

ADAPTIVE GEOGRAPHIES

Towards a Flood Resilient Mumbai Metropolitan Region

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THE CLIMATE IS
CHANGING
WHY AREN'T WE?







Impact of hurricane Katrina. source: architect



Climate Change. Vulnerabilities.
Flooding -Mumbai 2005



Climate Change. Vulnerabilities.
Flooding -Mumbai 2008



2011

Climate Change. Vulnerabilities.
Flooding -Mumbai 2011



Climate Change. Vulnerabilities.
Flooding -Mumbai 2015



Climate Change. Vulnerabilities.
Flooding -Mumbai 2018



Climate Change. Vulnerabilities.
Flooding -Mumbai 2019



Climate Change. Vulnerabilities.
Flooding -Mumbai 2020

The problem ?



→ Aim & Research Question



→ Operationalisation



→ Design & Planning Framework



→ Conclusion & Discussions



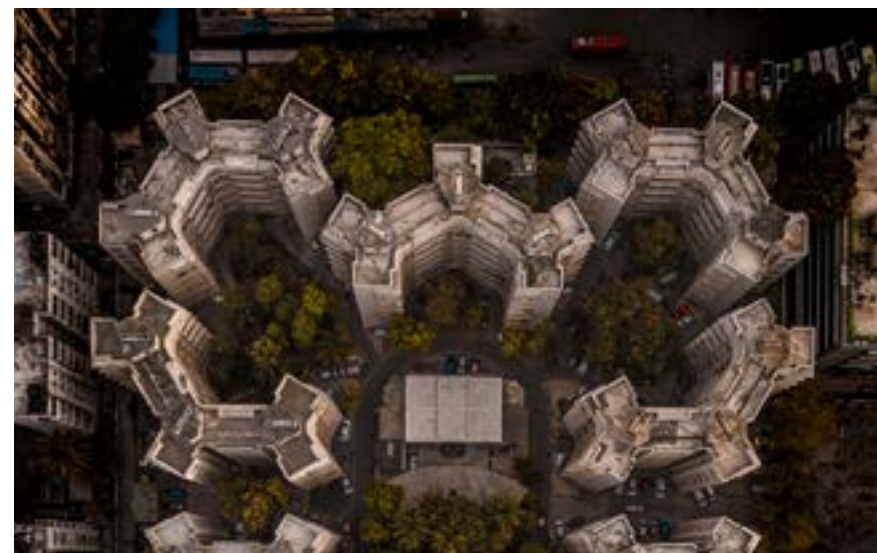
The problem ?



Operationalisation



Aim & Research Question



Design & Planning framework

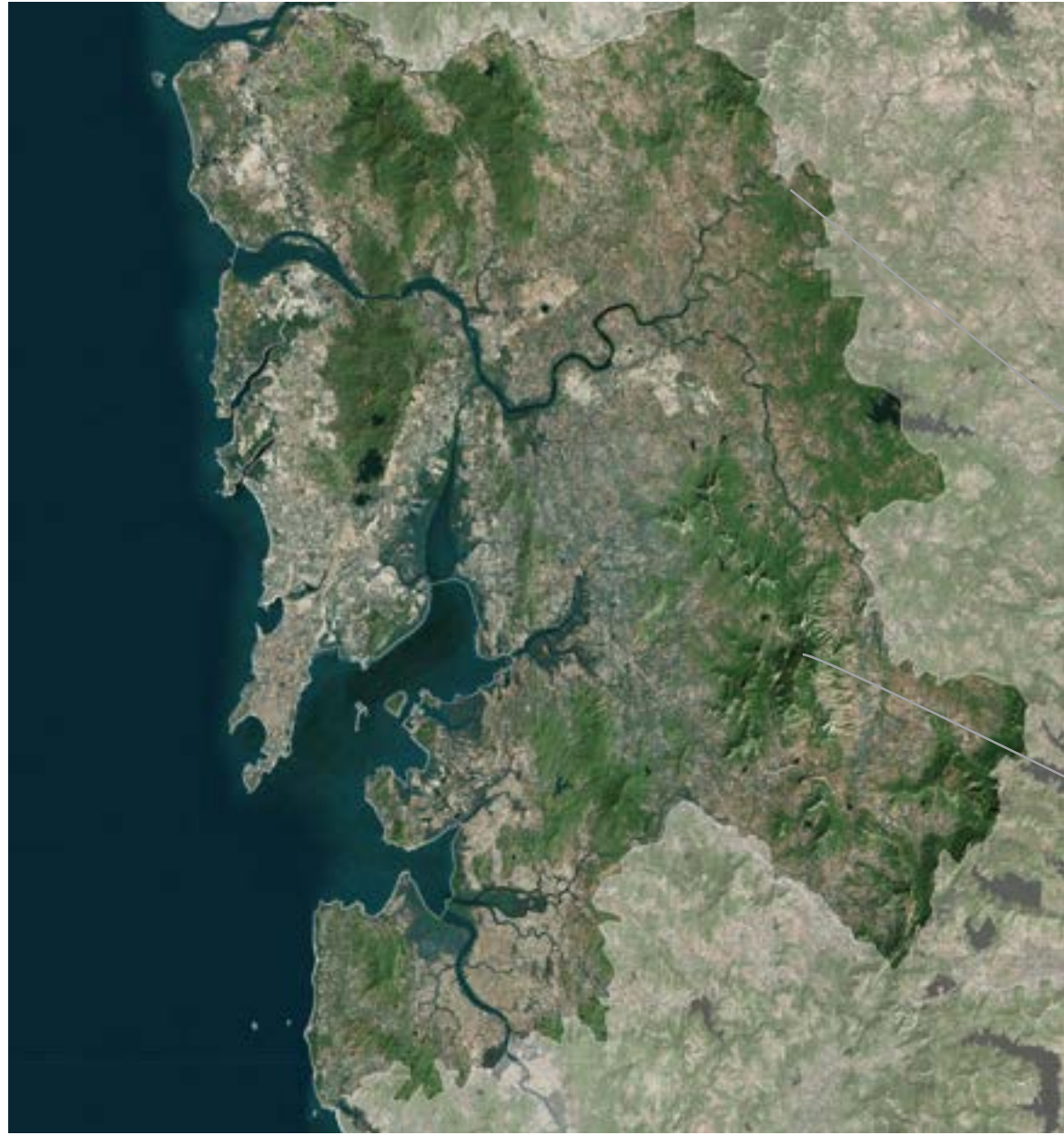


Conclusion & Discussions



An aerial photograph of a coastal city, likely Mumbai, India. The image shows a dense urban area with numerous high-rise buildings and residential structures. A prominent feature is a multi-lane highway bridge spanning across a body of water in the foreground. The city is situated on a peninsula or a narrow strip of land, with the ocean visible on the left side. The overall color palette is dominated by blues and greys, with some greenery interspersed among the buildings. A semi-transparent white box with the text "The Problem?" is centered over the middle of the image.

The Problem?



Mumbai Metropolitan region Population : 20,411,274

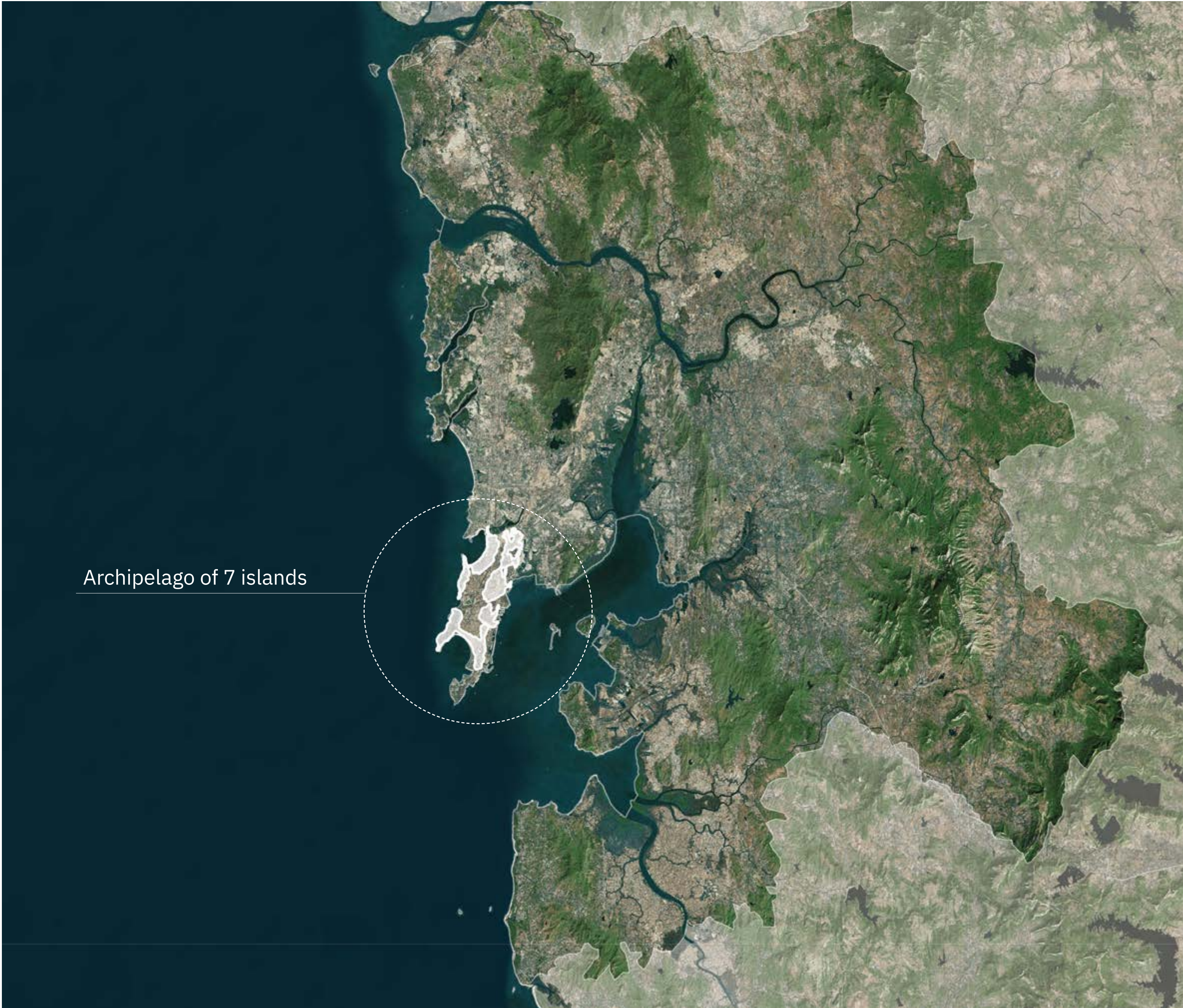


Province of Maharashtra
Area 307,713 km²

Area of Netherlands 41,543
km²

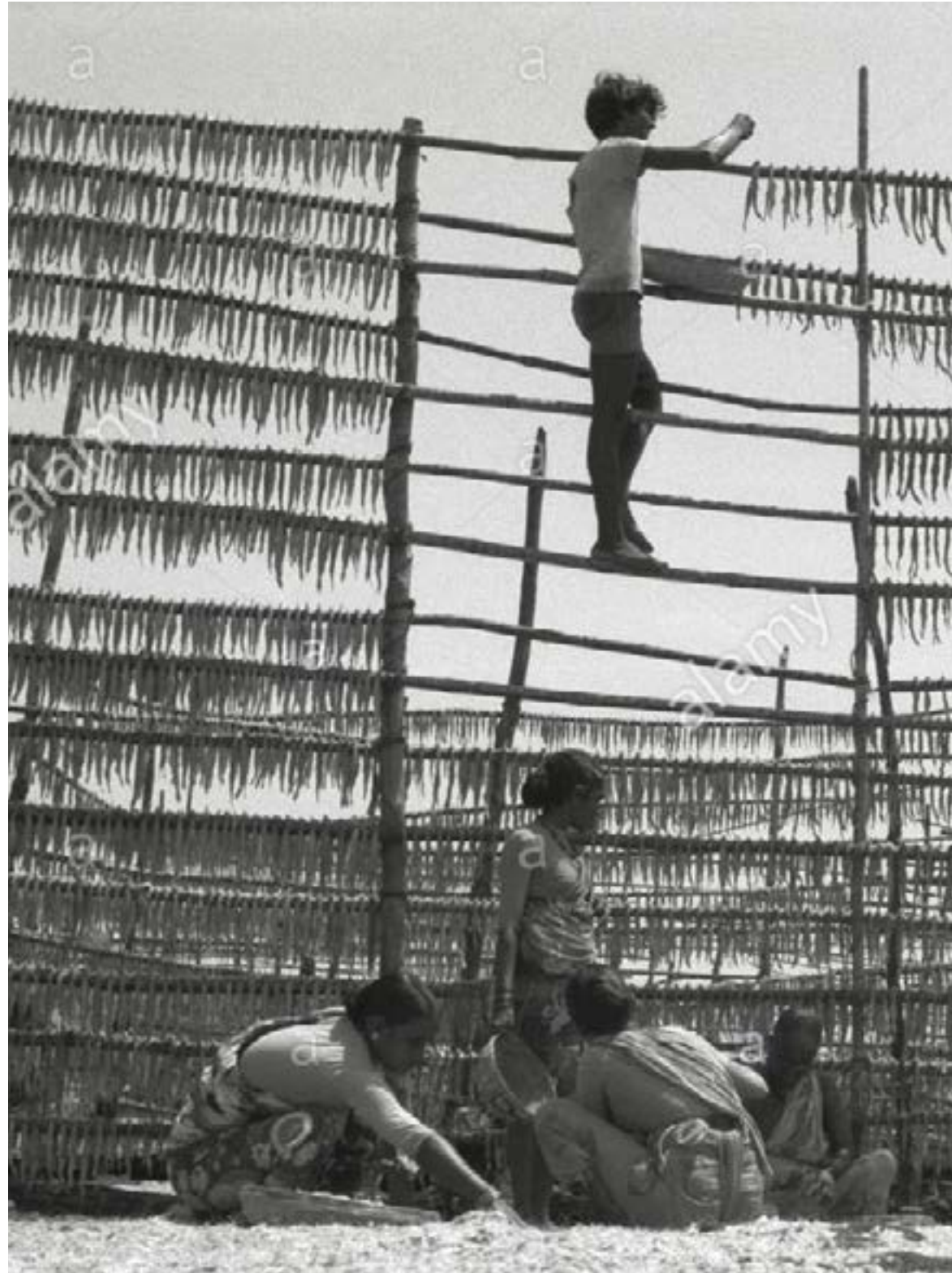


Mumbai Metropolitan region Population
20,411,274



Archipelago of 7 islands

Economy



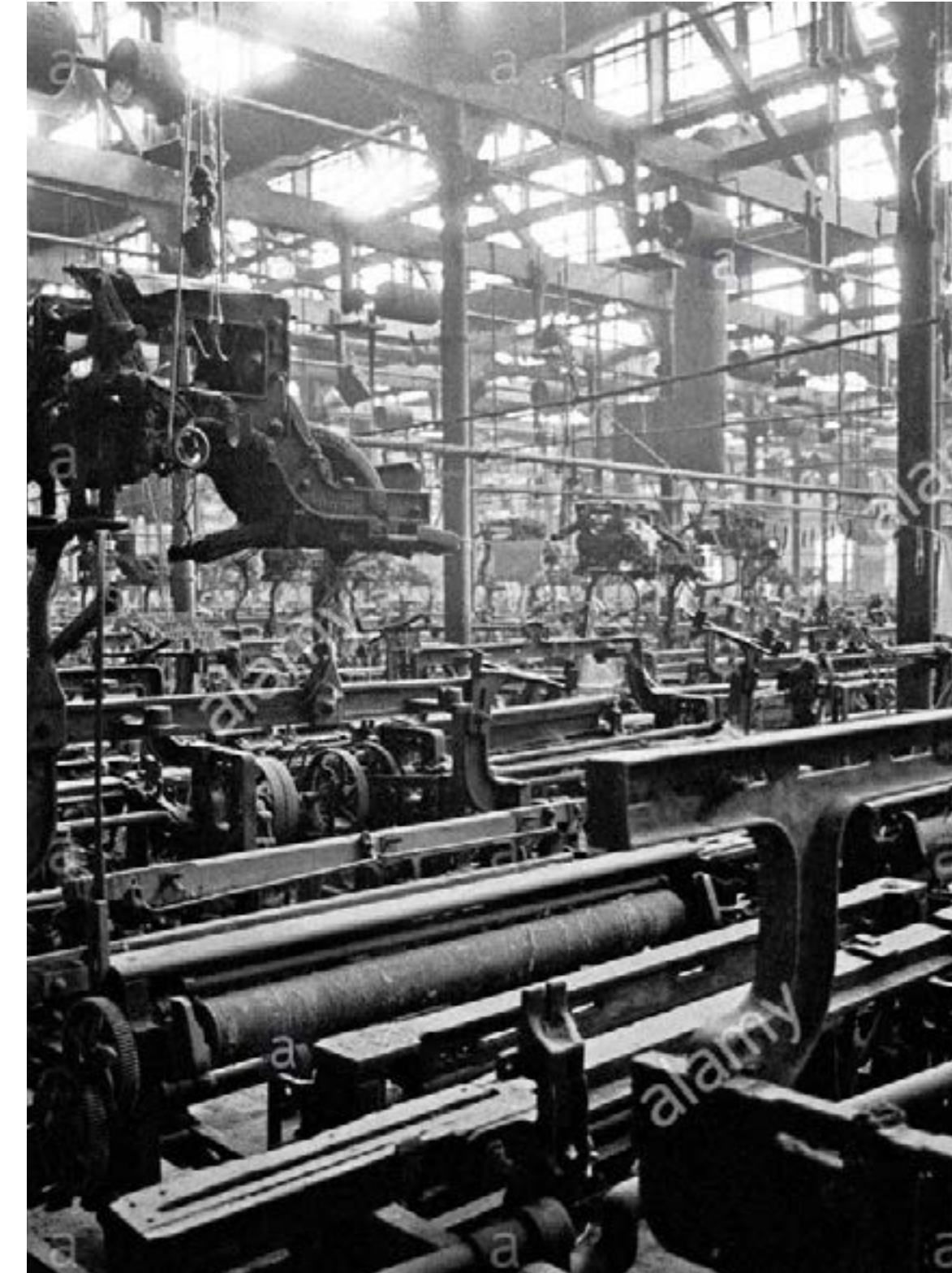
Fishing

Archipelago of 7 islands inhabited by a fishing community



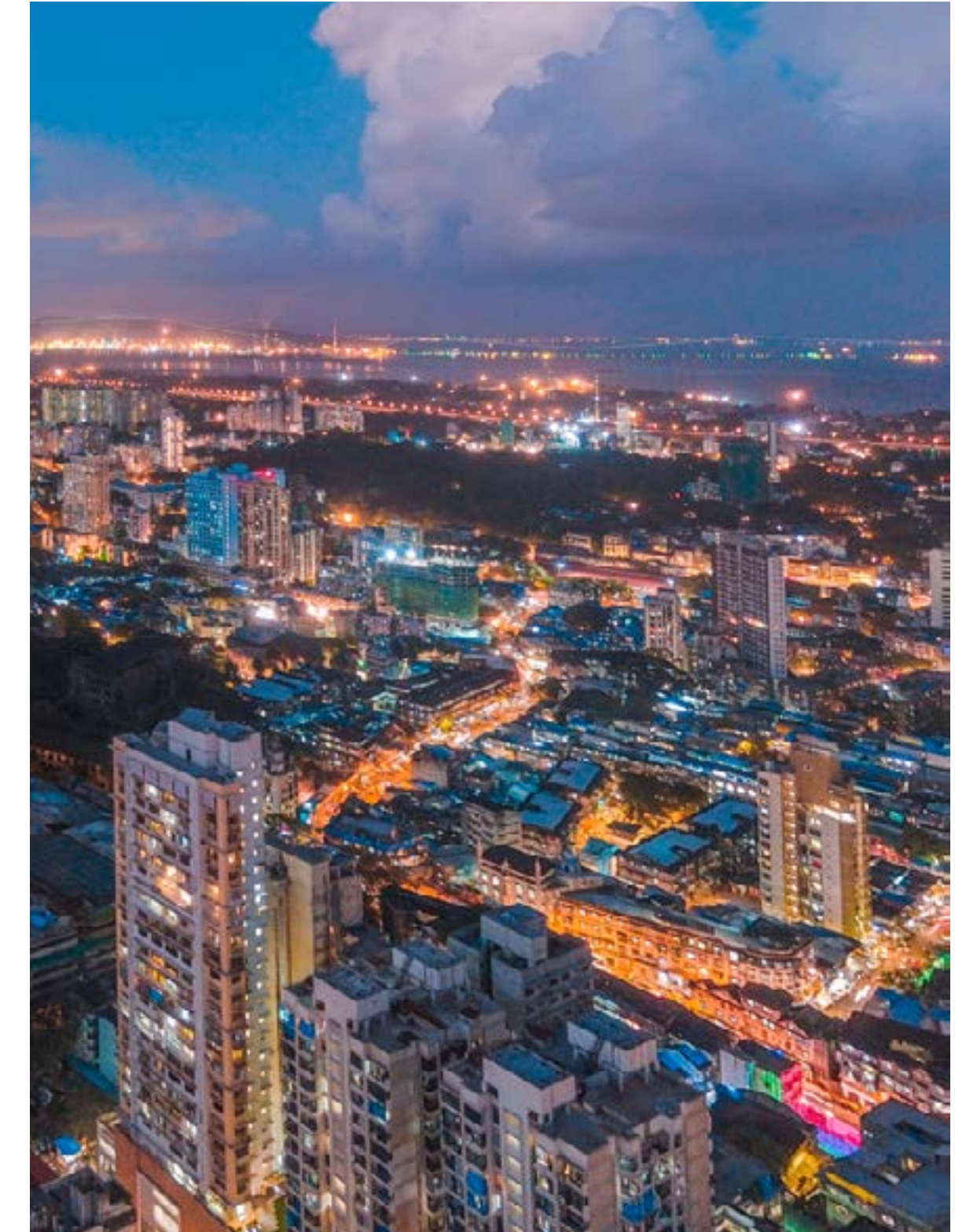
Port City

British East India Company colonised this island and reclaimed land to build a strategic port- Gateway of India.



