

Water Resilient Koliwada

*Adapting the Koli community
in Mumbai to sea level rise*

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Final Report May 2020

Submitted by **Abhinav Jaiprakash Singh**, Master of Urban Design Candidate, 2020 in partial fulfilment of the Master of Urban Design course, School of Architecture, Carnegie Mellon University

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declaration

I hereby declare that this written submission entitled "Water Resilient Koliwada" represents my ideas in my own words and has not been taken from the work of others (as from books, articles, essays, dissertations, other media and online); and where others' ideas or words have been included, I have adequately cited and referenced the original sources. Direct quotations from books, journal articles, internet sources, other texts, or any other source whatsoever are acknowledged and the source cited are identified in the dissertation references.

No material other than that cited and listed has been used.

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I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact source in my submission.

This work, or any part of it, has not been previously submitted by me or any other person for assessment on this or any other course of study.

A handwritten signature in blue ink, appearing to read "AJ Singh".

Signature of the Student:

Name of the Student: Abhinav J Singh:

Date: 17 May, 2020

Place: Pittsburgh, PA

acknowledgements

Taking cue from the quote by Marci Shimoff,

"It is support that sustains us on the journey we have started",

I would like to extend my most humble gratitude to the following people who have been instrumental in my journey

My parents Sunitta Singh and Jaiprakash Singh for supporting me in every way possible and allowing me to chase my dreams. My younger brother Anubhaav Singh, for following his dream, always asking me for his commission and being a constant source of entertainment. The rest of my rather large family, for celebrating all my achievements, big and small.

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Anuj sir and Mridula ma'am for always calling me out for my whining and keeping me grounded. My colleagues at STG Design, Architect Hafeez Contractor, Hingoo Architects and every other person who has contributed to my journey of learning and exploration, Thank you!

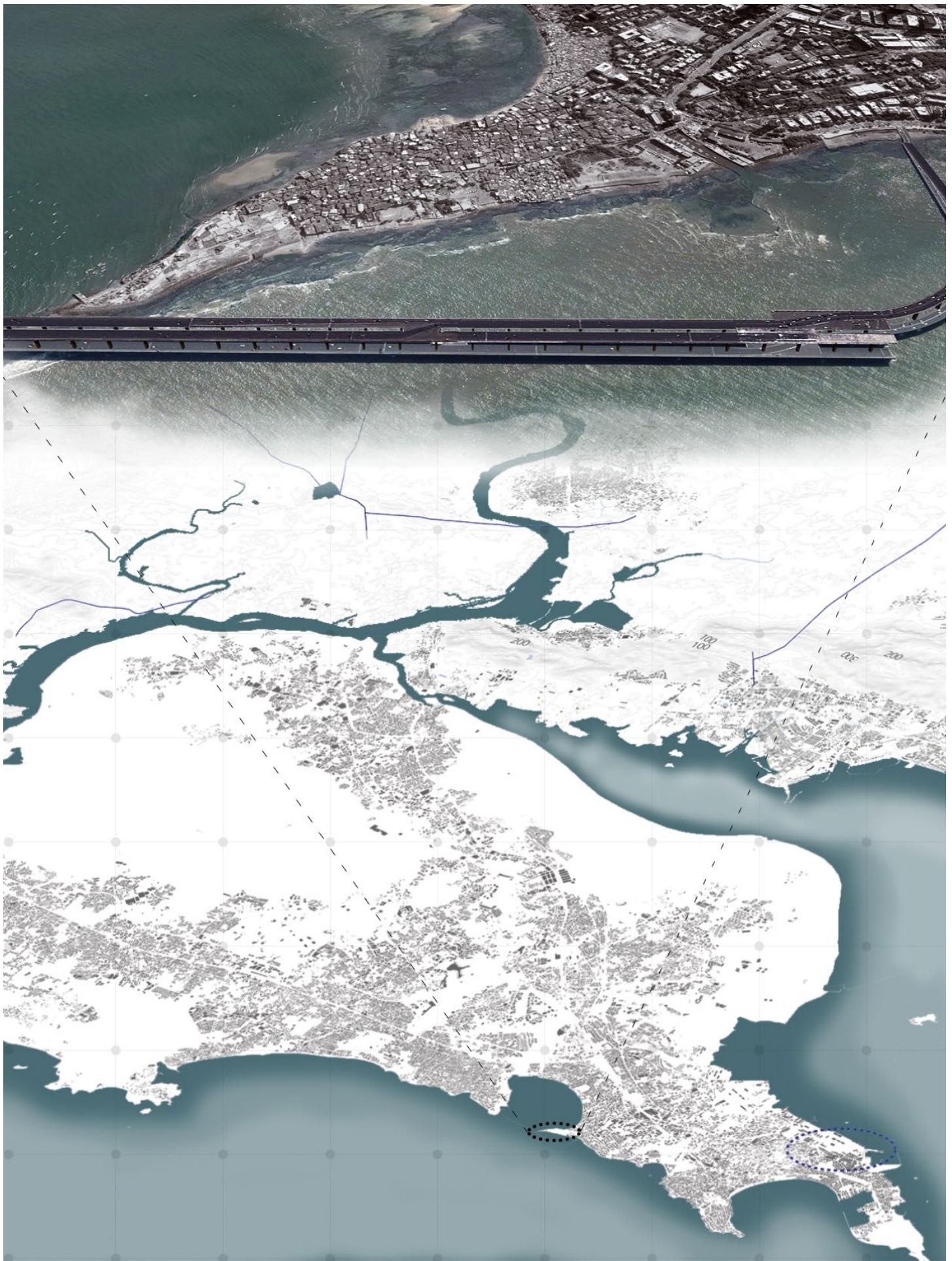
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Water Resilient Koliwada

*Adapting the Koli community
in Mumbai to sea level rise*

abstract



Mumbai is a fragmented and polarized metropolis in which luxurious high-rises are encircled by informal settlements and slums. The city's **contested** and **dysfunctional water infrastructure** is a striking indicator of its persistent social inequalities. Surrounded by water on three sides and with **rapid urbanization reducing the mangrove cover**, the city faces imminent challenges from **rising sea levels**.

Unreliable monsoons leave the taps running dry in thousands of households and the search for new sources of water supply have given rise to contested pipe politics in the city. The state has been unable to provide for a robust storm water management and waste disposal system, relying on **outdated infrastructure** constructed during the colonial era. Mumbai as a city though, thrives on the determination and rigor of its citizens, and has withstood and sprung back quickly from every challenge it has faced. The famed '**Spirit of Mumbai**' has been well documented in the face of adversity and is the city's biggest asset.

Urban Expansion of Mumbai

Mumbai, today, is a city of 21 million people. What existed as a cluster of fishing villages in the 1800's has rapidly grown into a global metropolis.

The growth of the city however, has come at a cost. Mumbai is **surrounded by water on three sides**. The 'waterlocked' city has suffered from severe shortage of space leading to unplanned growth. An endless sprawl of suburbs has cropped up at the expense of the city's delicate ecology. The haphazard building spree has led to an extensive reduction in the marshland area that is critical in the city's natural flood resilient system.

The population explosion in a span of 5 decades has strained the city's crumbling infrastructure, much of which was constructed during the colonial era and is in dire need for upgrade. As the civic body struggles to provide the teeming millions with basic necessities of housing, services and other amenities, the city's unabated growth continues, ignorant to an invisible threat from imminent sea level rise.

Urban Expansion - MMR

1980



1990



2000



2010

Percentage Of Builtup



20%



85%

Percentage Of Marshlands



85%



15%

Area of 19 Major Water Bodies

(Source: Water Resources Department (WRD))



1135Ha



645Ha

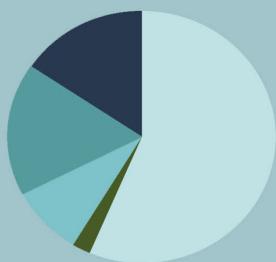
Population of Mumbai City



8Million



21Million



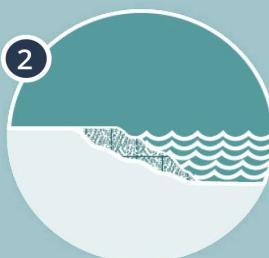
- Buildings
- Trees
- Tanks
- Parks
- Others

Greater Mumbai Corporation
Area Distribution



FLY ASH DUMPING

Industrial dumping in the river and canal has resulted in silting and formation of sand bars, obstructing the natural flow of water into the sea.



COASTAL POLLUTION

Mumbai's water bodies and channels suffer from water pollution eventually resulting into coastal pollution.



COASTAL EROSION

A relatively new threat to the city as a result of the construction of sea harbors. The harbor docks block the sediment flow running northwards along the coast causing sedimentation south of the harbors and erosion north to the harbors.



UNTREATED SEWAGE

Adyar and Kosasthalaiyar river suffer from chemical pollution due to industrial effluents discharged into the rivers. Buckingham Canal receives 60% of untreated sewerage surplus.



REAL ESTATE PRESSURES

The rising Real Estate demands has resulted in shrinkage of some of the important water bodies and marshes in the city eventually reducing the holding capacities of the water bodies.



DIMINISHING WETLANDS

Urban Development, poor management of wetland systems, legal and illegal dumping of solid waste and construction wetlands have collectively resulted in diminishing wetlands which were vital part of the hydro-ecosystem of the city.



Annual Average Rainfall

2300 mm



Total Catchment of Reservoirs

11057 mcft



River Discharge Capacity- Adyar

72000 c/s



Flood Discharge- Adyar 2015

>80000 c/s



Water Demand

4200 MLD



Water Supply

3300MLD



Water Deficit

900 MLD



Projected Water Deficit- 2030

1400 MLD

Mumbai's water paradox

Mumbai relies on the southwest monsoons for its water supply. Between the months of June and October, the monsoons dump almost **2300mm of rains** over the city and its catchment areas. By most calculations, this rainfall is **sufficient to provide for the 21 million residents** of the city through the remaining 8 months of the year.

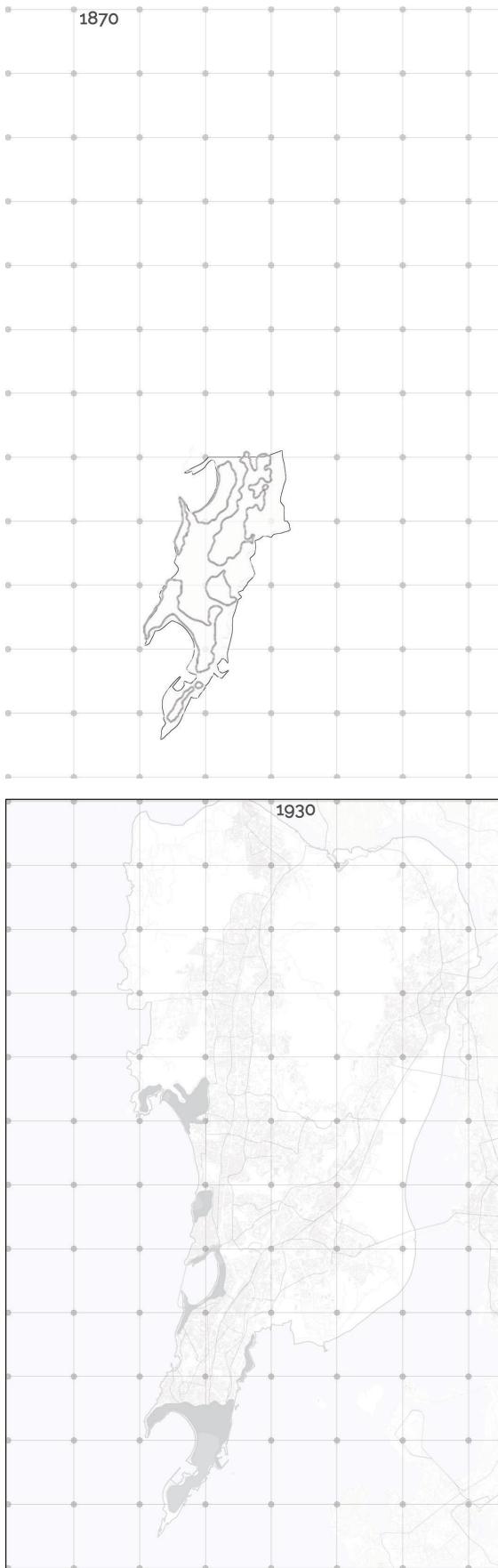
However, as opposed to the existing demand of 4200 Million Litres of Water Daily (MLD), the civic body is only able to supply the city with 3300 MLD , which leads to a water deficit of 900 MLD, or a 21% reduction which means that about a fifth of the city's population, almost **4.5 million people, endure a daily struggle** for access to clean drinking water.

Much of the city's topography lies below the sea level. With a sharp reduction in green cover in the city, the rainwater inundates the ageing storm water infrastructure causing the lowlying city, formed by extensive reclamations carried out by the British during the 1800's, to suffer from **extensive flooding every year**.

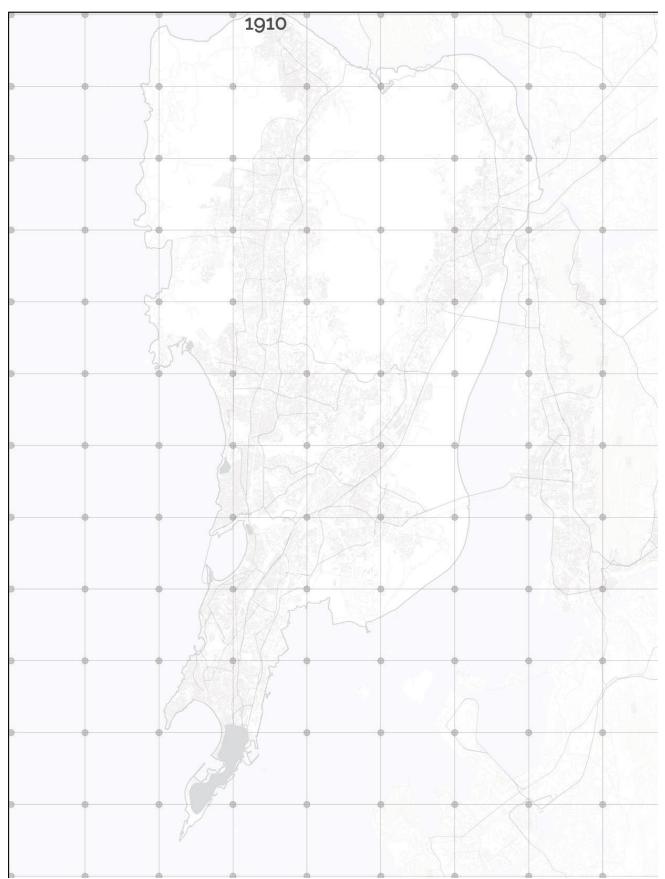
Mapping Mumbai's growth

Land and water have played an integral role in Mumbai's metamorphosis from a small cluster of 7 islands to the metropolis it is today. The city, which was originally 7 islands was growing in prominence under the British rule as the Kolis continued to engage in robust fishing acitivities.

The Hornby Vellard project, a century long reclamation project undertaken by the British East India Company, drained the city's marshland and merged it with the much larger Salsette island, thereby changing its topography forever and sowing the seeds of a vertical sprawl that continues unabated today.



map info source:MMRDA, maps: author



research question



Image:economic.co.uk

With multifarious problems such as sea level rise, unreliable monsoons, outdated infrastructure of storm water management, waste disposal and failure on behalf of the authorities in addressing the plight of the citizens, can the citizens prepare and equip themselves to deal with the precarious water challenges they face?

who is the thesis for

The Koli Community:

The original inhabitants of Mumbai



The Koli Fisherfolk



Spin off industries-net

umbai



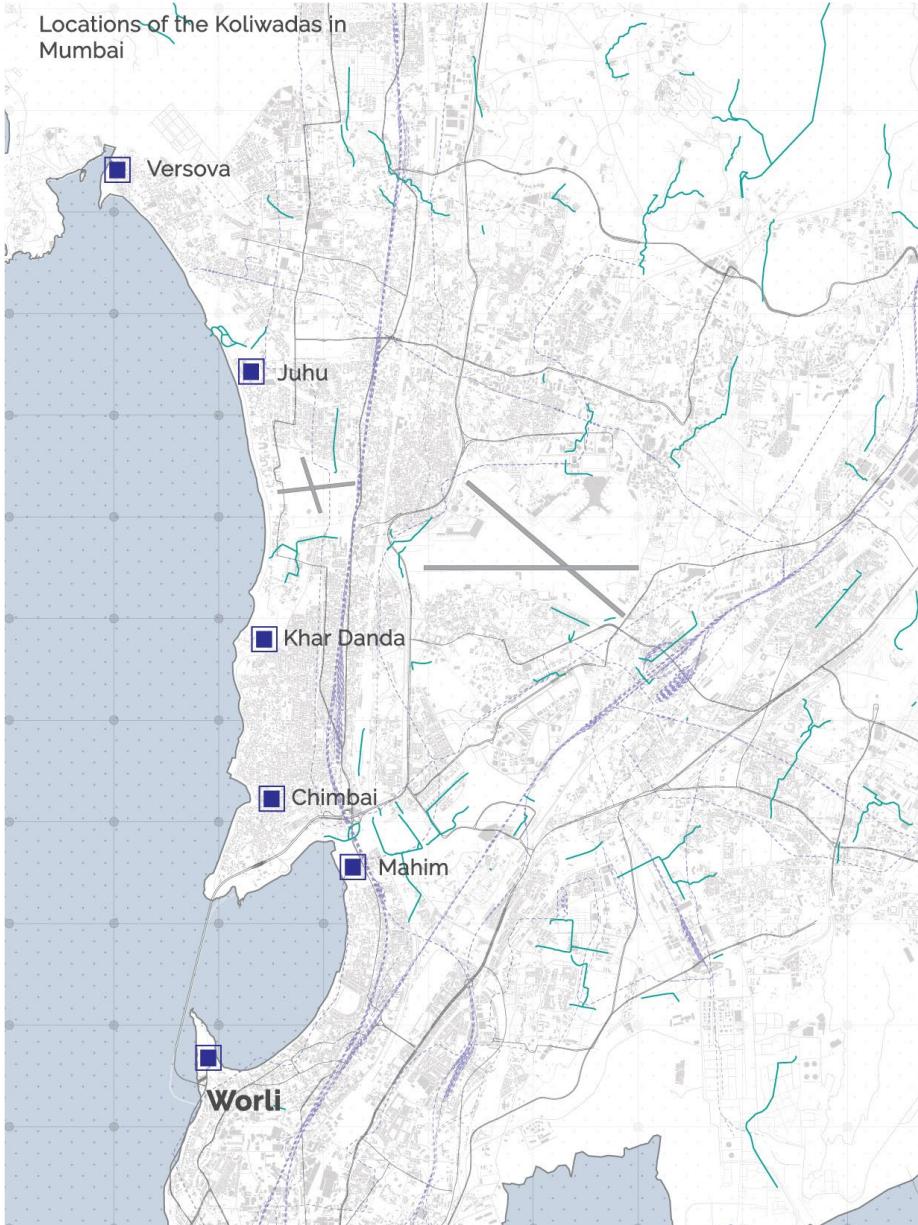
& boat making



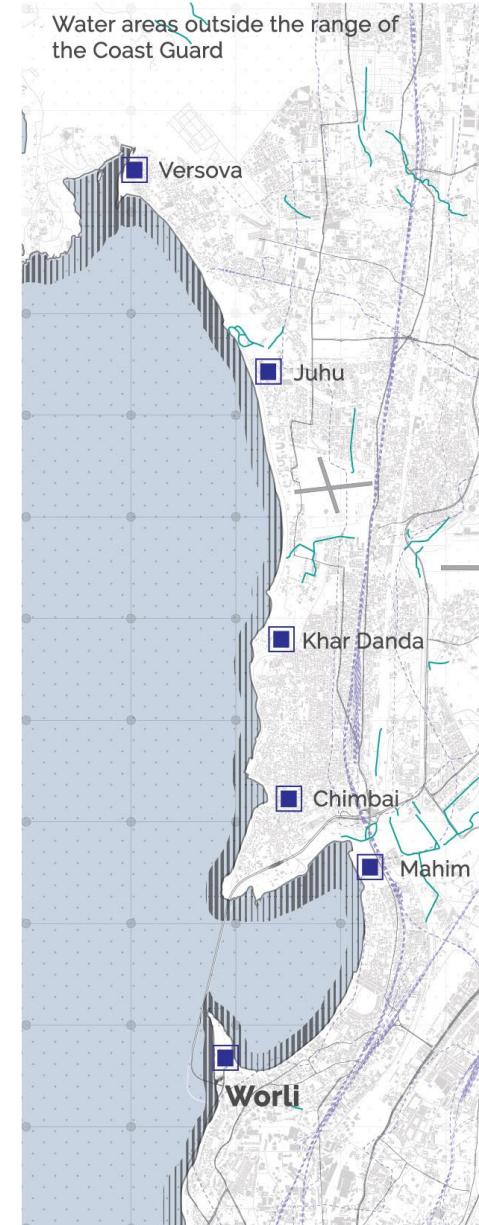
Women are equal stakeholders

Images:dnaindia.com,author

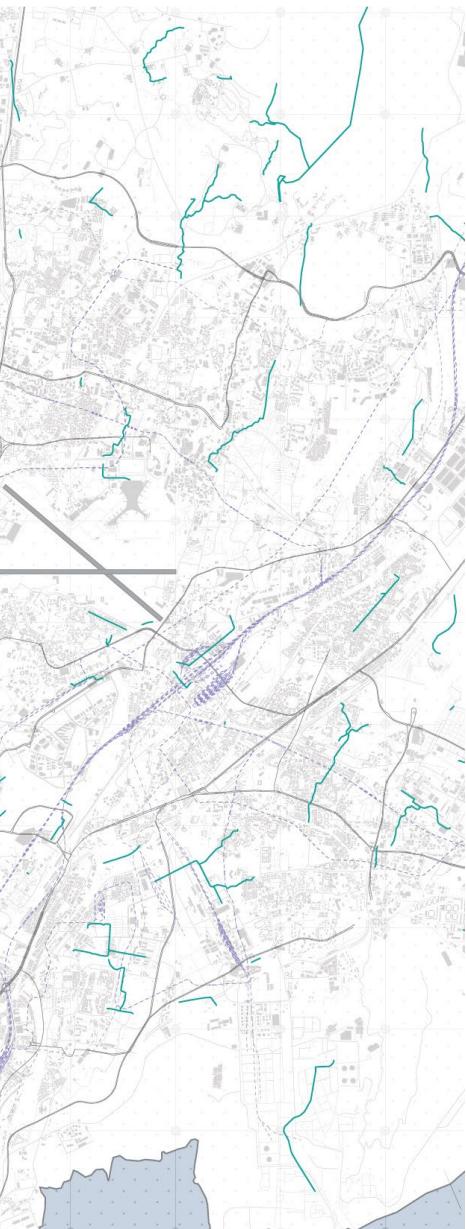
The Koliwada Network Analysis



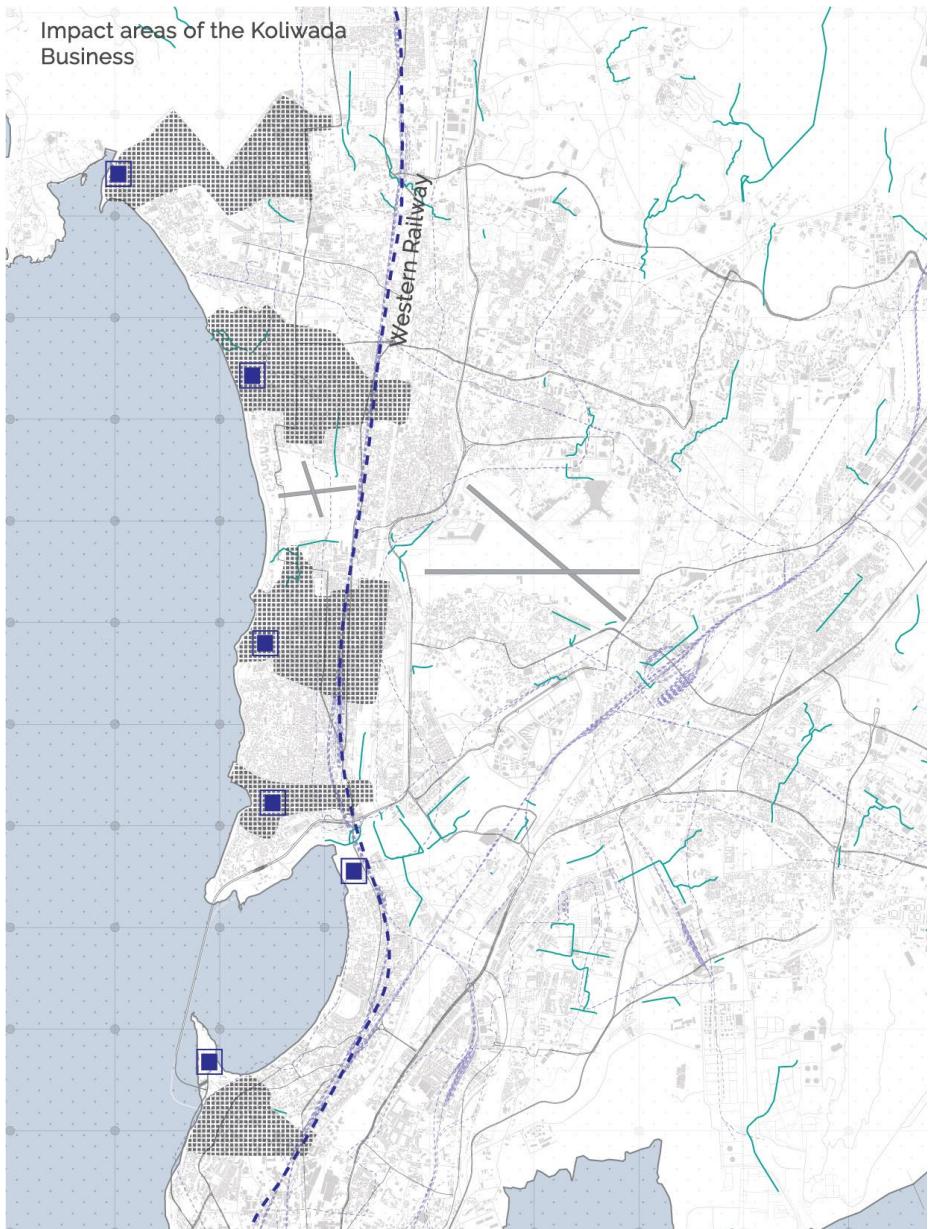
The Koliwadas are located along the western coast of the city



The Koliwadas occupy land inherited from their ancestors, which is presently classified as a sensitive, Coastal Region by the government



land that they
ancestors and is
s highly ecologically
ulation Zone CRZ 1



The Koliwadas depend on the Western Railway and the freeways of the city to transport their catch to major commercial docks.

Intangible Commoning culture at large scale
of harmonic existence between the network



The Koliwadas of Mumbai are located along the western coast of the city. Earliest documented records of the Kolis date back to the 13th century.

The Koliwada, a literal translation of the Marathi word for 'Koli village', is a settlement where the Kolis own the land parcels individually and the community has staked ownership of the village as a whole, however sketchy documentation of land holding records makes them vulnerable to real estate forces.

The Indian coast guard is authorized for safety of the naval borders from a distance of 150 feet beyond the mainland. Any construction or economic activity beyond that requires authorization from the State and Environmental Ministry

The Koli fishing catchment area spreads 2 miles into the sea and depends on the Western Railway to transport their catch to city markets and households

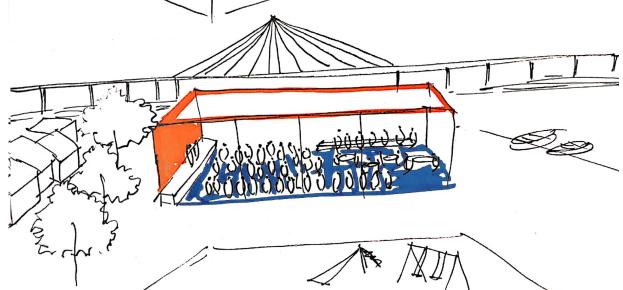
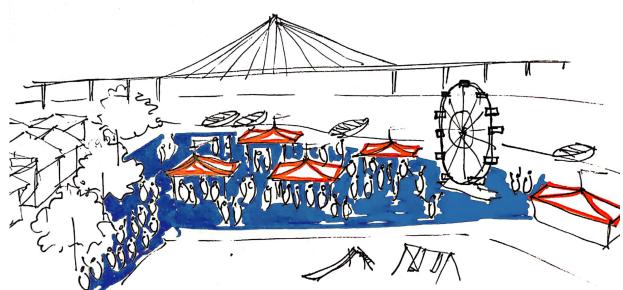
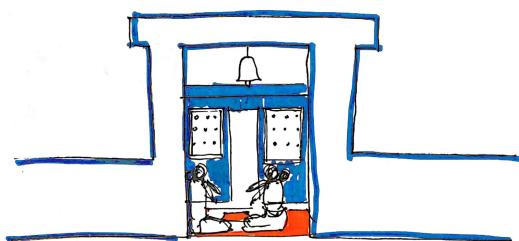
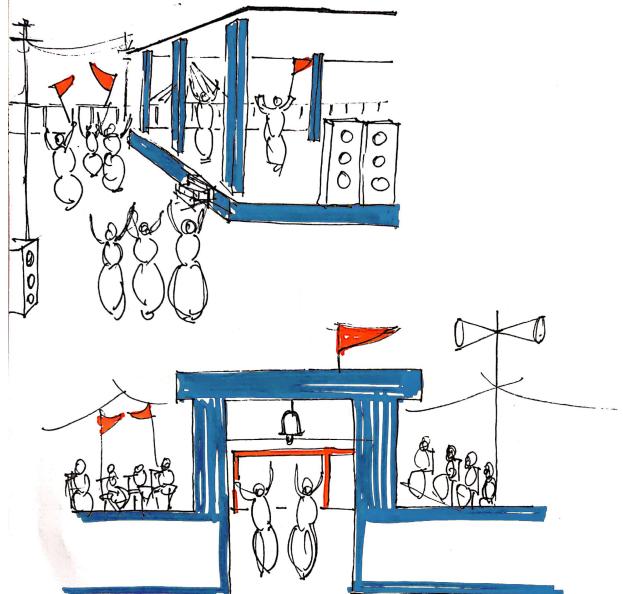
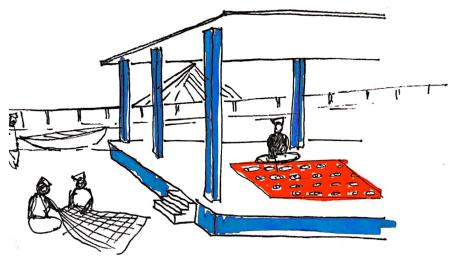
Existing commoning culture

Studying the livelihoods and culture of the Koli community reveals strong cultural ties and a culture of sharing between the community. The typical layouts of houses consists of a 'verandah' which is a public space for gathering and welcoming visitors as well as small scale social gatherings

The temples, mosques and churches are generally planned around courtyards to hold religious ceremonies and are linked with a community center which is run by the proceeds from the religious insititutions.

Public courtyards are used by the community for gatherings, polling, washing clothes, drying fish and even small scale businesses.

Each Koliwada has a large open space which is used to plan events for the entire neighborhood. Through crowdfunding, the Koliwadas manage to hold festivals, fairs and even wedding ceremonies.



info:CEPT, sketches:author

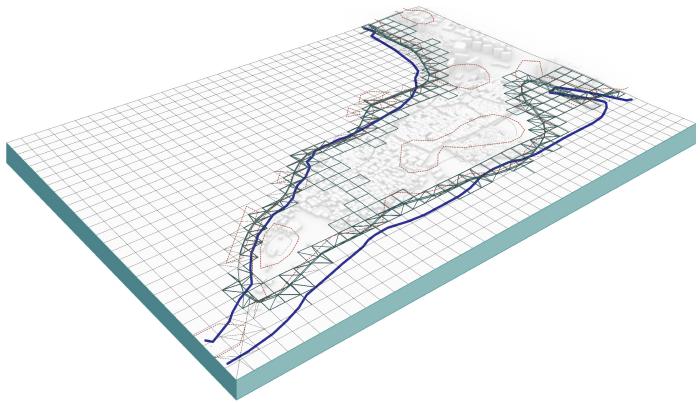
What are their water issues?

Inundation due to rising sea-levels

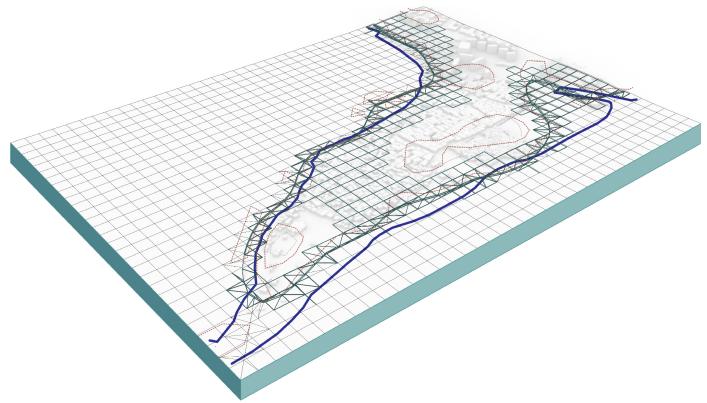
Conservative sea level rise estimates range from 1 feet by 2050 to 2 feet by 2100. Extreme estimates predict a 1 feet sea level rise by 2030, 2 feet by 2050 and 4 feet by 2100.
(climate.gov)

Mapping these conditions on site, gives a fair idea of the scale of the problem. The lowlying Koliwada communities are at risk of losing 90% of their land holdings to the sea by 2100.

