showing inclusion of different communities from the northern and southern region (source: Author)*

The design places a strong emphasis on meeting the needs and desires of the local community, while also allowing for occasional visitors to generate additional income. To ensure that the design becomes an integral part of the community's daily life, multiple entrances have been proposed, which would blur the boundaries between the traditional fishermen community in the north and the tribal fishing community and boat builders in the south. For the convenience of visitors, formal entrances have been marked in red.

Fig. 7.3 *Illustration showing possible entrances (source: Author)*

The spatial arrangement of the workshop spaces is inspired from the cluster typology of the region. It is observed that the houses are arranged along the street leaving a buffer at the center to act as a sponge. The ridges run parallel to the street.

Fig. 7.4 *Historic Map(left) and current gene of the town (source: Atlas of mutual heritage, author)*

The building would be on stilts in order to allow the stream to flow through. Since the traditional architecture here has building on twerps a combination of the two could be incorporated.

Fig. 7.5 *Stilt structure (source: author)*

Since it is an ecologically sensitive area and prone to cyclones construction would involve negotiations between prefabricated materials and providing structural stability.

Fig. 7.6 *Envisioned spaces (source: author)*

Fig. 7.7 *Living Wetland Theatre (source: author)*

Fig. 7.8 *View to mangrove trails (source: author)*

The food court could serve starters/ fastfood in the ground floor similar to the experience one can find along the marina beach stretch and formal dining on the first floor.

Fig. 7.9 *Ephemeral activities on ground to allow floodable space when in need (source: author)*

Punctures to allow visual connection and water to flow through on ground ***Fig. 7.10*** *Configuration of food court (source: author)*

Providing building cutouts towards waterbody to encourage activities and social cohesion along these edges.

Fig. 7.11 Courtyards to bring the waterbody to the forefront (source: author)

Juxtaposing a few buildings to provide a visual connectivity, embracing wind and distinction that it is for a private purpose while still maintain the essence of the native configuration.

Fig. 7.12 *Coverall arrangement (source: author)*

The thesis also aims to redesign the fish market to facilitate current needs, provide safety from floods and redefine the water edge. The project envisions a new design for the fish market that respects community needs, waste management. ecology, resilience and introduce a new experience for purchasing sea food.

Fig. 7.13 *Redesigning the water edge (source: author)*

Since the structure is in CRZ 1 and is more in a sensitive area. The approach for the design has been more sensitive towards the natural forces.
The structure could be a combination of amphibious and stilt structure that floats as the water level increases.

Fig. 7.14 Redesigning the water edge (source: author)

The configuration of the fish market is such that the landing, auction and retail all happen at one place. This has been done since the existing activities at site align with such typology, the building would have a fluidic form surrounded with mangrove to provide resilience against cyclones. Since it lies at CRZ1 No new proposal is allowed.

Fig. 7.15 Plan evolution (source: author)

Zoning

Fig. 7.16 Site zoning and circulation (source: author)

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CERTIFICATE OF COMPLETION

This is to certify that this thesis project titled "**Thesis Title**" was carried out by Sh./Smt. **Name of Student**, a student of **Name of Course**, at the **Name of Institute**. The research for this project was undertaken under the guidance of the afore mentioned institute and completed during the period of **Start Date** to **End Date**.

This project was shortlisted under the *Sponsored Thesis Project Competition on "RE-IMAGINING URBAN RIVERS" (Season- 3)* hosted by the National Institute of Urban Affairs (NIUA) and the National Mission for Clean Ganga (NMCG).

This report has been submitted by the student as a final deliverable under the competition. All parts of this research can used by any of the undersigning parties.

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