Textile Industry

In the nineteenth Century, Mumbai had a flourishing cotton textile industry



Financial Capital of the country

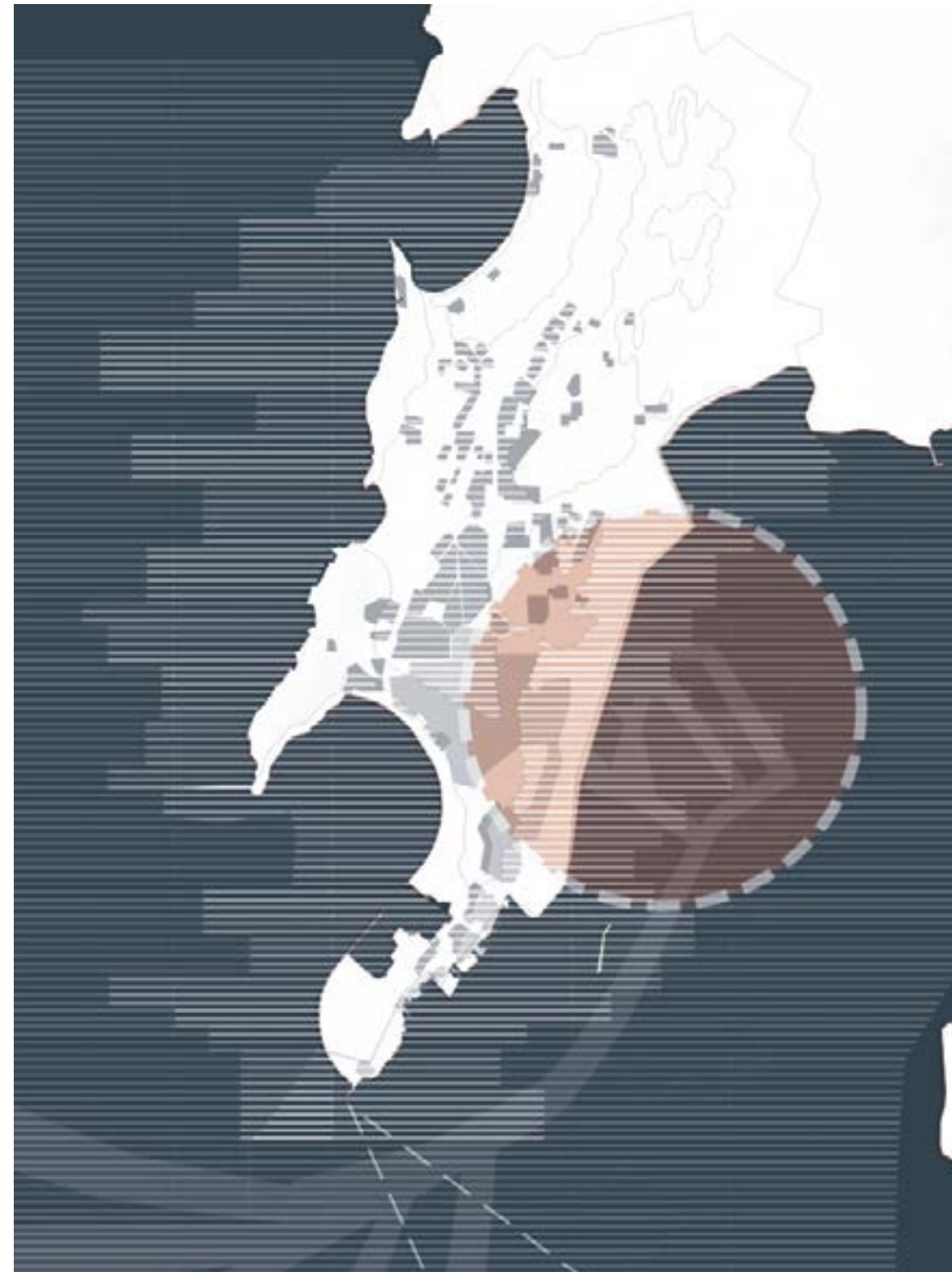
Later/ Now deindustrialised and became a hub for finance, commerce, entertainment and others.

Infrastructure



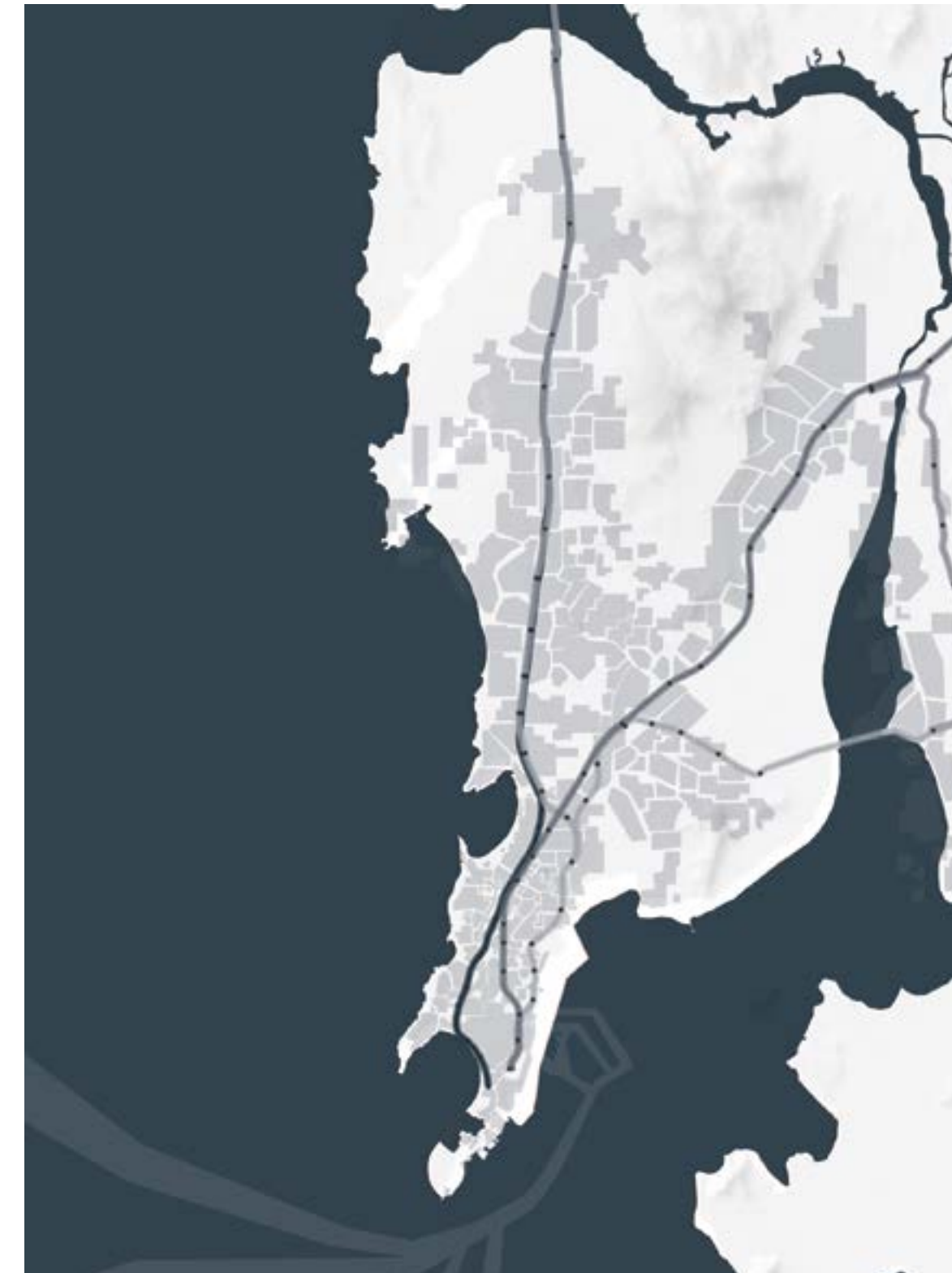
Water Infrastructure

The water became a basic structure or facility to which society responded to.



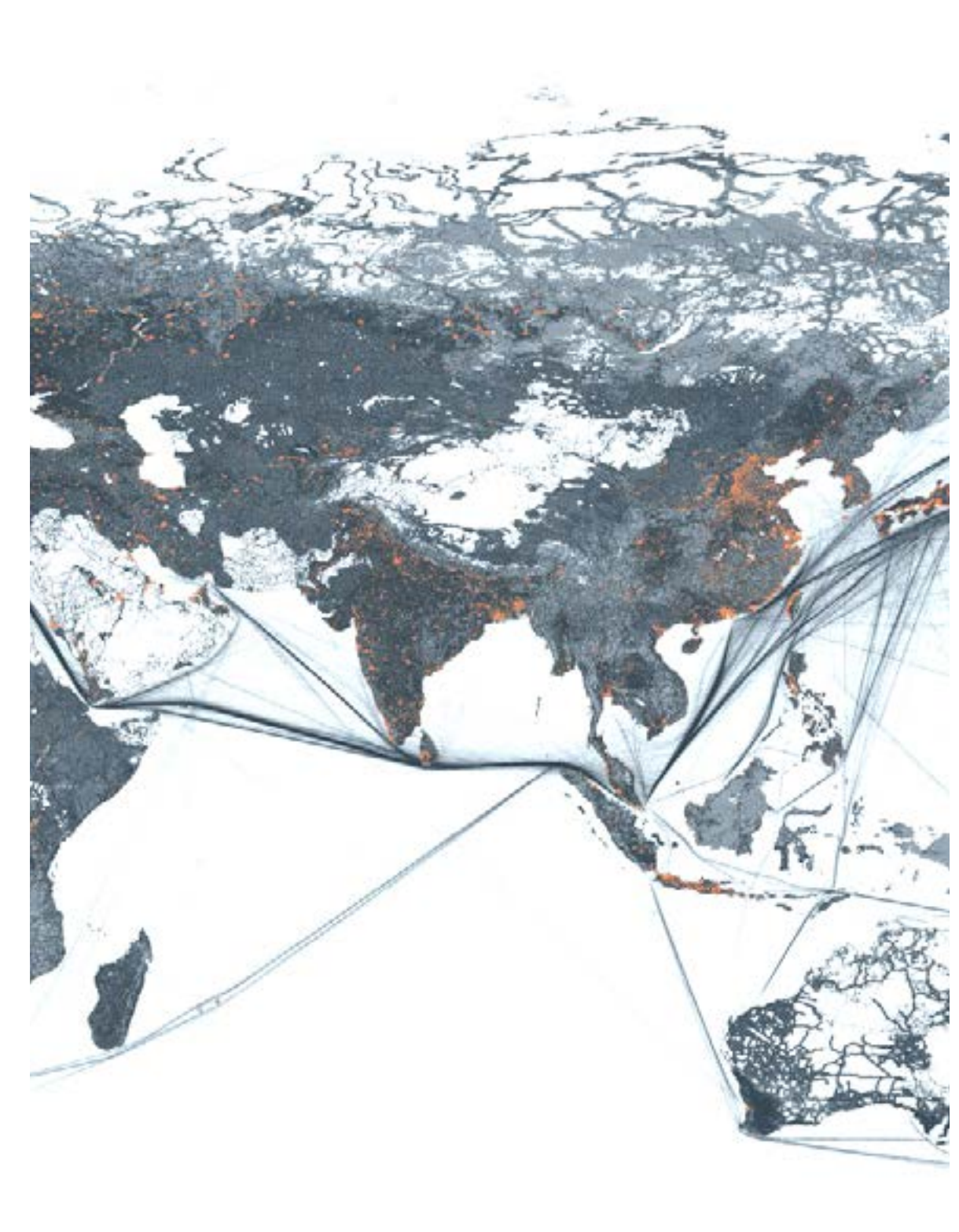
Port & Water infrastructure

Port and water became a basis for development of Mumbai as a port city.



Railway Infrastructure

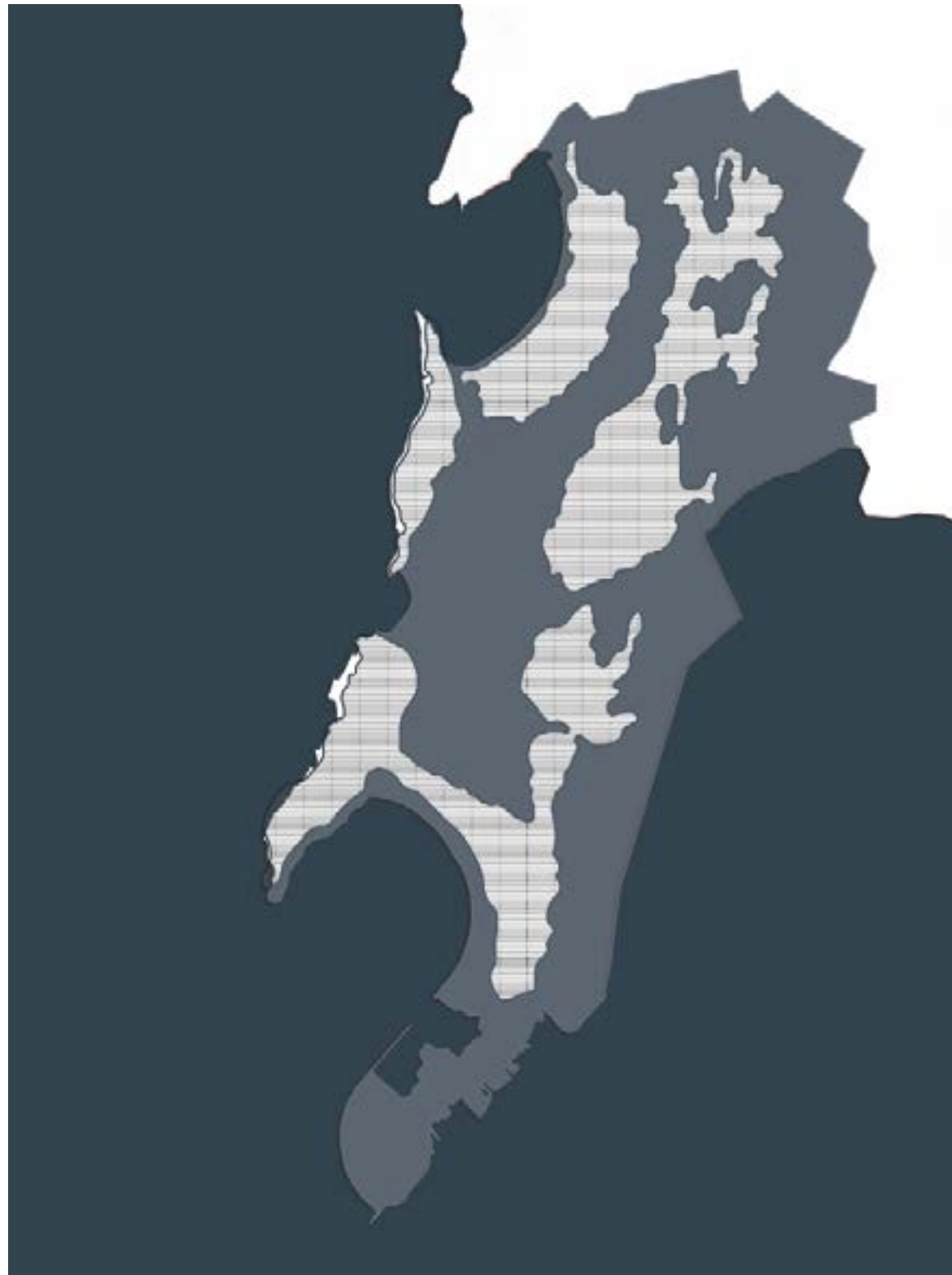
The Rail infrastructure guided the development and also enabled the economy to be connected to its hinterland.



Technological Infrastructure

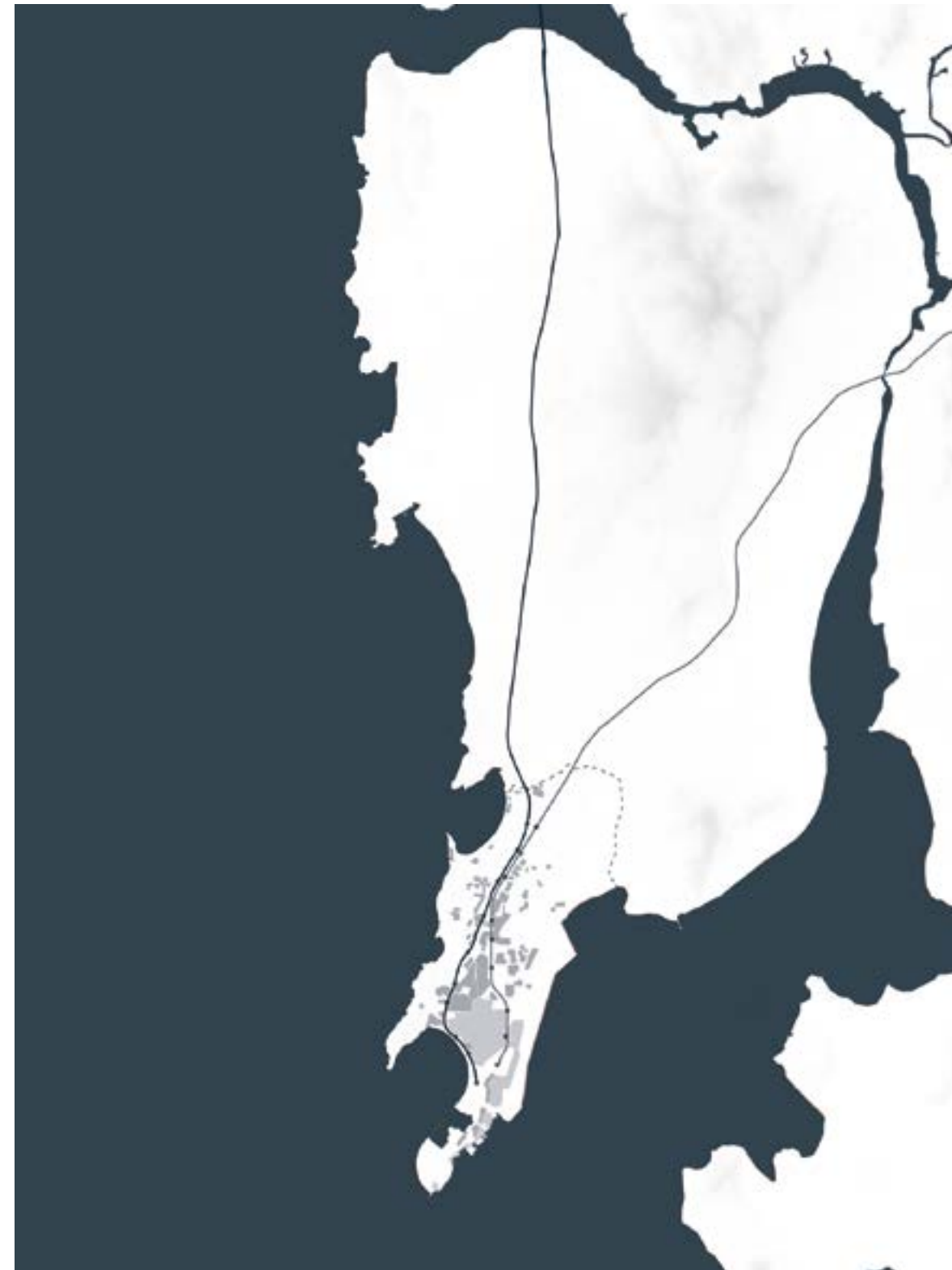
Deindustrialised due to technological advancements and outsourced its manufacturing and focussed on finance.

Morphology



Archipelago of 7 islands

Mumbai -7 islands with fishing community



Port City

British East India company had a port in Mumbai with few settlements



Development guided by Railways

With Industrialisation, textile mill began setting up and the settlement grew



Guiding the development

Eventually the urban area extended further



Why does Mumbai Flood ?

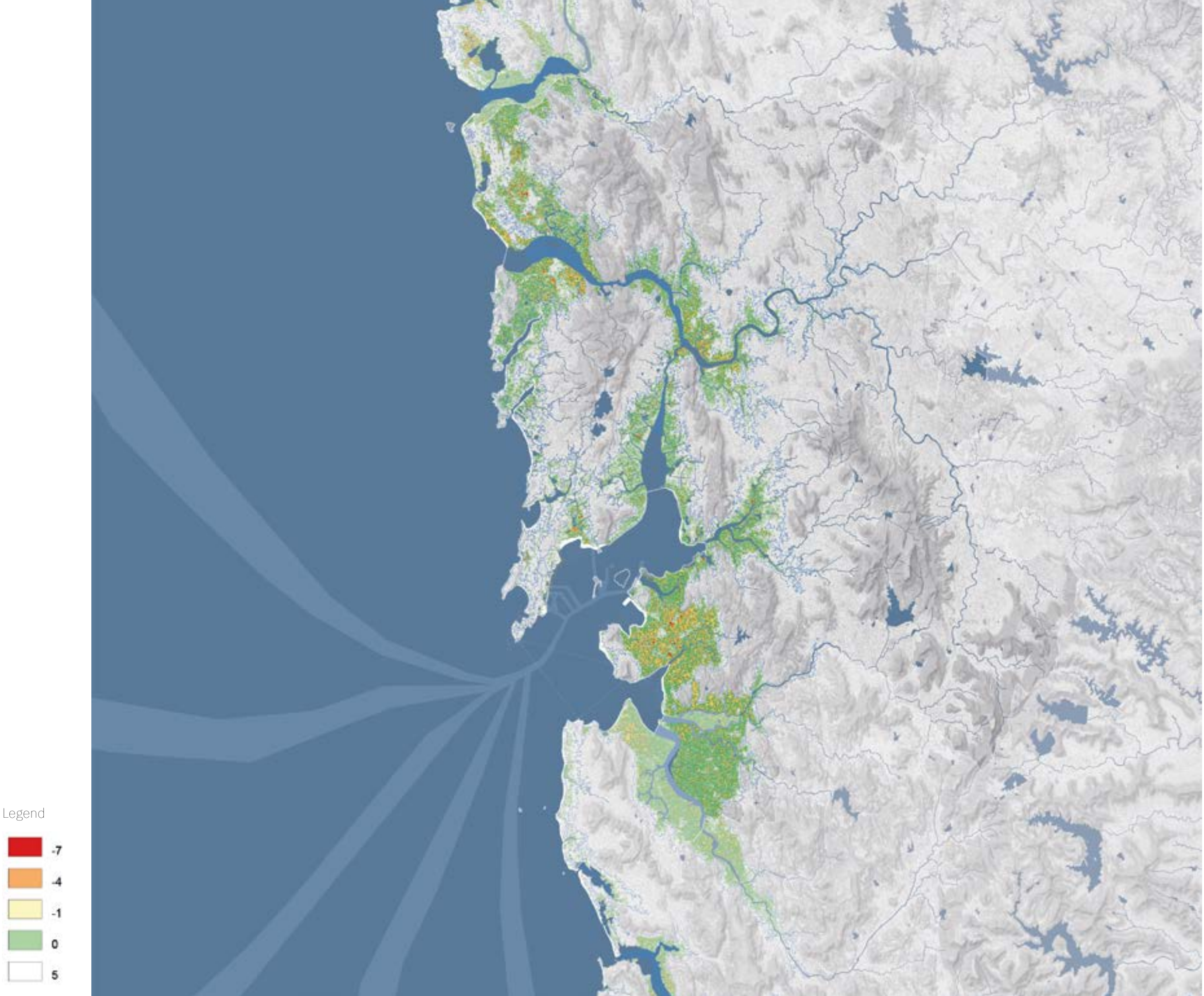
Natural Causes

Geographic sensitivity -High Precipitation Pattern



Natural Causes

Geographic sensitivity- Elevation below sea level



Elevation below sea level

Anthropogenic Causes

Focus on Global economic concentration

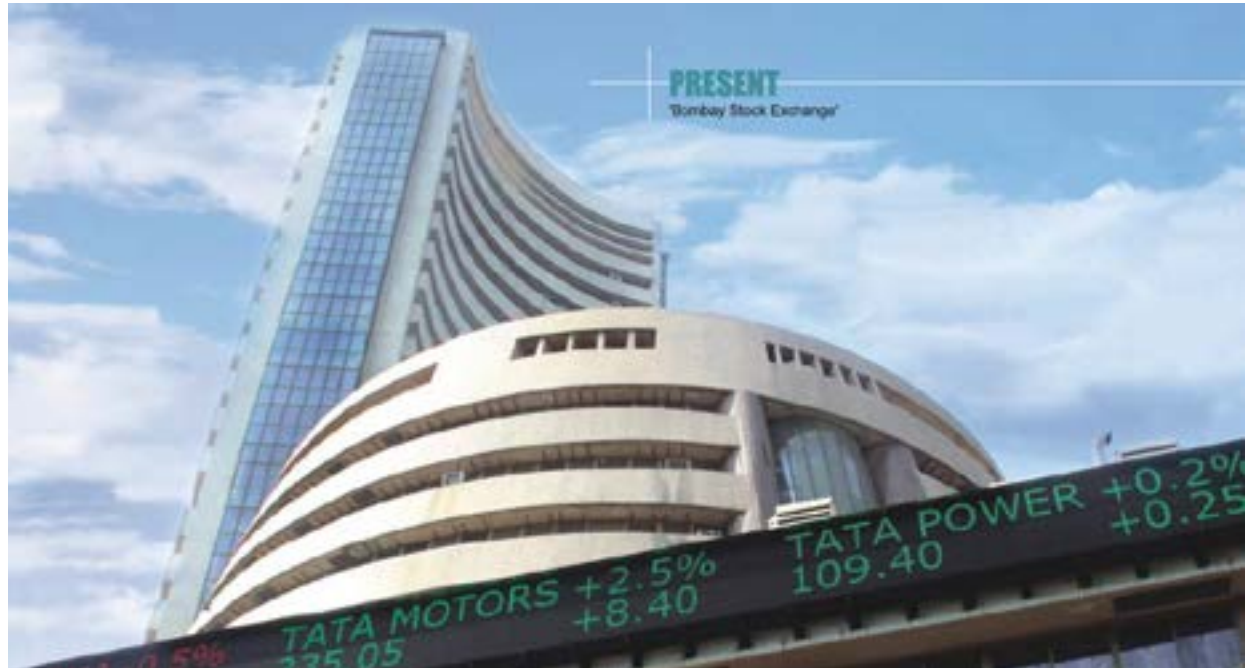


CITY OF GOLD

THE DEVELOPMENT OF BOMBAY AS THE NATION'S CENTER OF FINANCE, TRADE AND INDUSTRIAL ACTIVITY CONTINUED THROUGH THE FOLLOWING DECADES UP TO 1947 WHEN INDIA GAINED INDEPENDENCE FROM THE BRITISH RULE. SINCE THEN, BOMBAY-MUMBAI HAS CONTINUED TO EXPAND SKYWARDS IN THE FORM OF HIGH-RISE BUILDINGS, AND IN A NORTHWARD DIRECTION TO ACCOMMODATE ITS SWIFTLY GROWING POPULATION, WHICH IS ATTRACTED TO THE 'CITY OF GOLD' IN LARGE NUMBERS BY THE PROSPECTS OF ENTERPRISE AND EMPLOYMENT. THIS VAST AREA IS NOW KNOWN AS BRIHANMUMBAI METROPOLITAN REGION.