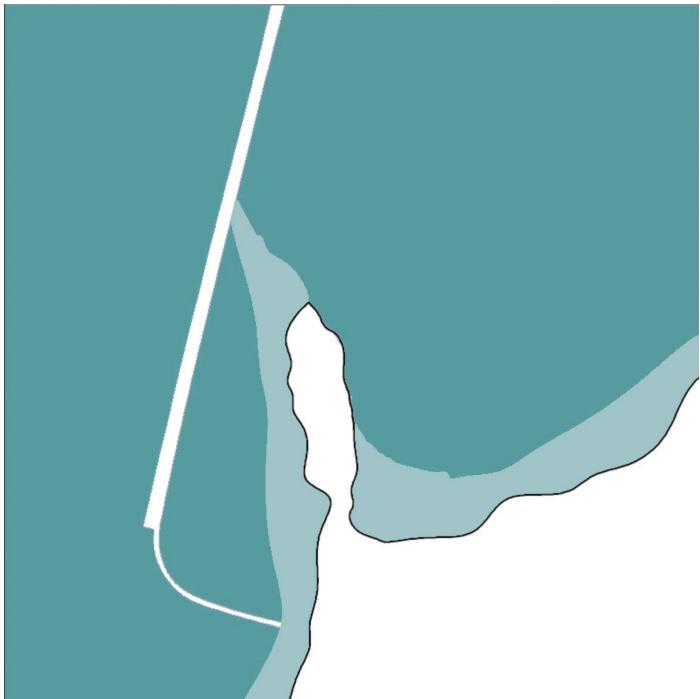
This leaves them in a precarious situation of turning into climate refugees. This thesis investigates alternate scenarios for this community by testing design interventions that allow the Koli community to accept and adapt to sea level rise.



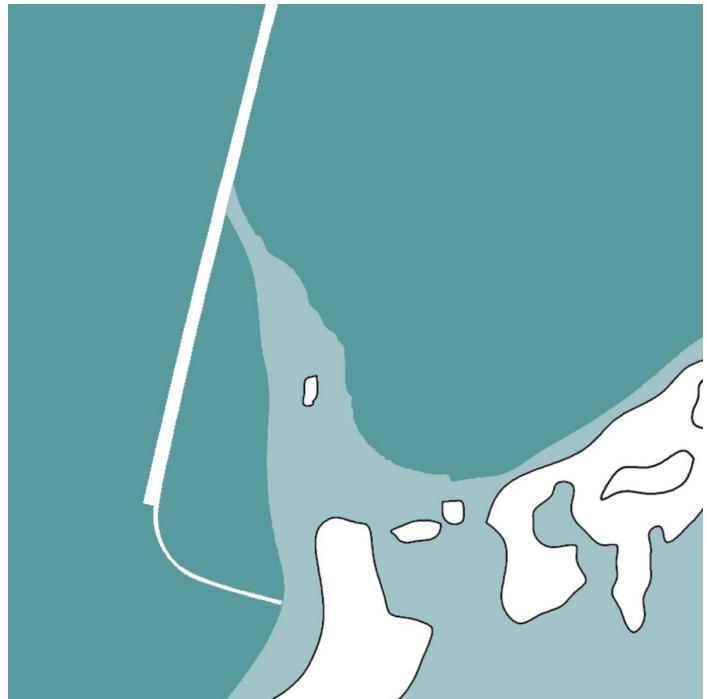
Using terrain mapping to gauge 1 feet rise



Using terrain mapping to gauge 2 feet rise



Mapping 2 feet sea level rise by 2050



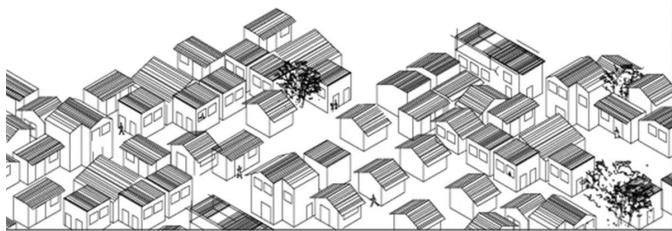
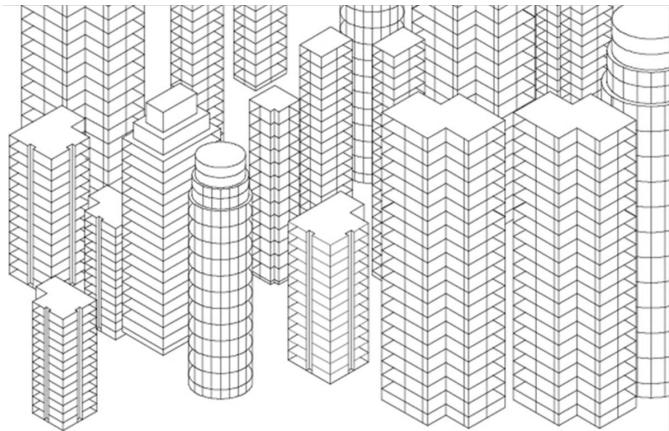
Mapping 4 feet sea level rise by 2100

Urbanization and real estate sharks

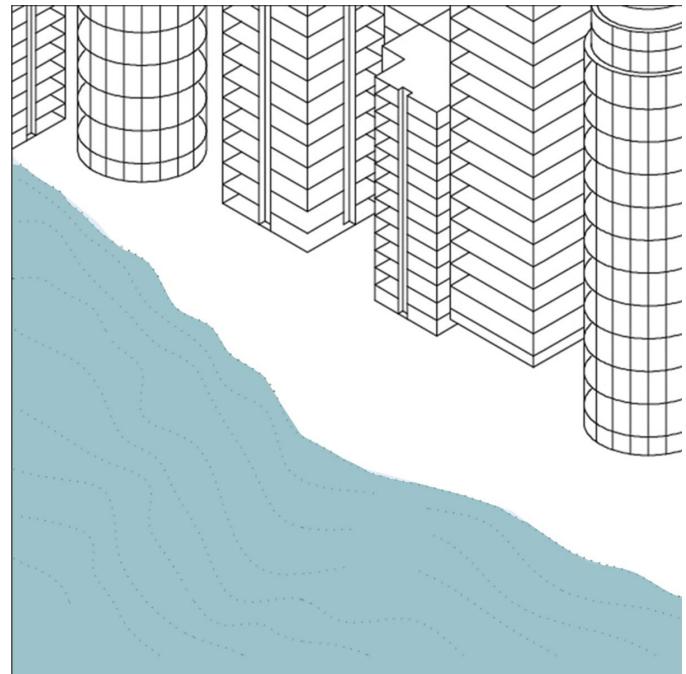
India in 1991 was at a historic juncture on its path to development when the government introduced several liberalization economic reforms, opening the market to the private sector and international investment to bolster a faltering economy (Bjorkman, 2015). Nowhere else were the effects of these economic reforms seen more clearly than in Mumbai, the country's financial capital, then a teeming metropolis of 10 million people (Demographia, 2006).

After having faltered with urban development for decades, the city's policymakers grabbed this opportunity to announce plans to turn the city into a global financial hub on the lines of Singapore . What followed was three decades of unprecedented growth, development and re-development with malls, residential high-rises and office towers replacing old neighborhoods and lower income housing townships sprouting on the periphery creating an endless urban sprawl.

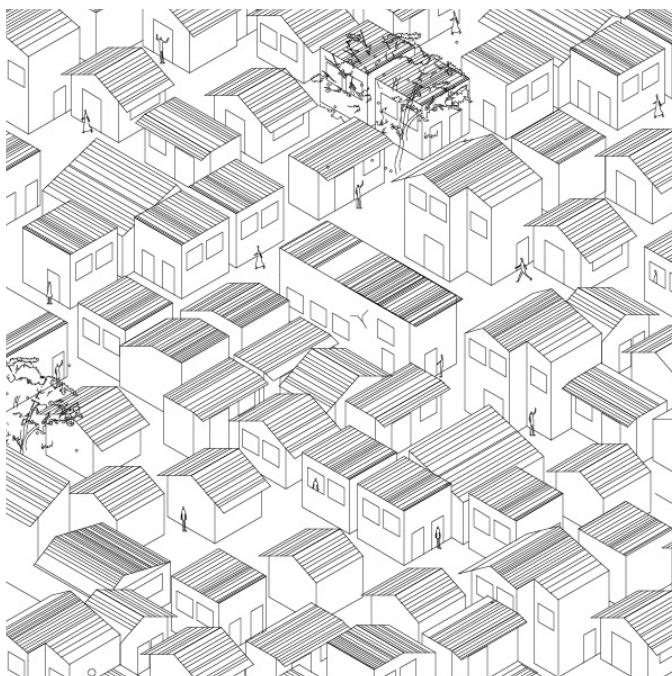
However, the fervor of the dazzling growth blinded the city about the cost it was unknowingly paying- the steady deterioration of its water and built infrastructure. Several informal settlements such as the Koli community have since been entangled in a legal tussle with the state to claim ownership of their land.



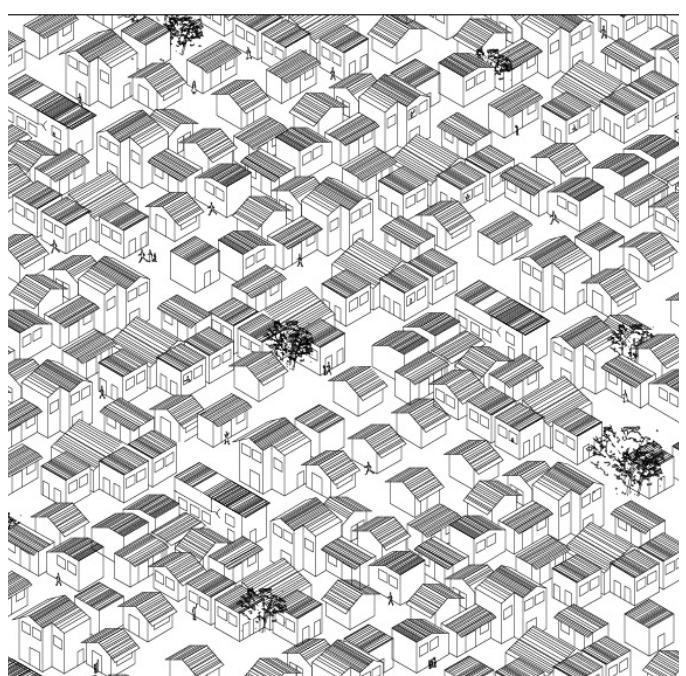
High rise clusters next to the Koliwada



Developers vying for the Koliwada land



low rise high density of Worli Koliwada



incremental unplanned growth

Info: archasm. , graphics:author

Photographic documentation





hypothesis

Integrating social, economic, spatial actors and proposing a design framework that combines inventive ecological and contextual infrastructural interventions, while tapping into the existing commoning practices inherent to the community can address water issues of the Koli community while aiding them in adapting to a new way of living through building new skills thereby making them more resilient.

methodology

1. Refining the scope to identify a particular water problem to address at the larger scale- sea level rise, which in turn can be basis of the design of systems that address smaller scale water and infrastructure problems of the community
2. Identify and refine the list of stakeholders and design a commoning strategy with a defined heirarchy and responsibilities
3. Decide upon the scales of intervention at the Macro, meso and micro scales for the ecological and infrastructural systems design
4. Investigate/Design the systems that would mitigate the effects of sea level rise, example breakwater design, aqua farms, ecological sea barriers with provision for fish farming
5. Design of an incremental housing typology/ system that adapts and responds to the predicted scenarios over the next 50 years

Scales of Intervention

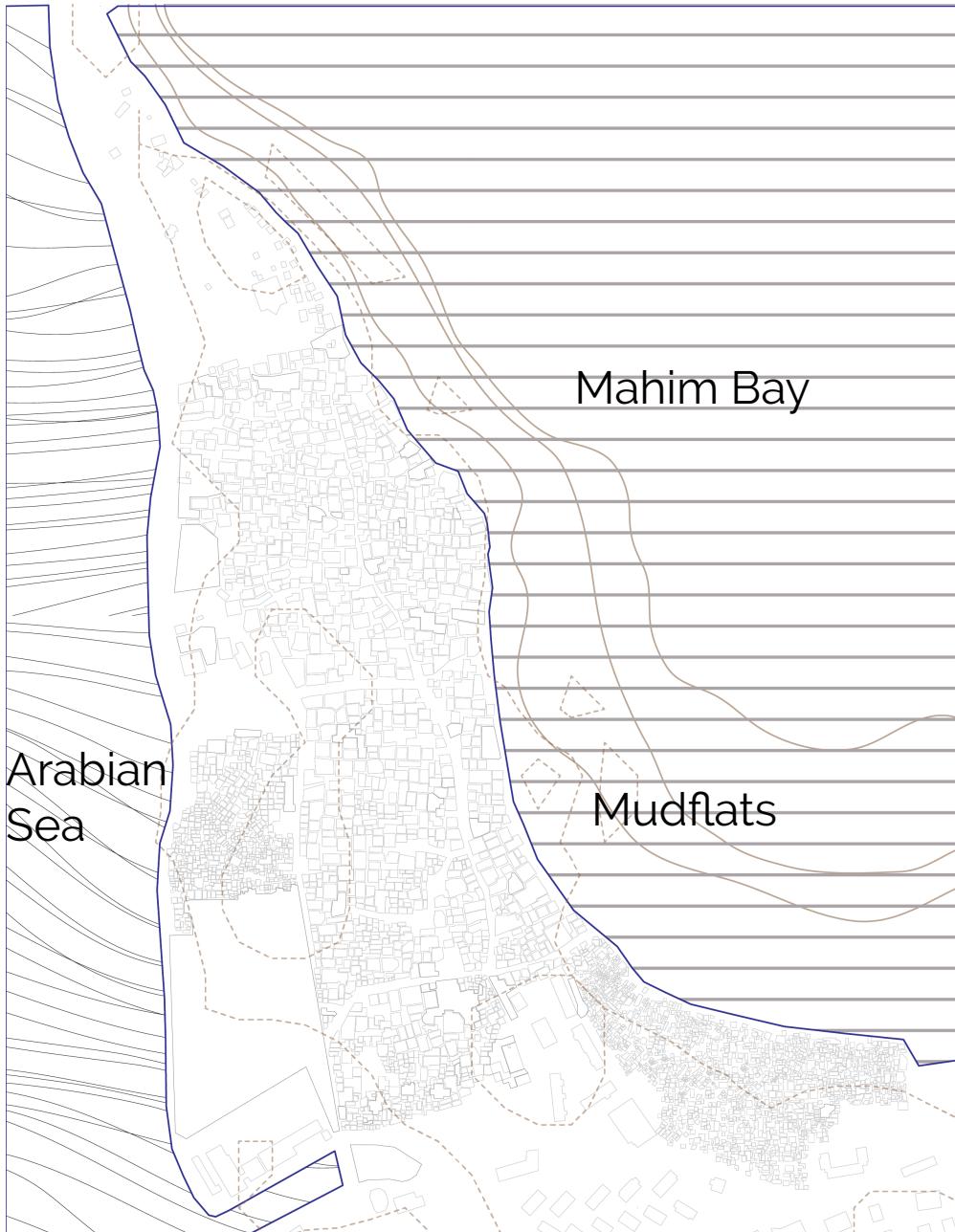
L

M

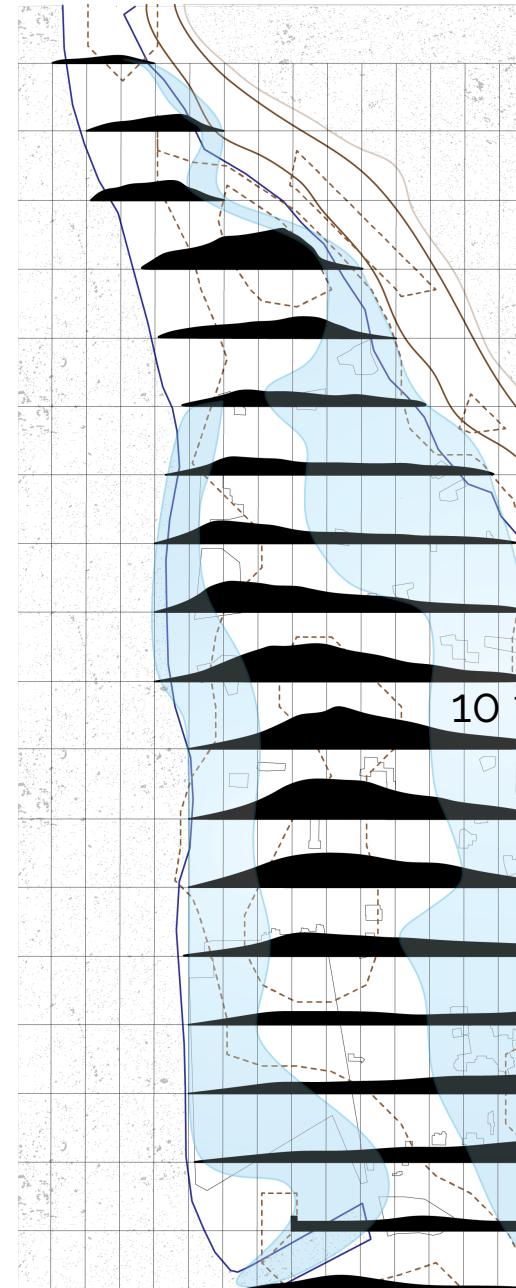
ECOLOGICAL SYSTEMS	<p>Map areas of Impact for 1 ft v/s 2 ft sea level rise</p> <p>Map existing topography and conduct a water flow simulation to check for flooding</p> <p>Cut schematic sections through site to check for edge conditions</p>	<p>Check for existing missing ecological connections</p> <p>Design and implement ecological systems can adapt to on the two different conditions example: breakwaters, aquaculture, mangrove planting, intertidal reef restoration</p>
INFRASTRUCTURE SYSTEMS	<p>Study the linear model of the fishing business and provide an alternative integrated solution to bolster their economy</p> <p>Study the physical connections of the site to the city and design improved modes of visual and physical connectivity</p>	<p>Map the existing network, overlying topography and understand the morphology of the neighborhood</p> <p>Introduce new connections and mark out what is to be demolished and rehabilitated</p> <p>Design an inclusive housing strategy for housing on land</p>

	S	XS
sting and ogical plement ystems that sea level rise stinct edge akwaters, levees, antation, -	Design the strategy for the implementation of aquaponic farms along with aquaculture to boost the fishing industry	Design systems of buoyant ecologies where in the fishing community can act as a hands on participant in the cosntruction through elememts present on site example: boats, pipes, tanks, tyres Design of fish nursery system
ting street rlay with nd the built of the d w to the water t the houses shed and on the bay cremental tegy for nd and water	Map cultural and busi- ness institutions on site and study their impact in the built fabric Reorganize, reimagine and reintegrate these insitutions into the new built fabric based on flooding predictions	Detailed design for housing modules on land and water where they harvest rainwater, adapt to rising sea level, have provision for incremental growth and vertical circulation, waste management for the demolished houses and respond to the bouyant ecologies

Mapping the conditions in Worli Koliwad

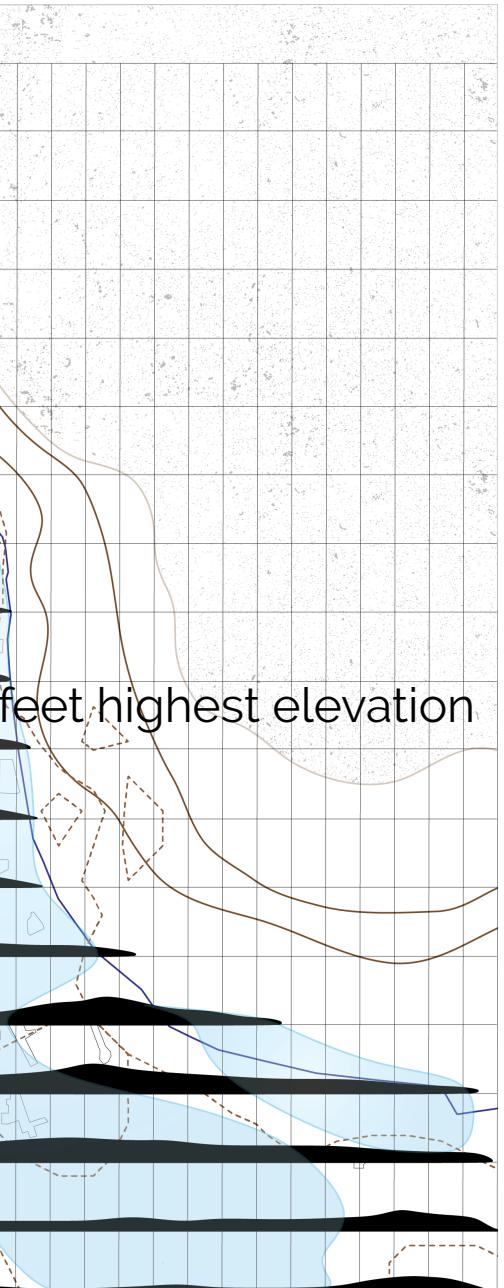


Mapping the edge conditions

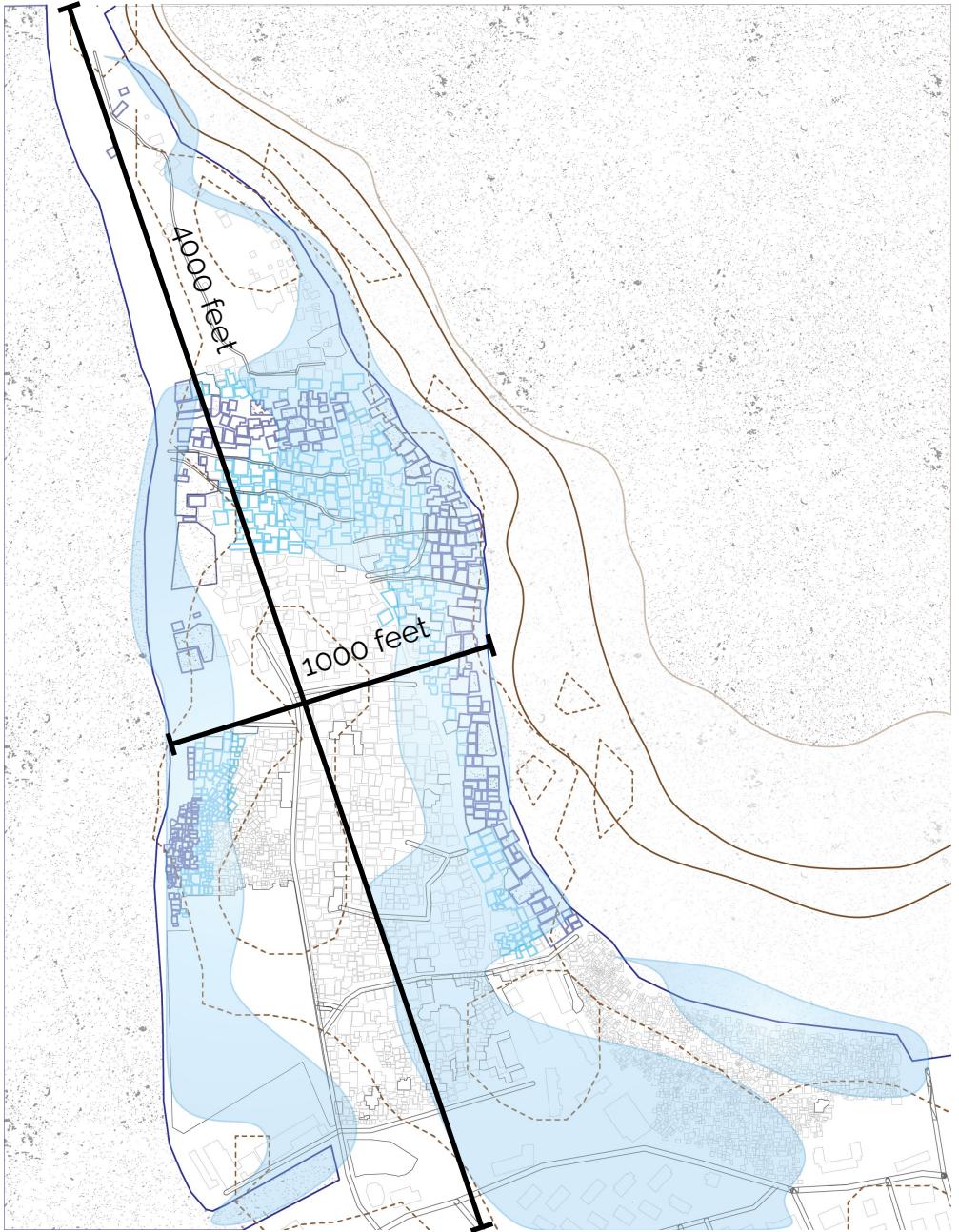


*Schematic topographic
with flood prone regions*

a

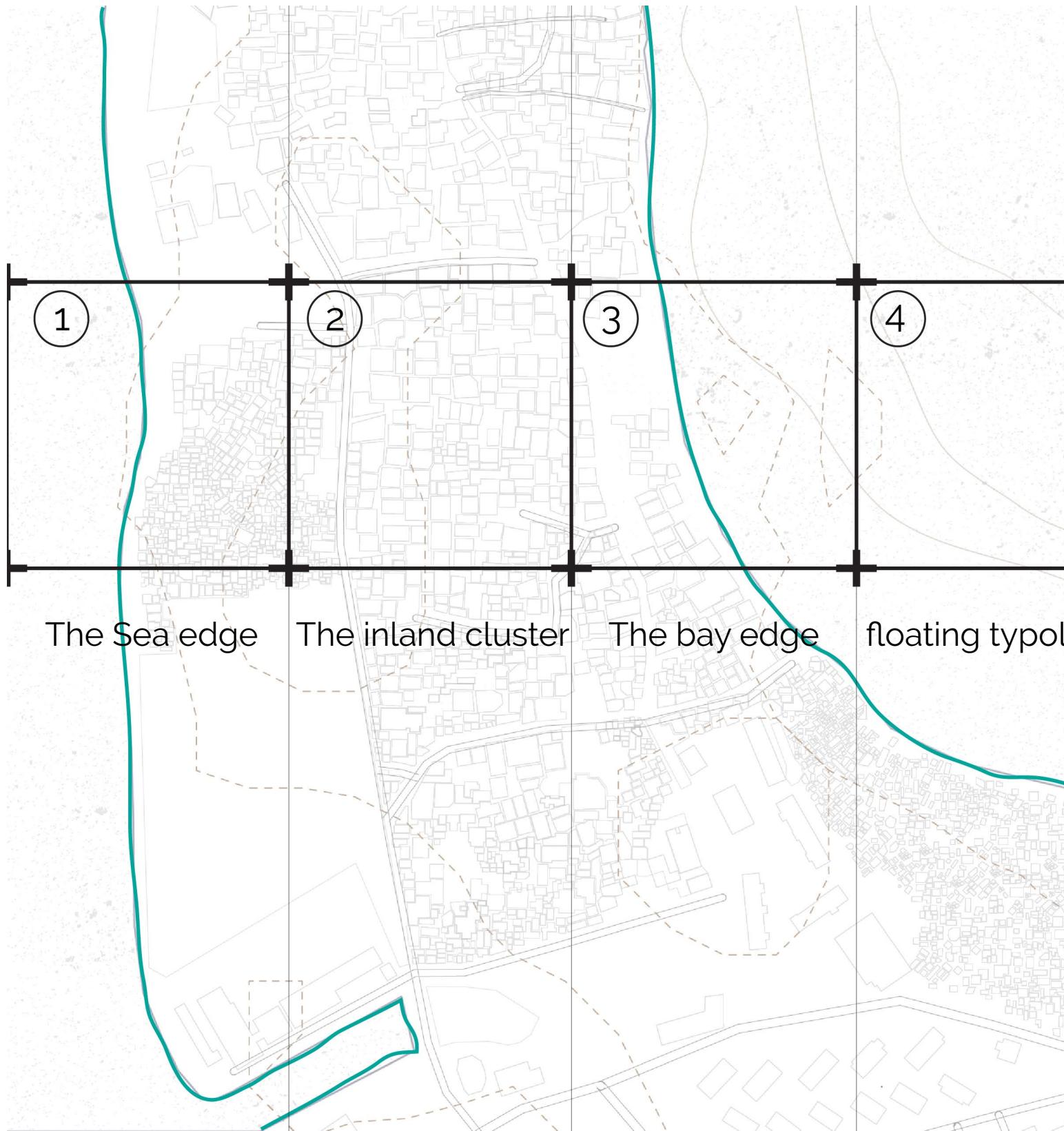


cross sections overlaid
on maps



*Identifying the structures most vulnerable to
inundation*

Defining the transect

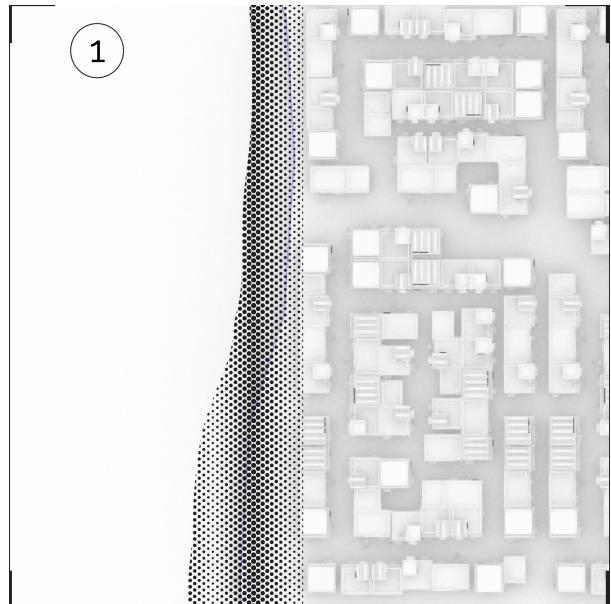


- 
1. The sea edge is the transect that interacts with the Arabian Sea. It currently has a dense cluster of informal housing and is topographically a low lying region most vulnerable to sea level rise.
 2. The second transect is the inland cluster with no interaction with the water and high terrain making it less vulnerable.
 3. The third transect displays similar conditions to the first however it is the location of the fish market and facing the bay, has an existing sea wall.
 4. The fourth transect consists of the delicate ecology of the mudflats that are created by the receding waters of the bay during low tide. This transect is the canvas to explore a new floating house typology.

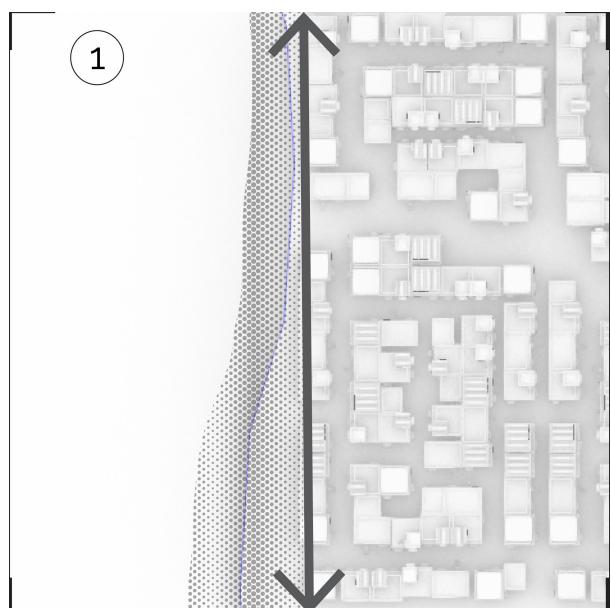
transect 1: the sea edge

Issues

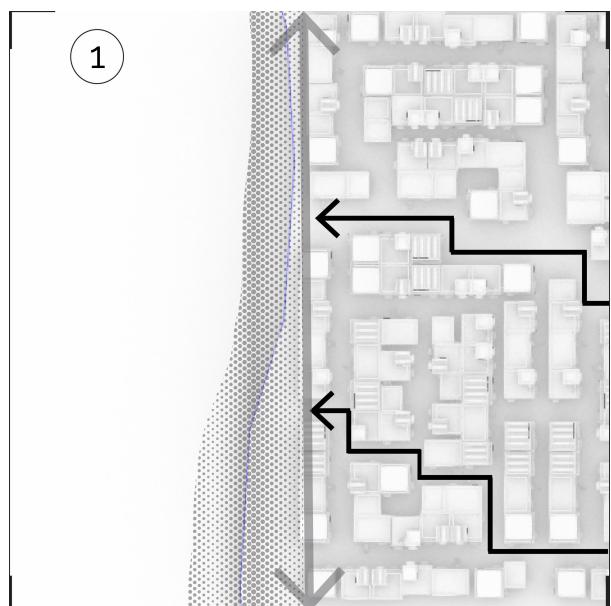
1. Rough coastal edge that acts as a hindrance and a poor edge condition to the murky waters of the Arabian Sea.