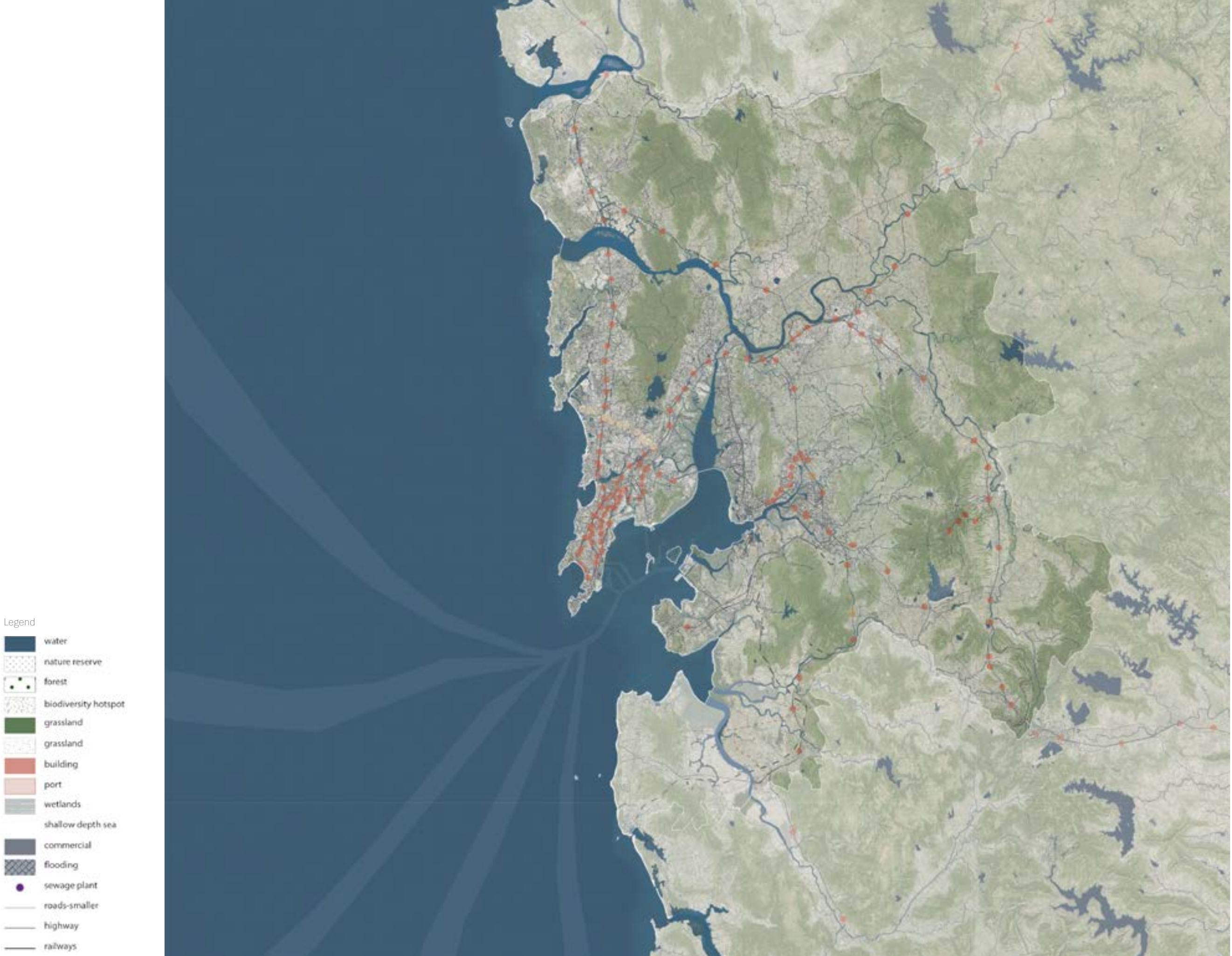


Development focussed on socio- economic system



Anthropogenic Causes

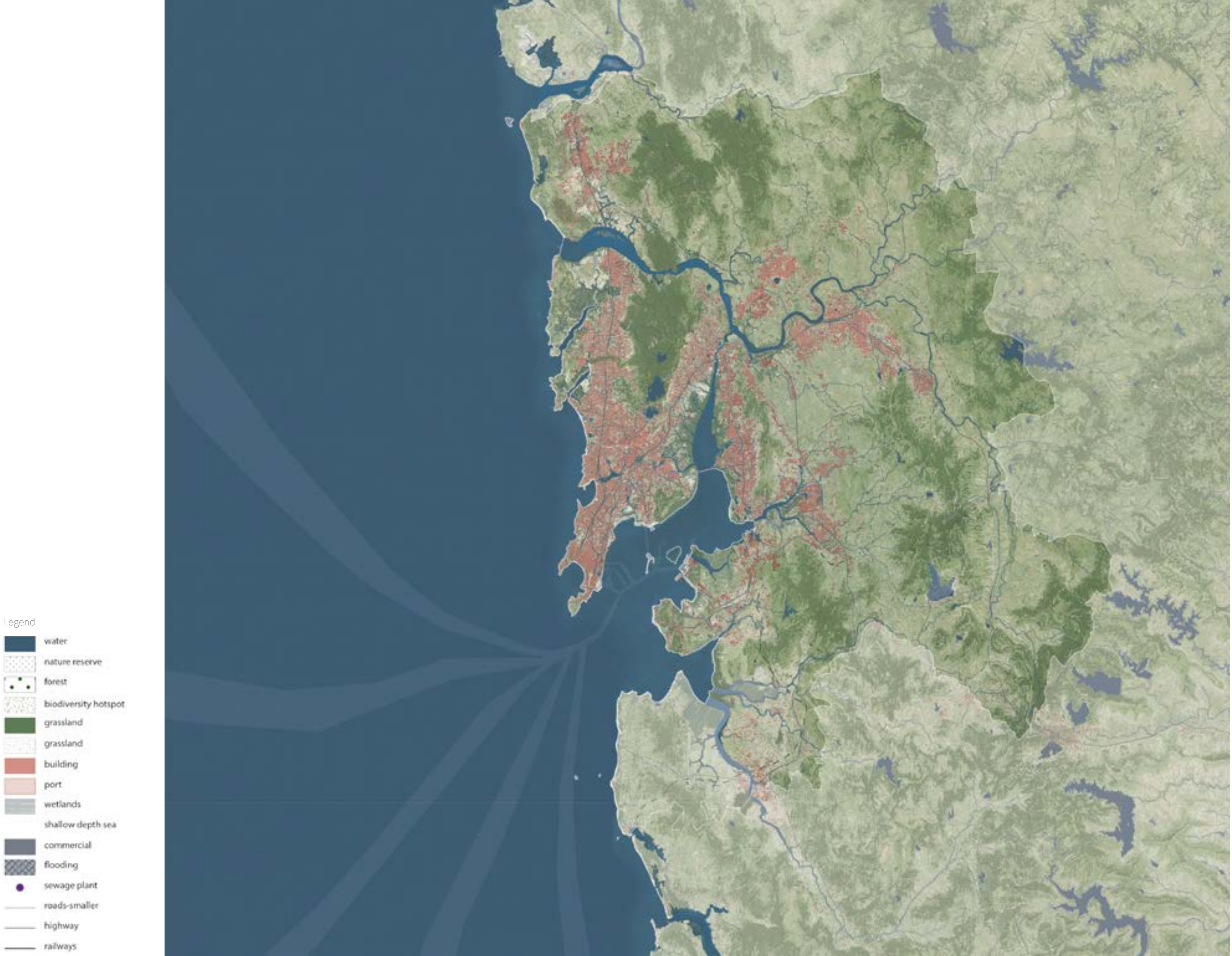
Infrastructure serving the global economic concentration



Development focussed on socio- economic system

Anthropogenic Causes

Urban development oriented towards infrastructure



Development focussed on socio- economic system

Anthropogenic Causes

Neglecting the ecological system



Encroaching Mangroves.

Image of development in Mangroves under Coastal regulation Zone

Mumbai's ecologically important salt pans may soon be opened up for real estate

By [Nikhil S Dixit](#) • October 16, 2019



Encroaching Saltpans.

act as natural barriers to prevent flooding in Mumbai, salt pans hold the seawater from entering the city and stop flooding. Hosts several species of birds and different types of insects

Anthropogenic Causes

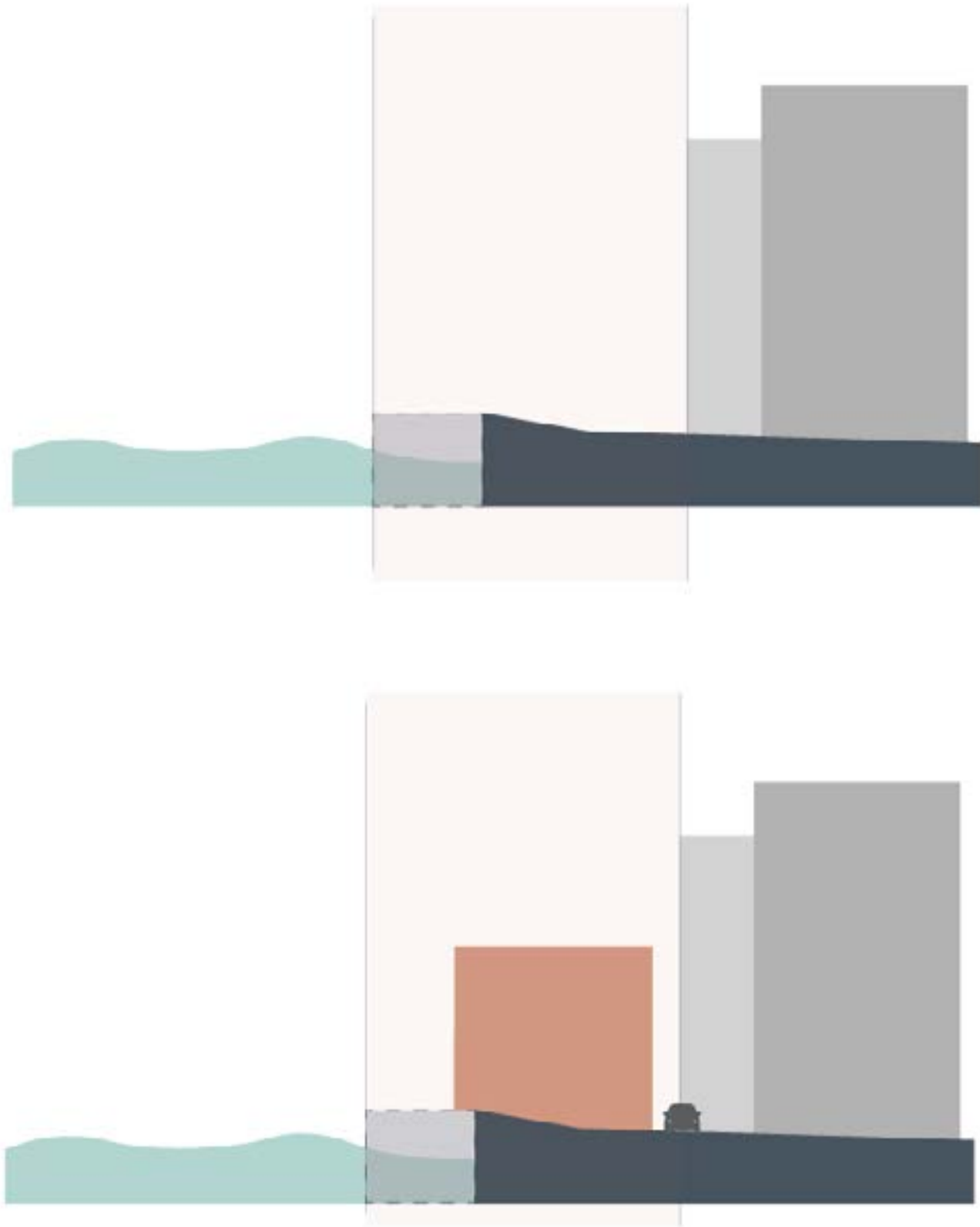
Conflict of space with Ecology & society

The government has introduced amendments to allow special economic zones (SEZs) to be set up in CRZ I areas.

Rampant pollution of the coast has forced Koli fishers to travel up to 10 nautical miles off the coast, where they face competition from trawlers and seiners.

In Cuffe Parade in South Mumbai, elite residential projects have expanded into fishing spaces of Koli settlements.

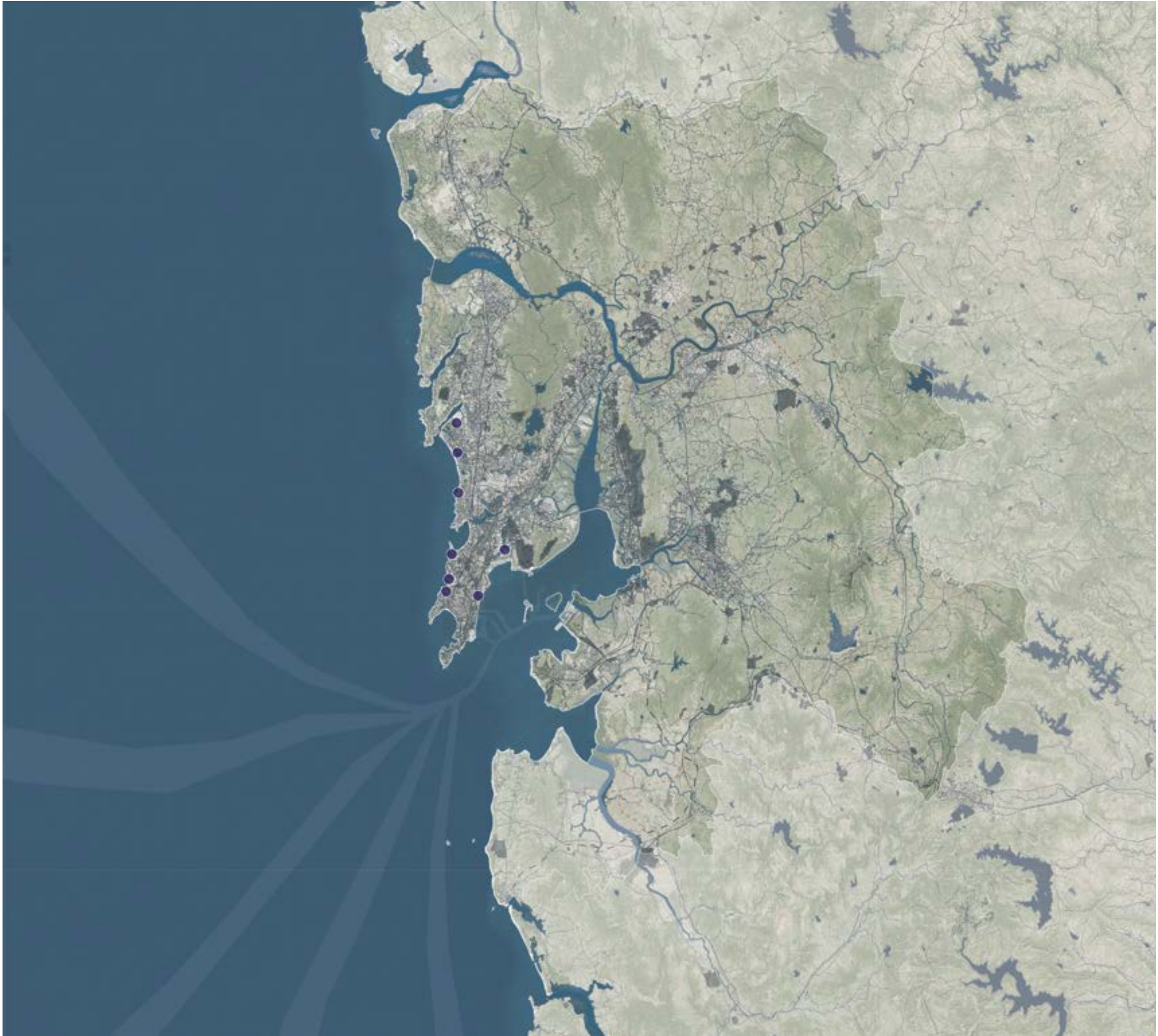
Kolis are then denied access to fishing activities on grounds of "sanitation" and "aesthetics."



Coastal Regulations

Coastal regulation zones being changed to allow SEZ developments for economic benefits and affecting the fishing communities

Anthropogenic Causes Storwater drainage network



Legend
● pumping stations
— railway lines
— roads with drains

14 years on, drainage system still unfinished

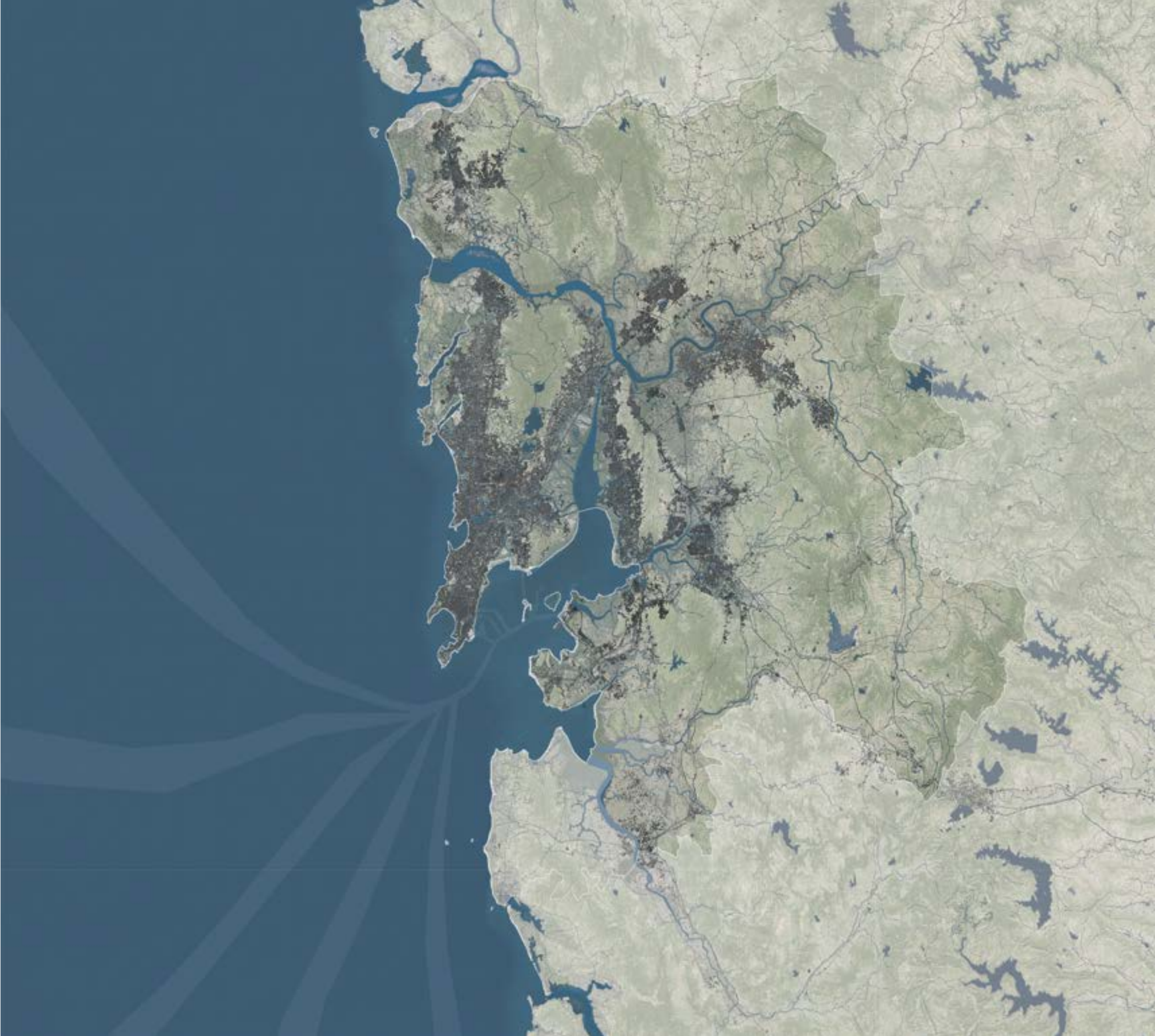
Experts from the Mumbai Vikas Samiti, a group of retired engineers and experts say that the Brihanmumbai Municipal Corporation (BMC) must finish the project on a war footing to prevent the city from coming to a standstill annually.

MUMBAI Updated: Jul 03, 2019 07:14 IST

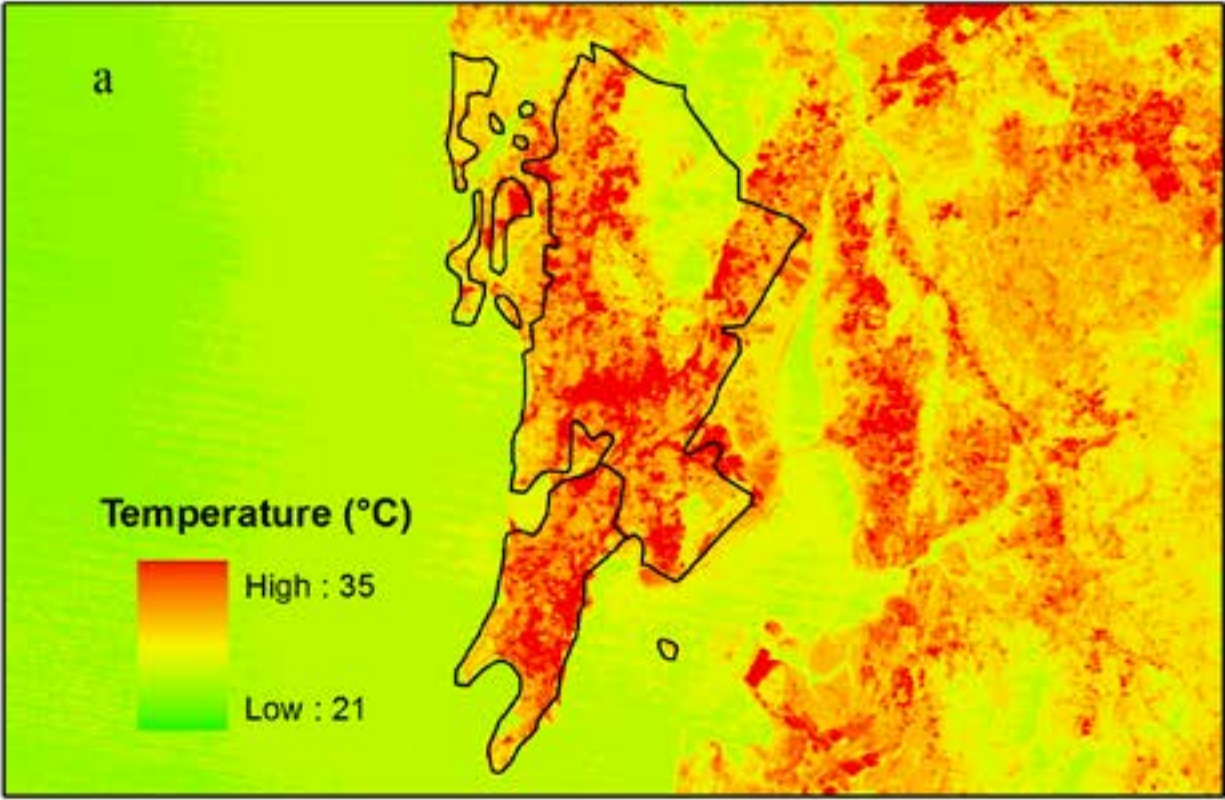
Incapacitative human-made infrastructure -
Short - term planning

Anthropogenic Causes

Impervious Urban built environment

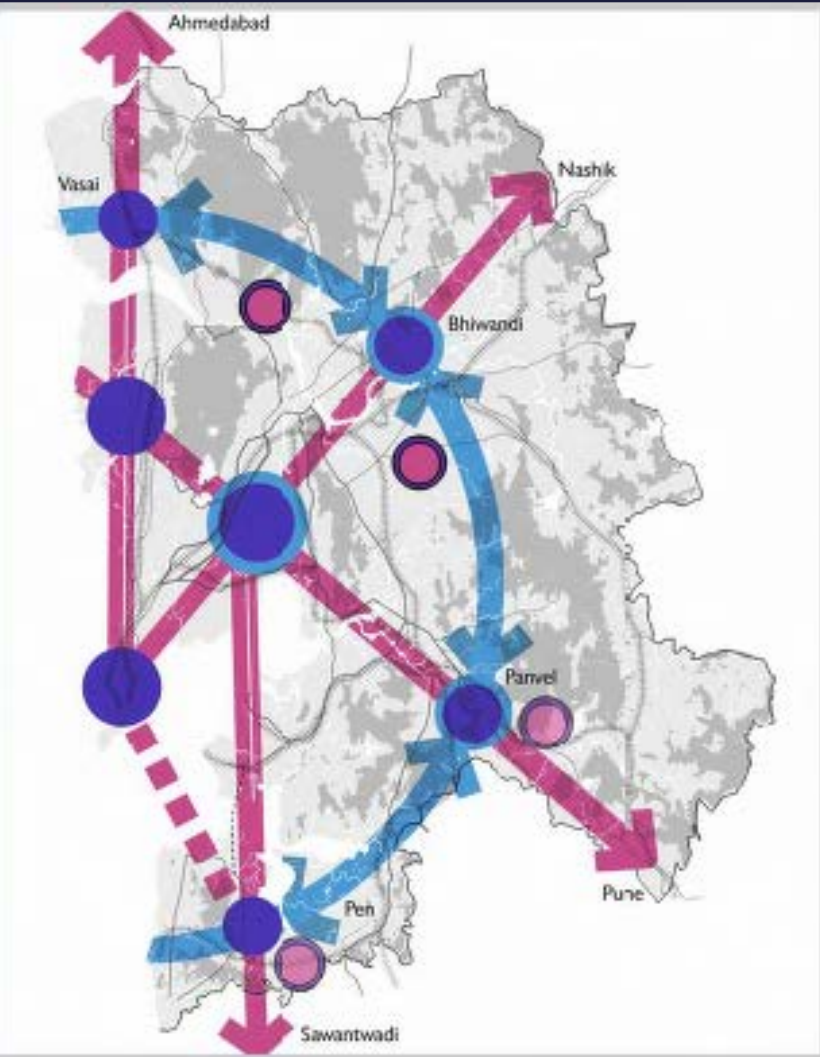


Imperviousness of the socio-economic system




Anthropogenic Causes

Regional Planning framework



**Draft
Mumbai
Metropolitan
Regional
Plan
2016-2036**

September, 2016



Find

Previous Next

- 1/3 ● Very few cities in MMR have a comprehensive storm water network. Master planning of storm water systems is imperative given the high monsoon incidence in MMR and large parts of the cities routinely experiencing **flooding** during the monsoons.
- 2/3 ● c) Dumping of construction and demolition waste in coastal areas and rivers are a threat to coastal wetlands including mangroves and mudflats also leading to **flooding**. Solid waste management sites on coastal wetland areas that lack scientific management also contribute to pollution of creeks. These are a further threat to marine life.
- 3/3 ● **5.10 Environment**

The environmental resources of the region provide an opportunity to work as a sink to help mitigate **flooding** risks and increase the region's resilience towards climate change effects like water scarcity or sea level rise. The environmental resources in MMR are currently overstressed due to pressure from urbanization. A series of strategies are envisaged with a view to conserve existing resources, create a much needed open space network in the metropolitan area and create an integrated green and blue web across the region; promote infrastructure systems like public transport that will actively mitigate environmental pollution and help transform and augment existing natural systems. They include projects, zoning, DCRs and policy interventions.

Find (1/1)

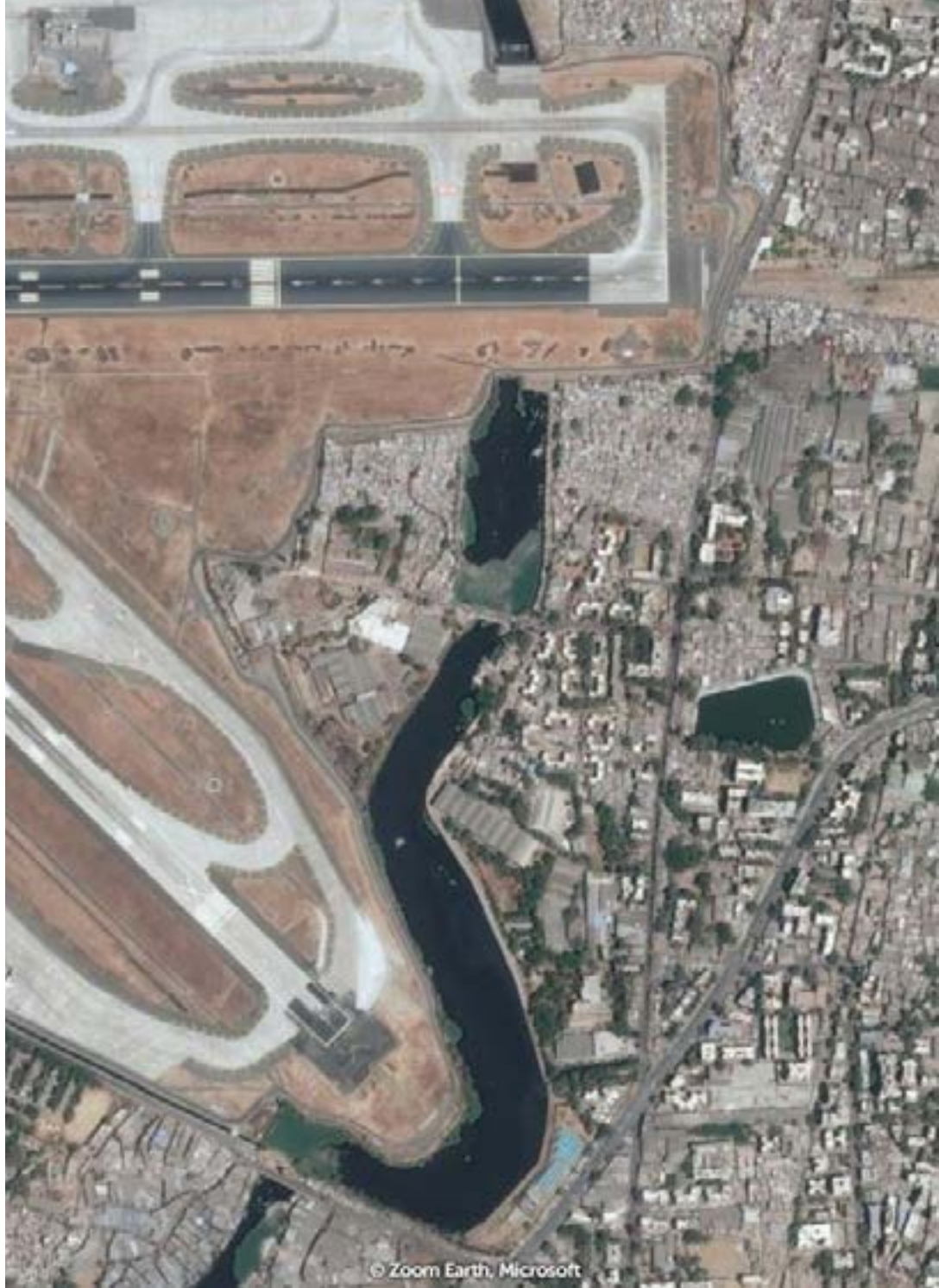
Previous Next

- 1/1 ● **5.10 Environment**
- The environmental resources of the region provide an opportunity to work as a sink to help mitigate flooding risks and increase the region's resilience towards **climate change** effects like water scarcity or sea level rise. The environmental resources in MMR are currently overstressed due to pressure from urbanization. A series of strategies are envisaged with a view to conserve existing resources,

Inconsideration of climate change impact
Lack of planning framework

Anthropogenic Causes Development Pattern

Airport runway extension



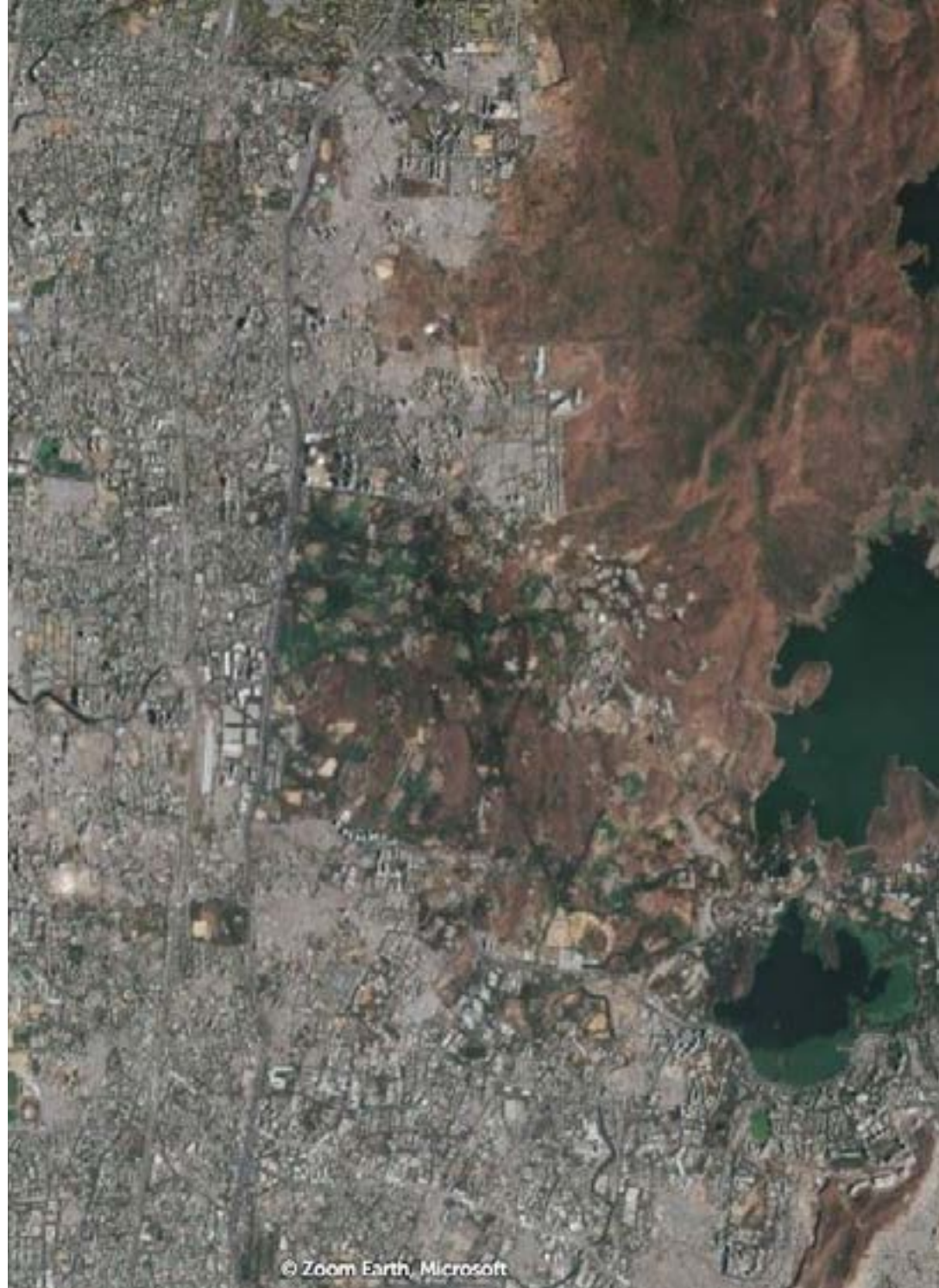
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BKC Complex reclamation



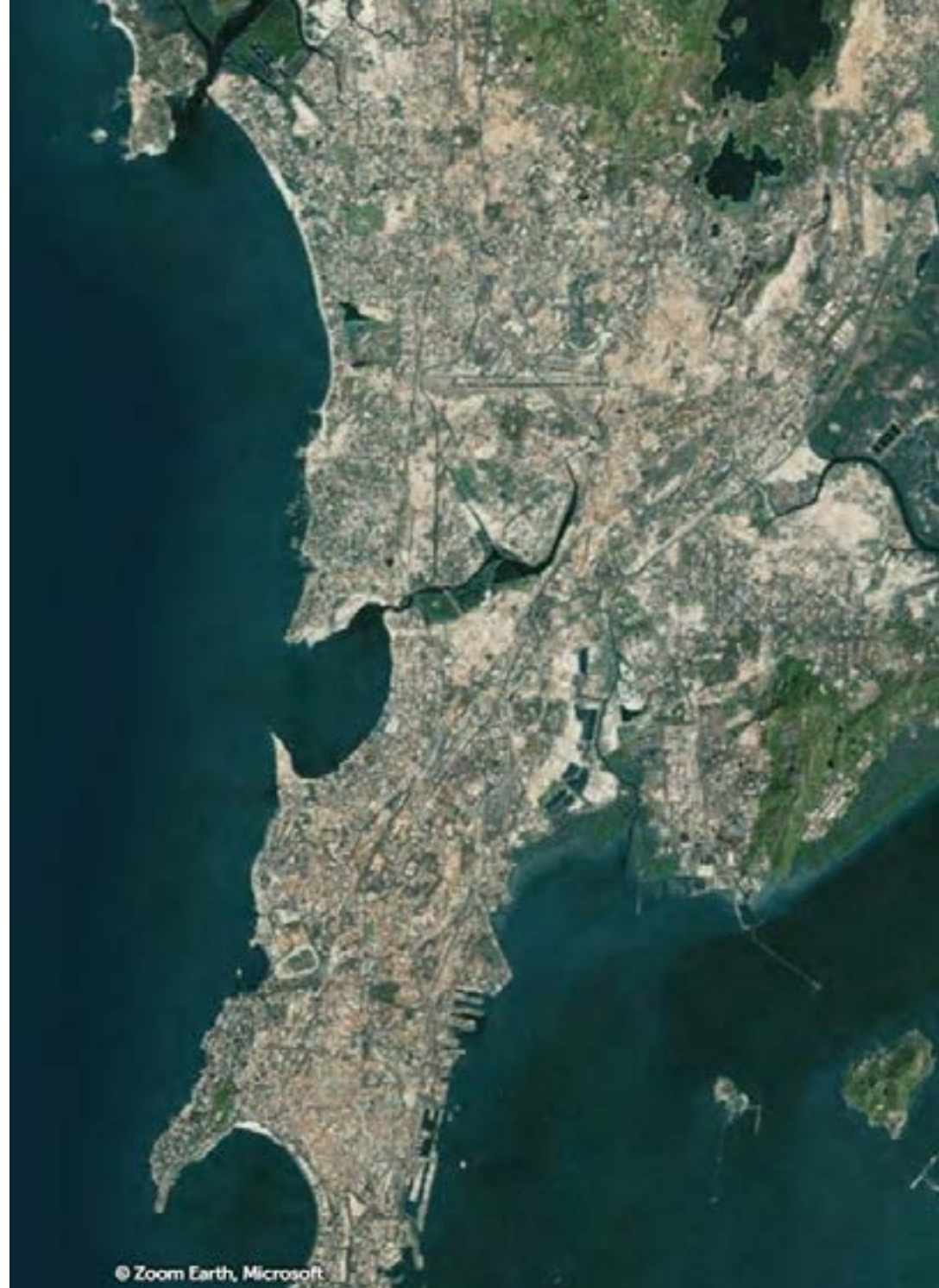
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Aarey colony- metrocar shed



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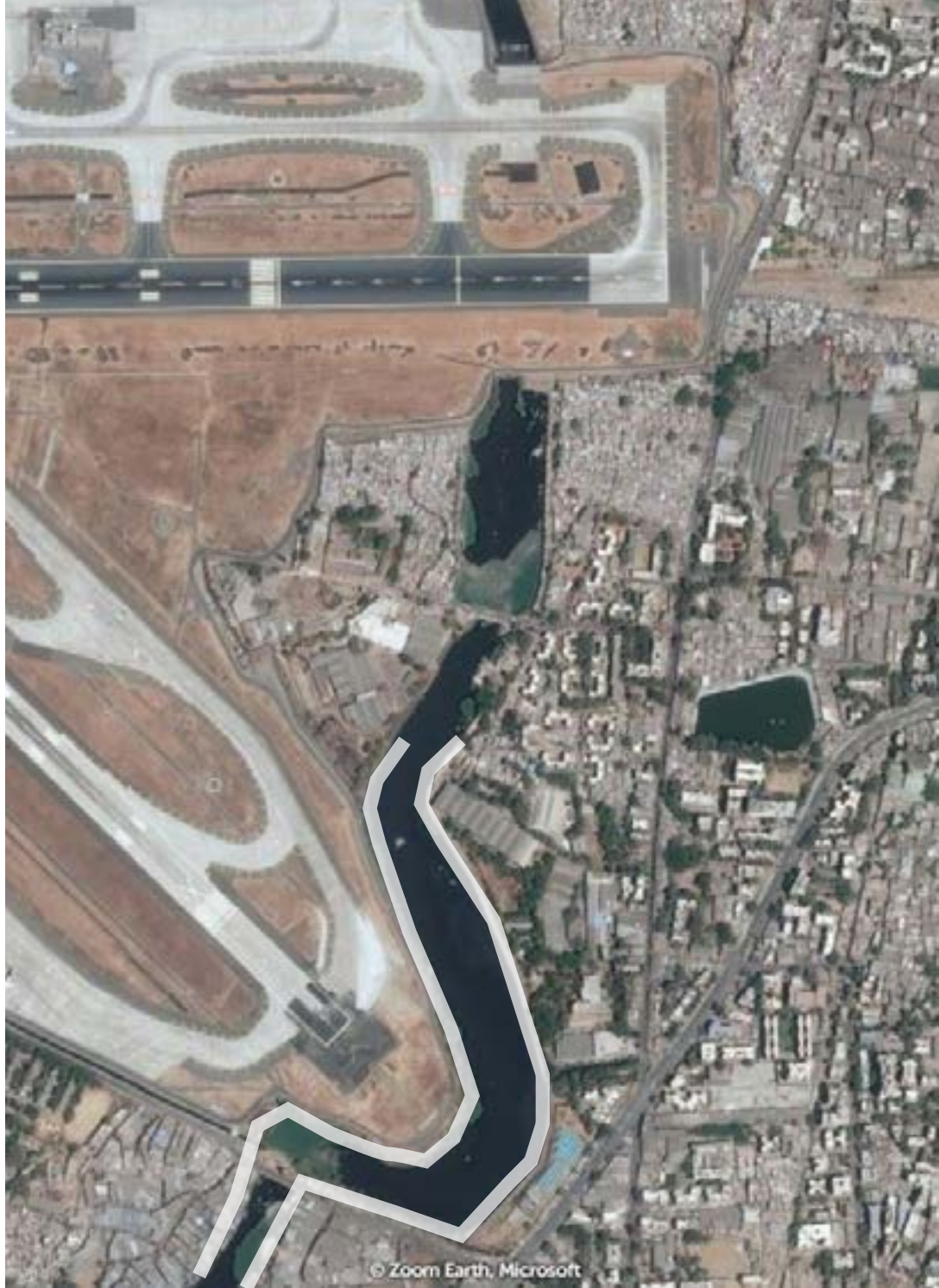
Coastal road project



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Anthropogenic Causes Development Pattern

Airport runway extension



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BKC Complex reclamation



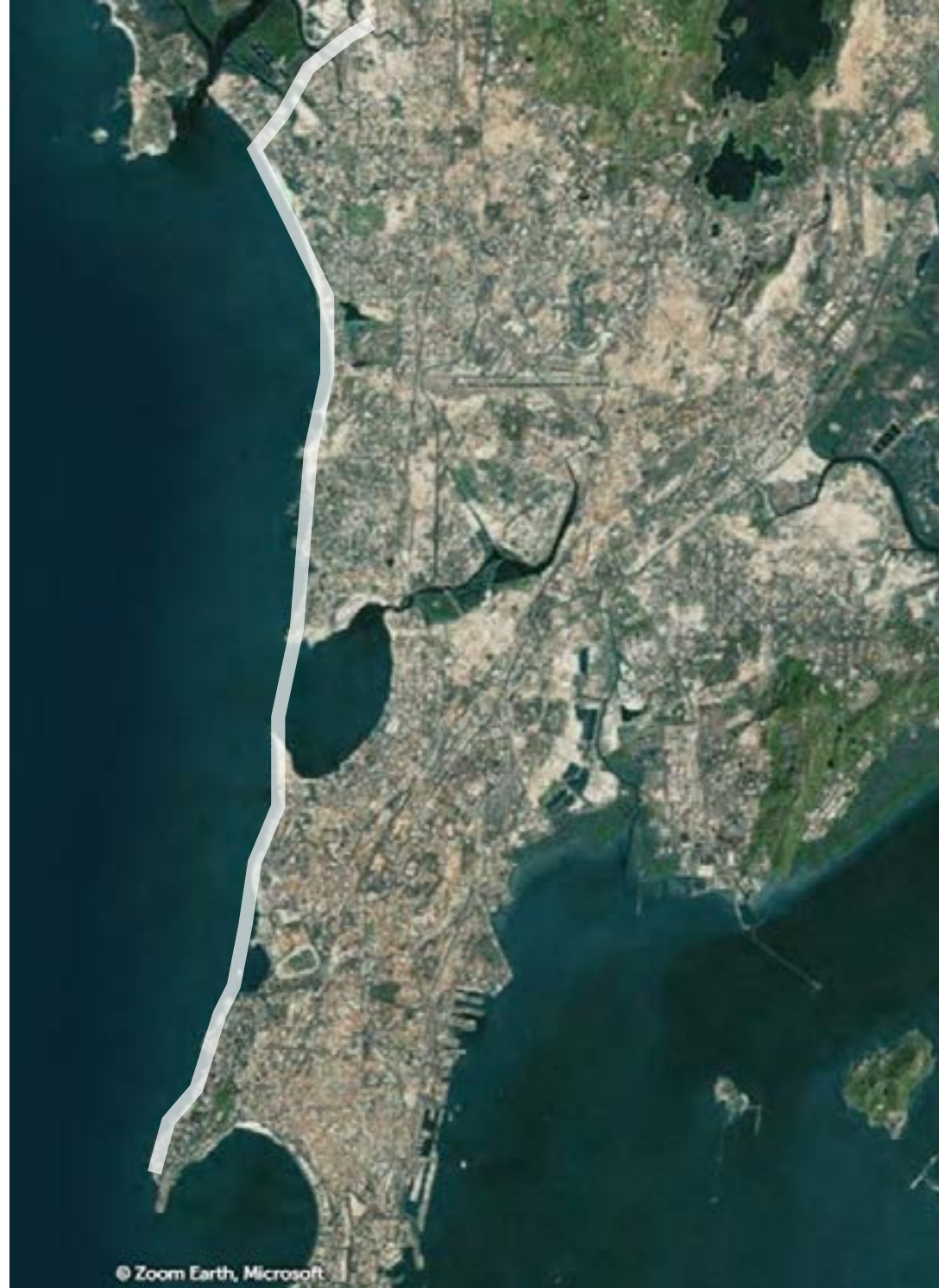
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Aarey colony- metrocar shed