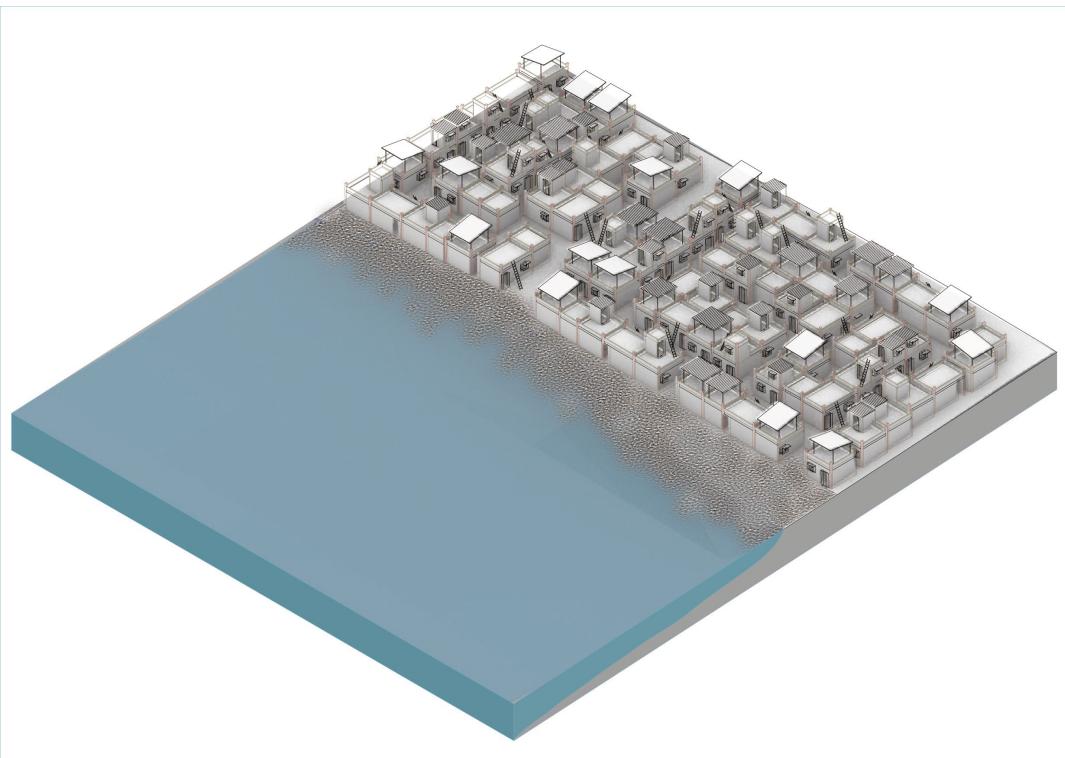
2. The shortage of land and relatively low and flat topography has encouraged several slums and informal structures to crop up. With no planning guidelines to oversee this haphazard construction, the buildings have created a sea wall of their own.



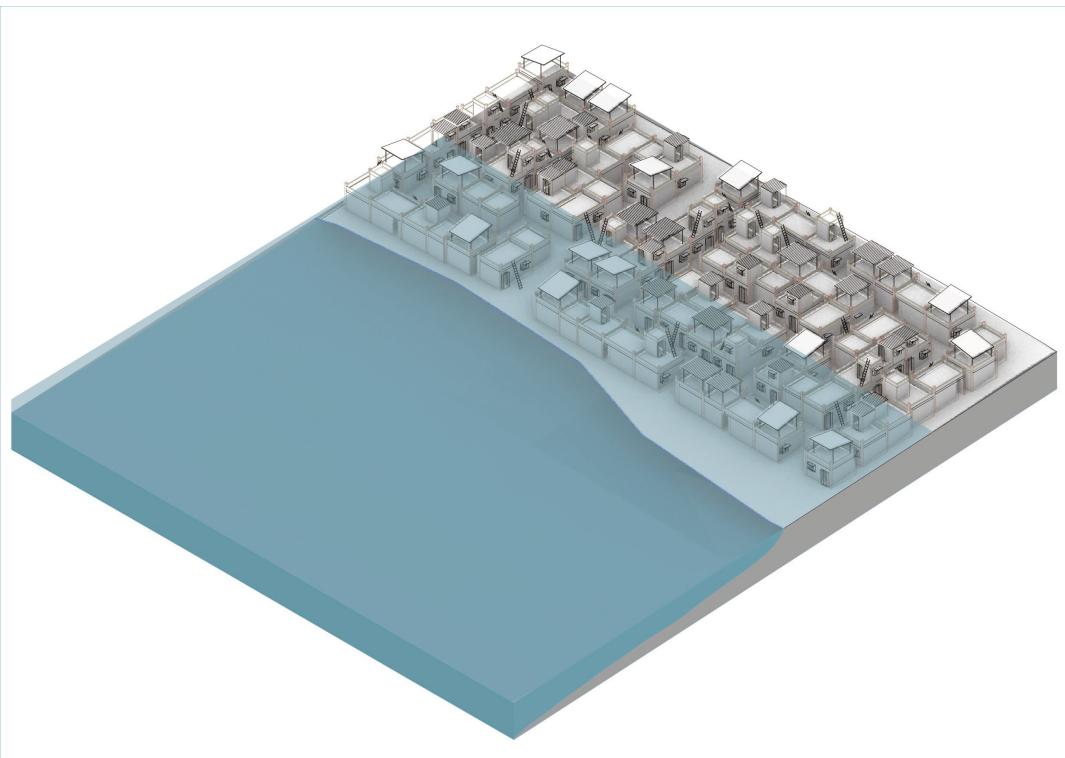
3. The two preceding conditions result in poor accessibility to the edge, both physically and visually,



Present v/s predicted



The existing built morphology of Transect 1



Graphical representation of the extent of inundation predicted for Transect 1

Tactics

Tactic 1: staggering the hard edge to create levees and wetlands that act as an ecological buffer against sea level rise. Clearing out the lower levels to allow for an incremental housing strategy to unfold by rehabilitating the displaced units on the mudflats.

1



Tactic 2: Creating better connections towards the sea for both the community and for the water run off from higher terrain. It is imperative for the ecological and infrastructural interventions to be designed in tandem to provide a holistic design solution.

1

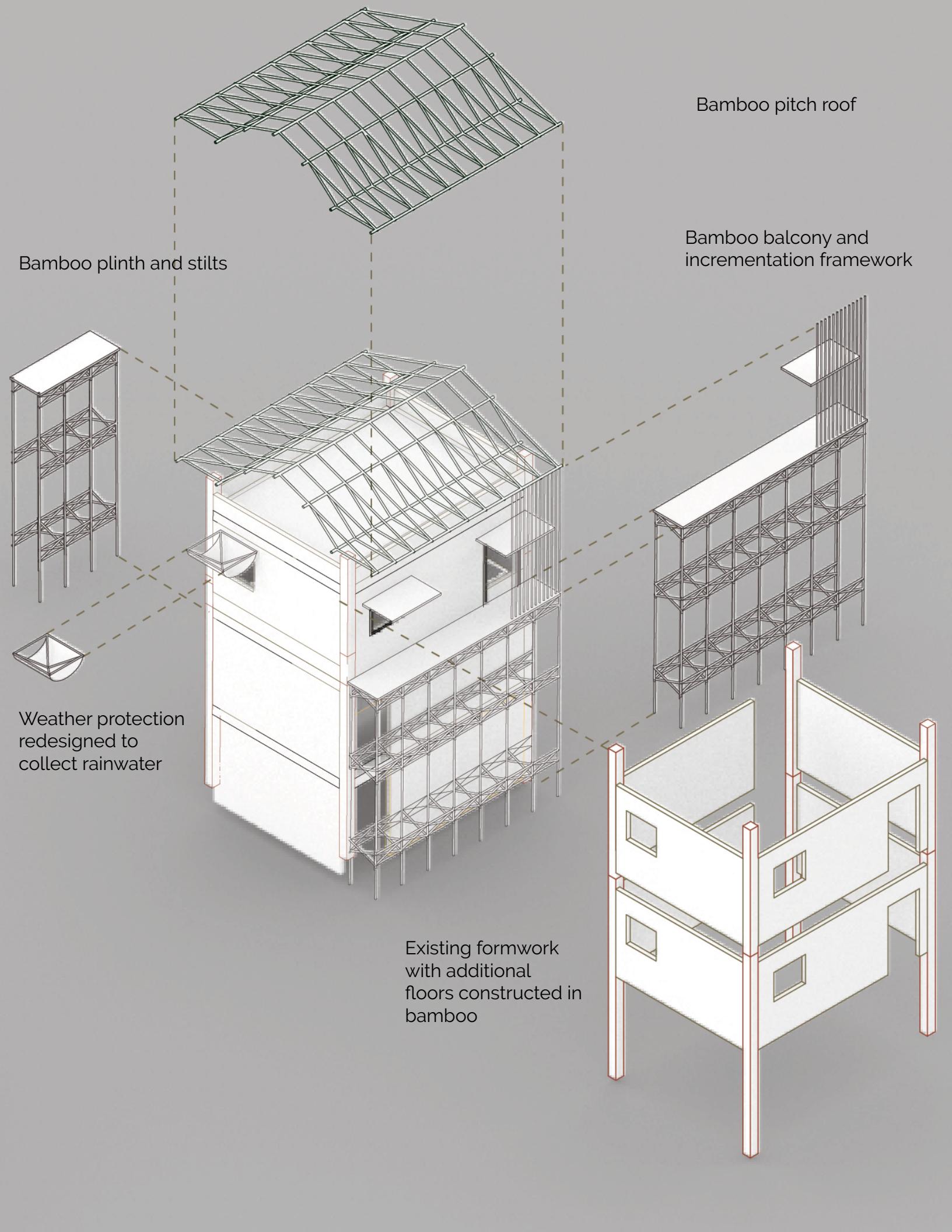


Implementation scale: S -The house

The existing Koliwada housing generally consists of houses constructed in a steel and concrete framework with locally sourced bricks as wall partitions. This type of construction is neither efficient in adapting to sea level rise or for physical refurbishment.

As part of the design strategy, the lower level of the houses is cleared to create space for the water to flow in. The lower levels can be used as storage space in dry conditions to respect the spatial constraints on site. The existing structural framework is carried forward by using locally sourced bamboo to create an incremental system. Bamboo decks and balconies are constructed to connect the houses together and balconies are designed on upper levels to create outdoor spaces which connect the houses visually.

A roof truss in bamboo is designed for the final phase to be raised with each phase of incrementation, creating a flexible unit. The sloping roof combined with the redesigned weather protection are intended to act as rainwater harvesting devices whereas the waste water is designed to be let out into a series of wastewater treatment wetlands



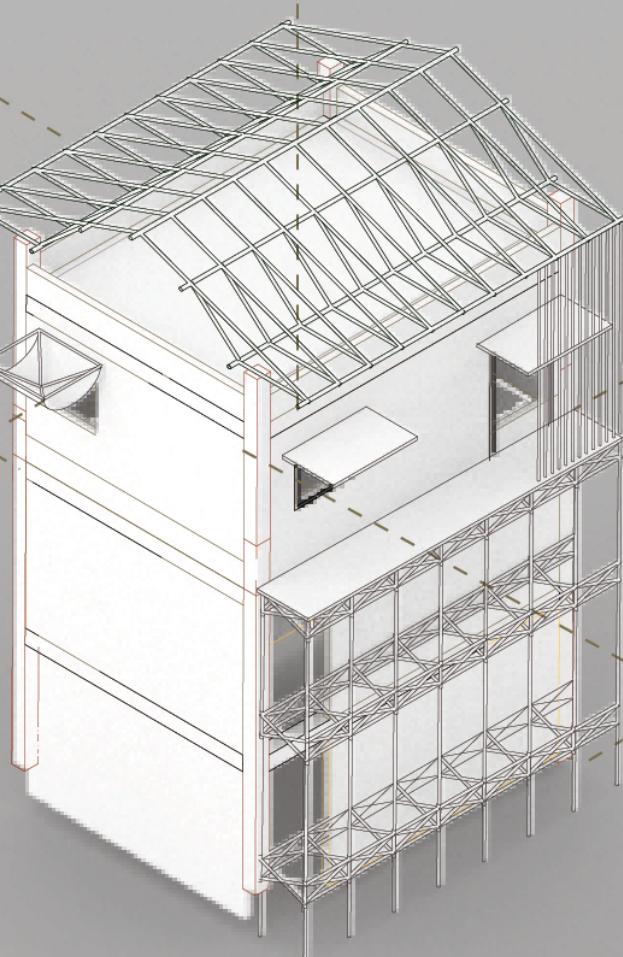
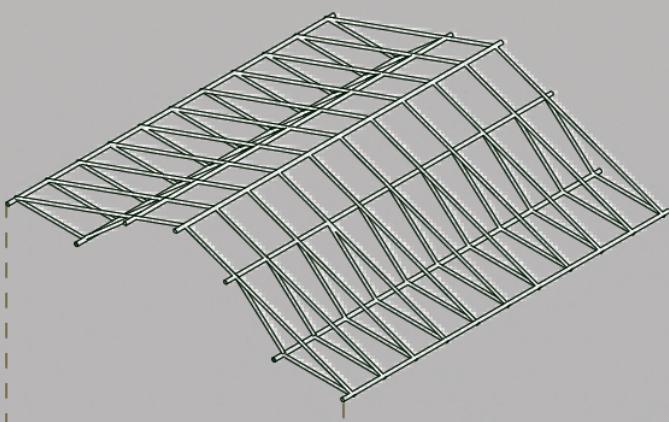
Bamboo pitch roof

Bamboo plinth and stilts

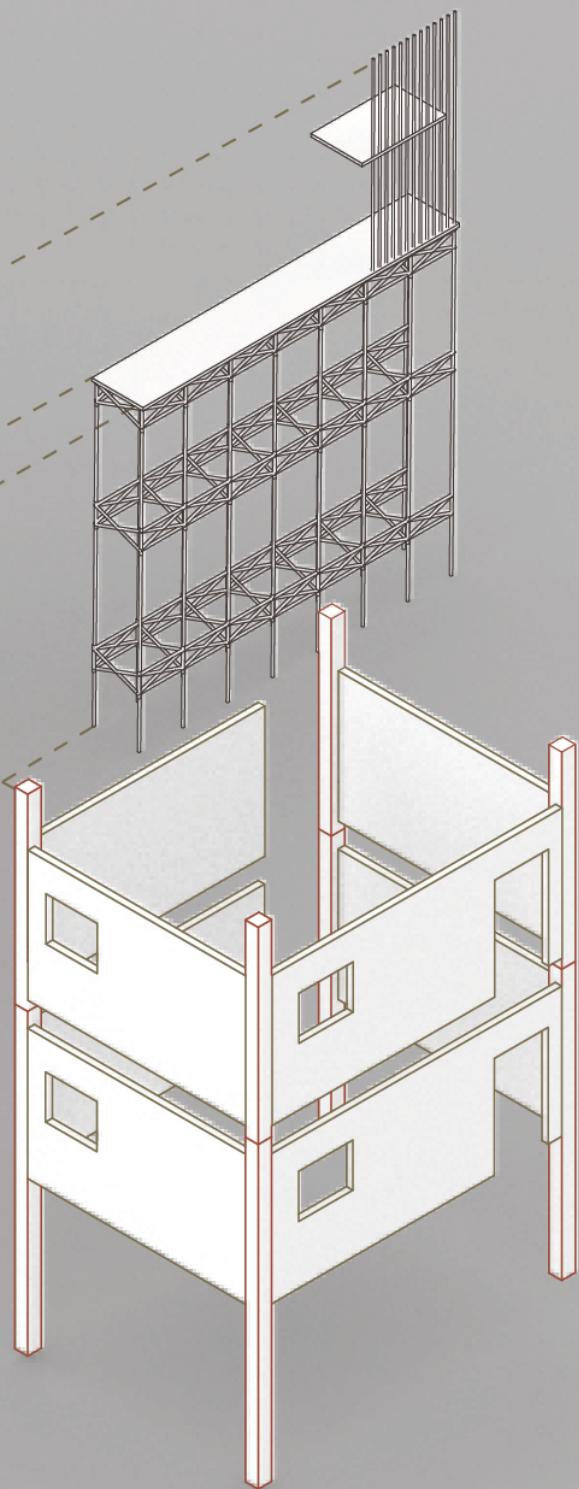
Bamboo balcony and incrementation framework

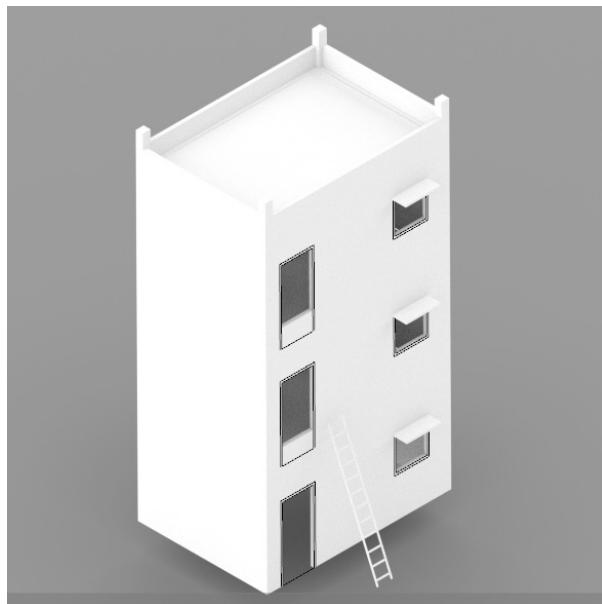
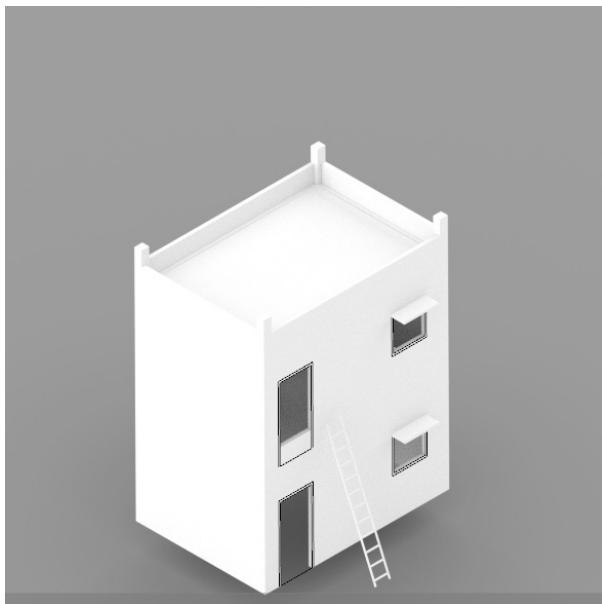


Weather protection
redesigned to
collect rainwater

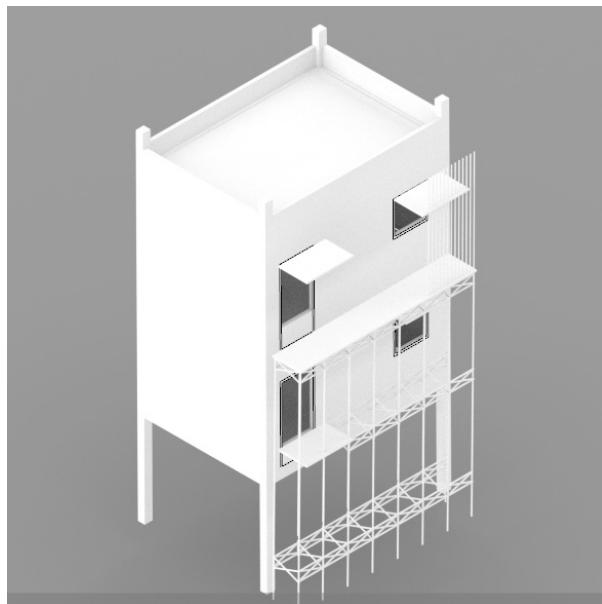
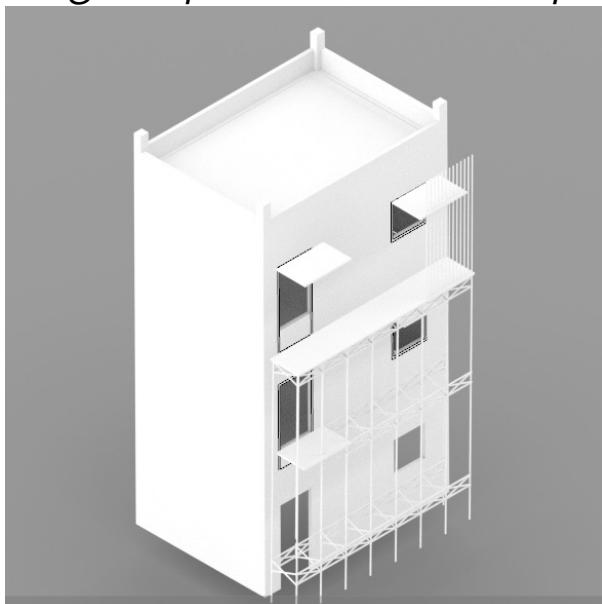


Existing formwork
with additional
floors constructed in
bamboo

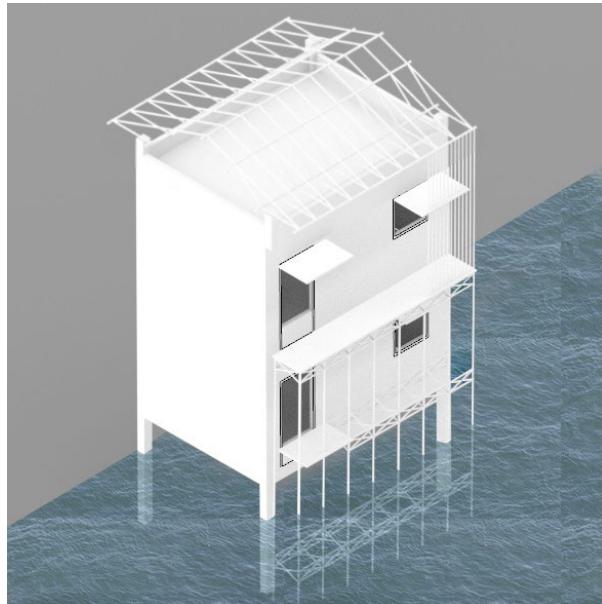
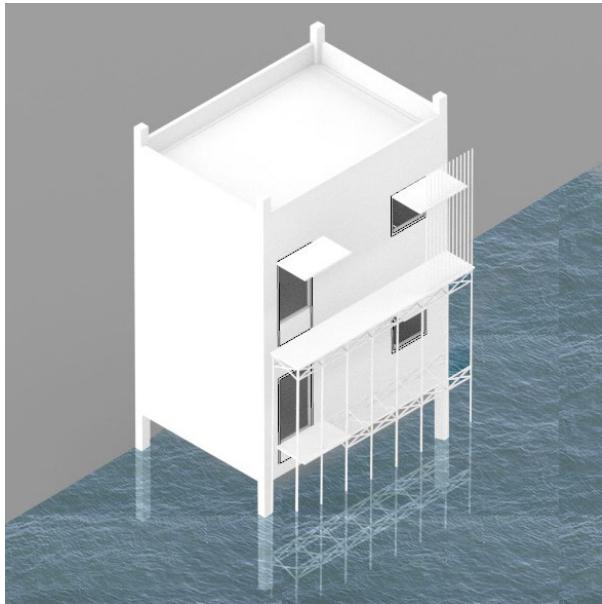




stages of incrementation: prepare



stages of incrementation: refurbish

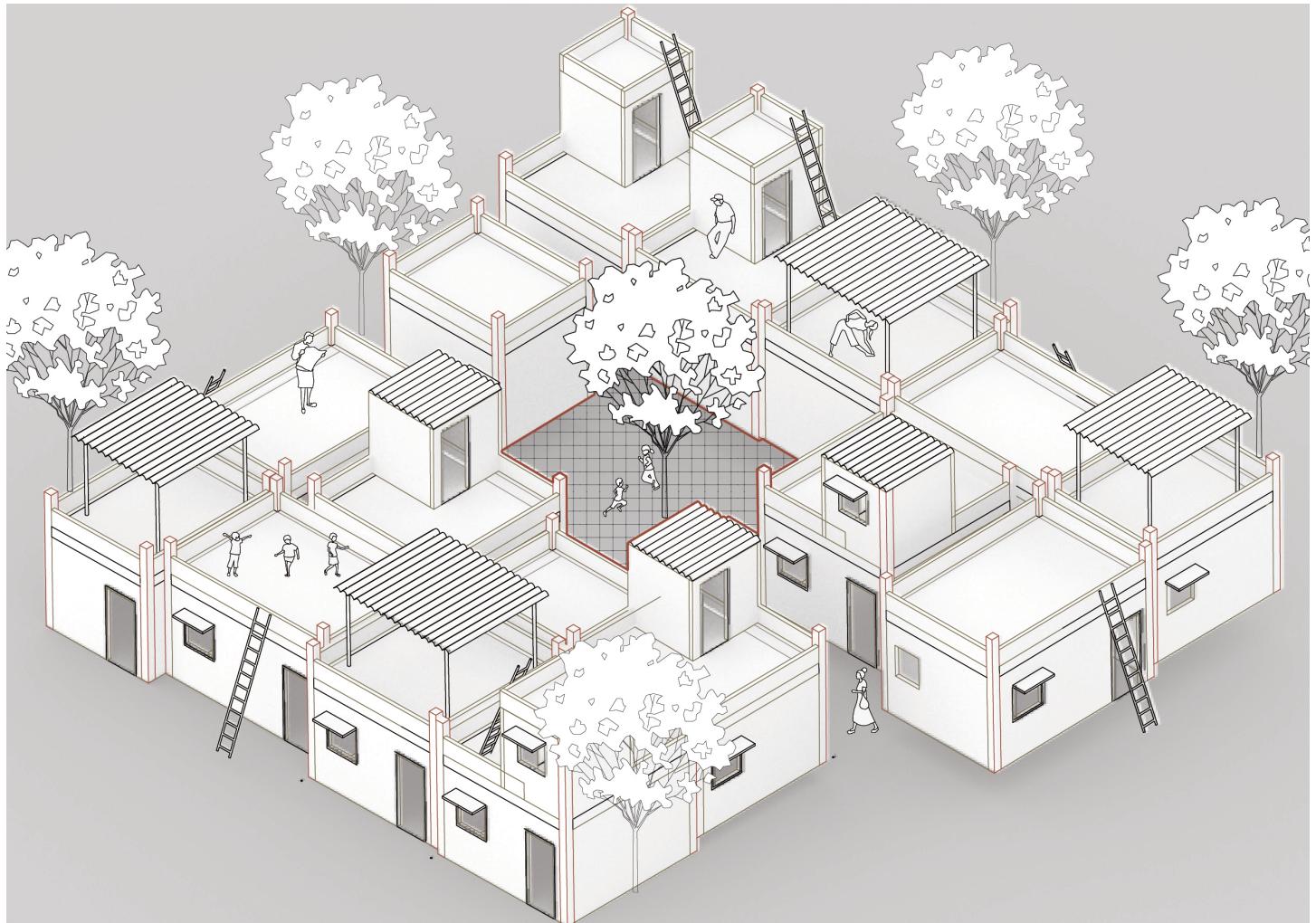


stages of incrementation: flourish

Houses, like people have personalities. And like the personalities of people, they are partly modeled by all that has happened to them

Louis Bromfield

Implementation scale: M -The cluster



Existing cluster typology with hard paved courtyards and the roof as a social space



Photographic documentation of the courtyards with the highrise development looming in the backdrop

Image: author



Greening the courtyards and setting up the infrastructure to enable them to com



As the houses continue to increment over the years, the courtyards function as s



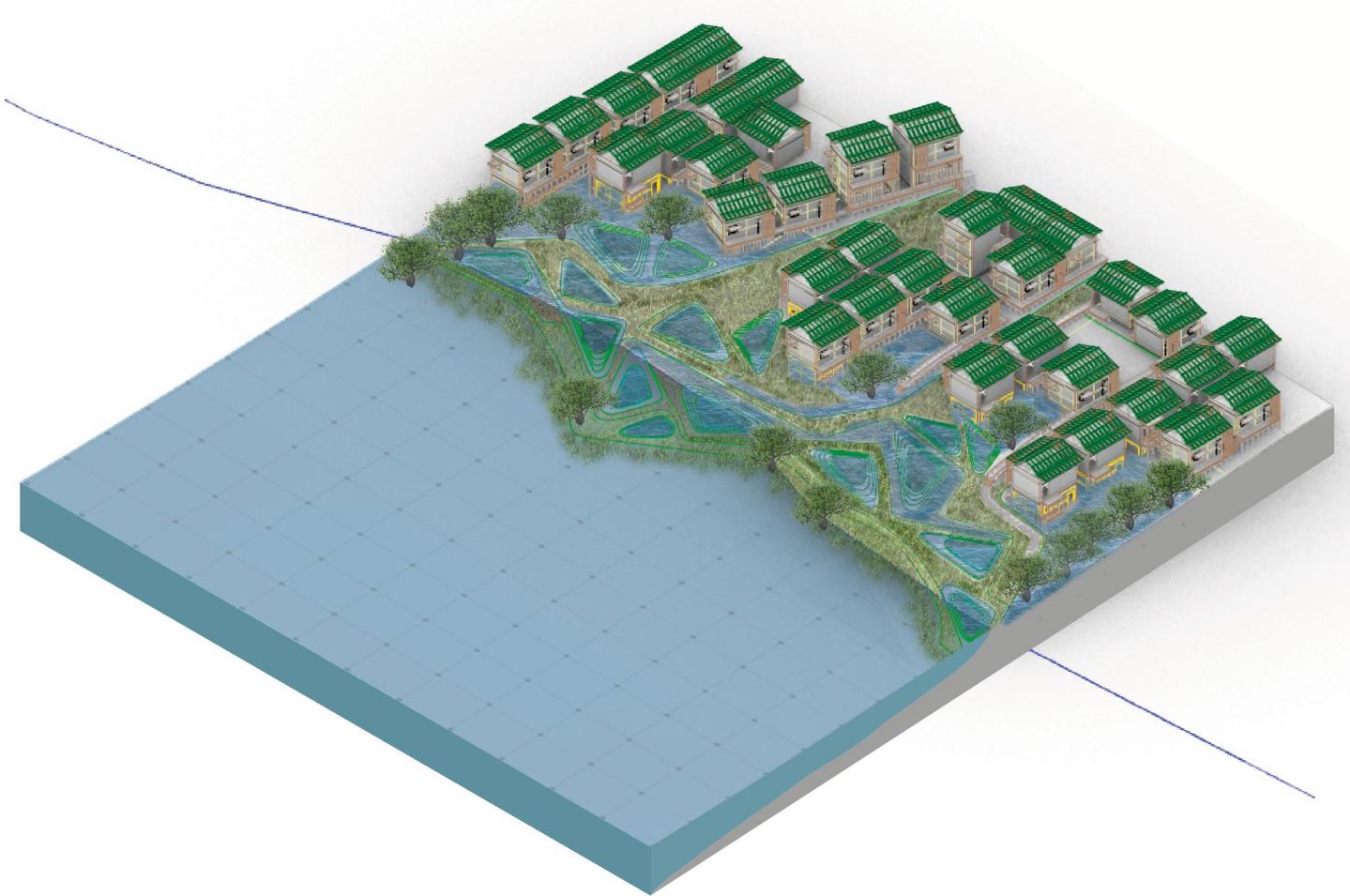
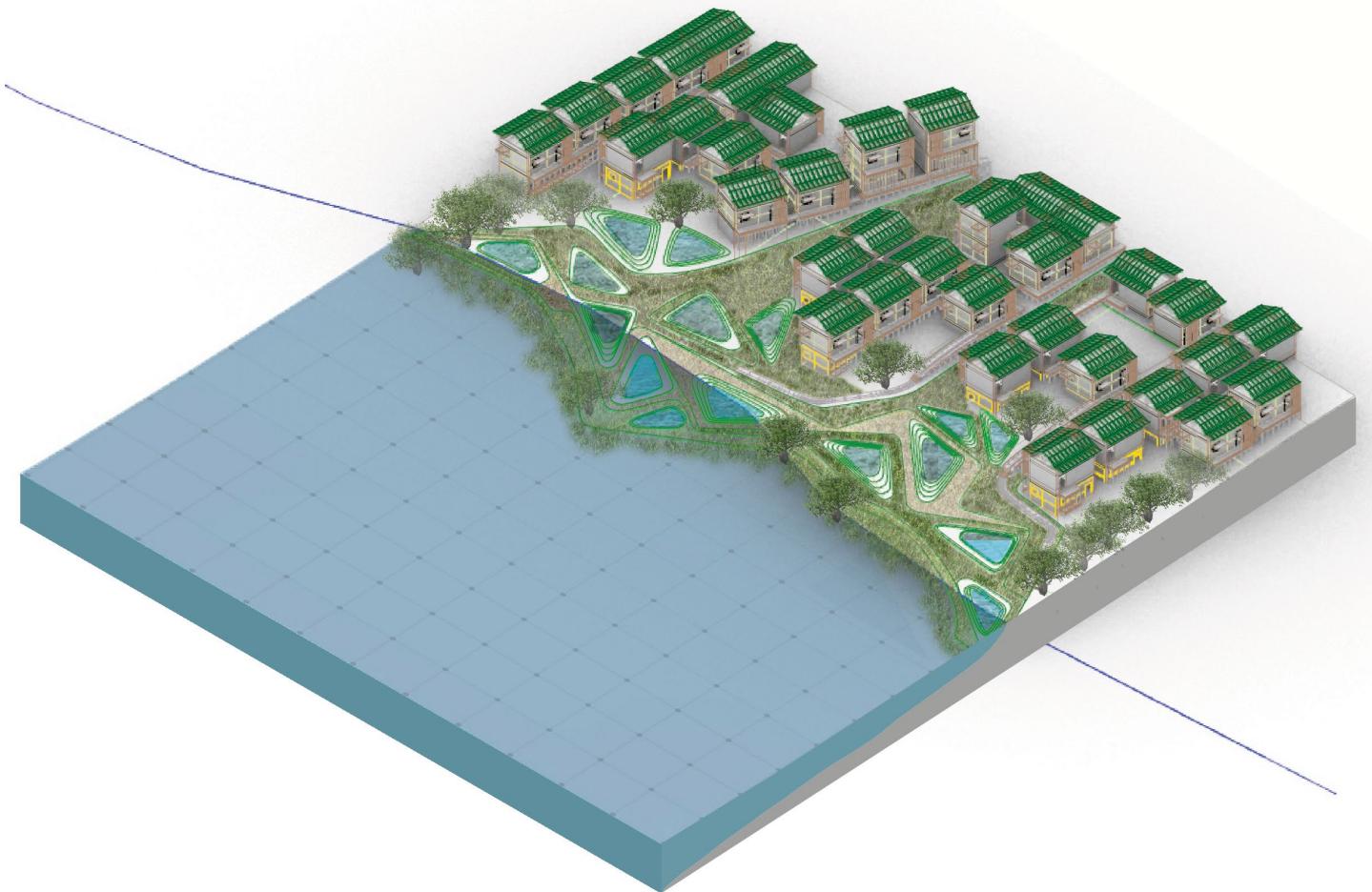
continue acting as a space of social gathering



social amenity, wetland waste water system and sea water lagoons

Transect 1: The Vision:

Designing the edge with wetlands and levees and creating better access to the water edge helps improve the connection with the edge. At the same time designing the houses to adapt and accept sea level rise and converting the courtyards into a network of wetlands creates a more resilient built typology



transect 2: inland cluster

Issues



1. Commercial streets with hard edges formed by the entrance to shops



2. Isolated hard paved courtyards forming a fragmented network



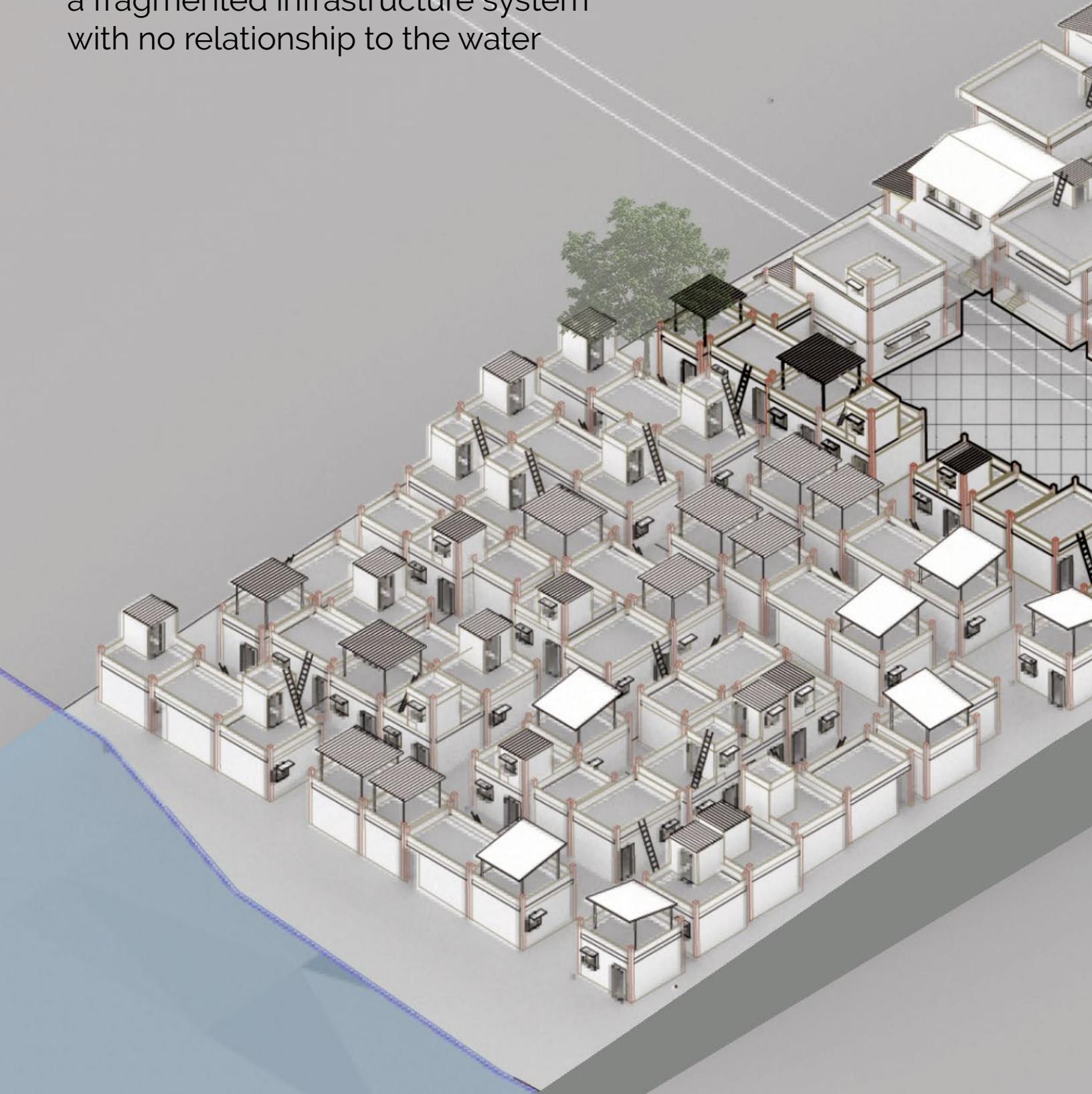
Walking through the streets of the Koliwada, the deeper one progresses into the hinterland, the more one loses their connect to water. The winding streets play out as the canvas for several social and economic activities. Rows upon rows of houses spill out into the tiny alleys teeming with people, animals and vehicles.

While the energy is palpable, it is impossible to ignore the underlying infrastructural issues. Most houses suffer from lack of proper ventilation, the waste water is often seen flowing through the streets untreated and the storm water drainage system seems unprepared to handle the downpour of the Mumbai monsoons coupled with the undulating terrain.

The houses in this transect are sturdier as compared to the first transect and are individually owned and partly rented out by the residents. This situation proposes a unique challenge of intervening in the least intrusive way and making a positive change in the built morphology.

Present Condition

Diagramming the two transects together highlights how the unplanned development has created a fragmented infrastructure system with no relationship to the water





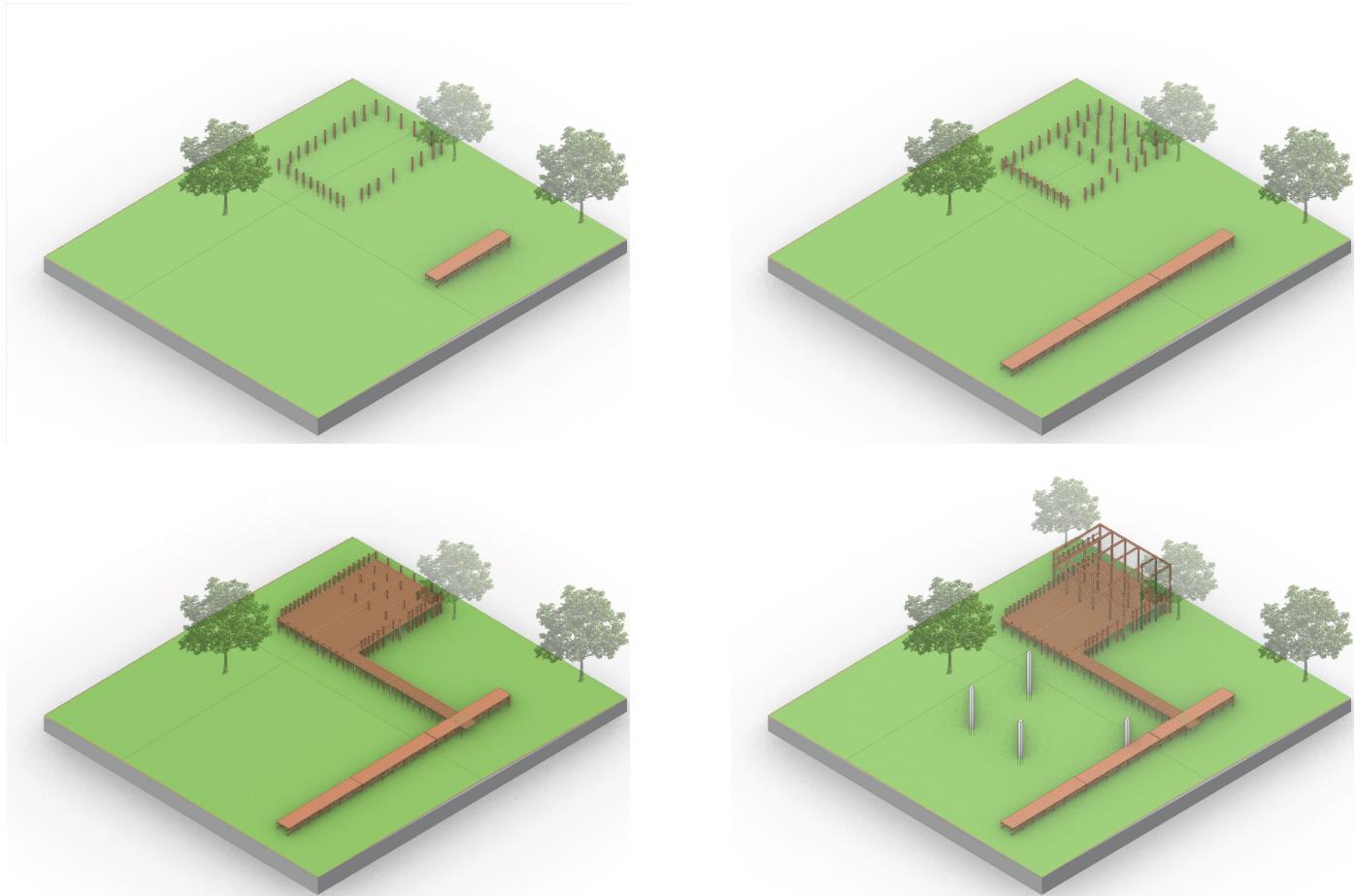
The changing topography protects the houses located higher up on the terrain from sea level rise but creates new problems of inland flooding exacerbated by the poor accessibility to the sea.

Tactics



Incrementally diagramming the tactics helps create an integrated strategy that can counter the isolated development patterns in the Koliwada. The commercial street with their hard porches are replaced by bamboo stilts to facilitate continued access but also turn the streets into green connections that link the courtyards together and create a network of waste water treatment wetlands that empty out into the sea.

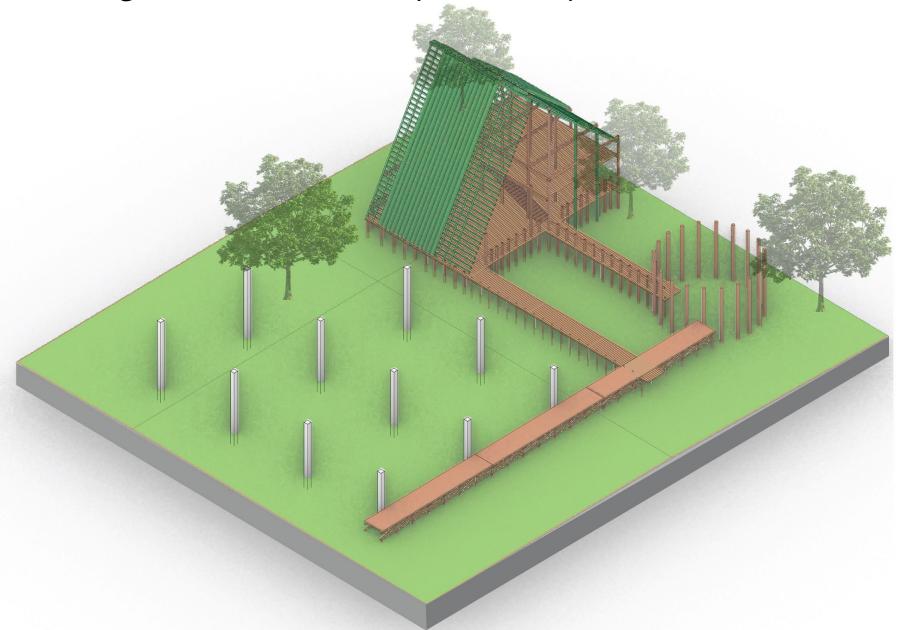
Integrating community infrastructure into the fabric



The strong social ties in the Koli community have inspired the design of a community center that can be constructed incrementally by the community itself. The community center would be integrated with local religious institutions who receive generous monetary donations from the community. The community center would play host to several activities such as skill building, coaching classes, community laundries, bamboo storage for community wide construction where volunteers are allowed to redeem the bamboos on a credit bases. The community center would eventually be integrated with the courtyards and waste water treatment system.



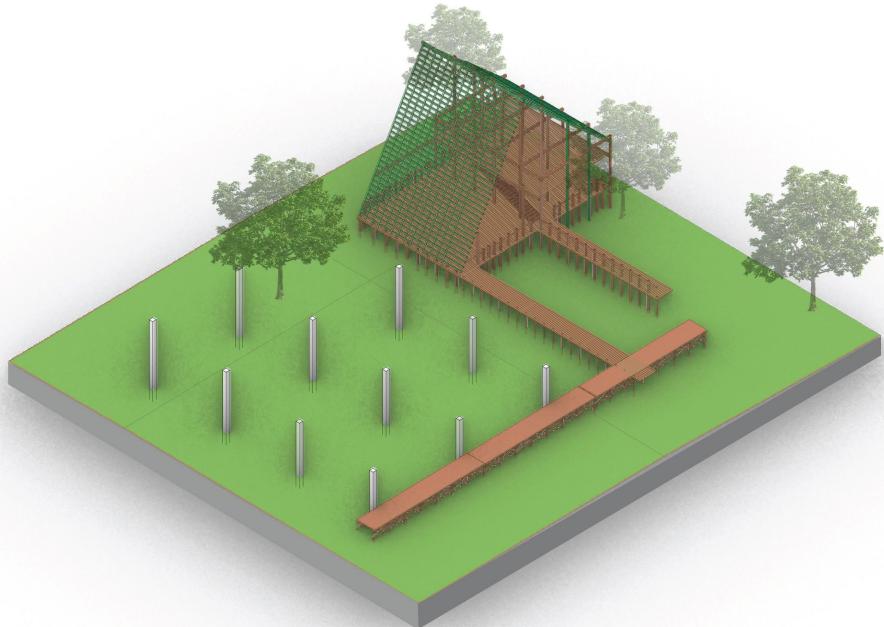
Documenting the incremental phases of construction, creating



Incremental formwork and bamboo storage facilities, the pitched



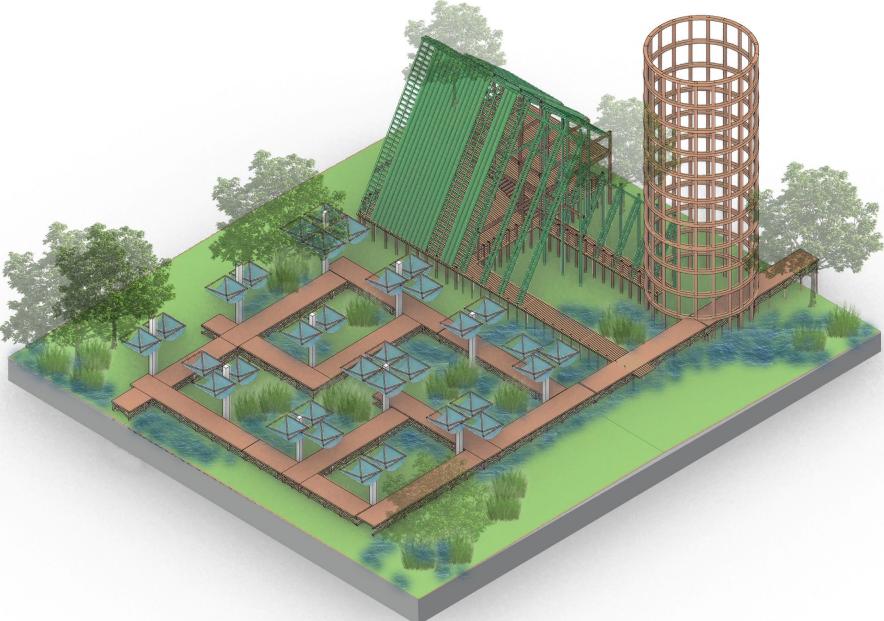
Integrating the community center with a wetland plaza that can



spaces for community engagement



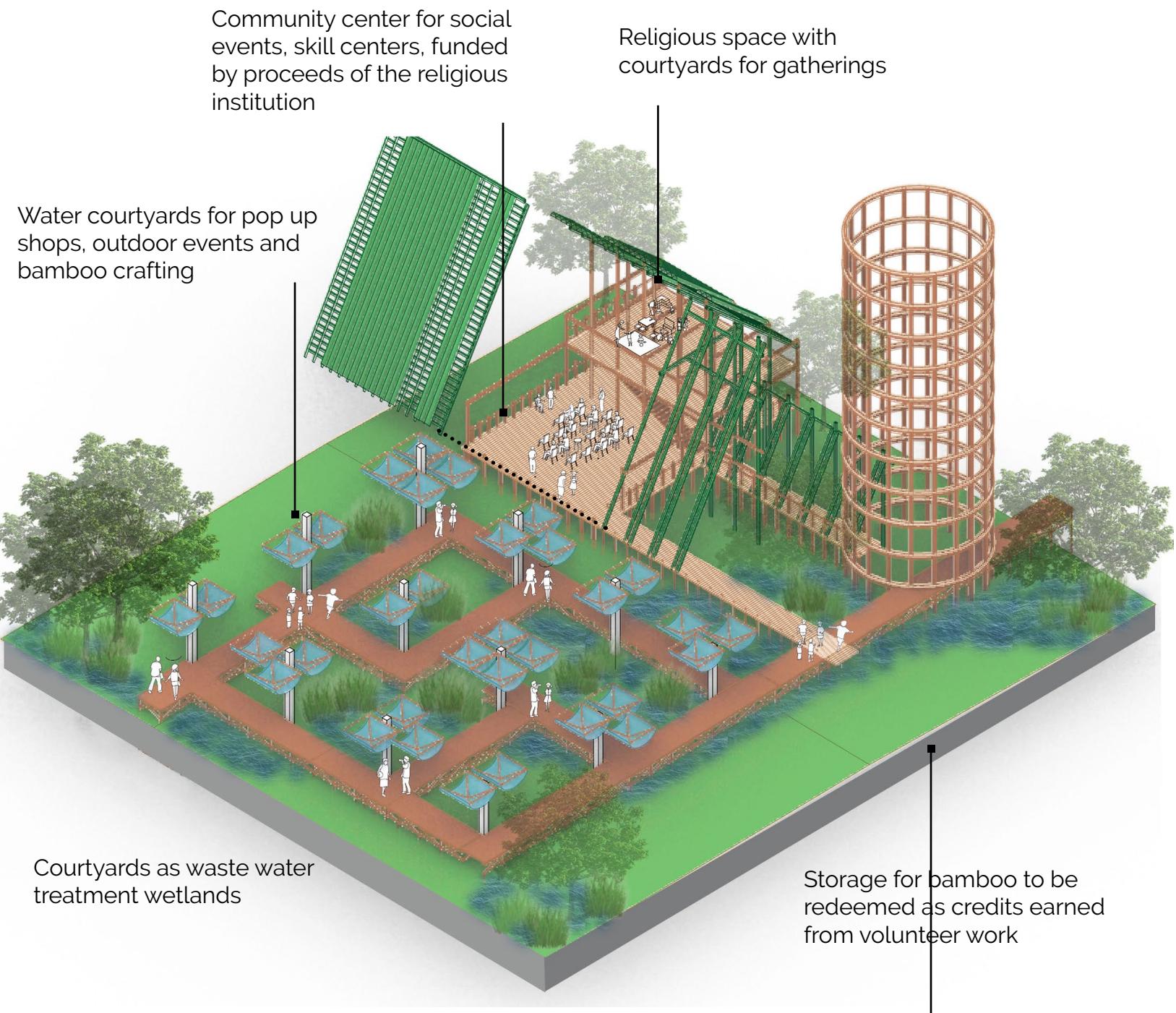
ed roof designed to collect rainwater



harvest rainwater, filter waste and function as a social space



Photographic documentation of the hard edges of the existing religious institutions with their paved courtyards and adjoining community centers in a dilapidated state



A new self constructed, eco friendly typology designed to harness the social and ecological capital of the Koliwada

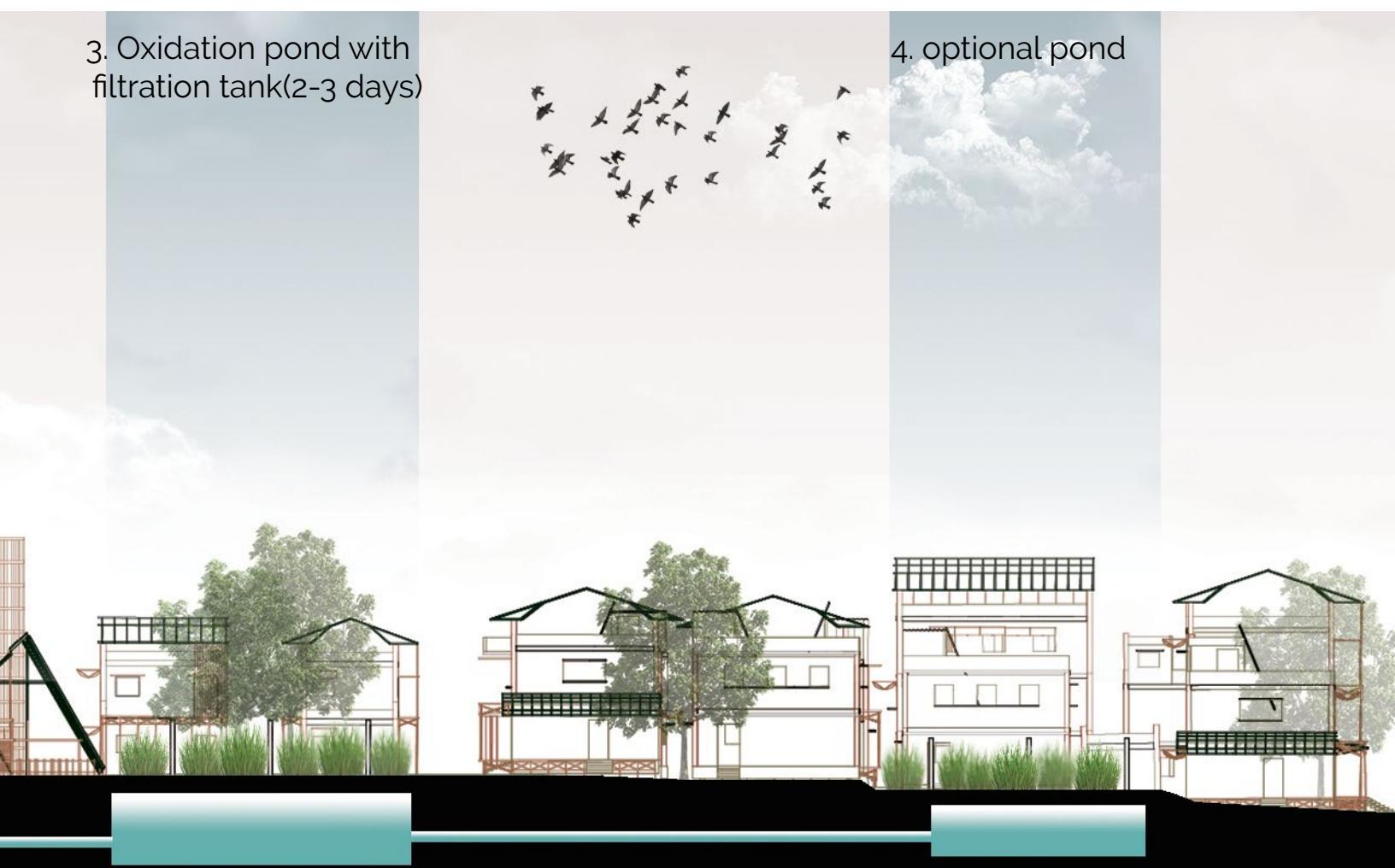
The courtyards as wetland waste water t

The Koliwada's are often in danger of being labeled as slum settlements by the government due to the large number of informal settlements and incremental growth leading to inadequate access to clean drinking water as well as waste water disposal. Without having to rely on the state to provide for these essential amenities, the Koliwada can pool together their resources to engage in the construction of a waste water treatment system. As the courtyards double up as organizational elements and ecological living systems, a truly resilient infrastructure network would be a pioneering development that would set an example.



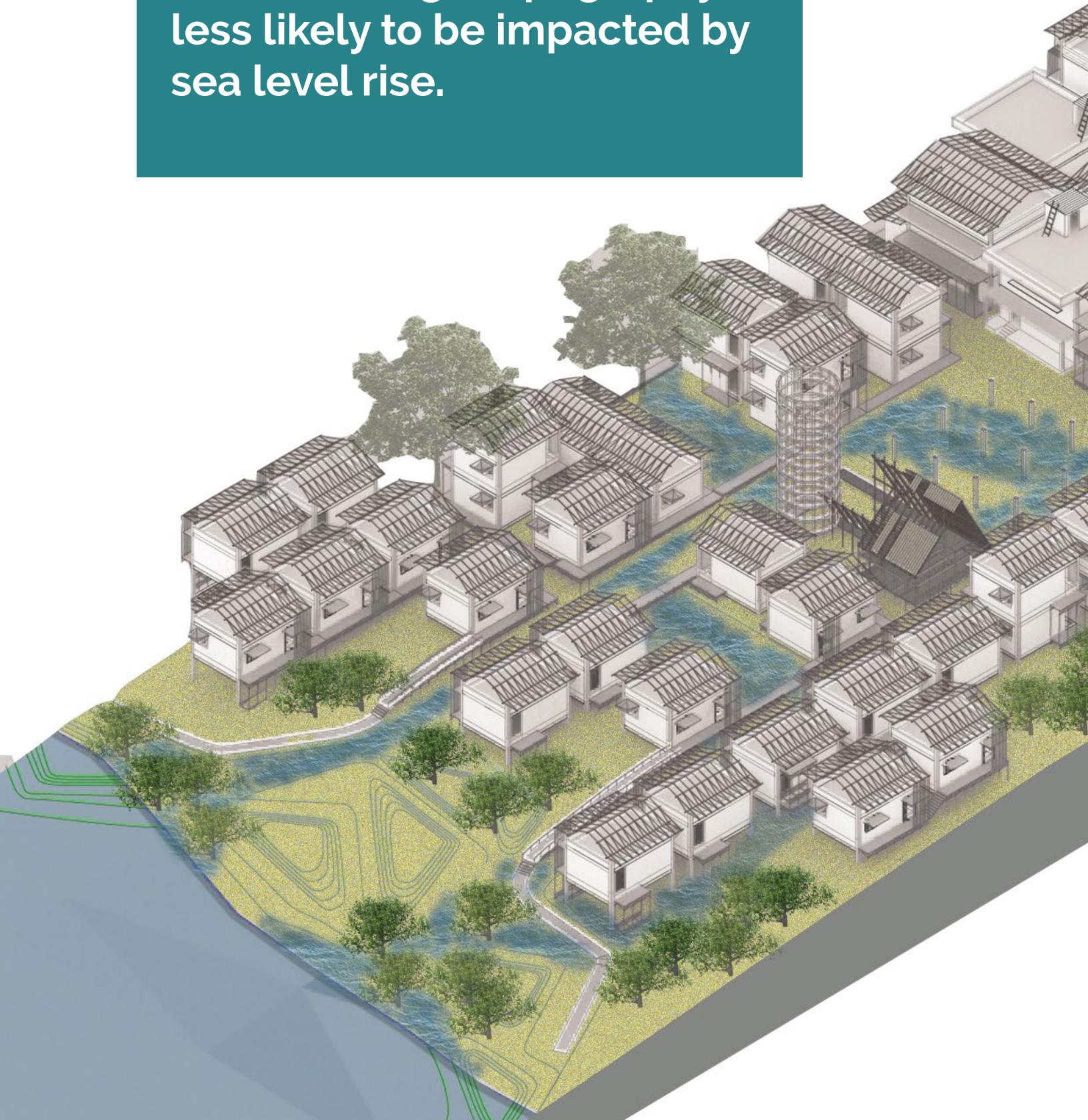
treatment system

The waste water system would consist of oxidation and maturation pods connected to tanks underneath to collect excess runoff. The tanks retain water as a storage device and pump excess water out to the mangrove system. The water in the ponds would oxidize the soil and the treated waste would act as a fertilizer allowing the community to engage in farming activities to meet their food needs and diversify their crop outside of fish to add to their economic benefits.



Transect 2: The Vision:

Transect 2 by virtue of being an area of high topography is less likely to be impacted by sea level rise.





However, it is imperative to increase the pervious surface by creating a network of wetlands that function as waste water treatment system. The streets are envisioned as green corridors while continuing to function as the commercial spine

transect 3: the bay edge

Issues



A sea wall constructed on the bay edge as a poor attempt to counter sea level rise



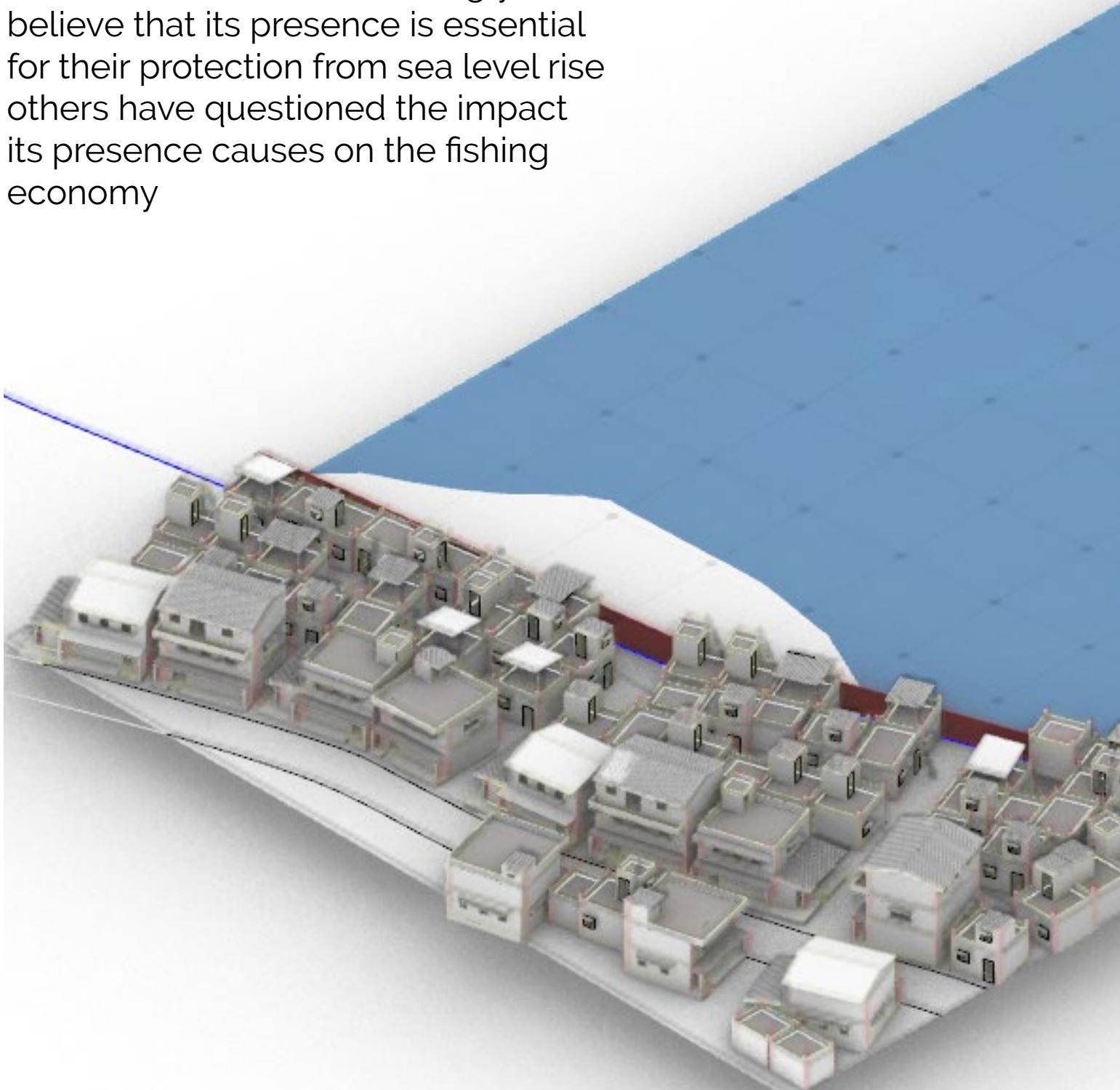
Inland planning leading to poor access to the water edge

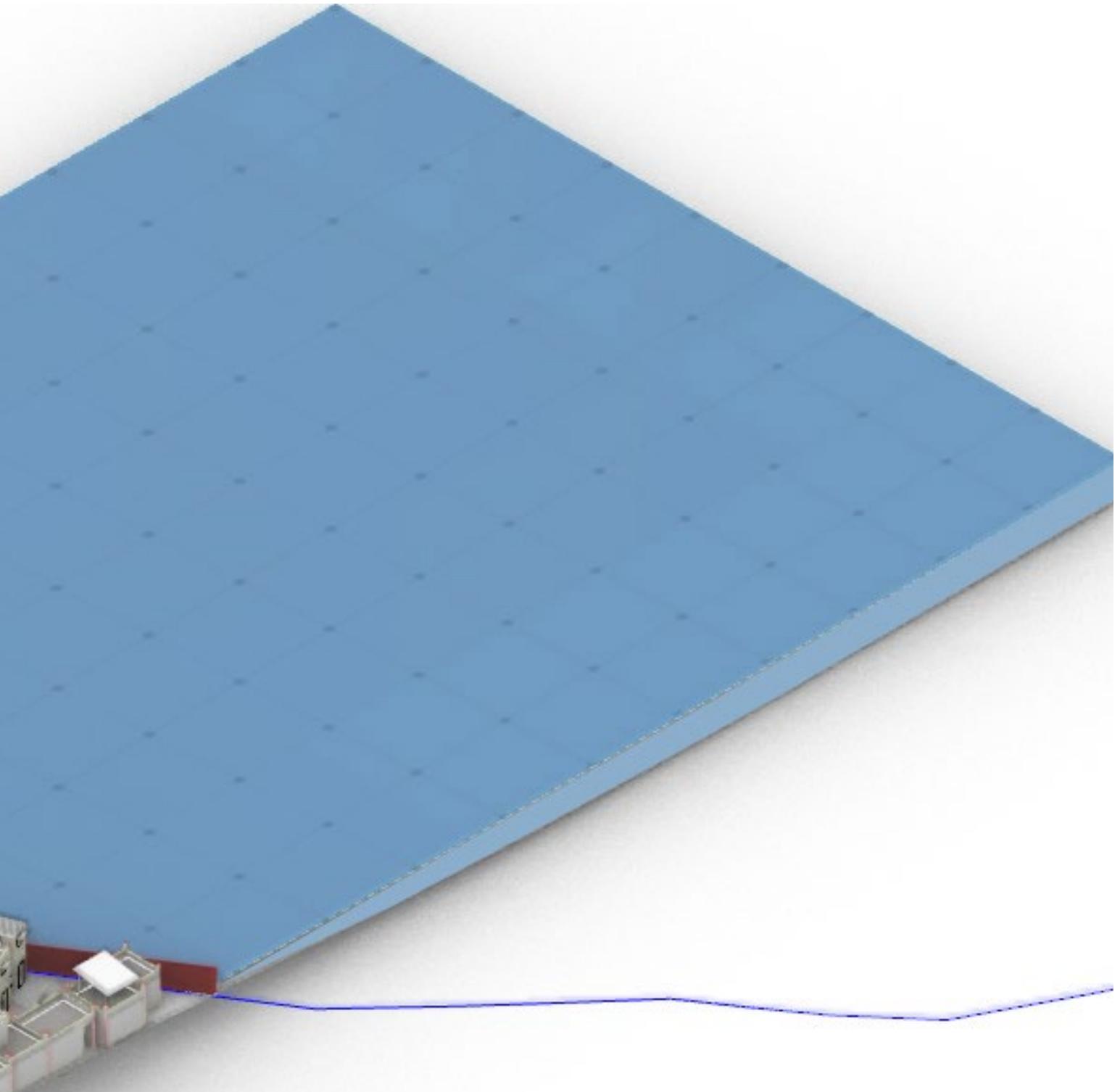


3. Commercial street connecting the fish market also acts as a barrier to the water edge

Present Condition

The sea wall has been a source of much community debate. While some have been led to wrongly believe that its presence is essential for their protection from sea level rise others have questioned the impact its presence causes on the fishing economy





Adding another barrier has increased the density of the planning and constricted the community to an inwards pattern of development.