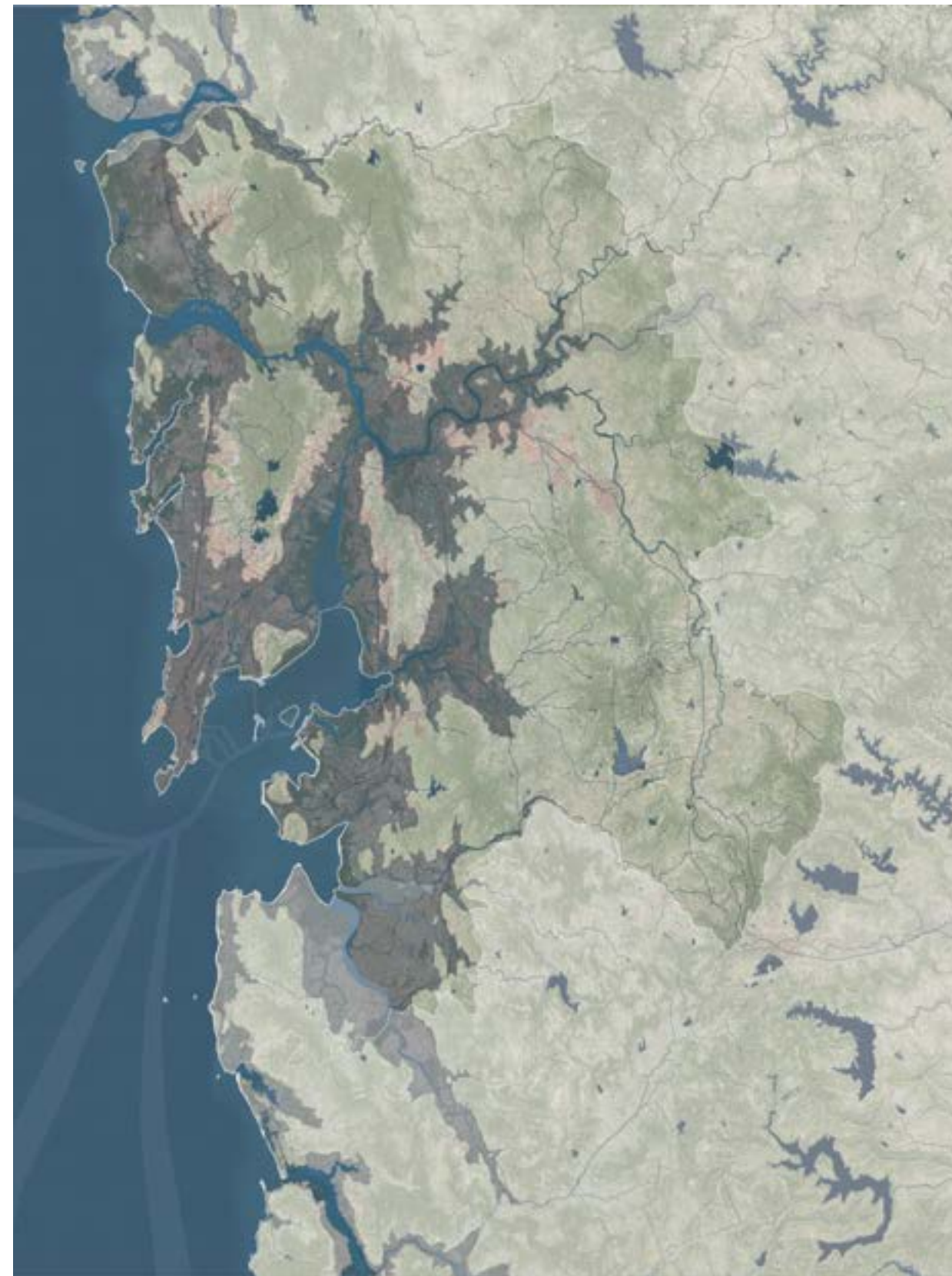
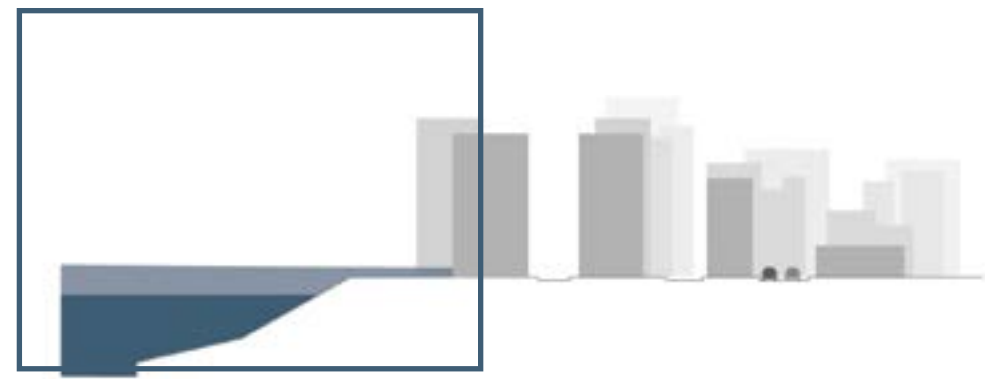
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Coastal road project



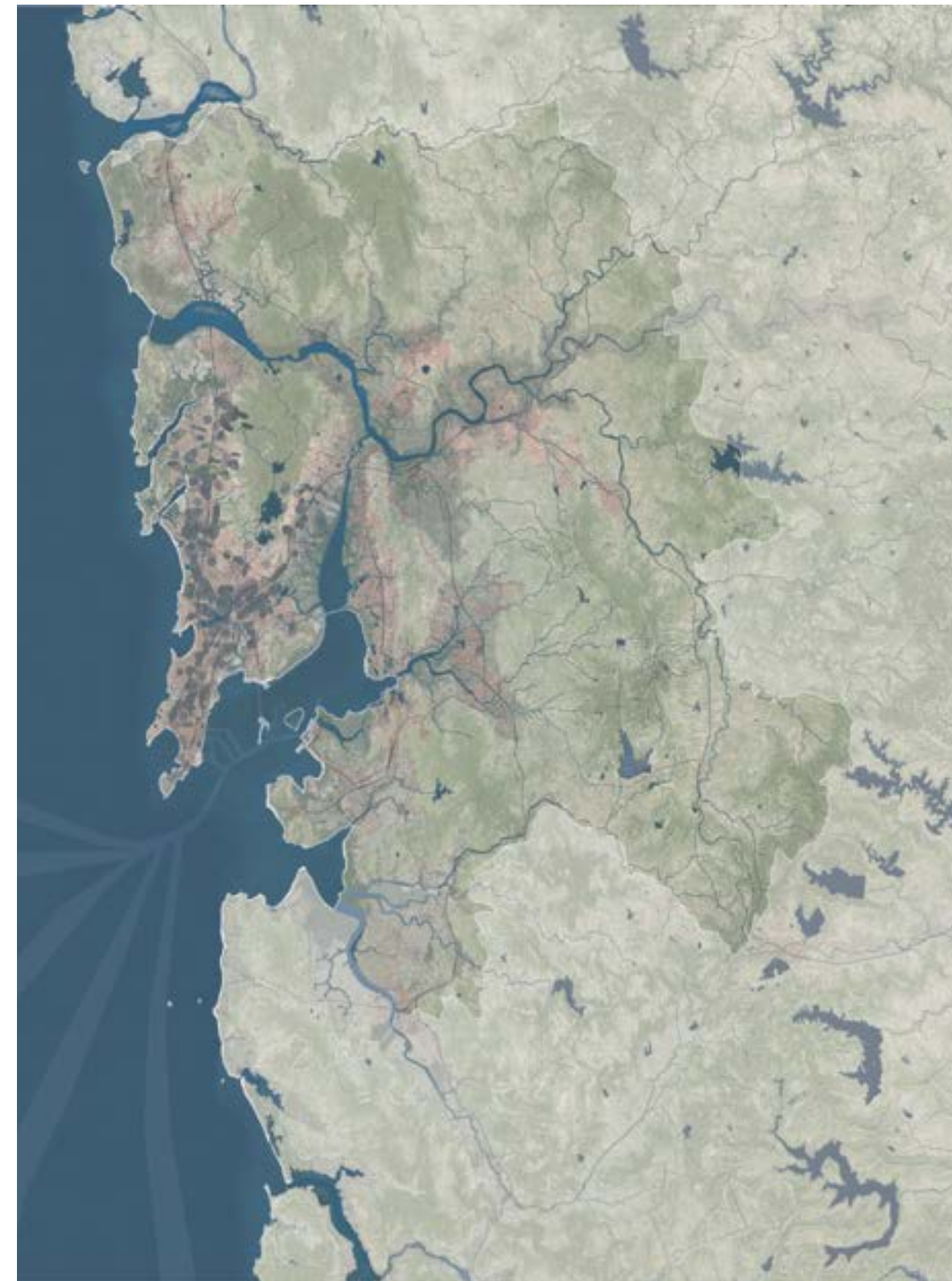
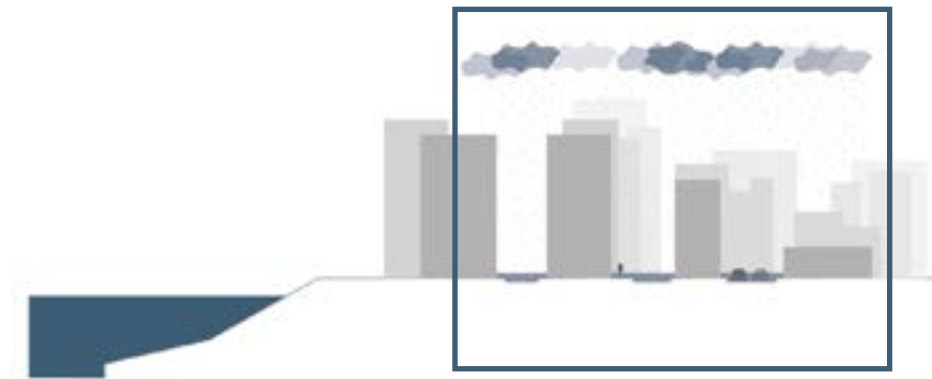
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Flooding



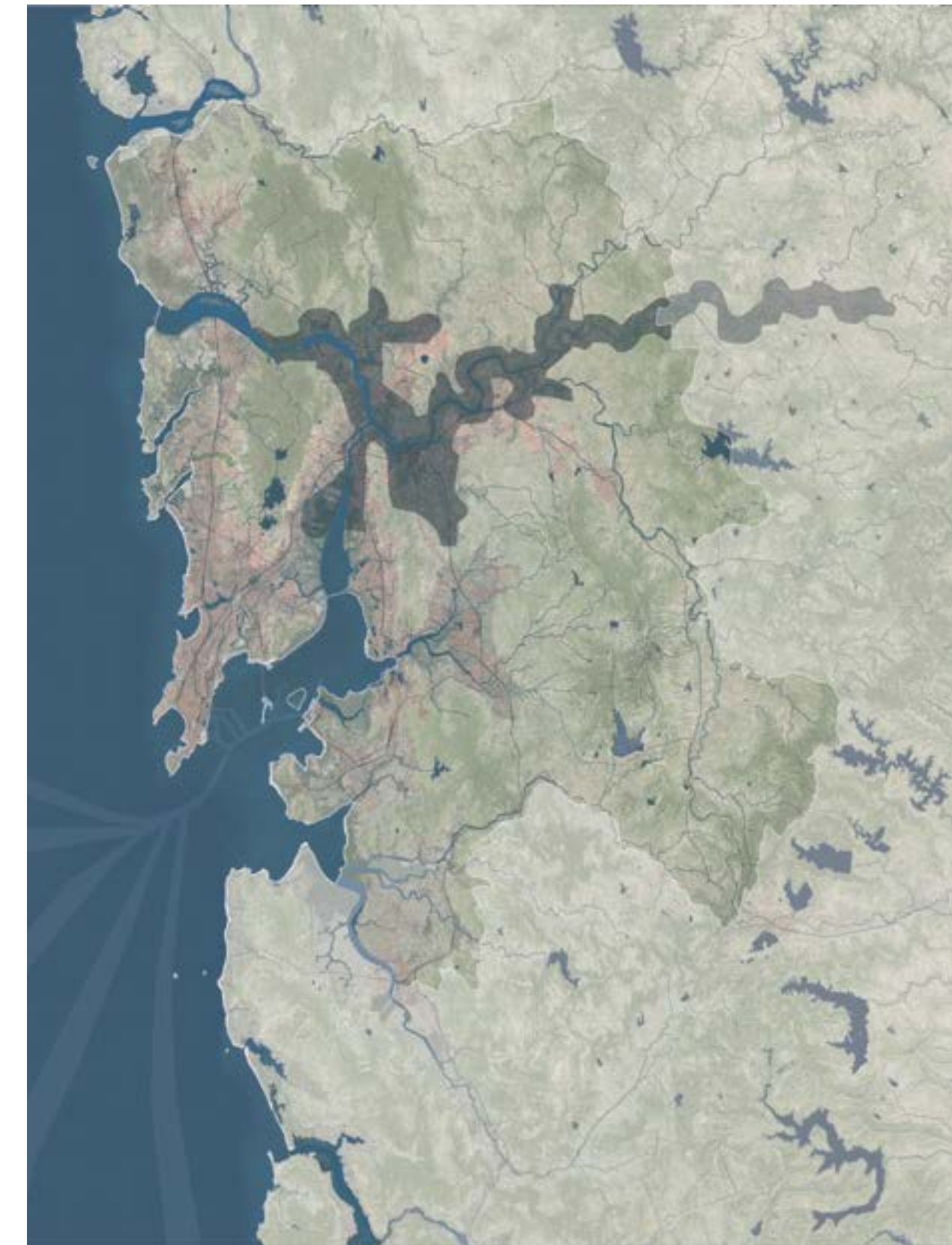
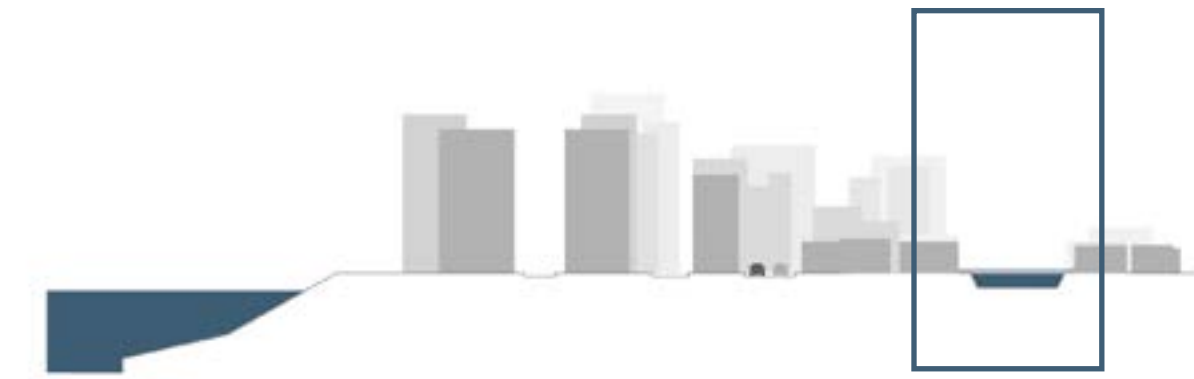
Coastal Flooding

Long coastline of 840km



Pluvial Flooding

excessive rainfall* (based on 2005 map)



Fluvial Flooding

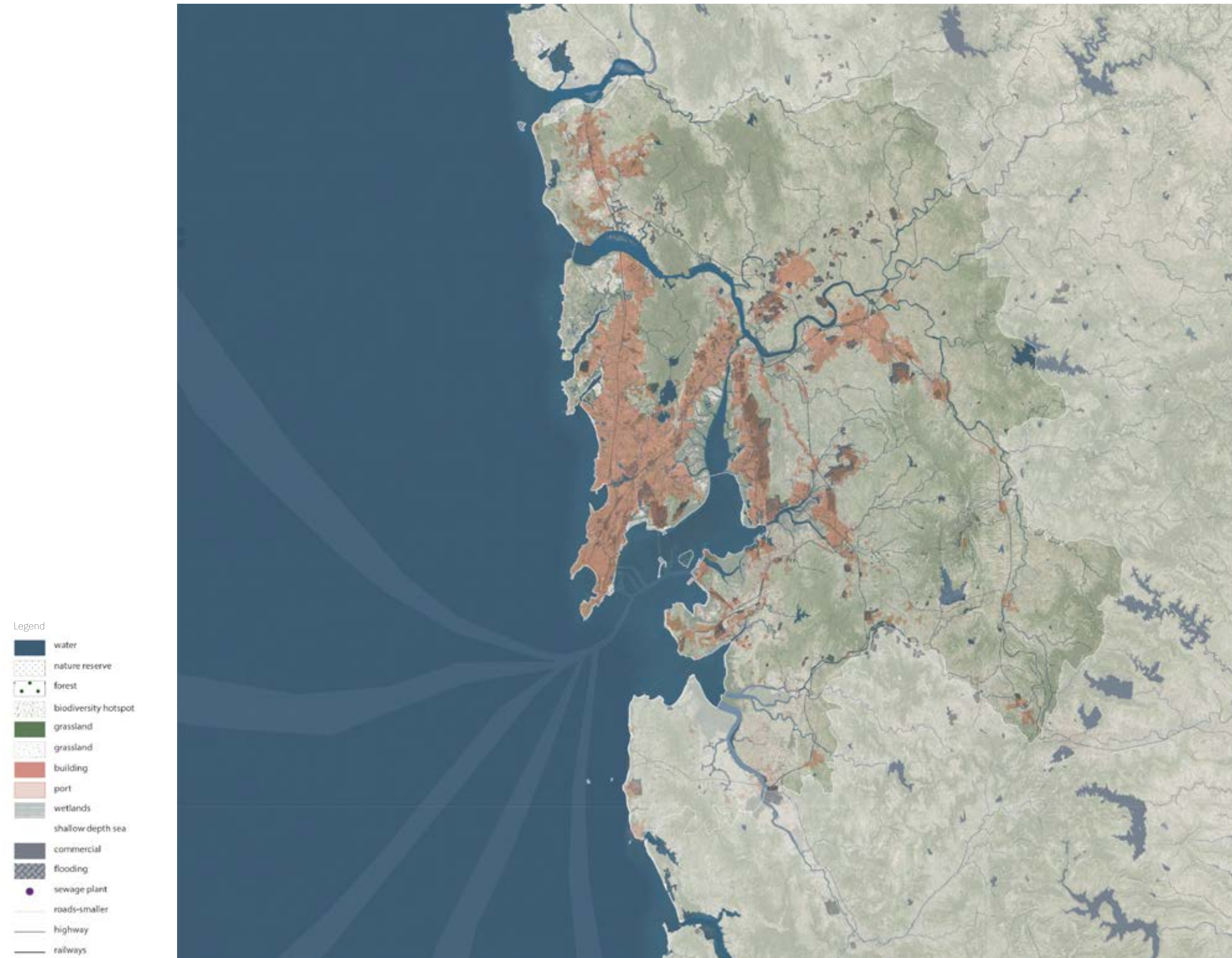
Flooding due to changing weather patterns

Socio-economic structure



Socio-economic context

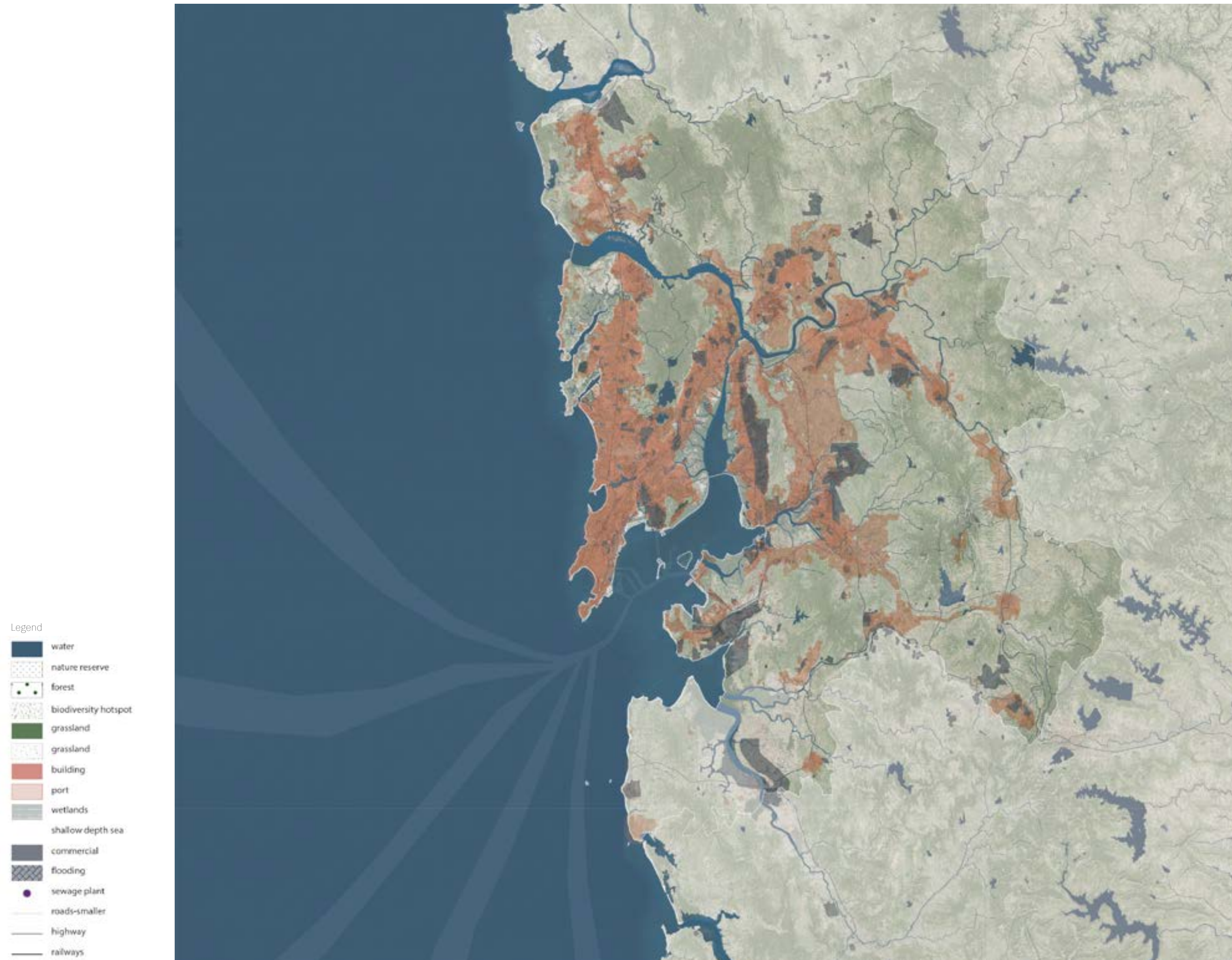
Urban development



existing built area

Socio-economic context

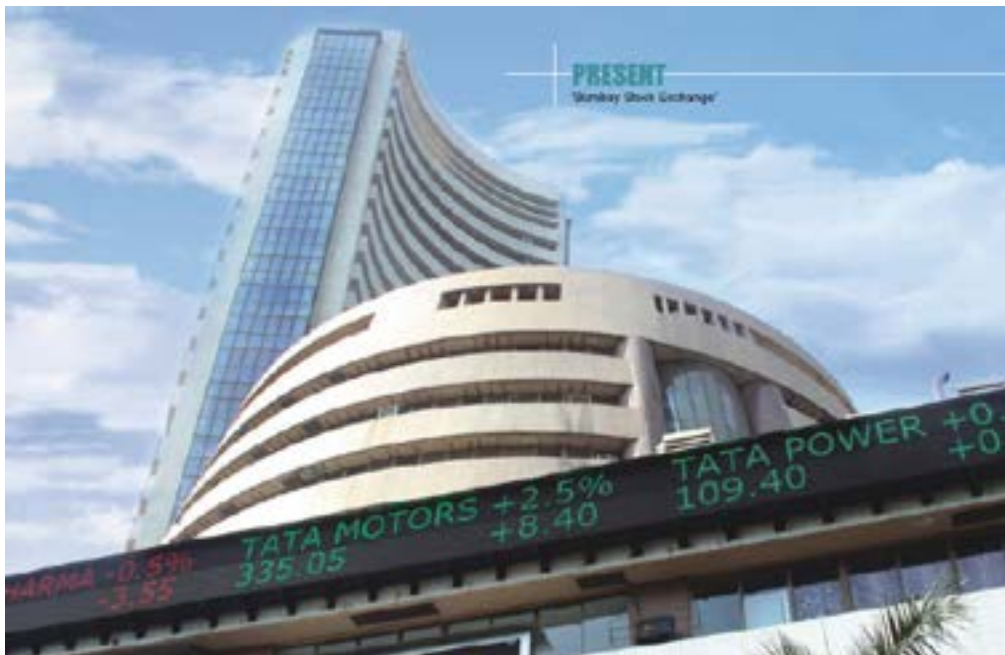
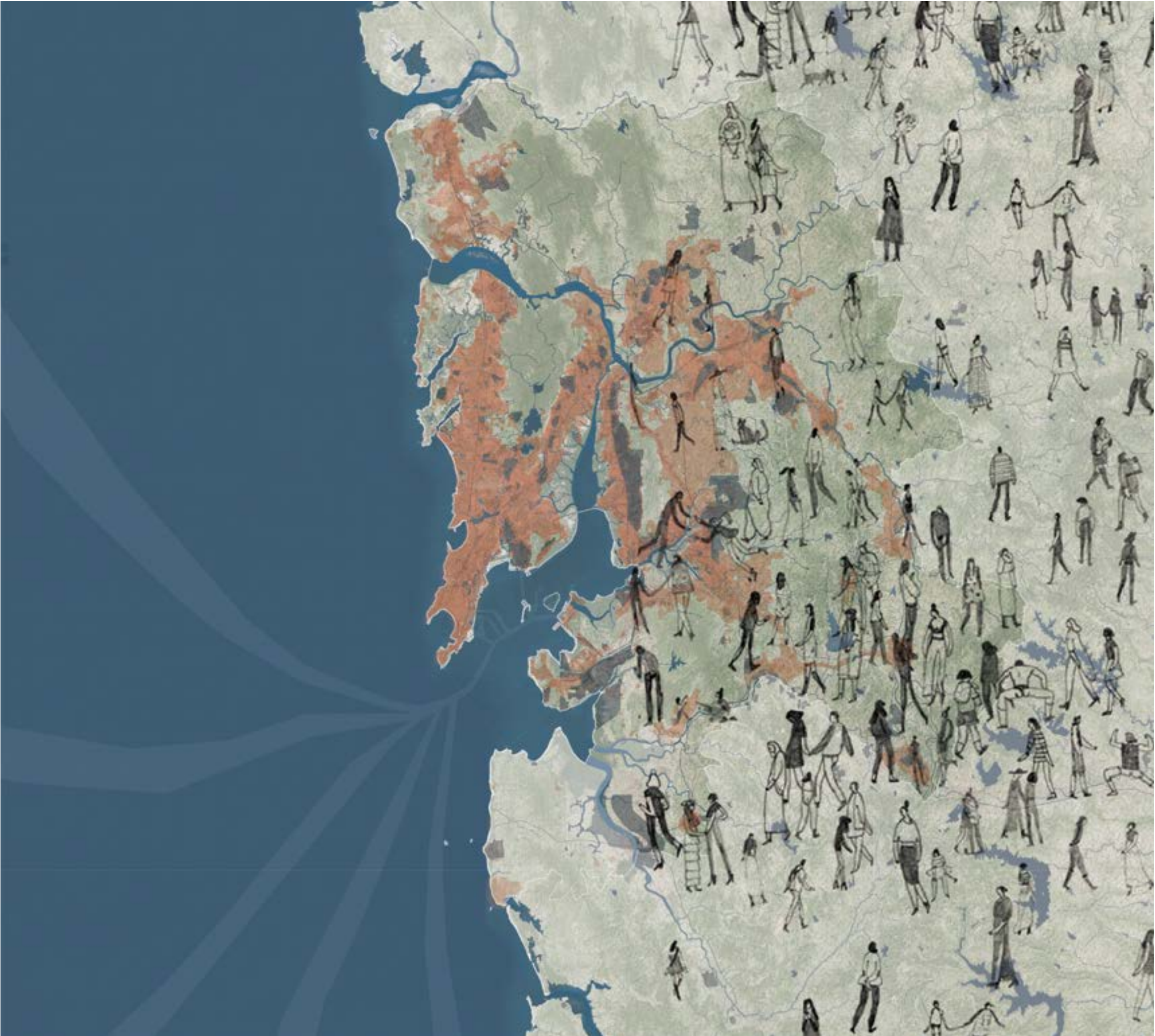
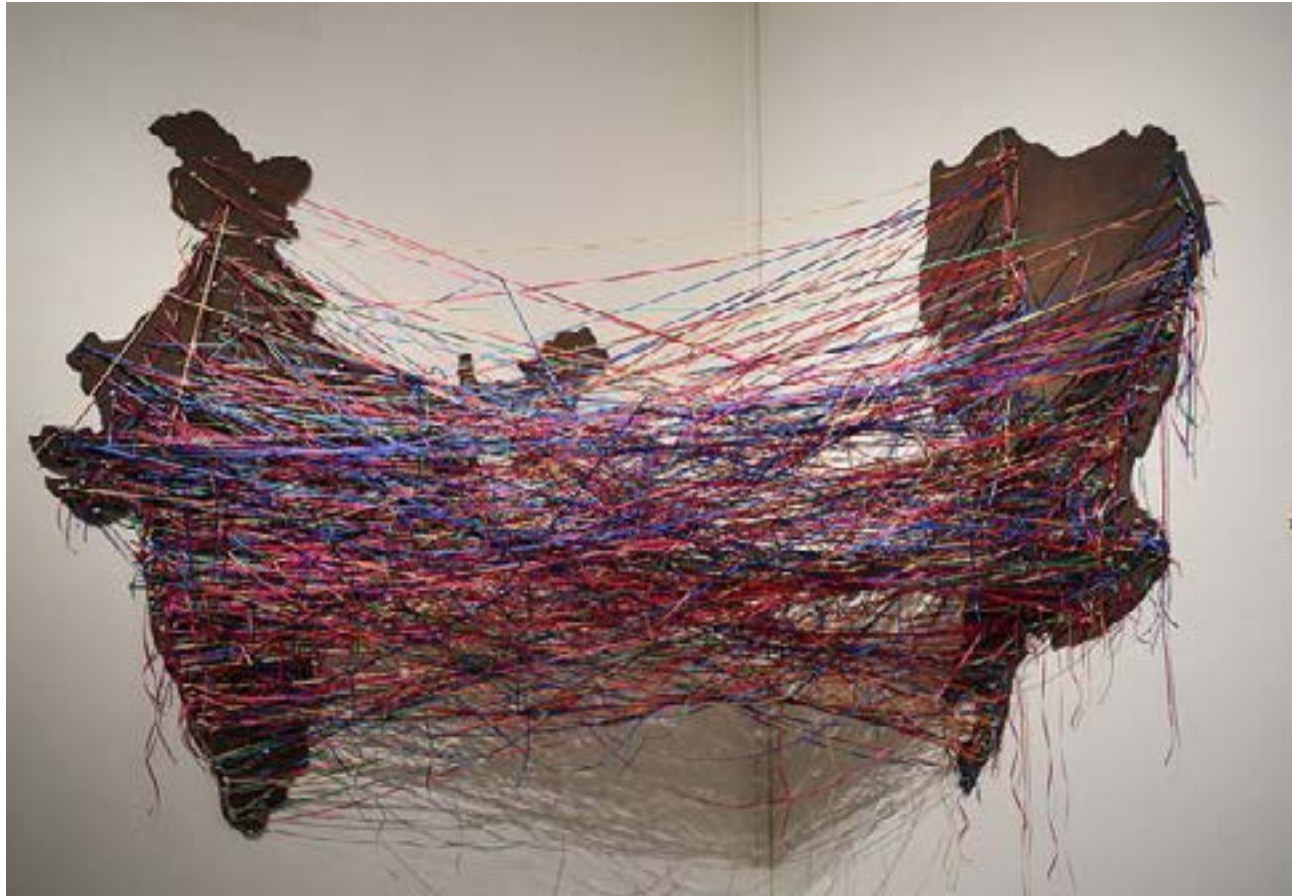
Proposed plan for future growth



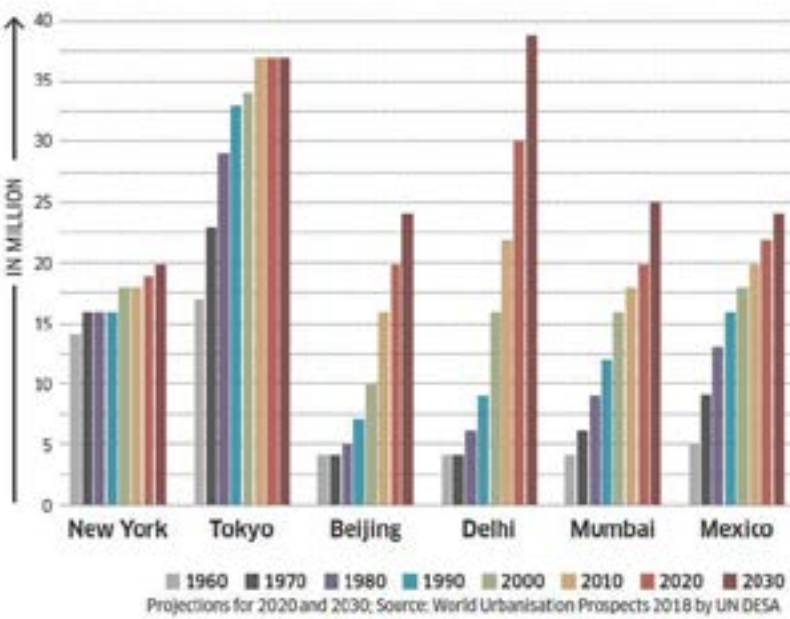
Increase in Urbanisation

Socio-economic context

Projected increase in urban population

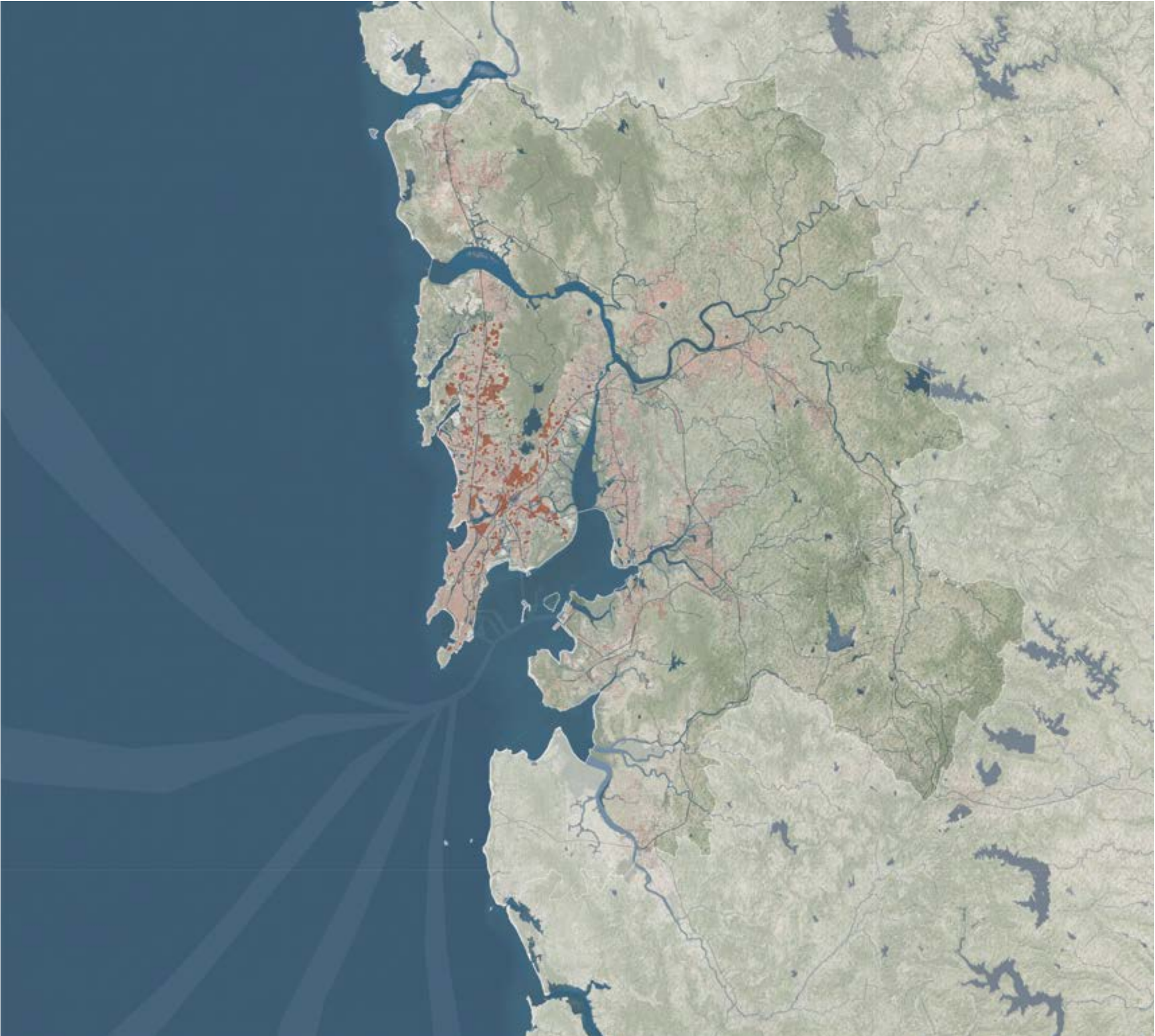


POPULATION GROWTH IN MAJOR GLOBAL CITIES



Socio-economic vulnerability

55% of the population in Mumbai are in Slums



Large proportion of this population is involved in informal economy



An aerial photograph of a residential complex featuring several interconnected, multi-story apartment buildings with a complex, stepped facade. The buildings are arranged around a central courtyard area filled with lush green trees and a paved walkway. The overall scene is captured from a high-angle perspective, showing the intricate layout of the architecture and the surrounding urban environment.

Research Aim & questions

Hypothesis

Infrastructure - Paradigm Shift



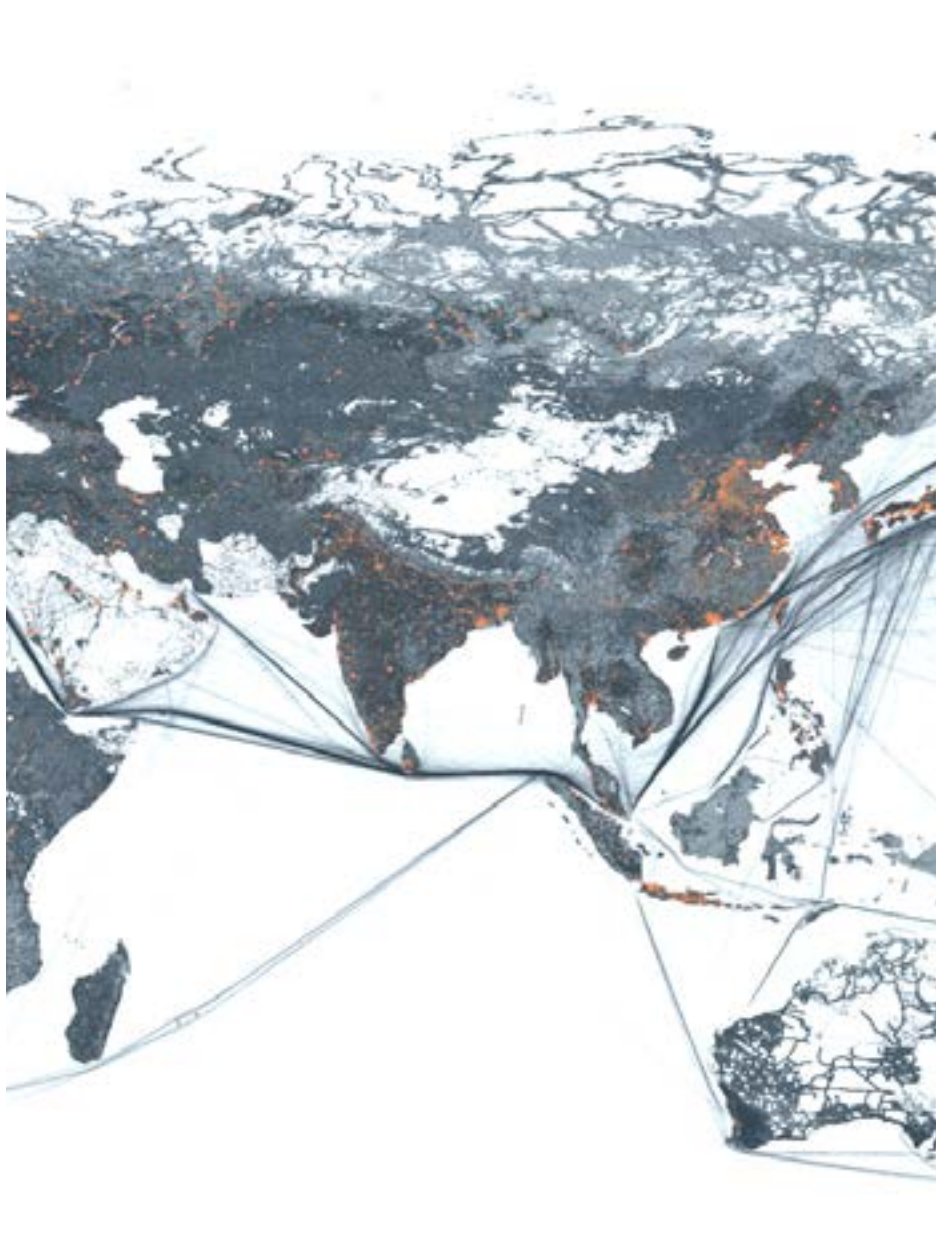
Water Infrastructure



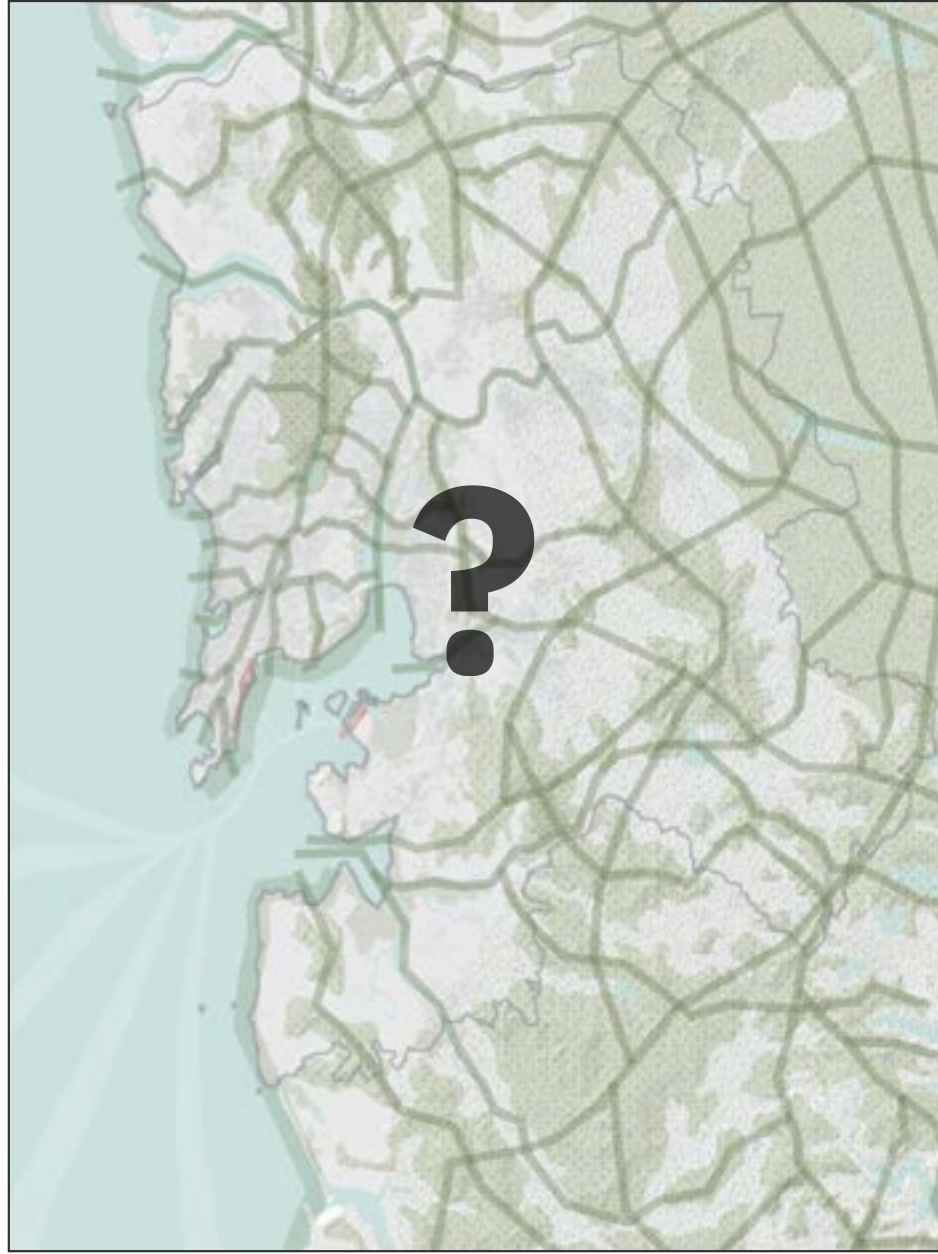
Port & Water infrastructure



Railway Infrastructure



TechnologicalInfrastructure



Ecological Infrastructure

Continuation of trajectory of development oriented around infrastructure with a shift of focus on ecological infrastructure and re-establishing the connection with ecology where society becomes a part of the nature rather than a separate entity.

| Research Question

To what extent could an alternate regional design and planning framework in Mumbai metropolitan region through **ecological infrastructure** provide a **climate resilient region** against **flooding**?

To what extent could an alternate regional design and planning framework in Mumbai metropolitan region through **ecological infrastructure** provide a **climate resilient region** against **flooding**?

| Sub- Research Questions

ecological infrastructure

- What are the current ecological infrastructures present in Mumbai Metropolitan Region that responds against flooding?
- What are the current ecological and social vulnerabilities in the MMR?