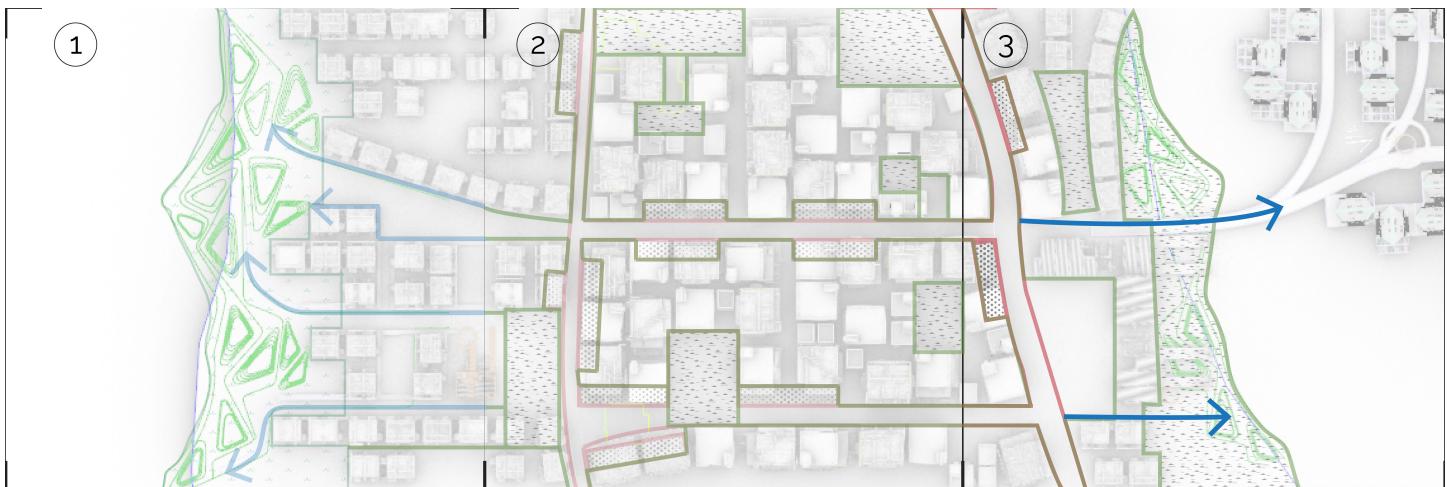
Tactics



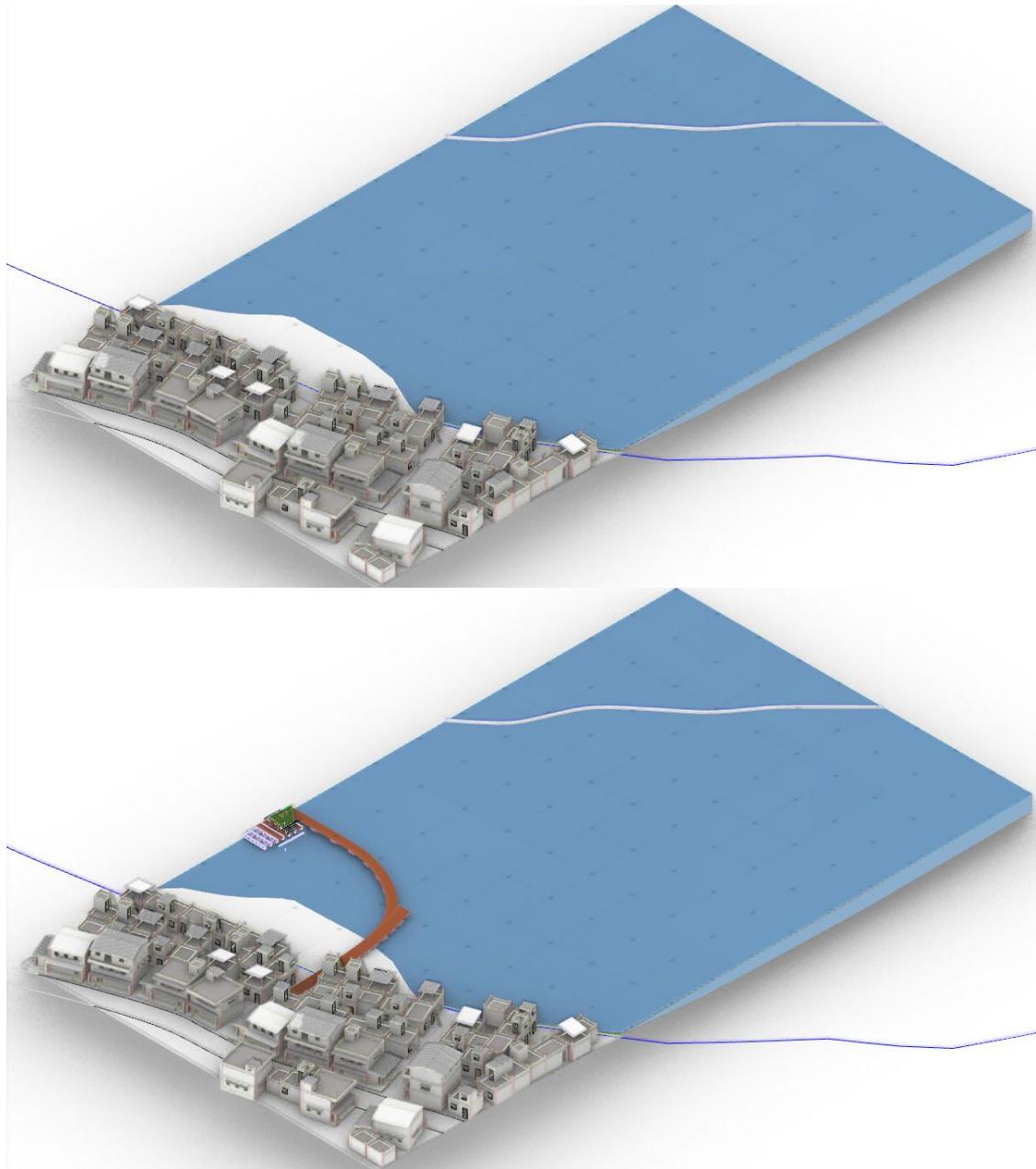
Continuing the green connections from the previous two transects and integrating the commercial street and courtyards



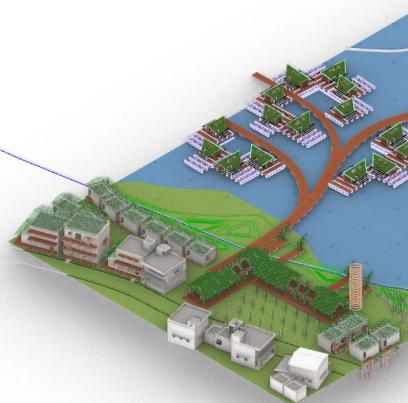
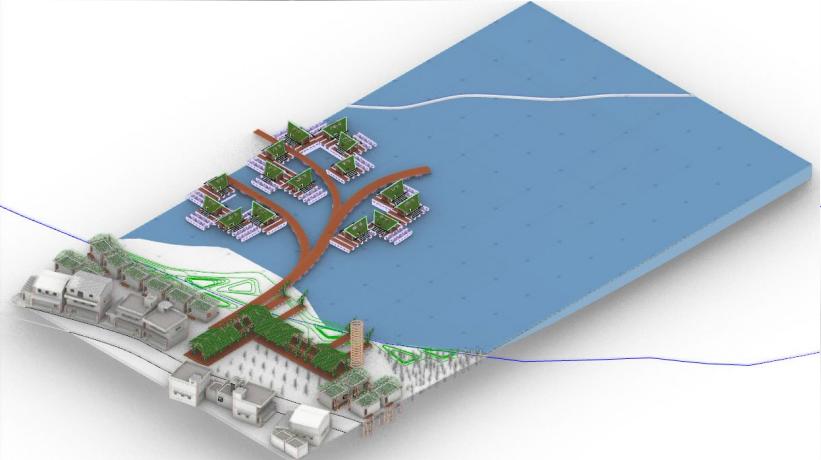
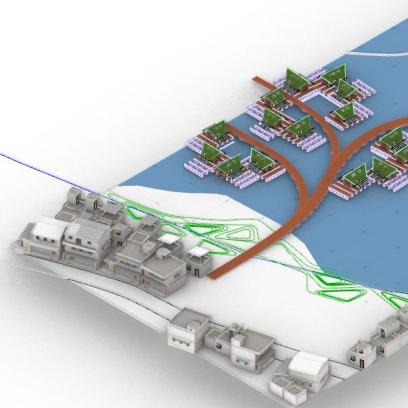
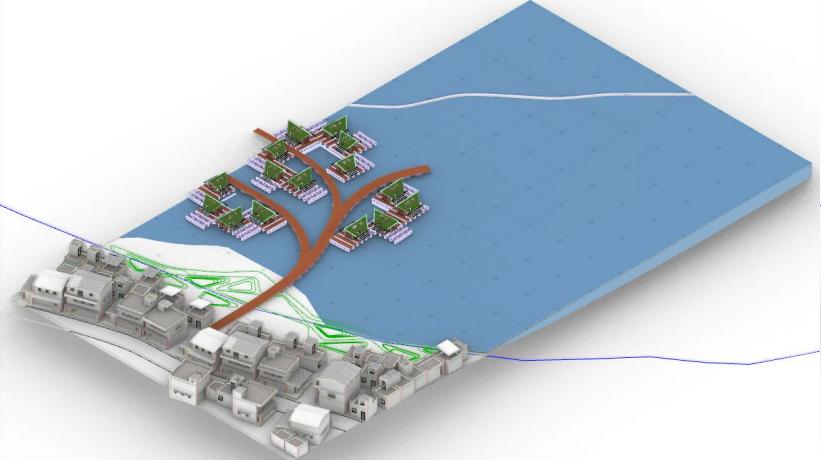
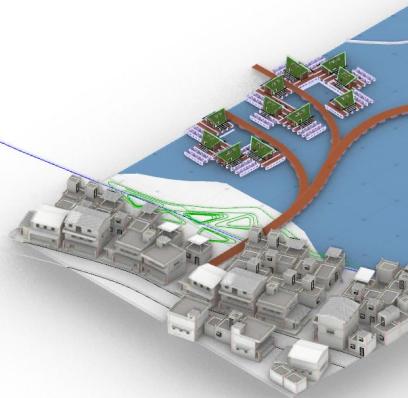
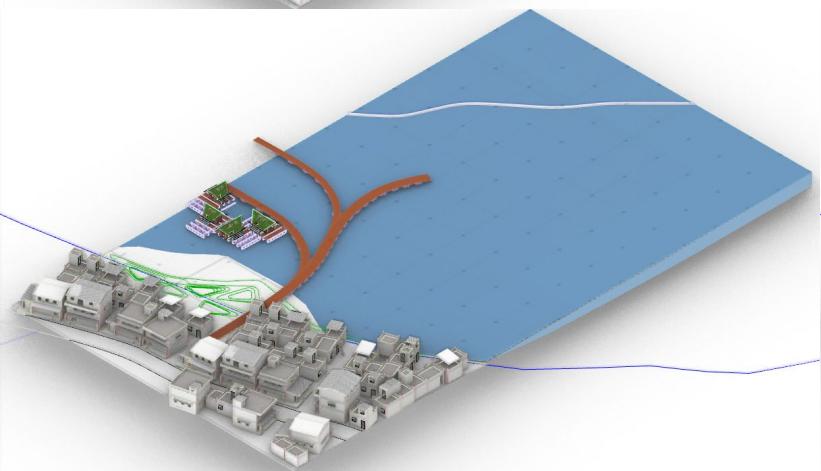
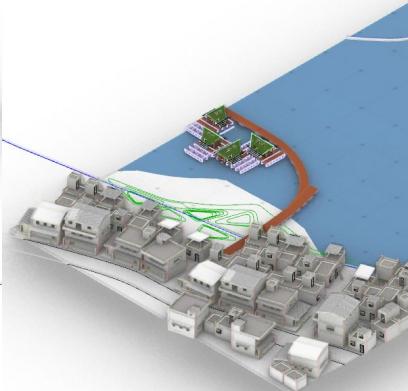
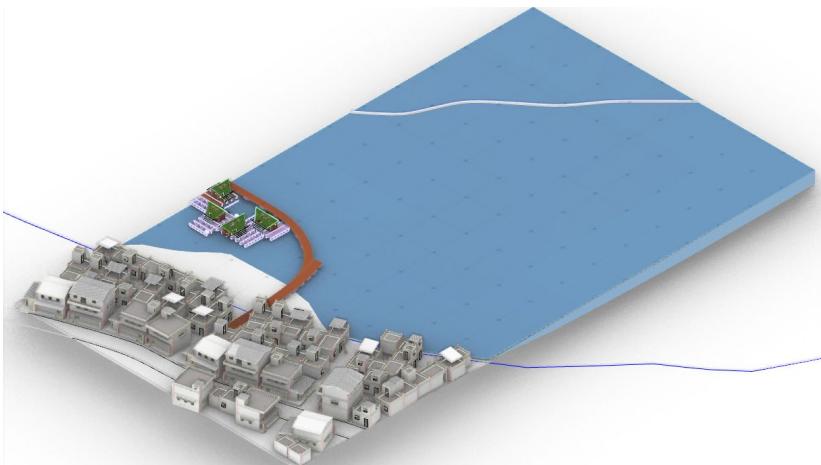
Extending the green connections on to the mudflats as a connection to the new floating typology

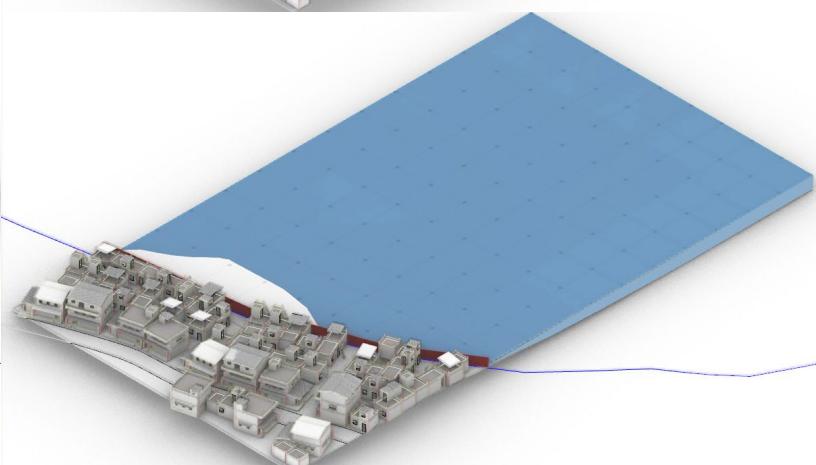
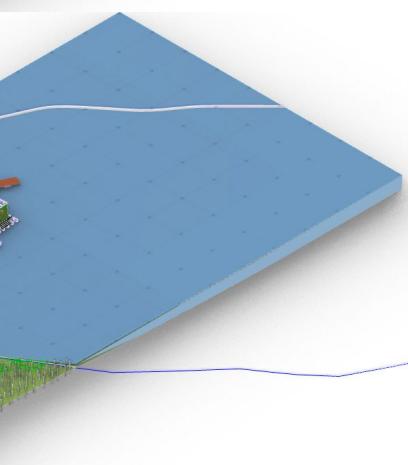
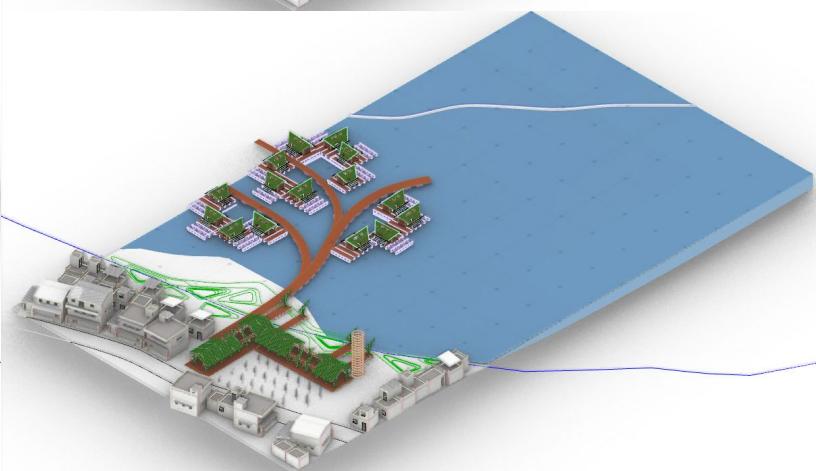
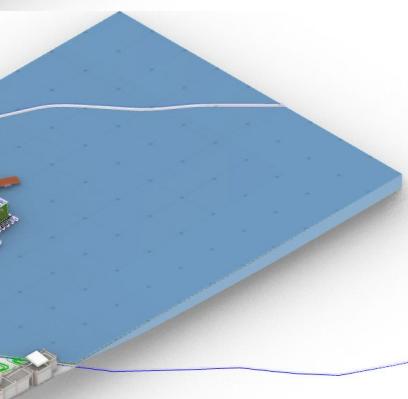
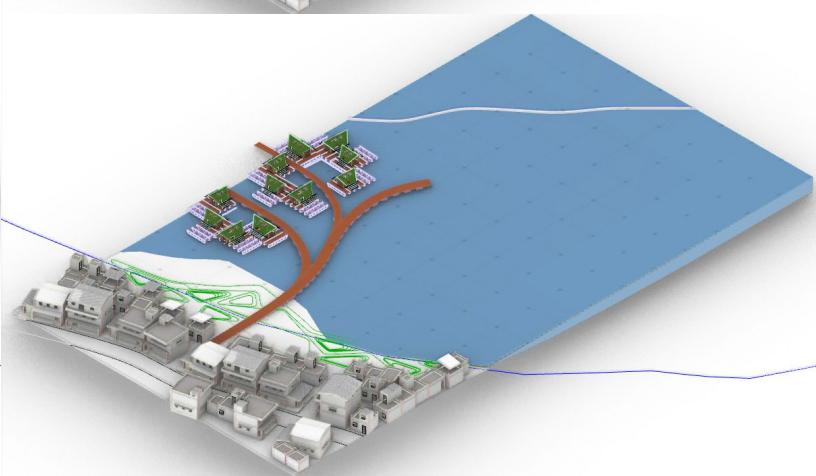
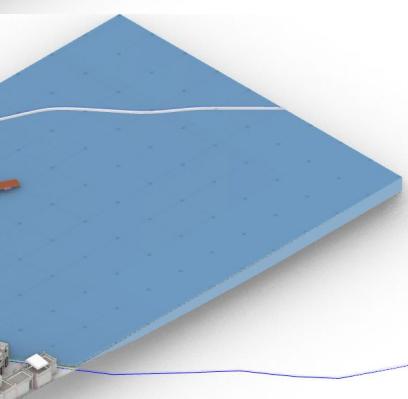
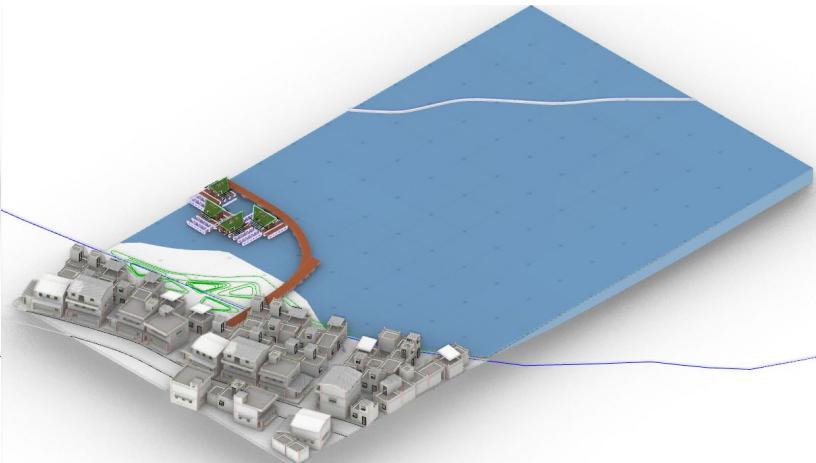
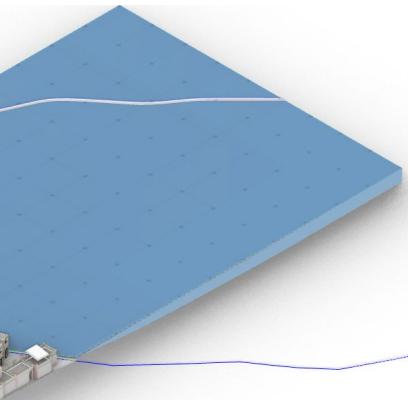


Phase wise implementation



The green connections once extended outto the bay allow for the construction of the new buoyant units. These units are used to rehabilitate the most vulnerable people before their houses are demolished to create softer edges with the bay





The Fish Market



Shed structure with poor access to both the sea and commercial areas, inadequate capacity

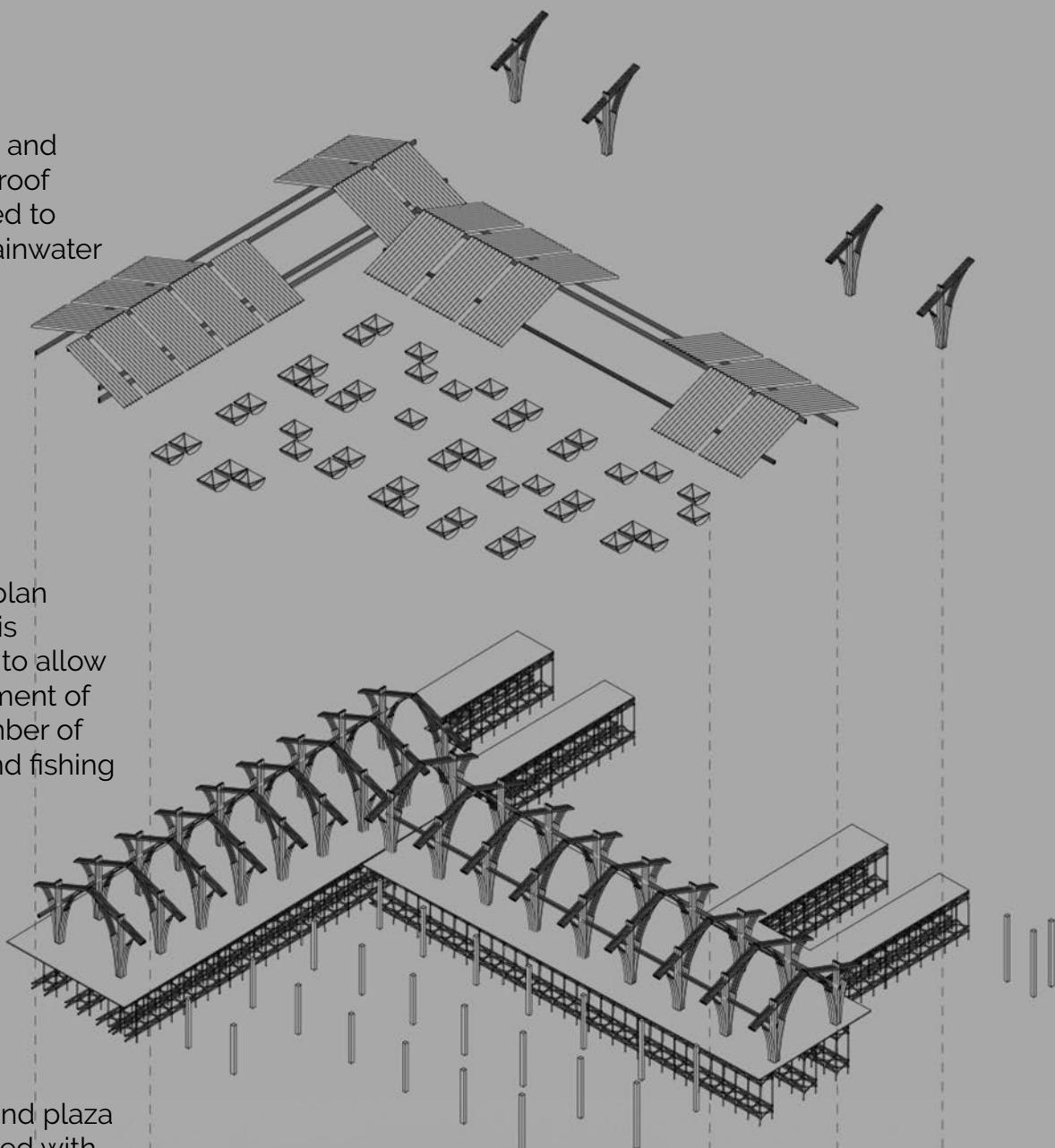
The fish market is the major source of income for the Koli community. Its location is in a dubious spot with a large courtyard turned into a makeshift seasonal structure that operates for 9 months of the year. There is an order however in this scene of commotion. The Koli women pay for their spots to sell the catch and are in charge of maintaining the hygiene and setting up for the sell. The inland location of the fish market has made it particularly cumbersome for the fishing catch to be transported from the harbor to the fish market for ancillary activities. The dense built up around has stifled the growth and possible economic benefit that a better designed and more functional fish market could have.



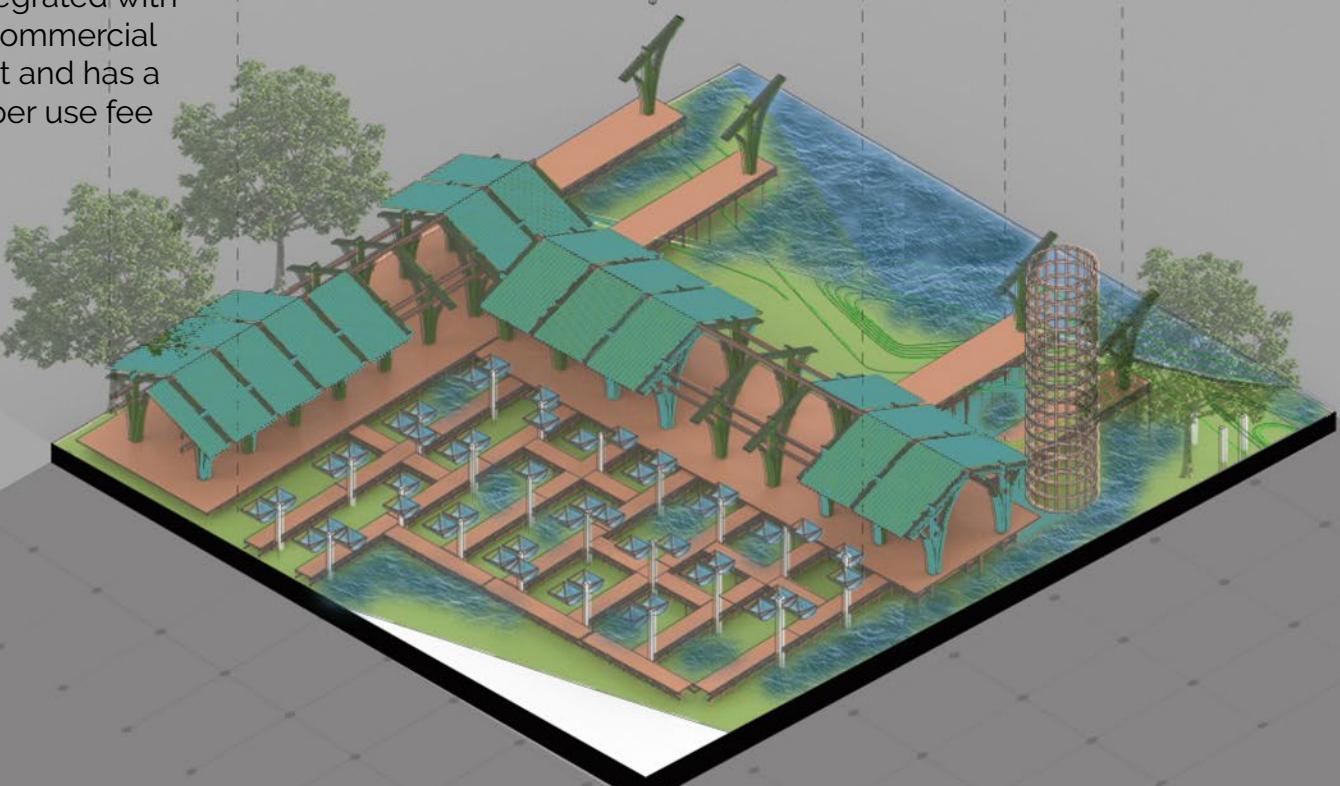
An dense built morphology around the fishmarket has prevented it from growing and adapting to increasing demands



The plaza and structure roof is designed to capture rainwater



An open plan structure is designed to allow for movement of large number of people and fishing cargo



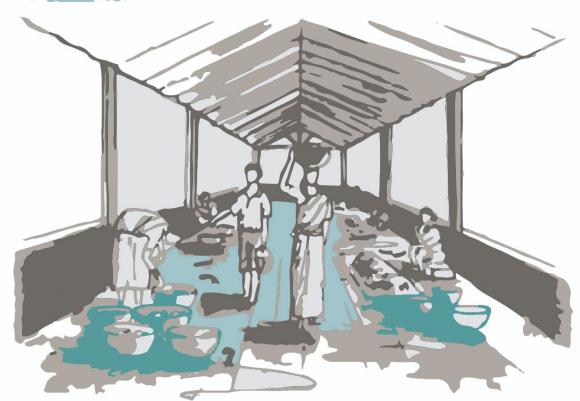
Unloading the catch from the trawlers to be transported on foot to the inland market



Washing, drying, net making act as a network of ancillary activities.