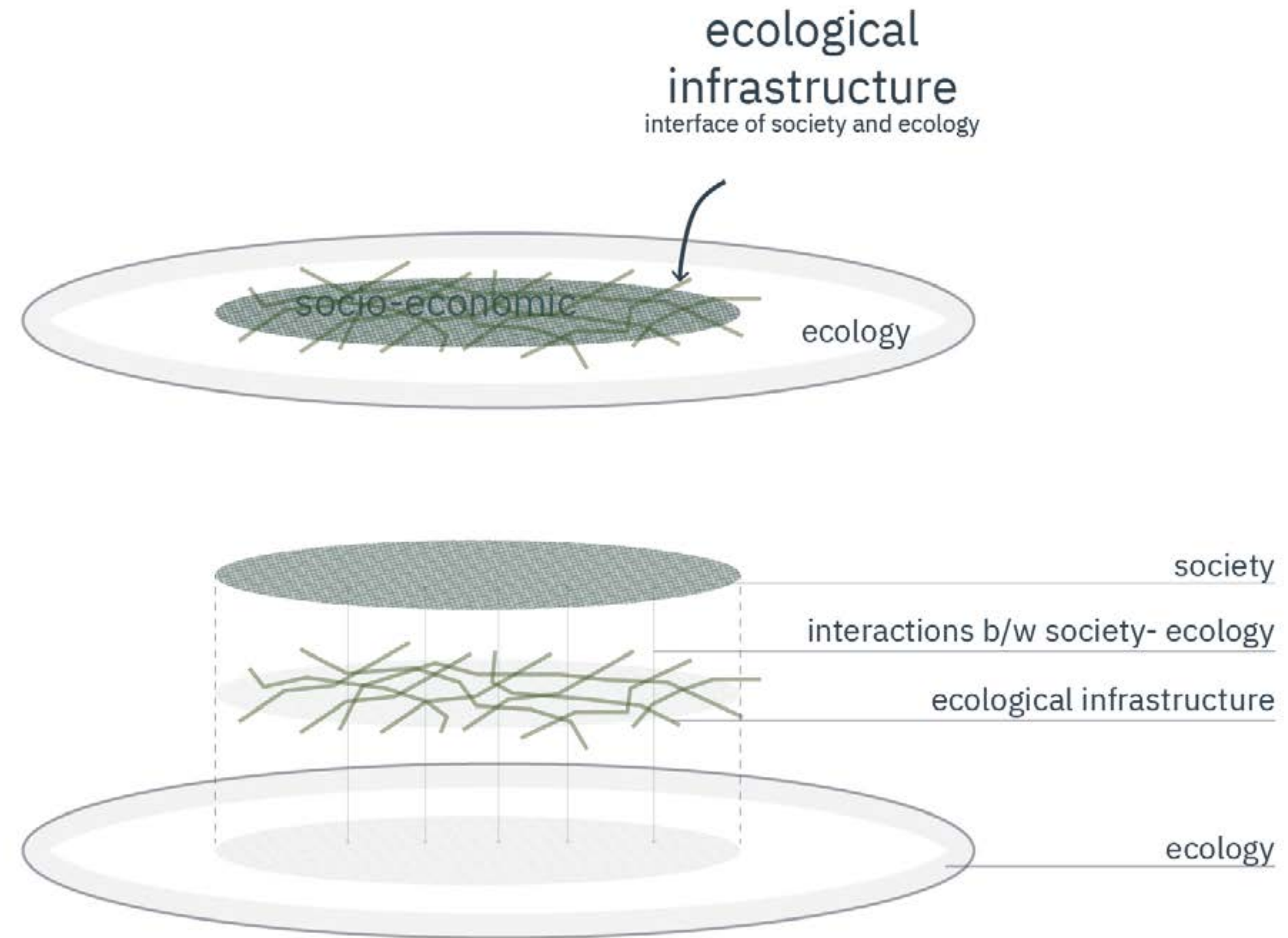
climate resilient region

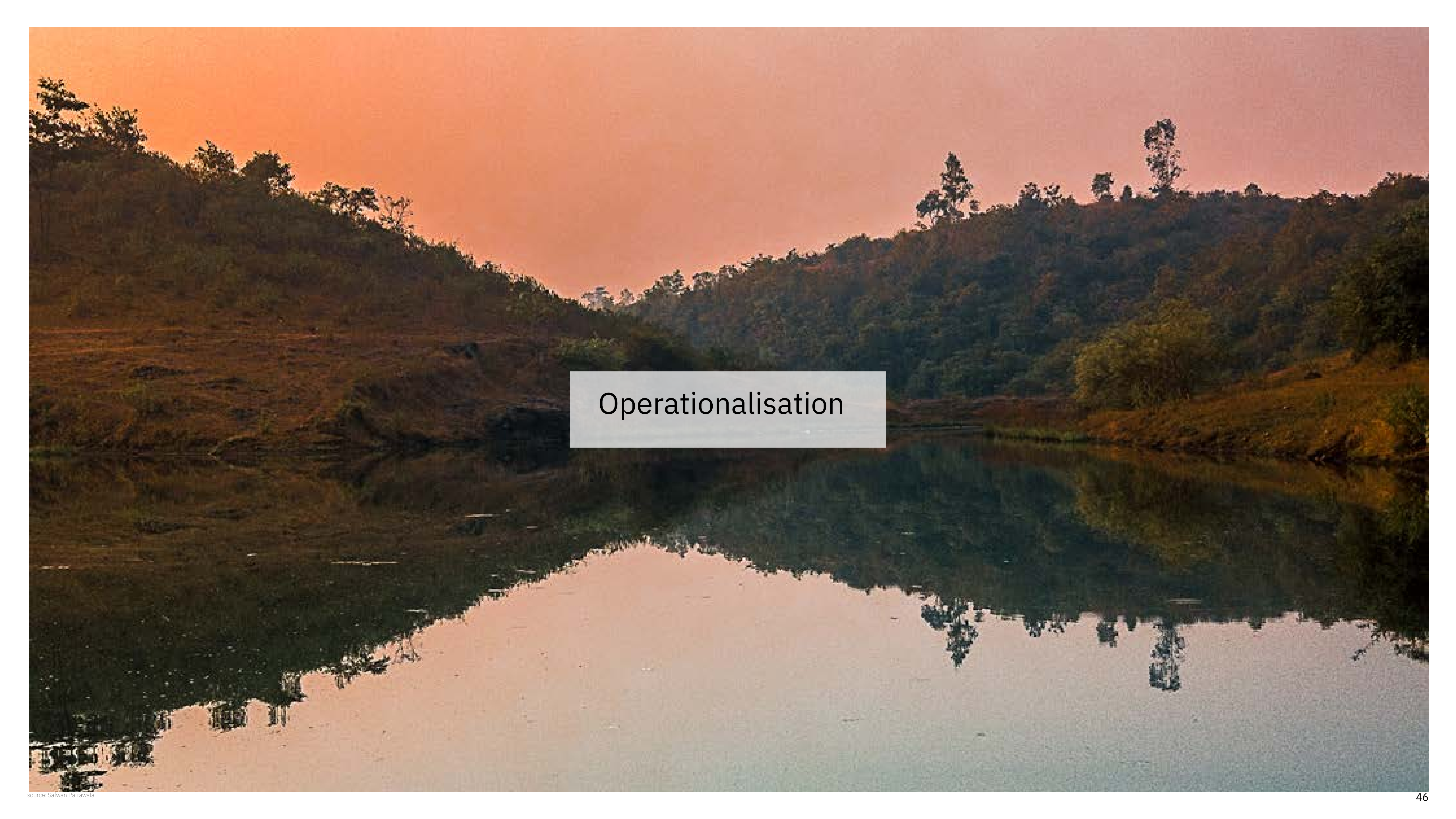
- How to operationalise resilience through ecological infrastructure?
- What would be the critical strategies at a regional scale to provide the adaptive capacity for different types of flooding in the region?

flooding

- What are the other physical infrastructures (man-made) to provide capacity against flooding?
- What is the current planning framework to tackle climate change and flooding?

Concept



A scenic landscape photograph featuring a wide river in the foreground. The water is calm and reflects the sky and the surrounding environment. The sky is a deep, warm orange, suggesting a sunset or sunrise. The hills in the background are covered in dense green forest. The overall mood is peaceful and natural.

Operationalisation



“The essence of planning is found in a *vision*, a persuasive story able to evoke and generate change. “

-Thogmorton(1995)

ECOLOGICAL CORRDIOR

- ① Increased percolation or recharging ground water
- ② Increased storm water capacity- storage
- ③ Increased drainage
- ④ Buffering capacity-Delineate ecological buffers & urban fringes
- ⑤ High integration of ecology with existing built area
- ⑥ Support biodiversity
- ⑦ Improve liveability



Absorptive capacity

+

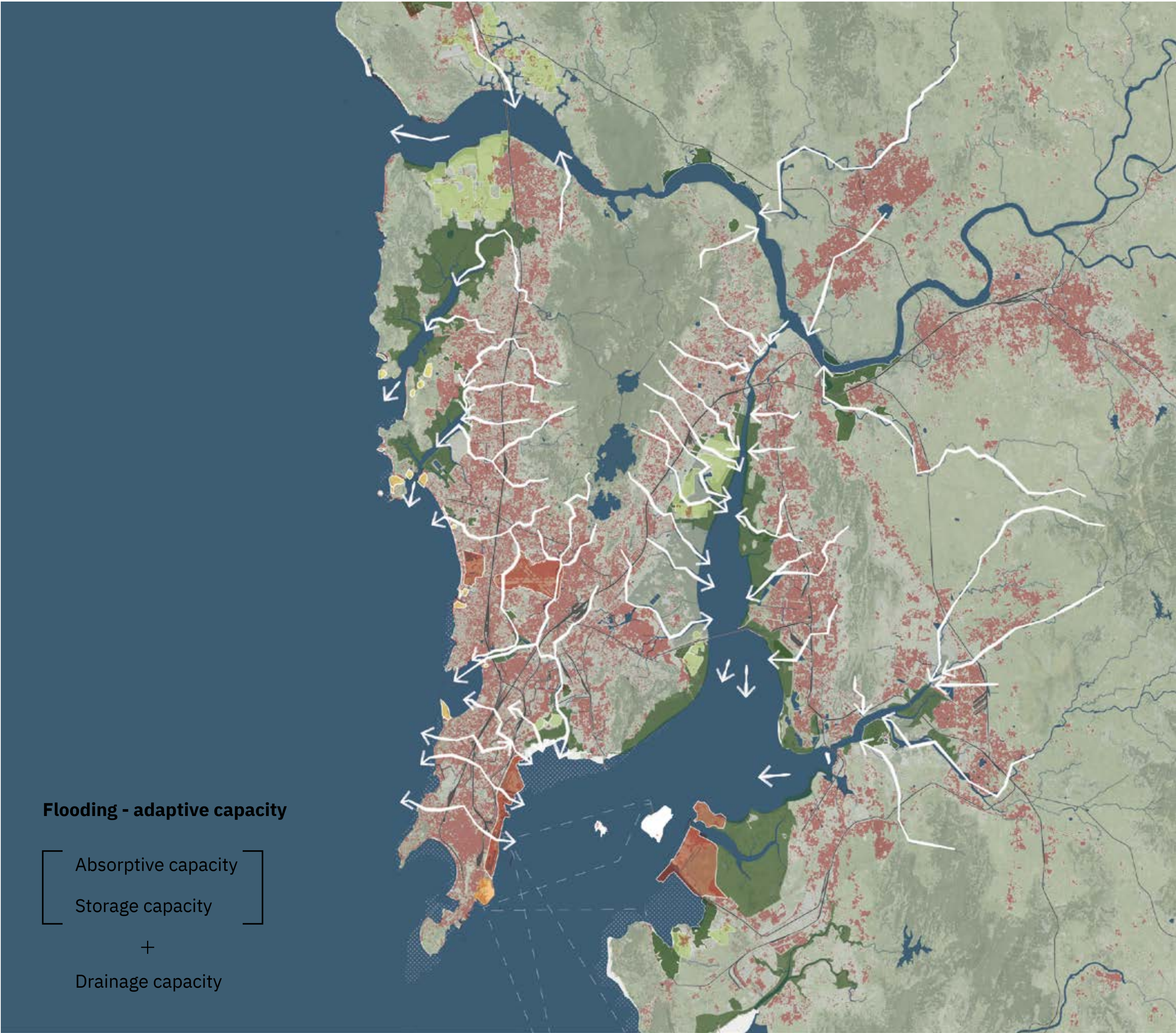
Storage capacity

+

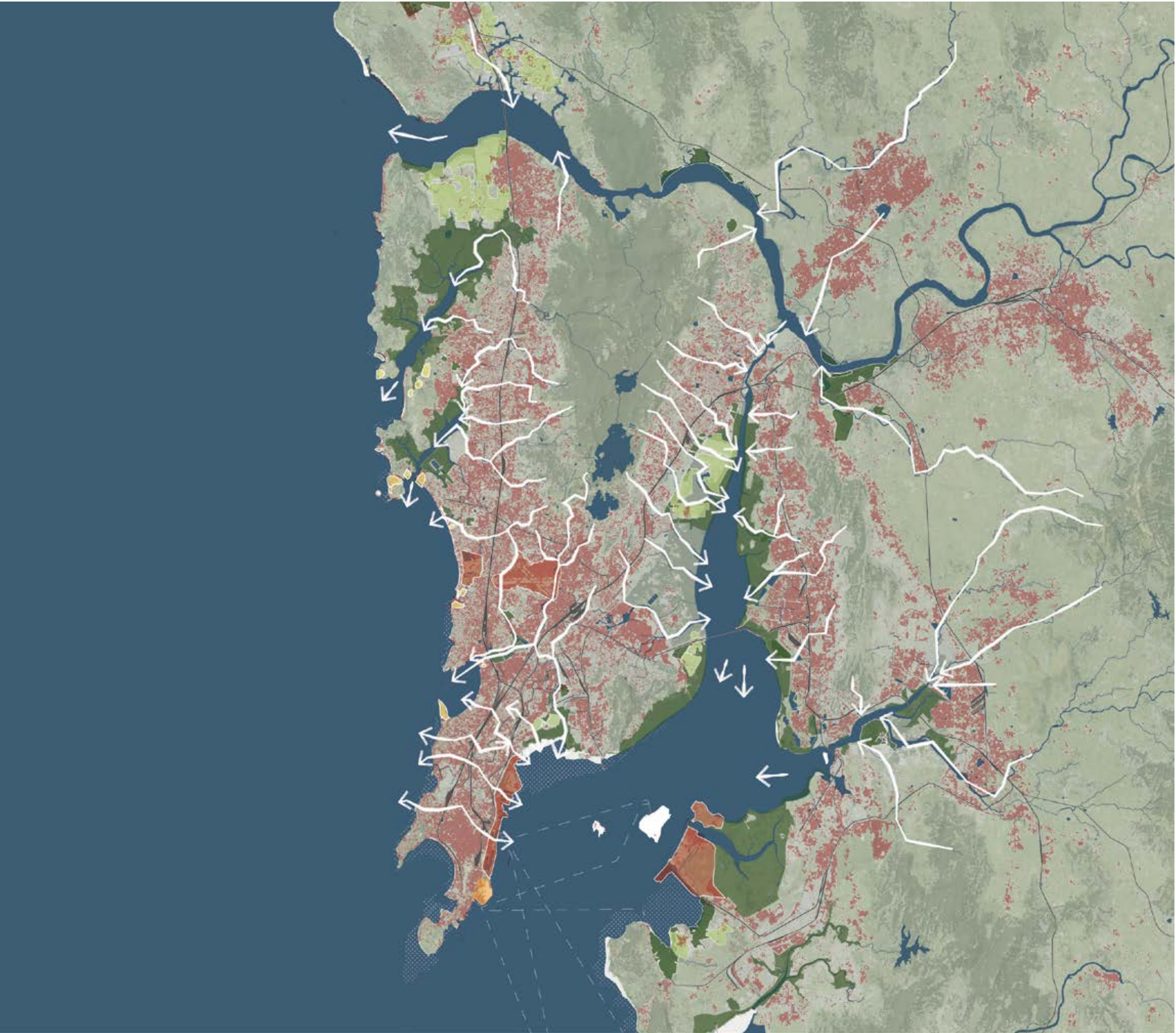
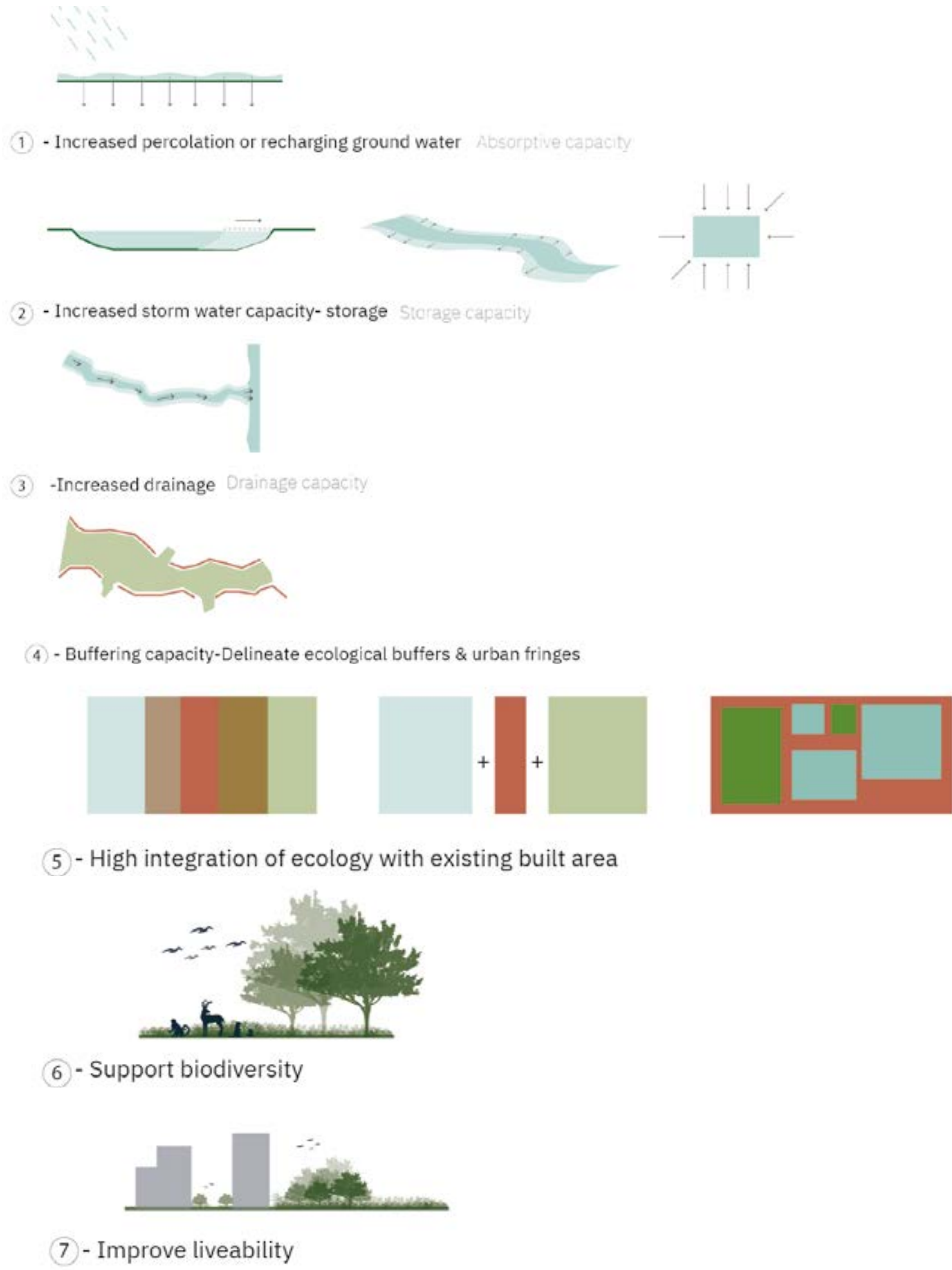
Drainage capacity