Preparing the catch for domestic and commercial sale



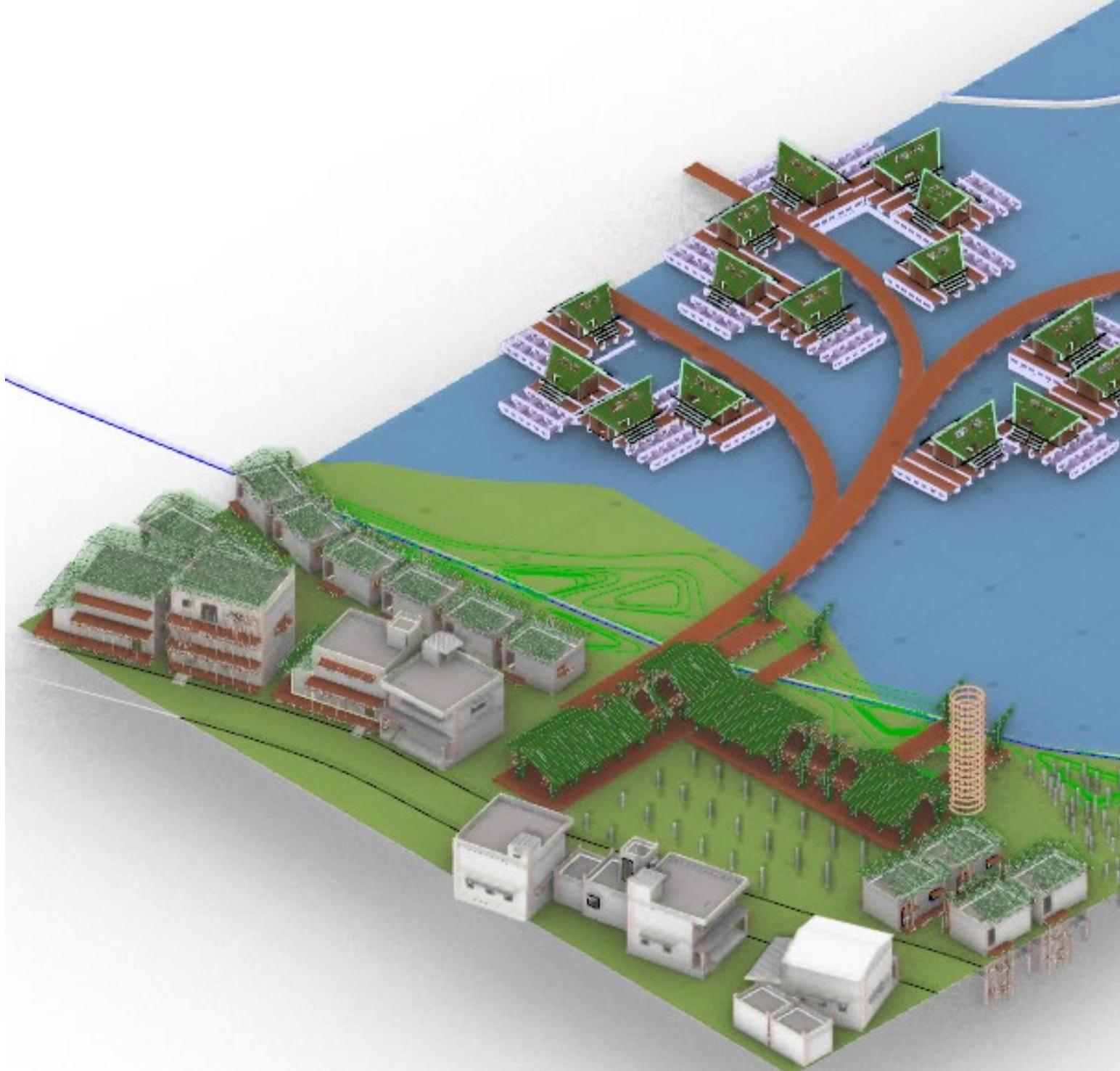
The unsold catch is stored in ice containers to be used by the community as reserve food stockpile

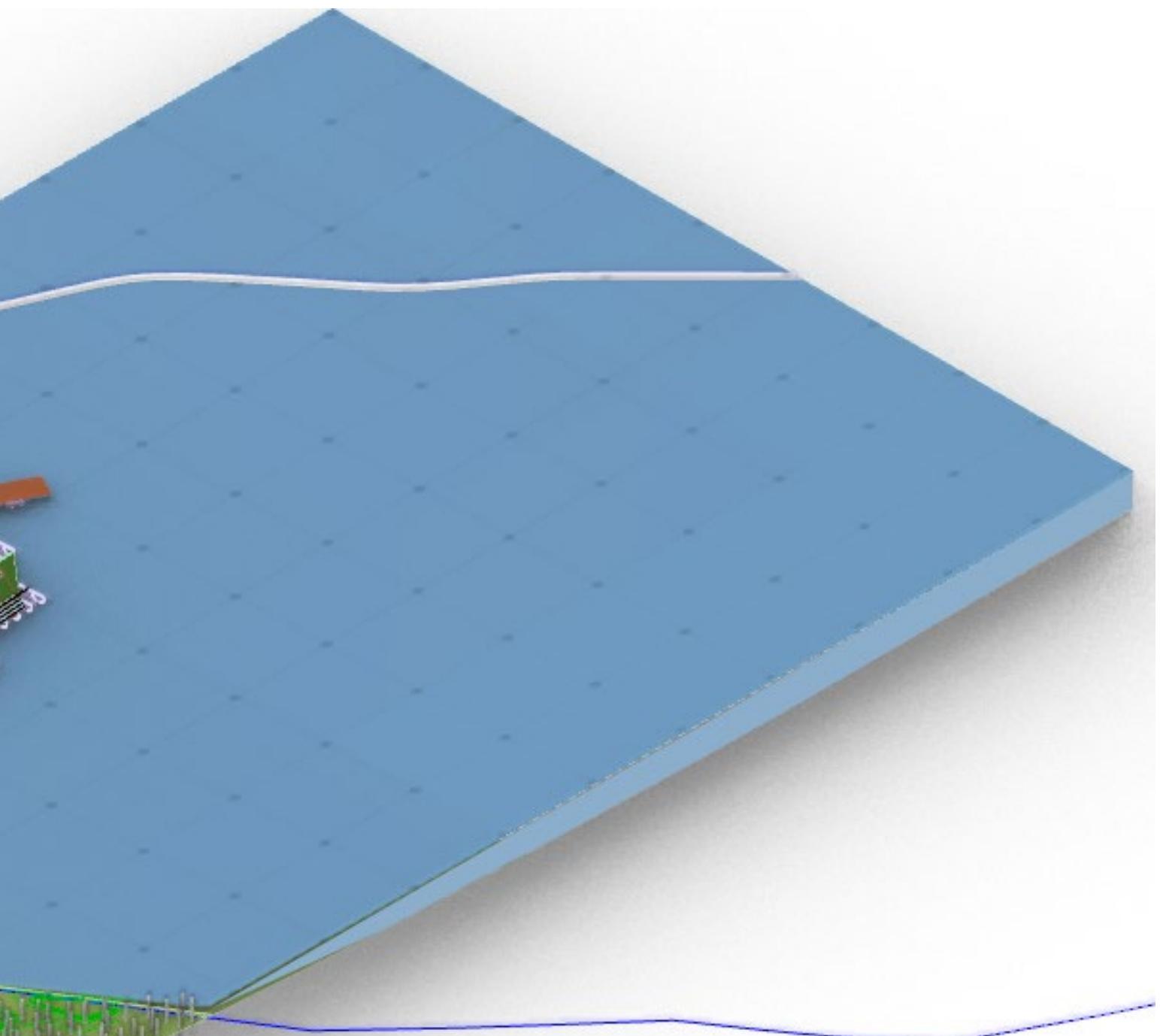


Transporting the catch through the railways to large ports to be taken to processing centers.



Transect 3: The Vision:





Exploring the possibility of a new floating typology of houses that would adapt to the waters of the Mahim bay and the design of a more efficient fish market

transect 4: buoyant unit



The Mahim Bay is a shallow basin where the Koli community has been carrying out their fishing activities for centuries. The calm waters recede upto 200 feet from the mainland during low tides twice daily creating a vast expanse of mudflats. Respecting the sensitive ecology of the region, a design of a new floating typology

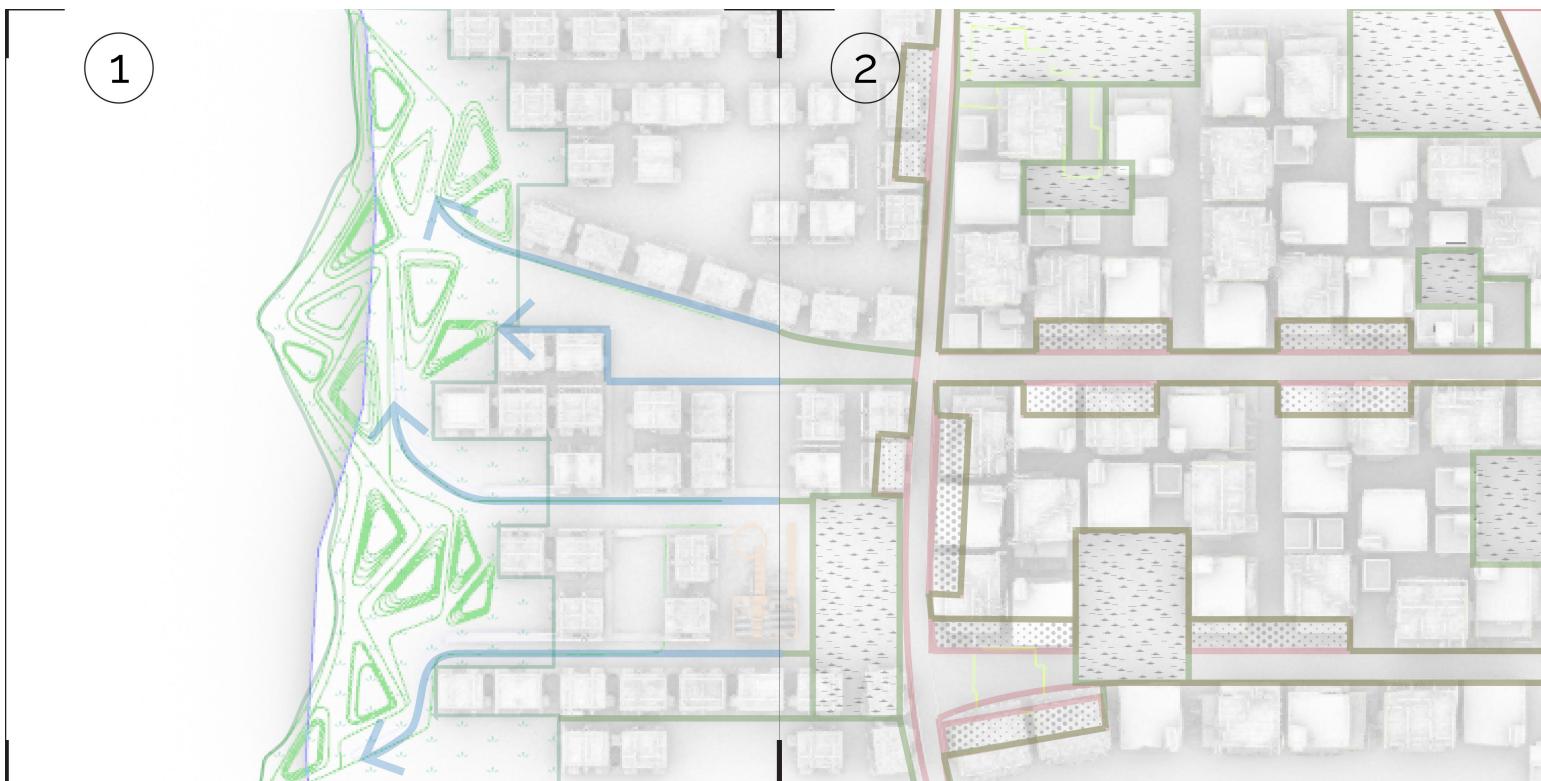


Tactics



Using the debris from the broken sea wall to construct a breakwater to protect the city.

The network of pontoons connecting the floating houses is connected to the main canal and branching out into smaller lanes.





calm the waters of the Bay

the main green axes and follows a similar street pattern of main street



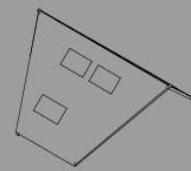
The buoyant cluster: planning

The buoyant unit is designed as a living entity that supports the livelihoods of the Koli community and the individual families that would reside in them. A cluster of units are arranged around a water courtyard that would act as a social congregation space but also function as an aquaponic farming system.

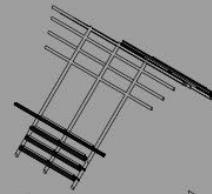
The water courtyard arrangement allows for sufficient space between the units that results in increased access to sunlight.

Physical access to these clusters has been designed through a network of bamboo pontoons that stay afloat on top of barrel and boat sections. The submerged aquaponic system consists of freshwater mussels submerged in the water to act as both fish fodder and an organic cleansing element.

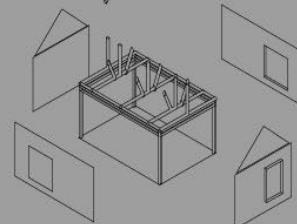
A front and back system of access to each individual unit helps design openings that can allow maximum sunlight inside the space.



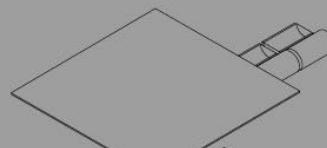
Bamboo roof



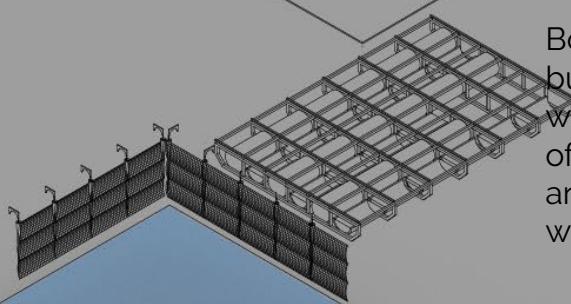
Bamboo framework



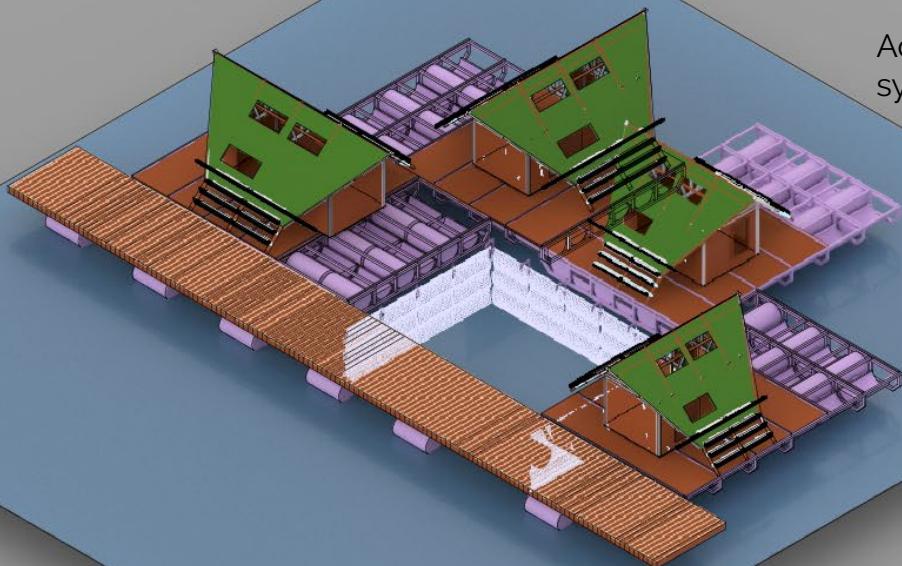
Bamboo walls



Bamboo pontoons



Boat sections for buoyant systems as well as the storage of harvested water and collection of waste water



Aquaponic farming system

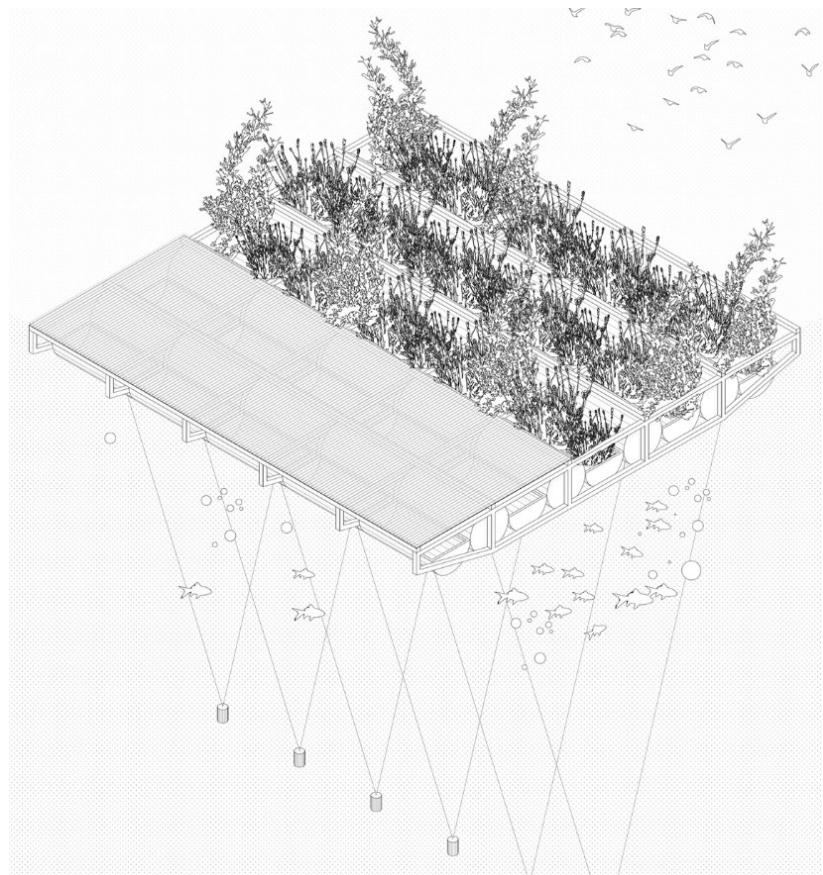
Shaping daylight for floating cities

A pitched roof system with a bamboo truss is introduced for several reasons. The sloping roof is meant to increase the rainwater harvest that can be collected in the barrels under the pontoon but most importantly, the form of the roof is used for weather protection, increasing the sectional volume of the space and using it to reflect light off the surface of the water underneath.

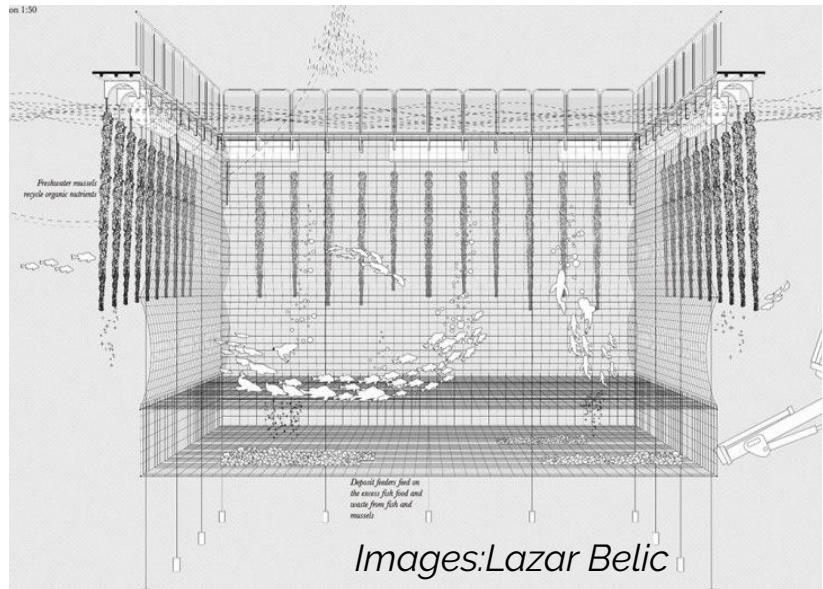
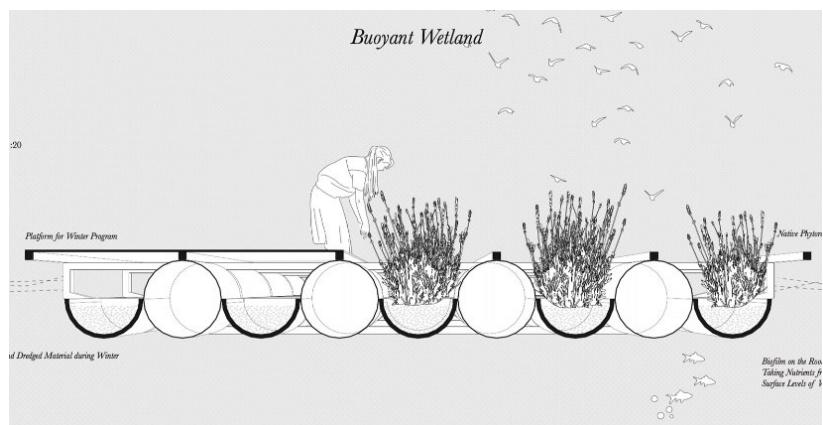
Openings in the walls and the pontoon are designed accordingly and tested through simulations to check how they use the fluid and reflective nature of the water underneath to affect the quality of light in the space

In return, the roots of the plants oxidize the water underneath maintaining a critical ecological balance. An alternate row of water drums is used for storage of wet waste from the unit, to be pumped or carried to the mainland and for rainwater harvesting aided by the pitched roof.

The buoyant units are designed as living systems which use the boat sections from discarded boats and water drums as their floating mechanism. The pontoons are punctured to help reflect light off water's surface to illuminate the spaces within.



The water courtyard aquaponic system is a cyclic process where the fertilizers from household waste and fish waste is used for farming



In return, the roots of the plants oxidize the water underneath maintaining a critical ecological balance. An alternate row of water drums is used for storage of wet waste from the unit, to be pumped or carried to the mainland and for rainwater harvesting aided by the pitched roof.

Images:Lazar Belic

It is important to understand the vivid qualities of water to factor it into the design process and how an illumination experience can be created by lighting the structures in and around it. Light reflected from water can dance and undulate on the surfaces creating a sense of motion and drama in the spatial setting. The specific water conditions need to be factored into the design by using it as the ground plane while running simulations in ClimateStudio. The combined role of both daylighting and water have governed the methodology of design in this research.

This study uses the following daylight metrics to inform the design of a new typology of Koliwada

Useful Daylight Illuminance (UDI):

A dynamic climate-based metric is the UDI which measures the amount of another dimension on what is considered adequate daylight to work in and overheating issues. The thresholds proposed being below 100 lux would lead to dark and above 2000 lux would lead to visual and/or thermal discomfort of the year when illuminance lies within one of the three illumination ranges (Nabil 2001). It provides information not only on useful daylight levels, but also of glare or unwanted solar gain.

Annual Sunlight Exposure(A)

It is defined as the cumulative amount of visible light or the direct illuminance considering the sun. It is used to describe how much of space receives direct light (glare) or increase the cooling load. This measure specifies the illuminance level, 1000 lux, for at least 50% of the sky. (Y. Elghazi 2014) (Illuminating Engineering Society)

Metrics

Spatial Daylight Autonomy (sDA):

Spatial Daylight Autonomy describes how much of a space receives sufficient daylight, which for residential and commercial spaces must achieve (sDA 300 lux / 50% of the annual occupied hours) for at least 55% of the floor area. It calculates the percentage of analysis points that exceeds a specified Illuminance level (300 lux) for at least 50% of the total occupied hours from 8am-6pm over the year. (IES 2012)

*nt of illuminance on a horizontal work plane. It adds
n, added as an upper threshold so as to avoid glare
and above 2000 lux, where below 100 lux would be
comfort. UDI is the percentage of the occupied hours
anges: 0-100 lx, 100-2000 lx, and over 2000 lx (A.
but also on excessive levels that could be the cause*

(ASE):

*sible light incident on a point of interest over the course of a year,
n only. Annual light exposure is measured in lux hours per year. ASE
ives too much direct sunlight, which can cause visual discomfort
etric calculates the percentage of the analysis points that exceeds a
least 250 hours of the occupied hours without any contribution from
(Engineering Society & The Daylight Metric Committee 2013)*

Module details for simulation

The Koliwada housing sizes on the mainland are used as a metric to determine the size of the floating units. The units are typically 15 feet x 20 feet in size with the pontoons around being 30feet x 30 feet. The roof is kept at a constant pitch angle of 45degree from a centre median. The window to wall ratio (WWR) is varied between 20% to 40% to test for different fenestration permutations. In order to recreate the setting and the depth of a waterbody, an open box is modelled to be placed under the surface of water and assigned a dark material which allows for accurate simulations

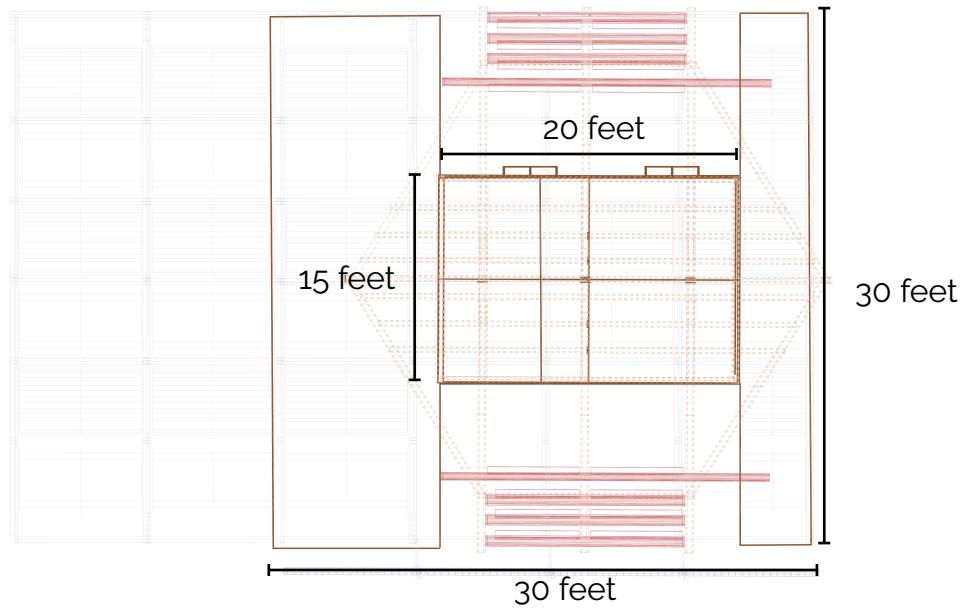


Fig 9.1 Plan layout of the house and pontoon

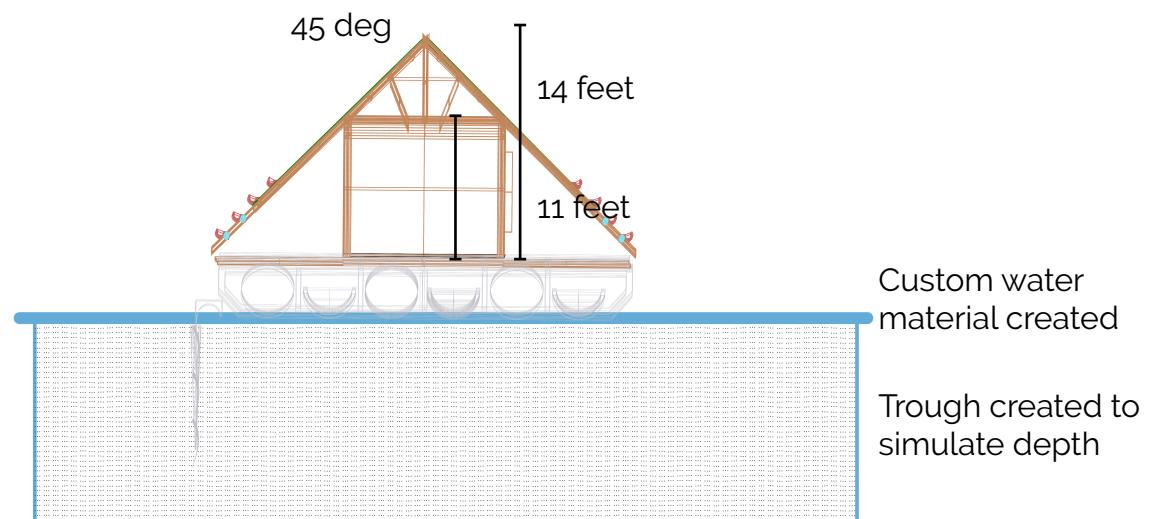
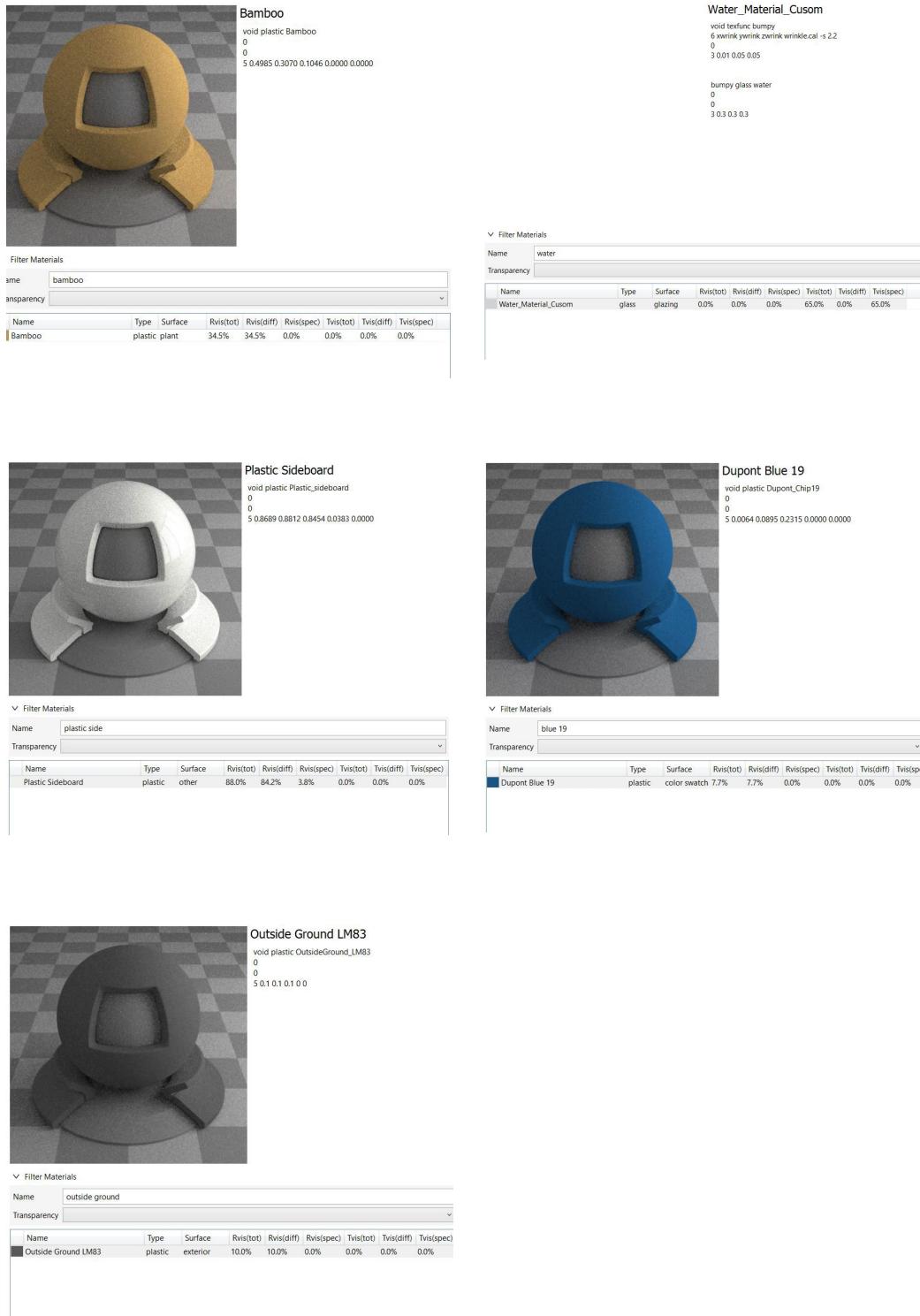


Fig 9.2 Section

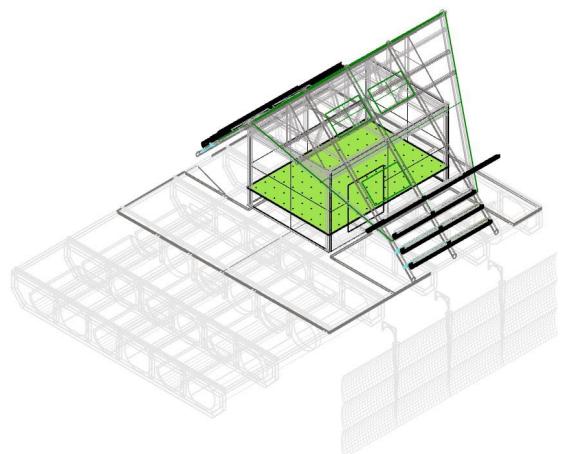
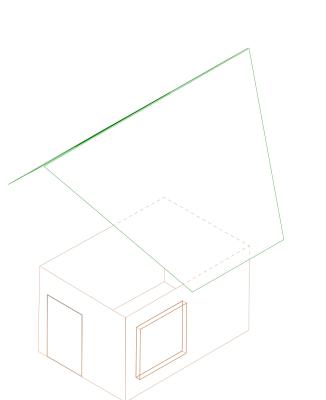
To run the simulations in climate studio, each surface is assigned to a separate layer in Rhino3d. Each layer is assigned a specific material as shown in figures 9.3-9.8. A custom water material is created to act as the surface of the water as shown in Figure 9.4.



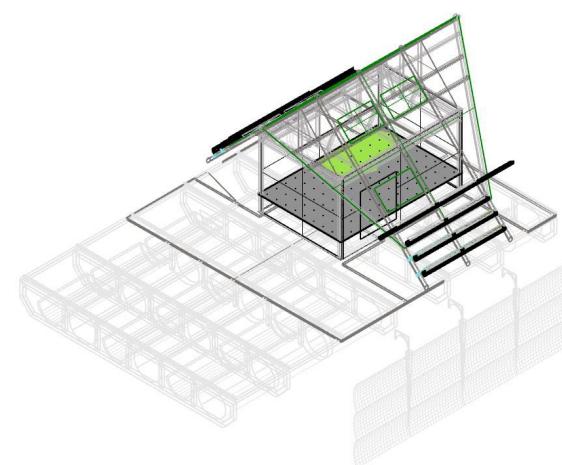
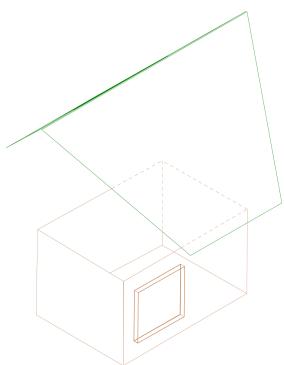
Figg.2-9.8. Setting up different opaque and transparent materials with different visual transmittance and reflectance values

Simulation iteration results

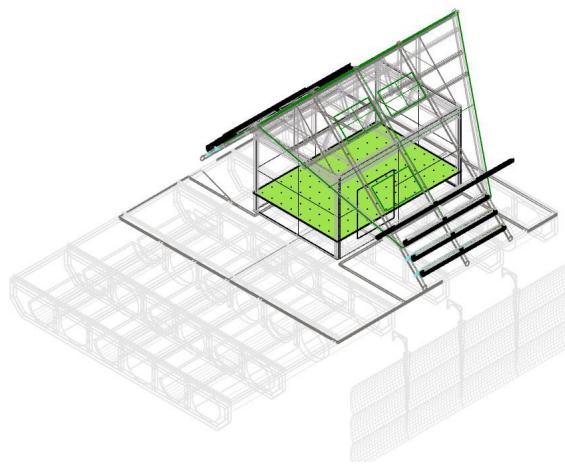
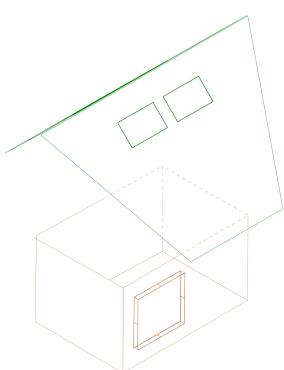
The first five run with an i



Iteration 1: Opening facing geographic north. WWR: 30% sDA achieved: **0%** ASE a

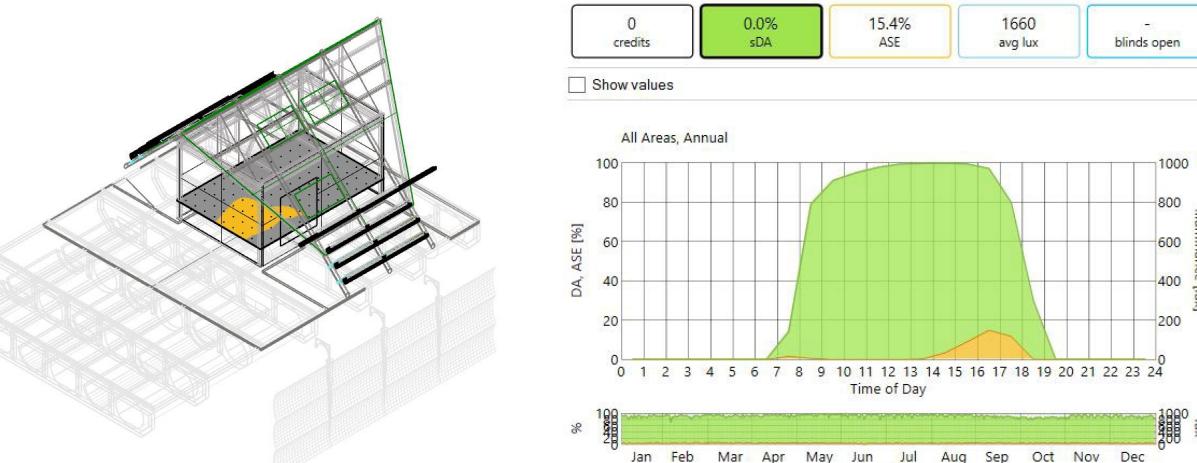


Iteration 2: Opening facing geographic north. WWR: 20% sDA achieved: **18.8%** AS

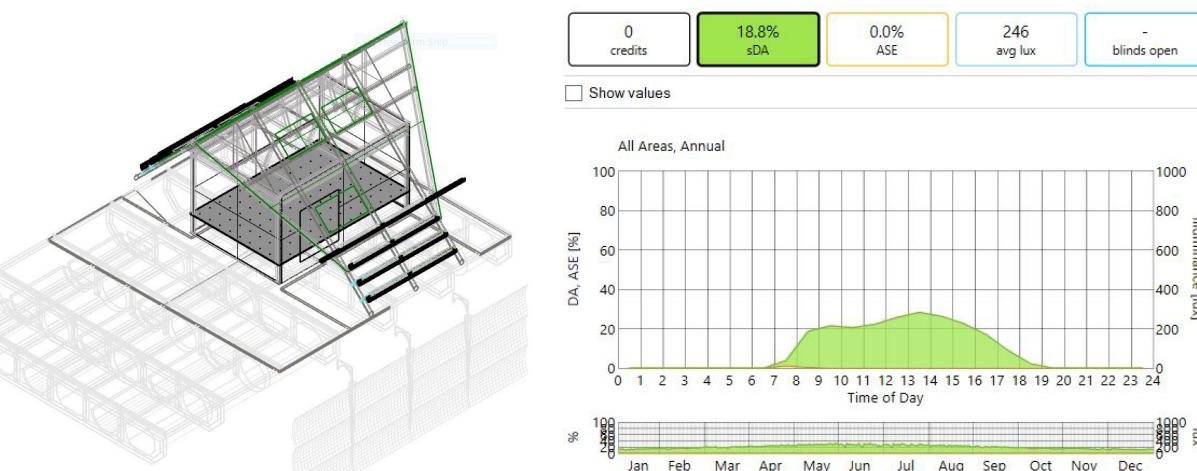


Iteration 3: Opening facing geographic north. WWR: 25% sDA achieved: **100%** AS

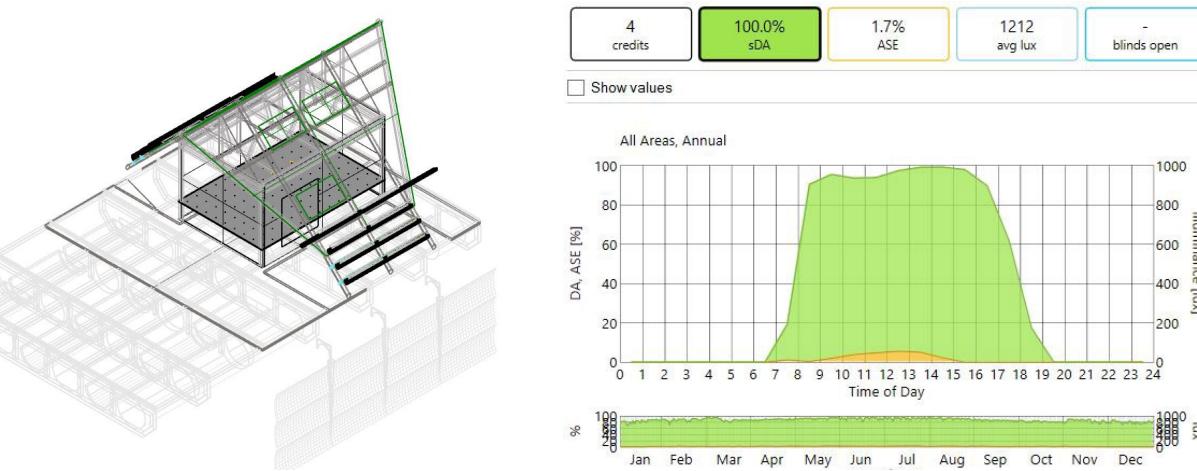
simulations use water as the ground plane. A singular simulation was run built ground material in climate studio to compare the two conditions



achieved: **15.4%** Outcome: Not desirable for no sDA and ASE>10%



SE achieved: 0% Outcome: Not desirable for low sDA

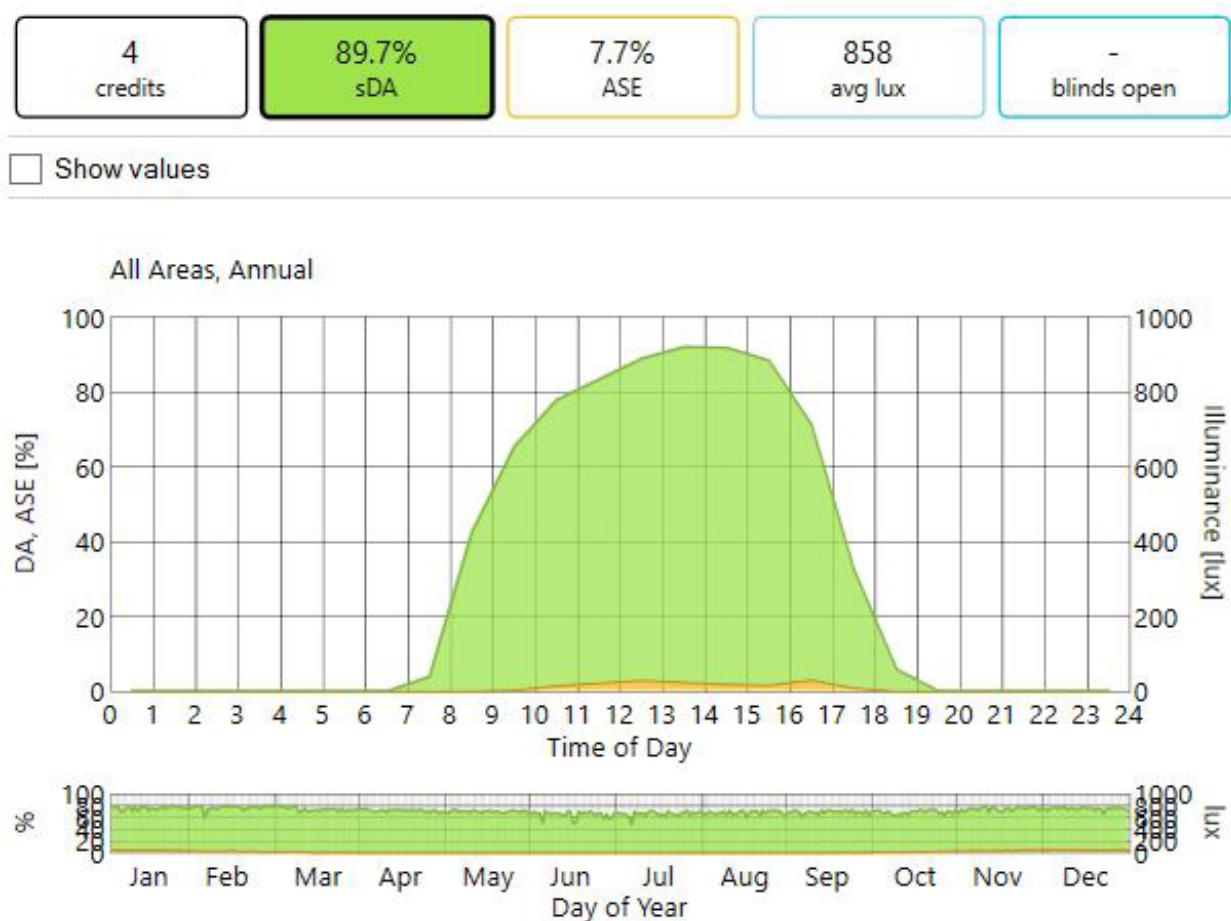


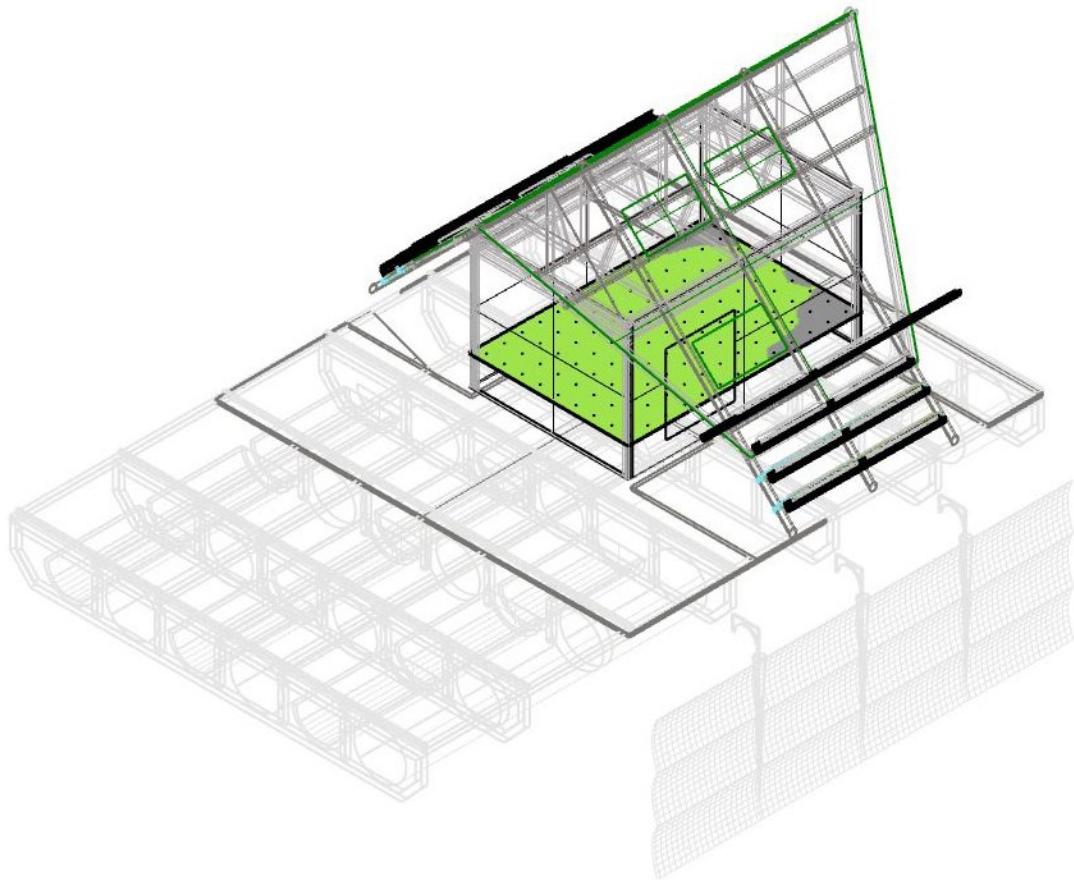
SE achieved: 1.7% Outcome: Not desirable for possibility of extreme glare

The optimal design

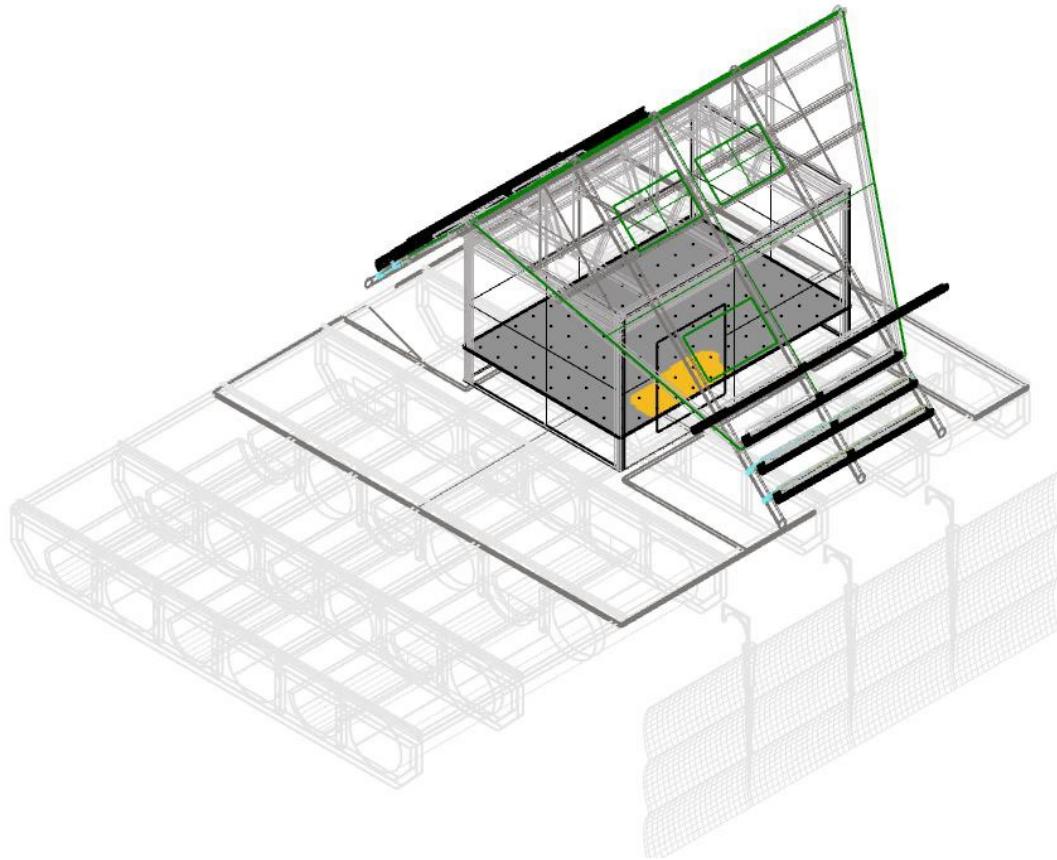
The results for the simulations helped determine the design of a unit with a window to wall ratio of 23%. The final module included a fenestration on the south facade with an additional skylight fenestration on the south side of the pitch roof. A favorable Spatial Daylight Autonomy (sDA) value of 89.7% and Annual Solar Exposure (ASE) value of 7.7% helped gain 4 credits.

The simulation also revealed favorable numbers of 75.2% sDA and 7.7% ASE for the unit with an outdoor ground plane displaying that the unit would perform well in both conditions though the reflective quality of water improves its daylight performance considerably.



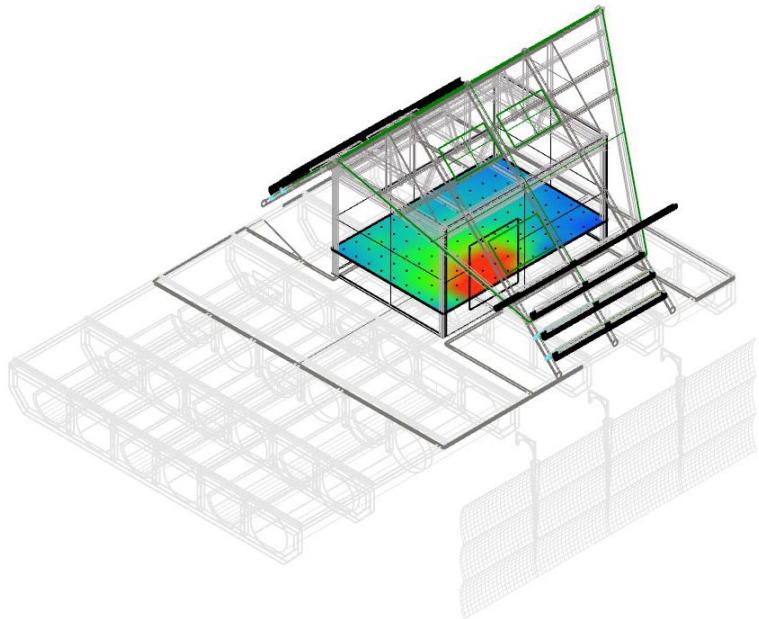


Iteration 7 Water plane: Opening facing geographic South. WWR: 23%
sDA achieved: 89.7% ASE achieved: 7.7% Outcome: extremely desirable

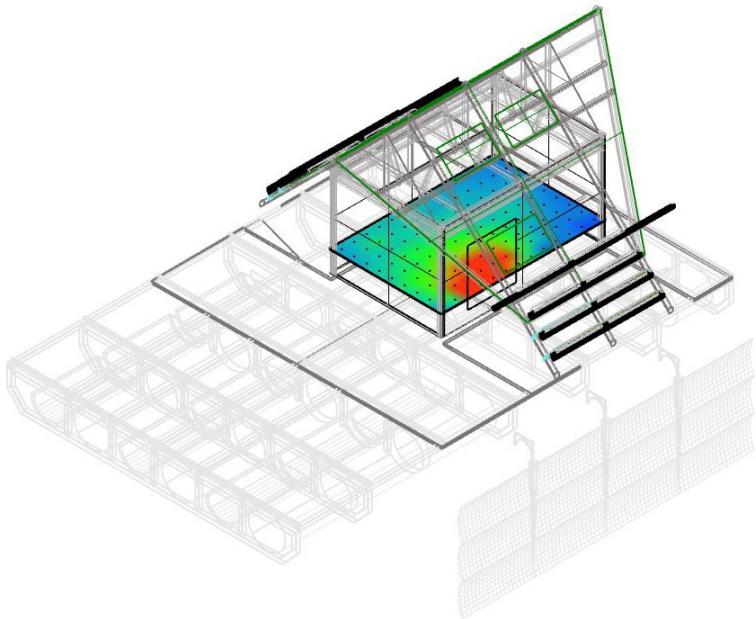


Illuminance and Annual Solar Glare

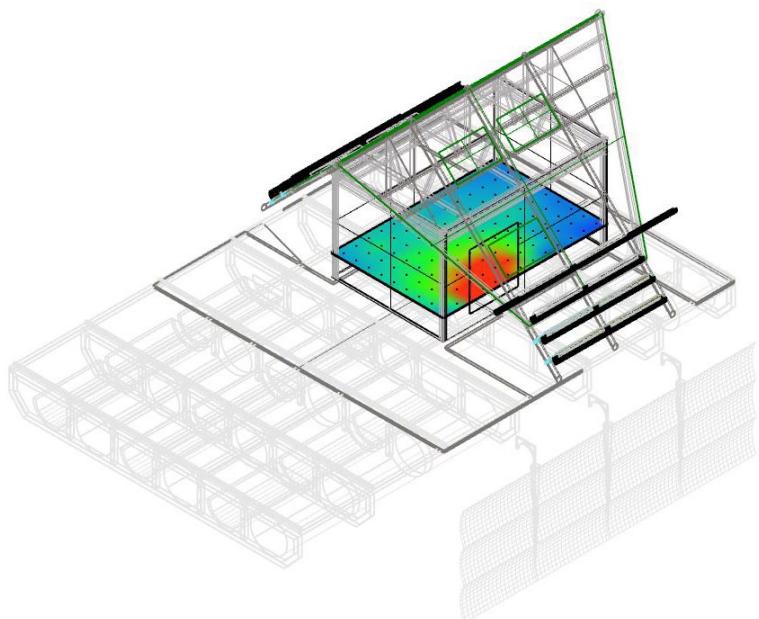
The f
inbuil



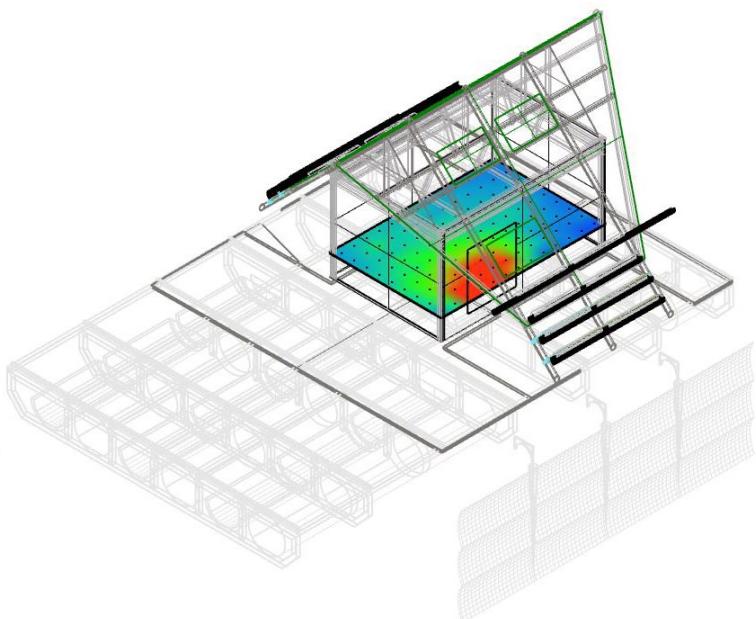
March 21 10.30 am



March 21 12.30 pm

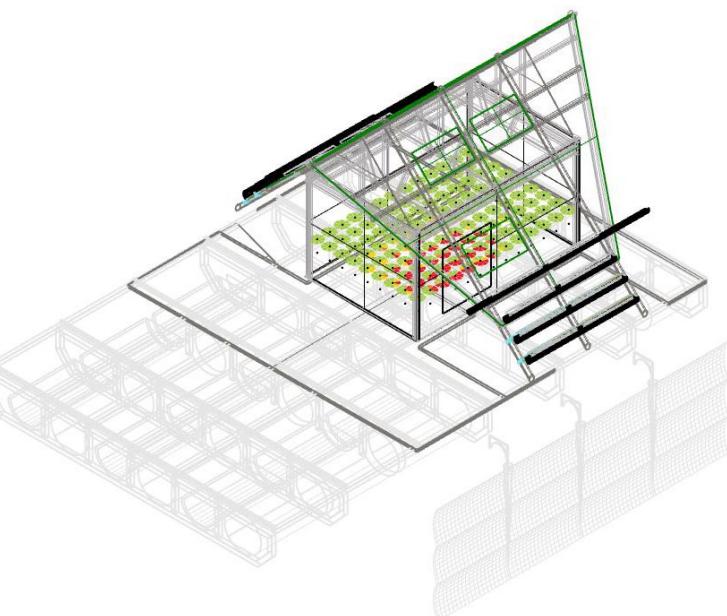


March 21 2.30 pm

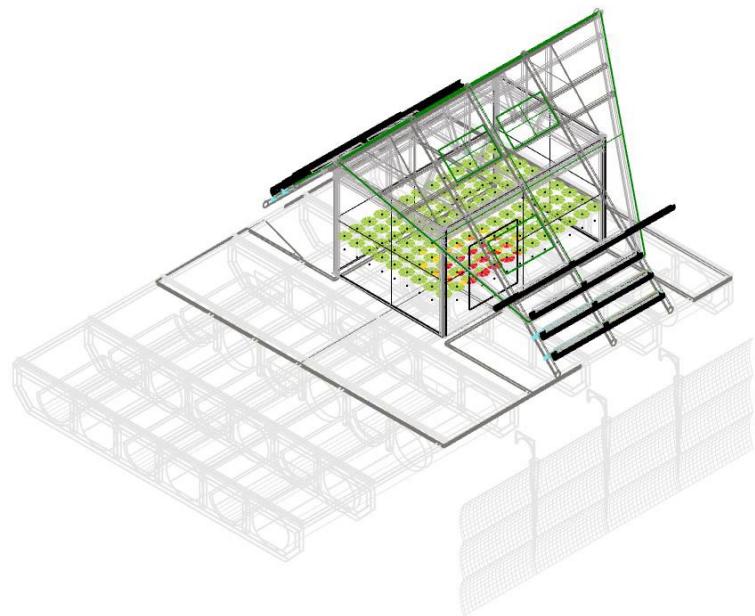


March 21 4.30 pm

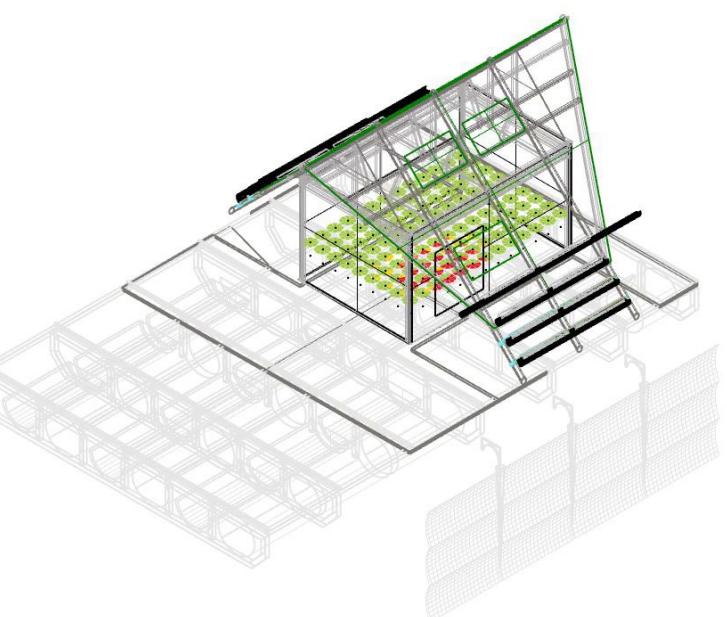
rst five simulations use water as the ground plane. A singular simulation was run with an
t ground material in climate studio to compare the two conditions



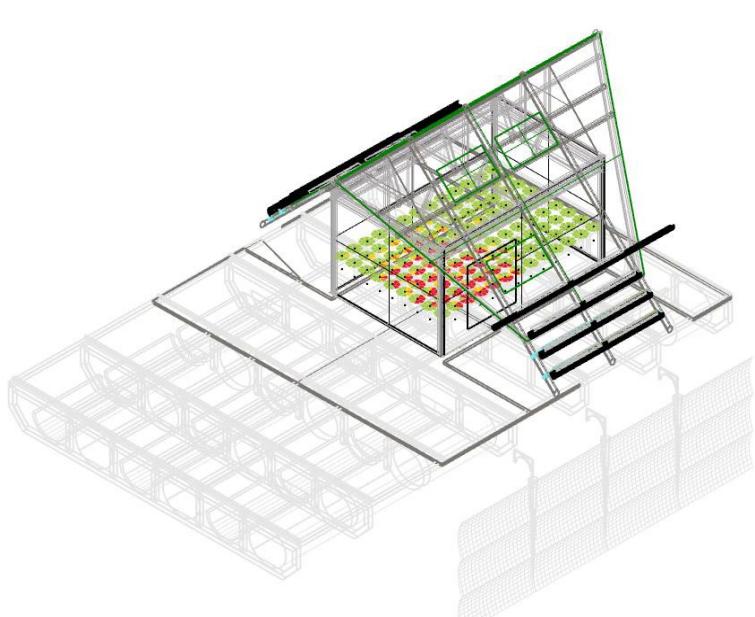
March 21 10.30 am



June 21 10.30 am



Sept 21 10.30 am



Dec 21 10.30 am

Kommuning Koliwada

Case study 1:

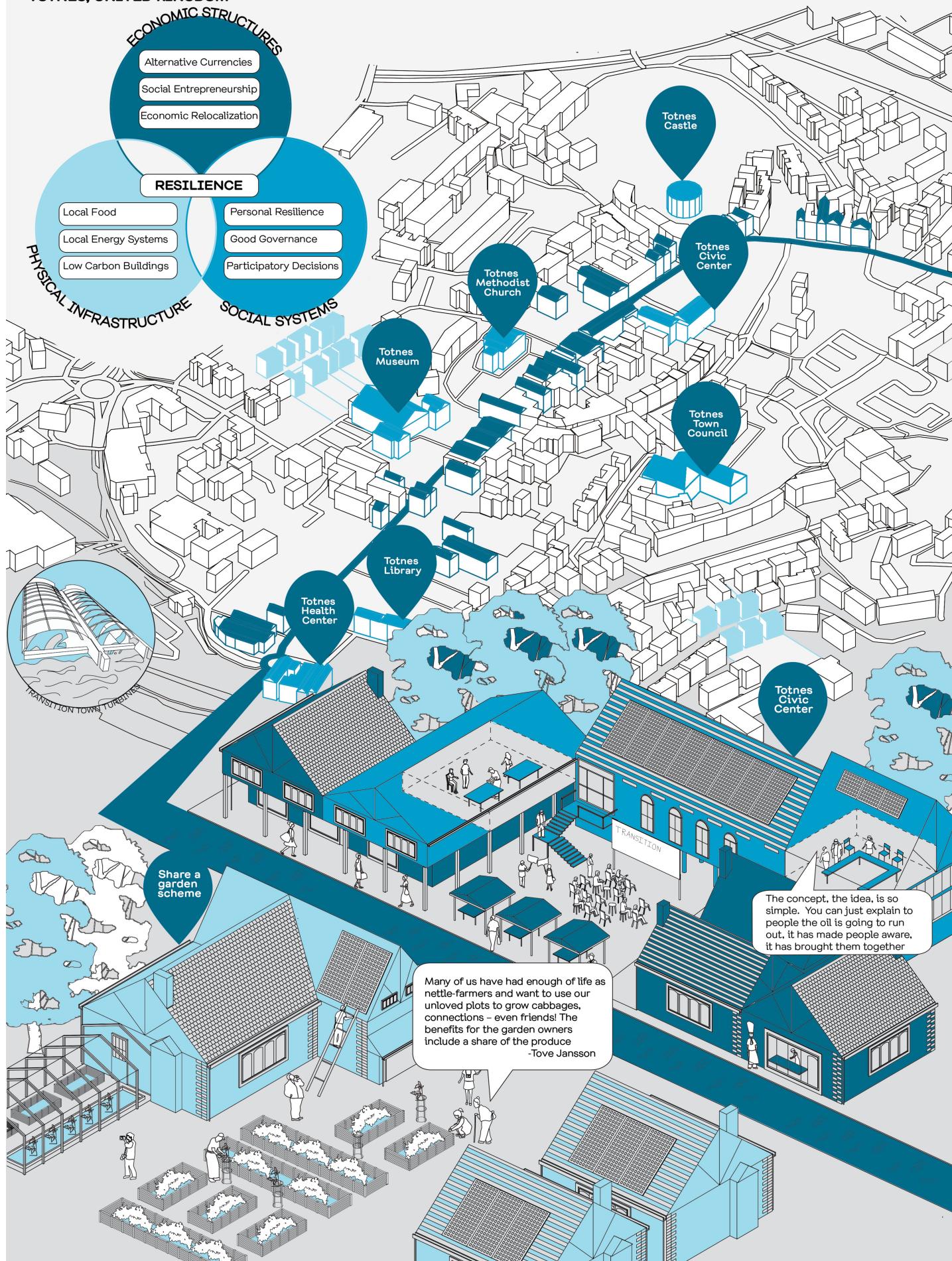
Transition Town Totnes began with presentations and film screenings organised by Naresh Giangrande and Rob Hopkins in late 2005, an awareness raising period which culminated in September 2006 with a launch event called the Official Unleashing of what then became known as Transition Town Totnes.

The Transition Town movement is based on the core principles of relocalization and community resilience. Transition aims to go beyond the general idea of localism, that is, the delegation of power to the local level, to localization, making sure the core needs of the community (food, energy, building materials) are met locally. The movement hopes that this idea will give a huge boost to the local economy while reducing oil vulnerabilities and carbon emissions.

Transition Town Totnes also challenges the idea of resilience from being the ability to adapt to shocks to a desired state, one that benefits local communities economically and socially.

TRANSITION TOWN TOTNES

TOTNES, UNITED KINGDOM



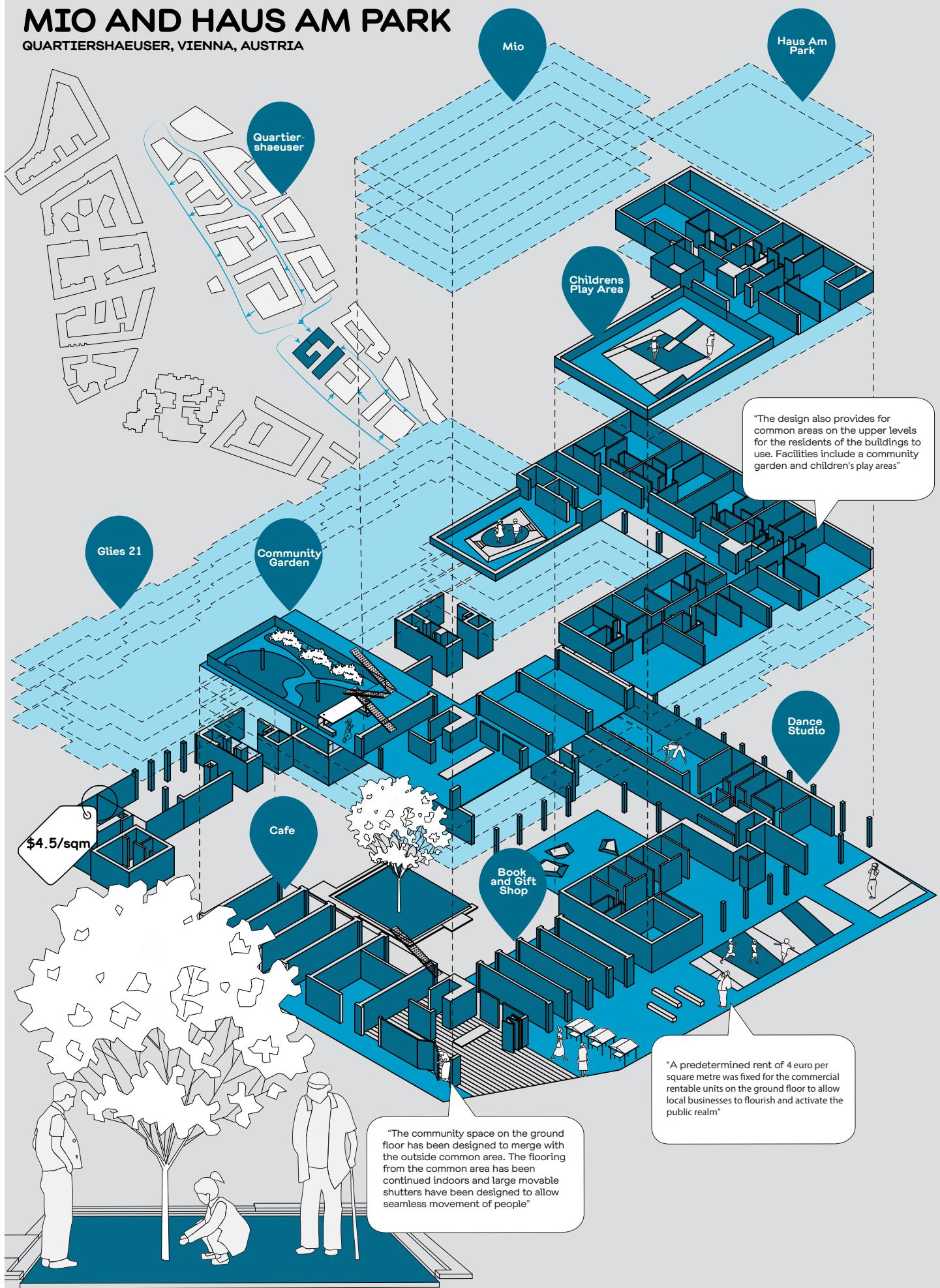
Case study 2:

Based on a cooperative master plan, a district of diverse uses is developing where eleven of the buildings are going to be so called Quartiershäuser characterised by the idea and aim to fuse service and living in a modern urban context. Characteristic of these are a public use of the ground floor which aims to animate the immediate neighbourhood. To ensure this outcome, the future users of the ground floor spaces were involved already during the competition phase.

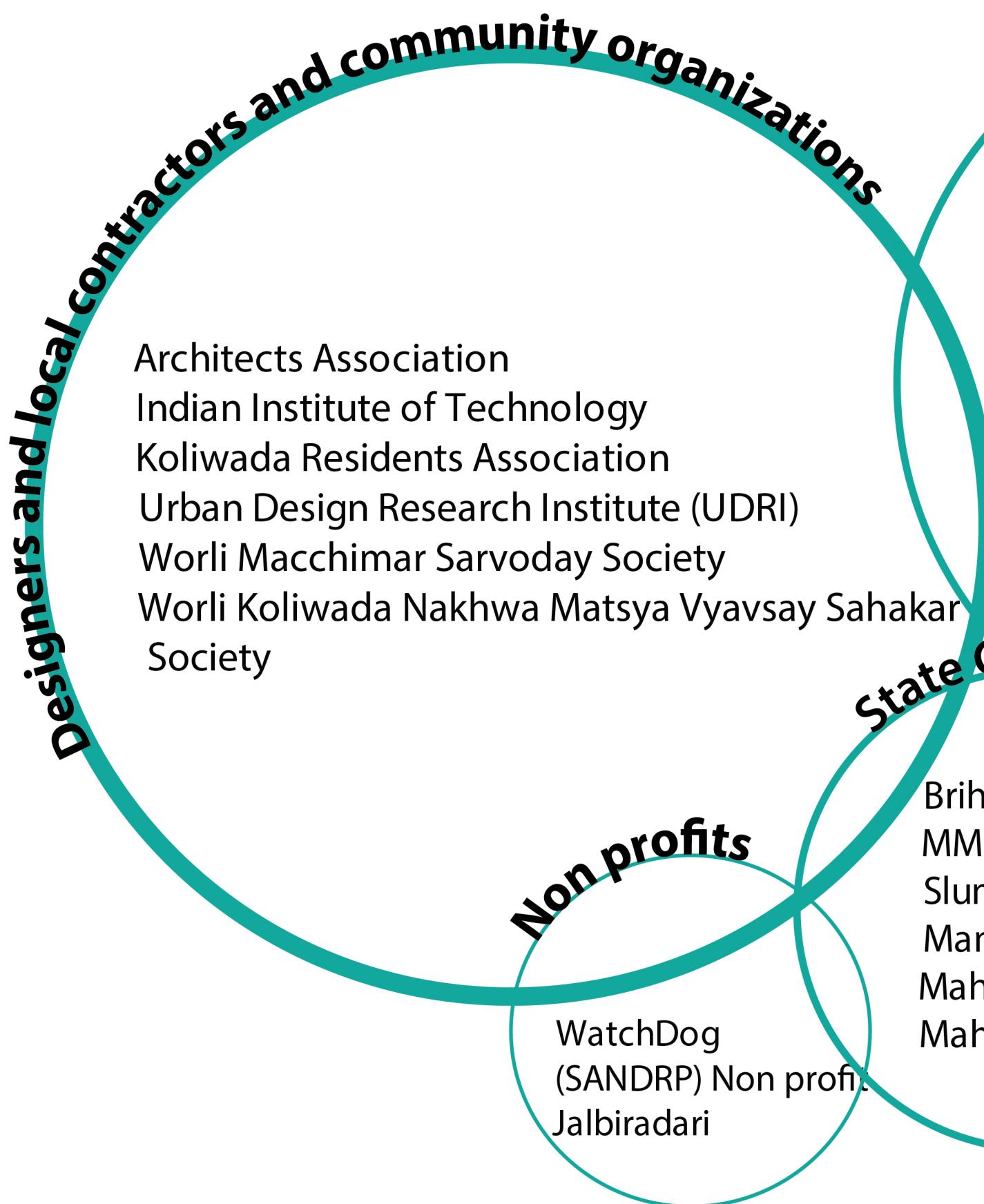
The park, public and semipublic as well as private spaces enter into a symbiosis with flowing transitions. The forecourt is a barrierfree meeting zone and combines the uses of the ground floor and the city via the dance studios Kids Stage. The atrium presents a calm space for recreation whilst simultaneously providing an interface with the neighbourhood. The playground faces the adjacent building group. A roofscape with various communal and private terraces crowns the building. The communal terrace Chilletarium on the roof of the fourth floor serves as an area of relaxation whilst vegetables are grown on the roof of the sixth floor with panoramic views over the city.

MIO AND HAUS AM PARK

QUARTIERSHAEUSER, VIENNA, AUSTRIA



The stakeholders, the process and the p



hases

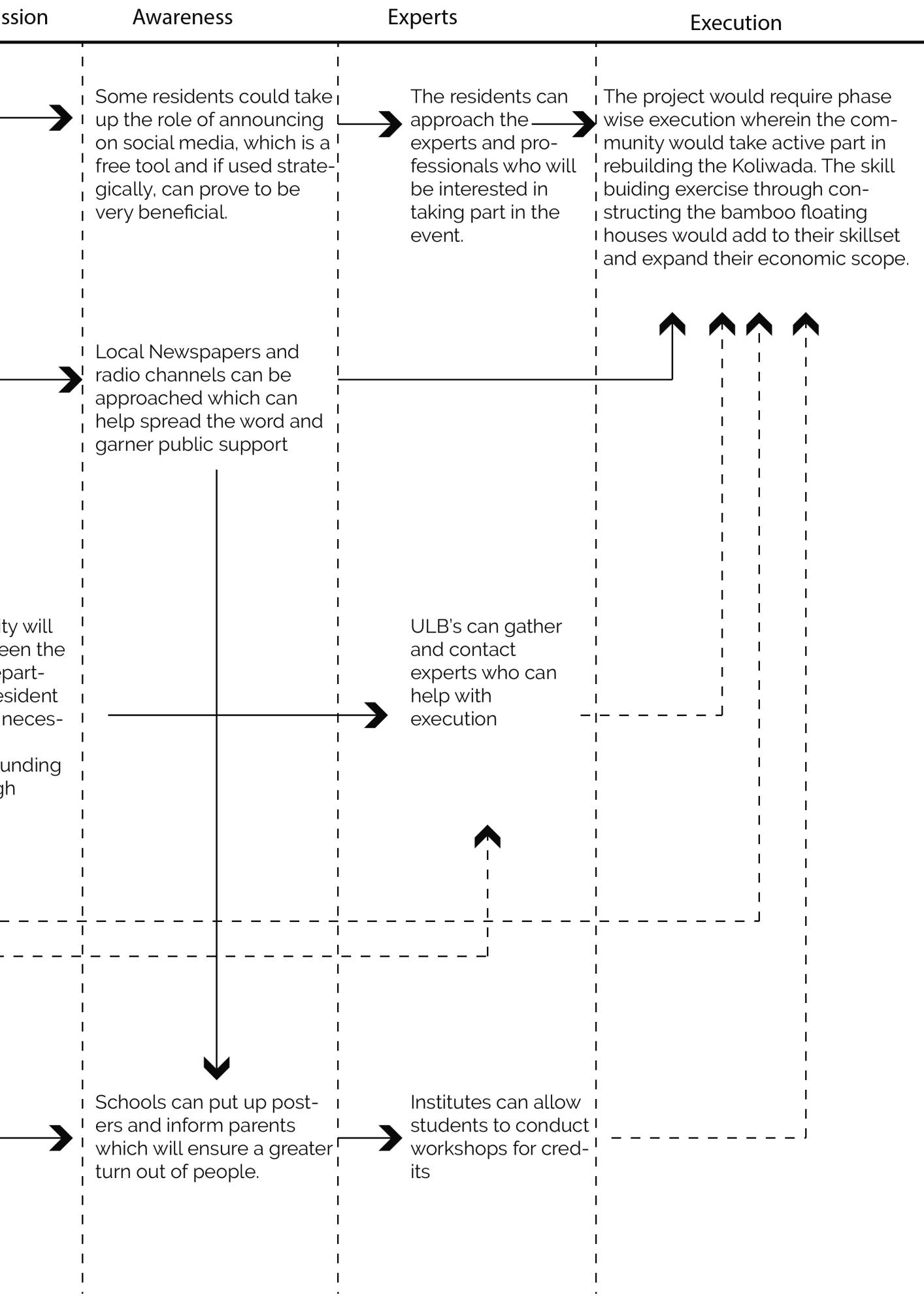
Central Government

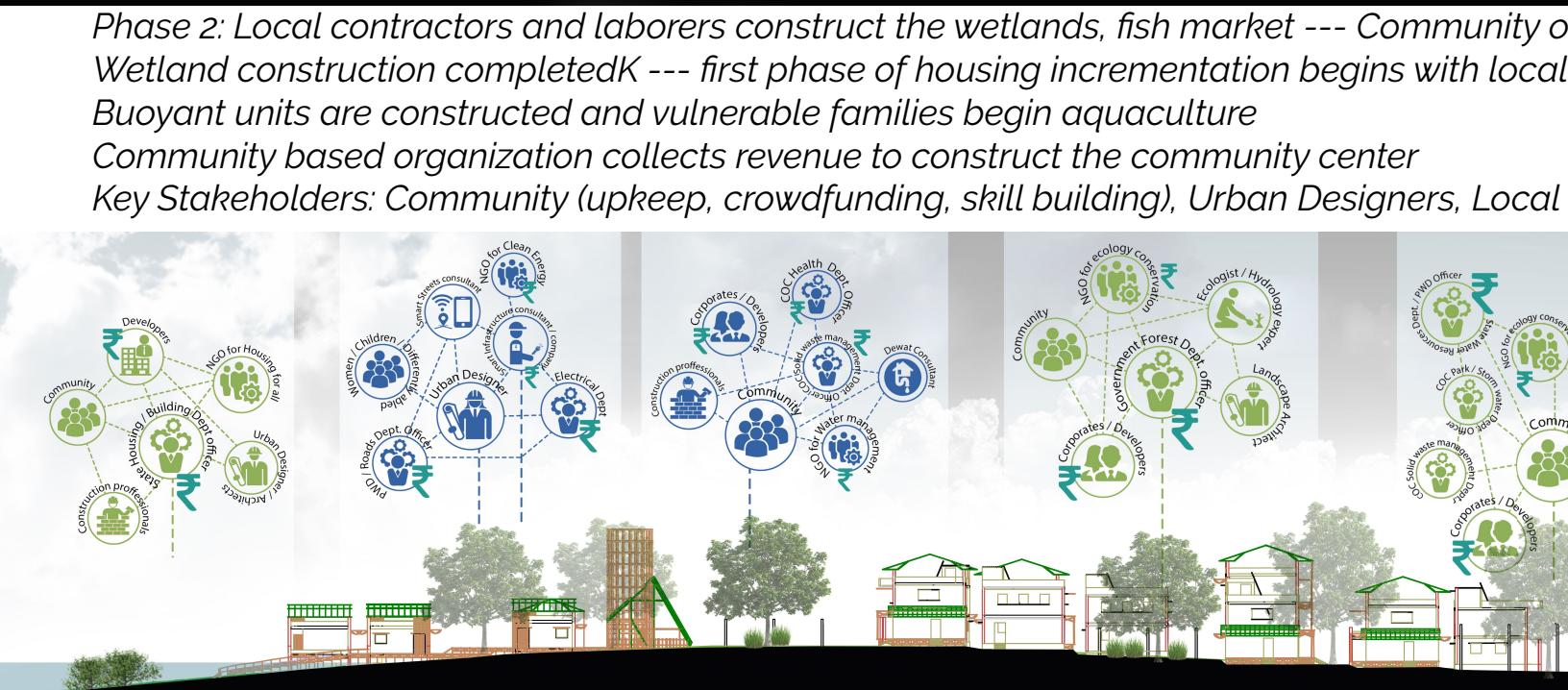
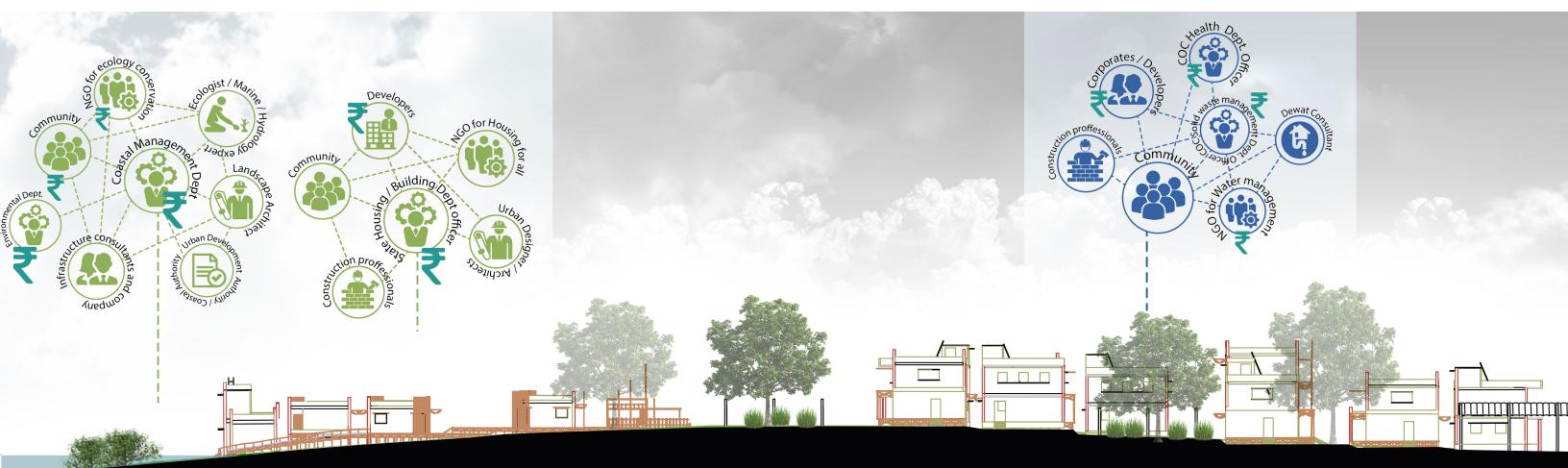
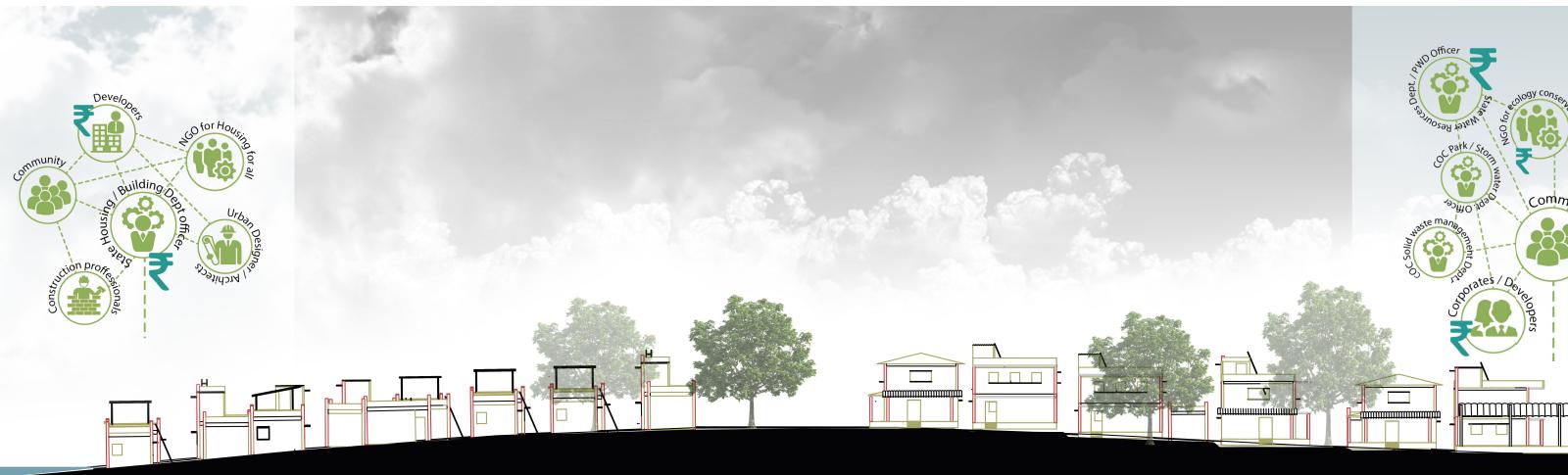
Maharashtra Government
Ministry Of Human Resources
Ministry of Tourism
Ministry of Ayush
Ministry of Youth Affairs
Ministry of Sports
Environmental Clearance Board
Ministry of Drinking Water and Sanitation
Ministry of Agriculture
Biodiversity Institute of India
National Green Tribunal
Heritage Ministry
Railway Ministry

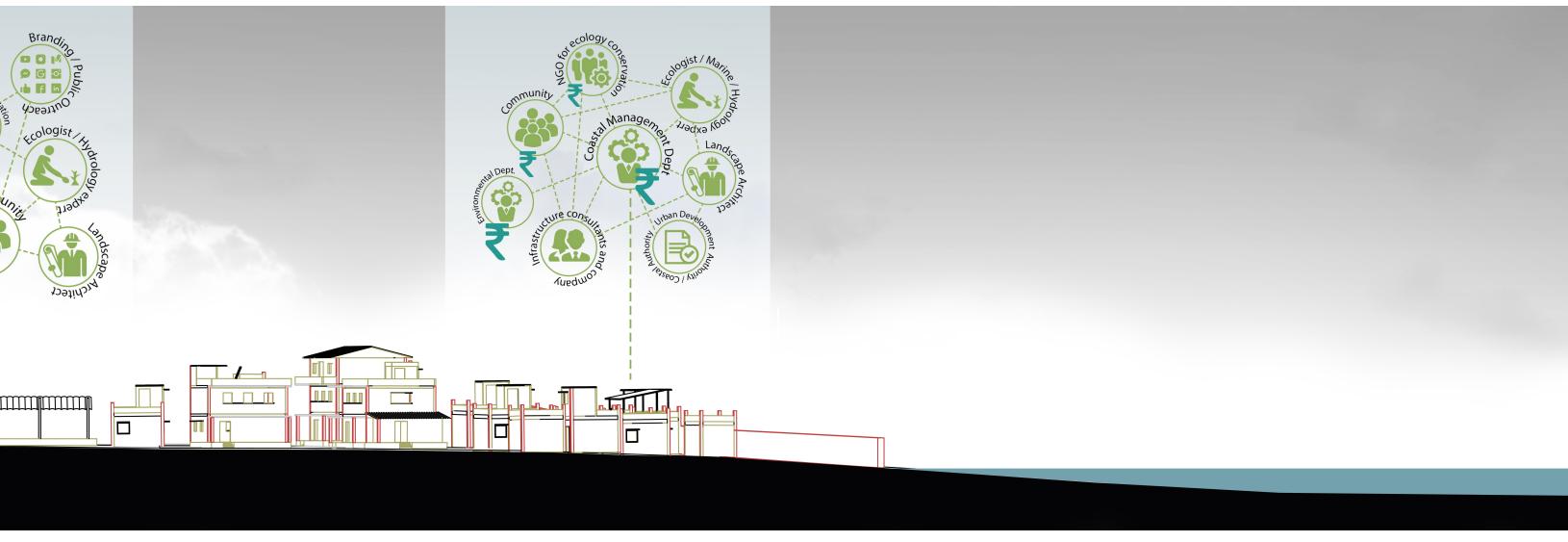
Government

Mumbai Municipal Corporation (BMC)
MRDA (Mumbai Metropolitan Region Development Authority)
San Rehabilitation Authority (SRA)
Mangrove Conservation Board
Maharashtra Housing and Area Development Authority (MHADA)
Maharashtra Coastal Zone Authority (MCZ)

	Collaboration	Funding	Coastal Permission
	A group of residents can come together and contact corporates that would be interested in funding/helping out with this initiative. There could be one coordinator from the resident group.	Residents can contribute through crowd-funding	
	Media companies, which act as major sponsors and advertisers should be contacted to initiate the project. They can give inputs as to how other nations have implemented such schemes		
		The local authorities can get funding from various bodies Tapping into the JNNURM for pilot project?	The local authorities coordinate between roads & traffic departments and the relevant group to get the necessary permission required. Some funds can come through ULB's as well.
		The corporates can help in funding by way of Corporate Social Responsibility (CSR). NGO's can help by coordinating this The Koliwada Land Trust can be tapped into. The network can be chalked out by NGO's who are experienced in CSR funding	
	Institutes can help by providing space for the initial meetings. Students can help set up, organize and mobilize the community and resources for the event. Experts to be invited from IIT, NIT, UDRI for pilot project testing		







finished units on the less vulnerable bay side
 --- secure local contractors and labor
 o relocate), State(Permissions) World Bank and PMAY (Funding)



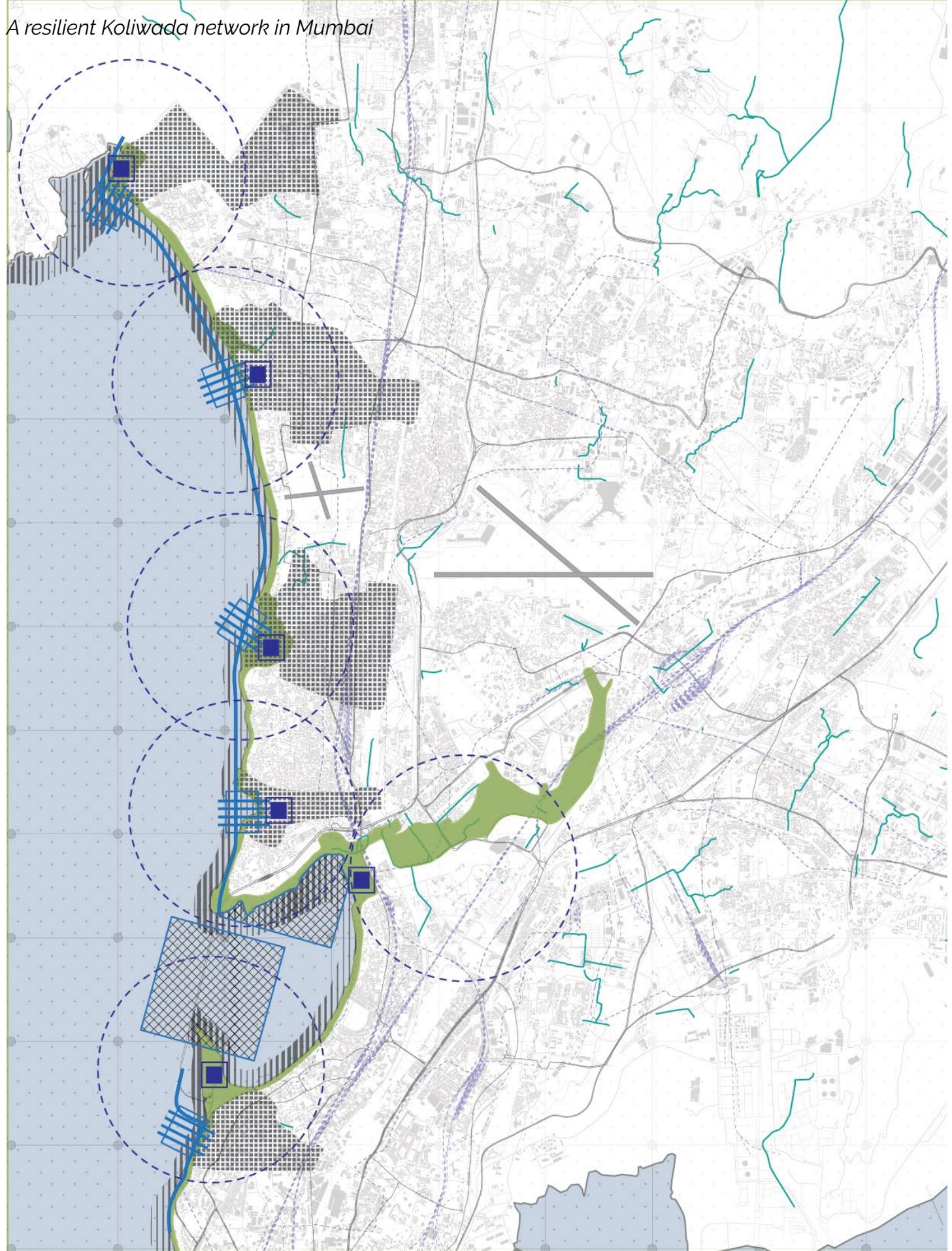
organization takes over the upkeep and begins collecting revenue to pay back the soft loans
 lly sourced bamboo and bamboo crafting used as a skill and community building exercise

contractors and laborers, World Bank and Koliwada trust (Funding)



The final vision

The proposal is envisioned to have a ripple effect across the various Koli communities of Mumbai that could potentially be duplicated in different Koliwadas across the city with the intention of creating a green corridor on the western coast of Mumbai through a resilient Koliwada network.



Reviews

Final Presentation

Attendees

Studio Faculties

Stefan Gruber

Associate Professor, Track Chair, Master of Urban Design , Carnegie Mellon University

Mary Lou Arscott

Studio Professor, Associate Head, School of Architecture, Carnegie Mellon University

Stephen Lee

Professor, Head of School of Architecture, Carnegie Mellon University

Stephen Quick

Adjunct Faculty, Carnegie Mellon University

Hal Hayes

Studio Professor, Carnegie Mellon University

Jonathan Kline

Associate Studio Professor, Carnegie Mellon University

Stefani Danes

Adjunct Faculty, Carnegie Mellon University

Ray Gastil

Director, Remaking Cities Institute, David Lewis/Heinz Endowments
Directorship of Urban Design and regional engagement

Azadeh Sawyer

Assistant Professor in Building Technology, Carnegie Mellon University

Guest Critics

Kaja Kuehl,

Professor for Urban Design, Columbia University GSAPP

Rami el Samahy

Principal-Over Under, Boston, Visiting Faculty Massachusetts Institute of Technology (MIT)

Tobias Armborst

Principal-Interboro, NYC, Faculty, Vassar College

Past Alumni

Paul Moscoso Riofrio

Tamara Cartwright

Ernest Bellamy

Sai Prateek Narayanan

Link to the final review Video:

<https://mail.google.com/mail/u/1/#search/jonathak%40andrew.cmu.edu+thesis+critics/FMfcgxwHNMXKJwkMJDCQtHfzPbTqdLjs?projector=1>

Link to thesis website presentation:

<https://thesis.soa.cmu.edu/Abhinavv-Singh>

Jury notes

"This is a really complete proposal and you have been working diligently on it. The four transects as a method is really effective as a technique, and the idea that it could apply to this but also other Koli communities. Really exemplary work."

"This is one of the most fascinating presentations I have seen in a thesis - congratulations excellent work".

"This is very impressive from the larger scale to the whole peninsula system to the details of the pontoon. Who is your next audience for this? The large scale axons give us a very strong overview, and it seems like it would work well for a funder. But I wonder how might you target the presentation to different audiences, particularly the locals in the Koli community? I also wonder how you might allow for things to not line up quite so perfectly,

"Hearing you respond to the questions is amazing - Your depth of knowledge and actual interaction is very impressive. You should try to weave more of this into the way you present. There is a great opportunity in co-creating this with the community and you should try to weave them."

"I think it's fantastic to have a thesis review where most of us are asking how you are moving the project forward, this is a sign of the maturity and depth of the work. I wonder if you could begin to use forms of representation that can be more of a tool of empowerment, not so much a pretty picture for the layman. How could you make drawings that allow the residents to have more agency."

"In general you have been very smart about knowing your own strengths and limitations - maybe Mary-Lou is right, you need a filmmaker to partner with."

"Recalling Stefani's comments from mid semester, you maybe need to break this down for the community to show how the steps can occur, in manageable increments.

Your work in my class is really great and you should definitely include your simulations"

Everyone - Congratulations!

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Master of Urban Design 2020

**Carnegie
Mellon
University**