Flooding - adaptive capacity

Absorptive capacity
Storage capacity
 +
 Drainage capacity



ECOLOGICAL CORRDIOR



ECOLOGICAL CORRDIOR 



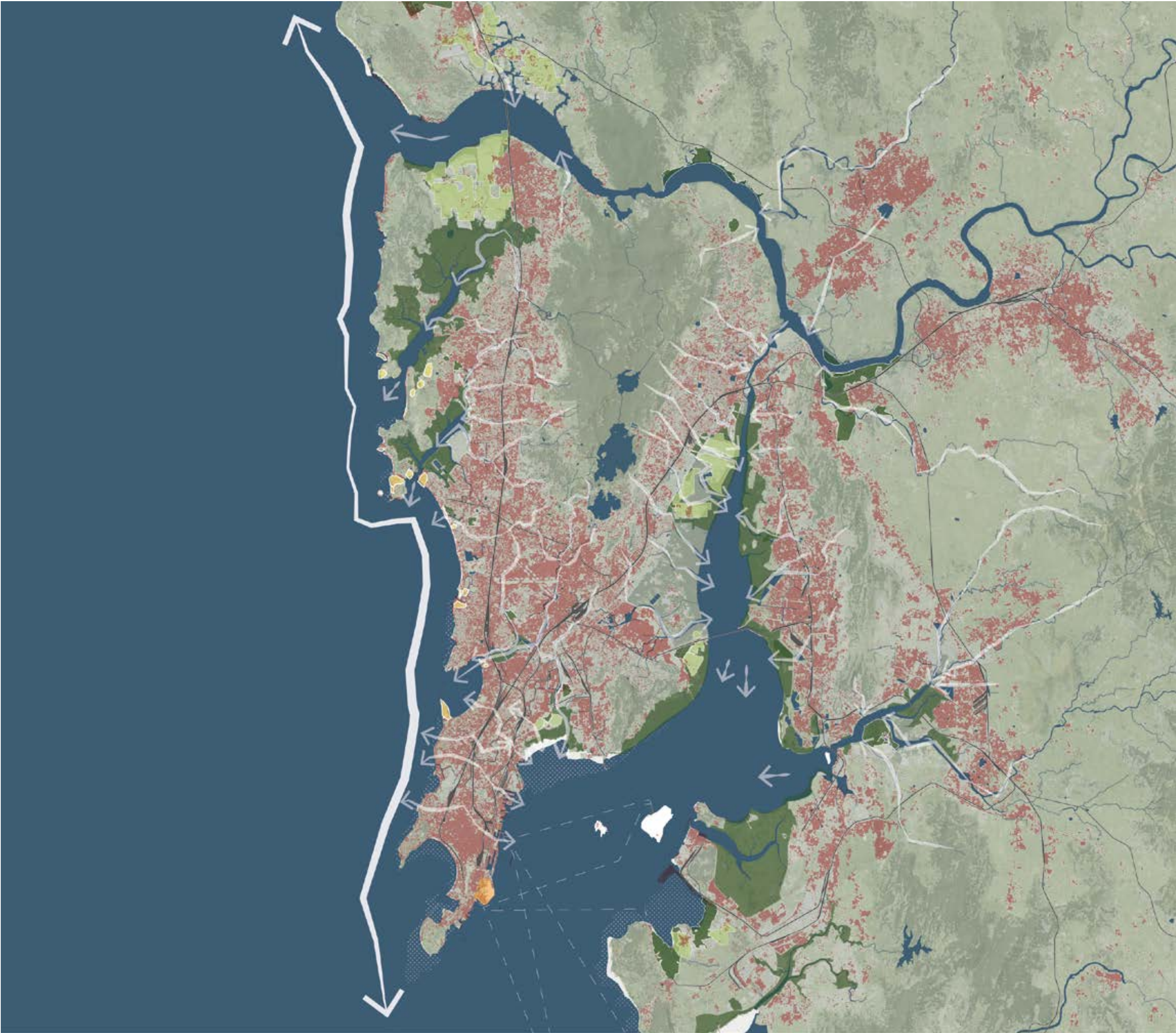
COASTAL PROTECTION

Coastal Protection

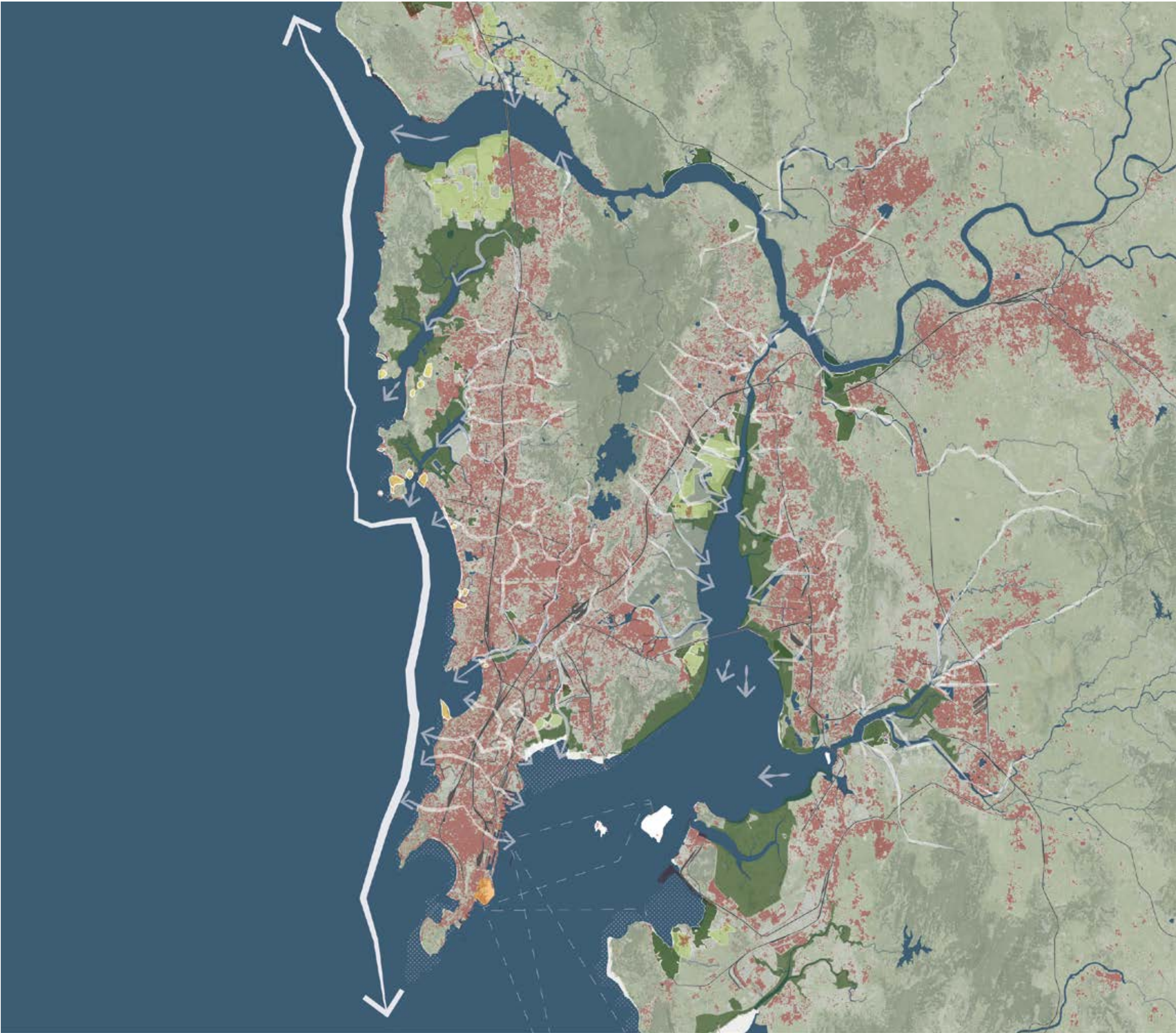
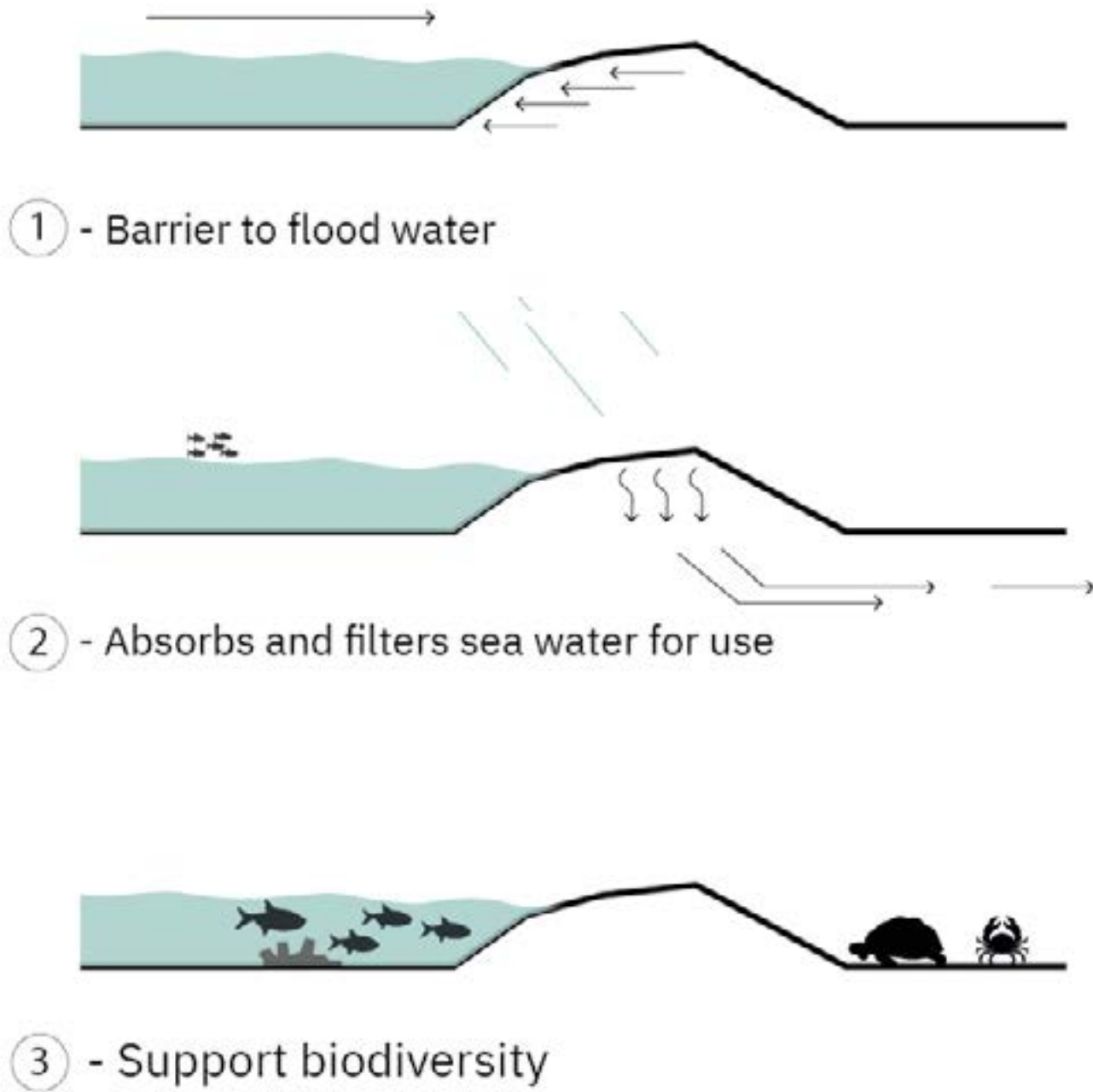
Flooding - Pluvial/Storms and Coastal

- ① Barrier to flood water
- ② Absorbs and filters sea water for use
- ③ Support biodiversity

Absorptive capacity
+
Storage capacity



COASTAL PROTECTION

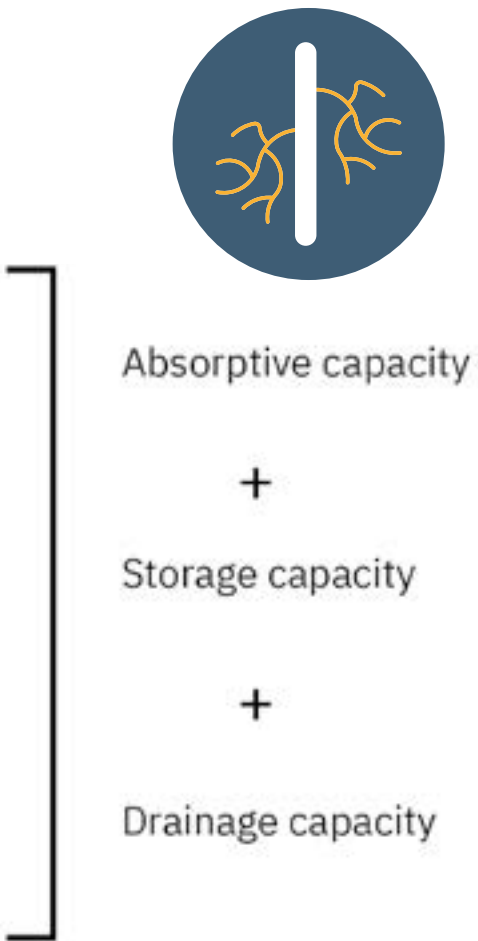


COASTAL PROTECTION

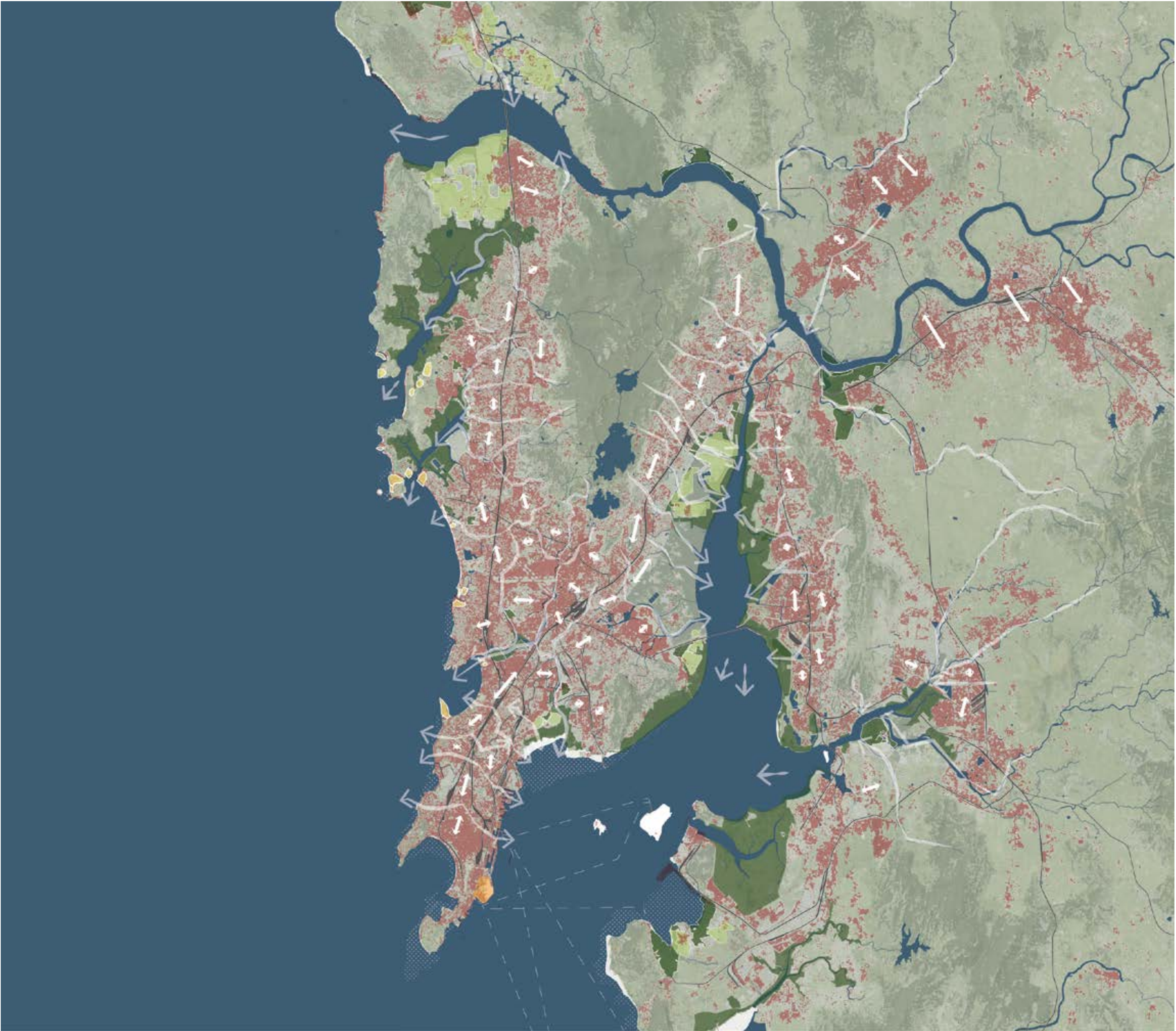
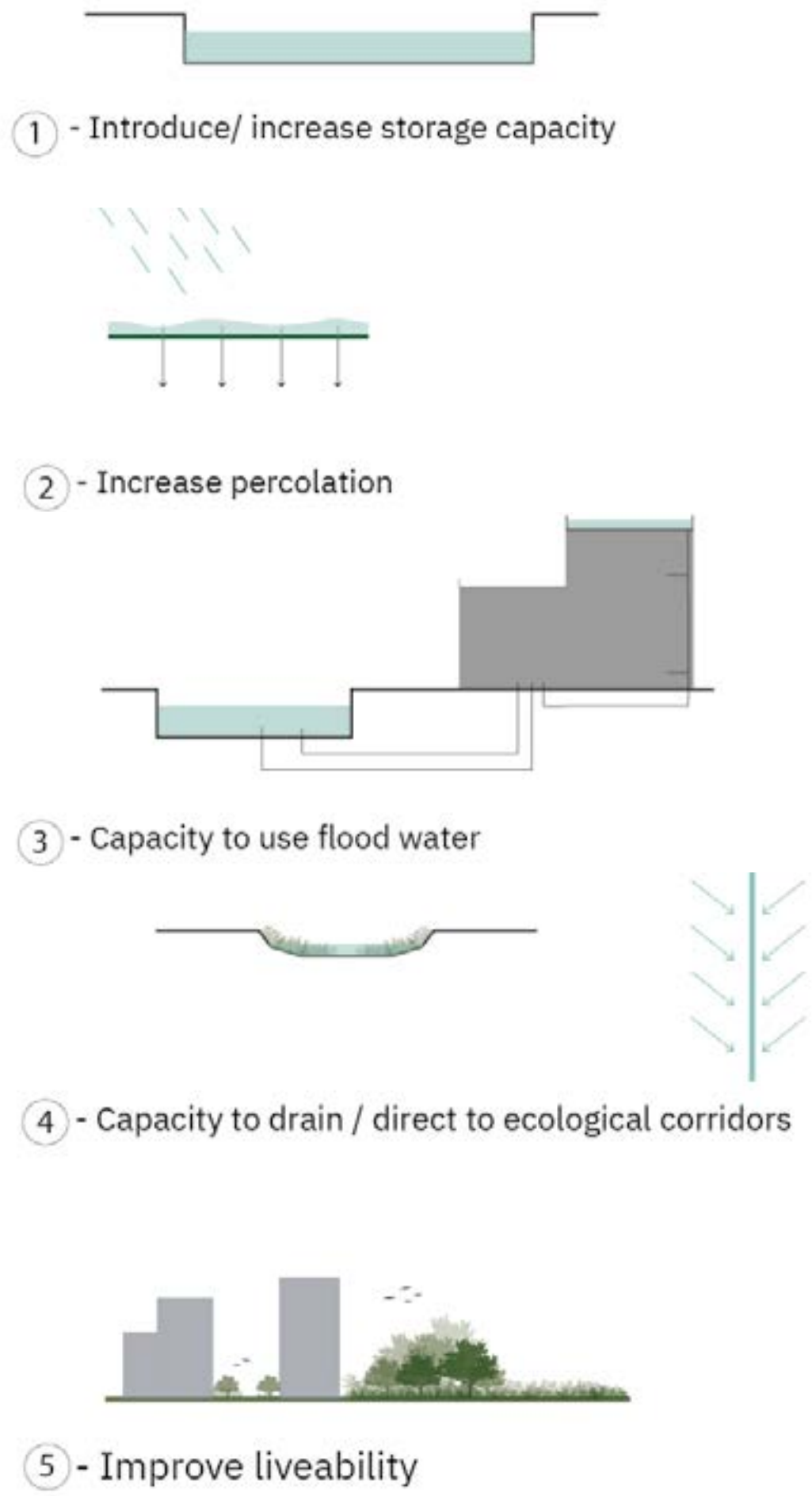


CAPILLARIES

- 1. Introduce/ increase storage capacity
- 2. Capacity to use flood water
- 3. Capacity to drain / direct to ecological corridors
- 4. Improve liveability



CAPILLARIES





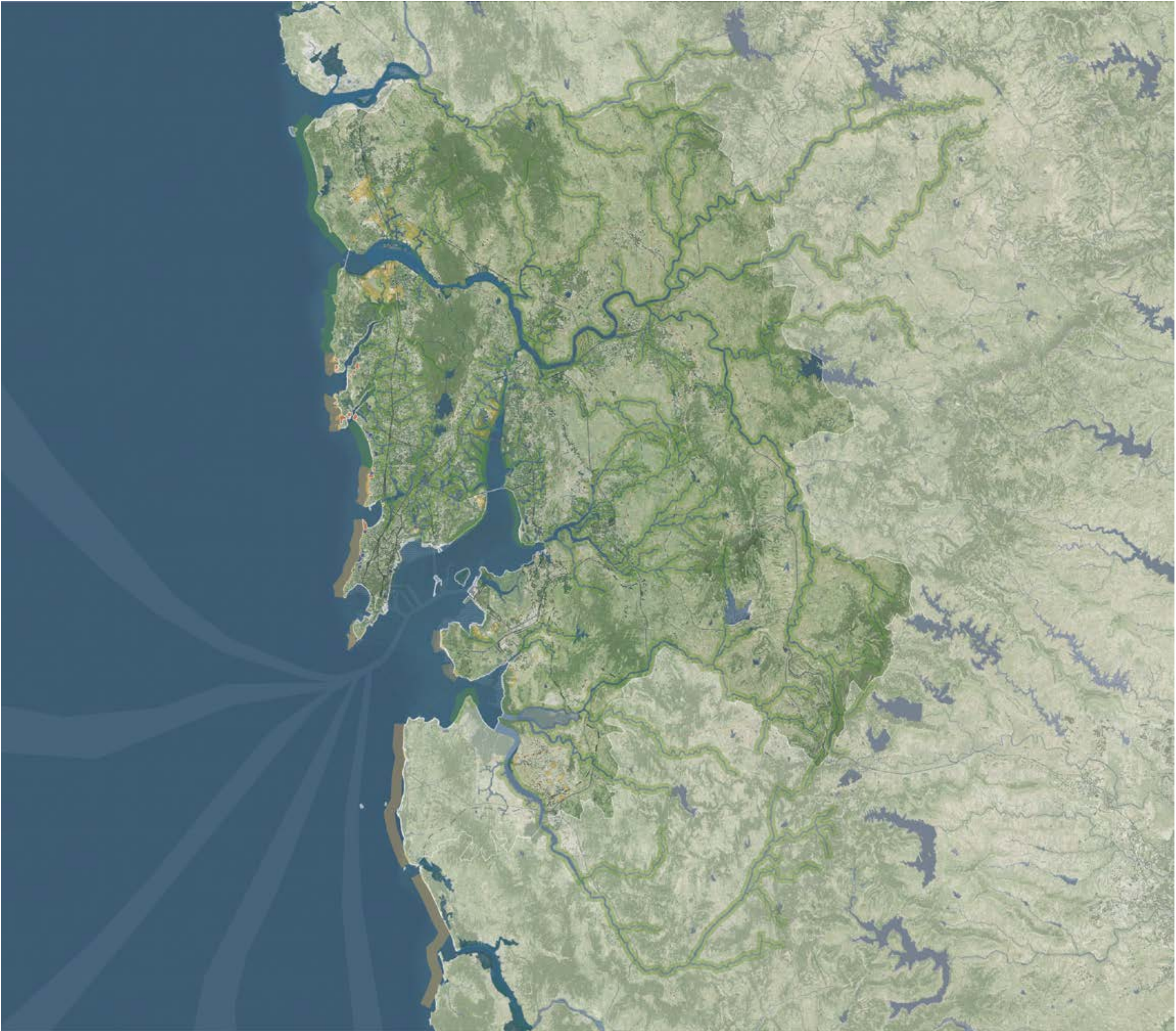
VISION

The 3 Principles :Ecological Corrdior, Capillaries & Coastal Protection



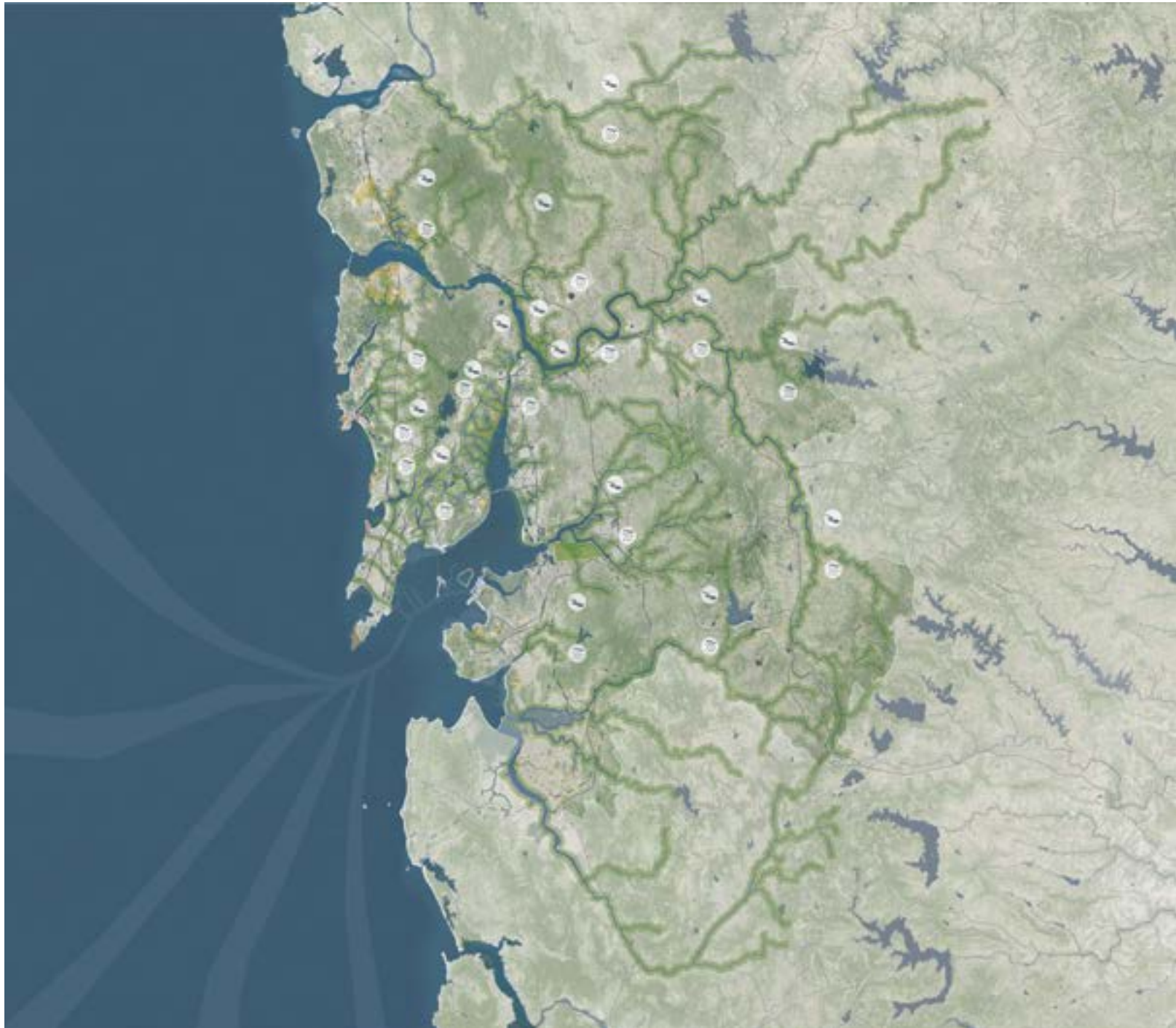
REGIONAL VISION

Extrapolating the 3 Principles on the Region

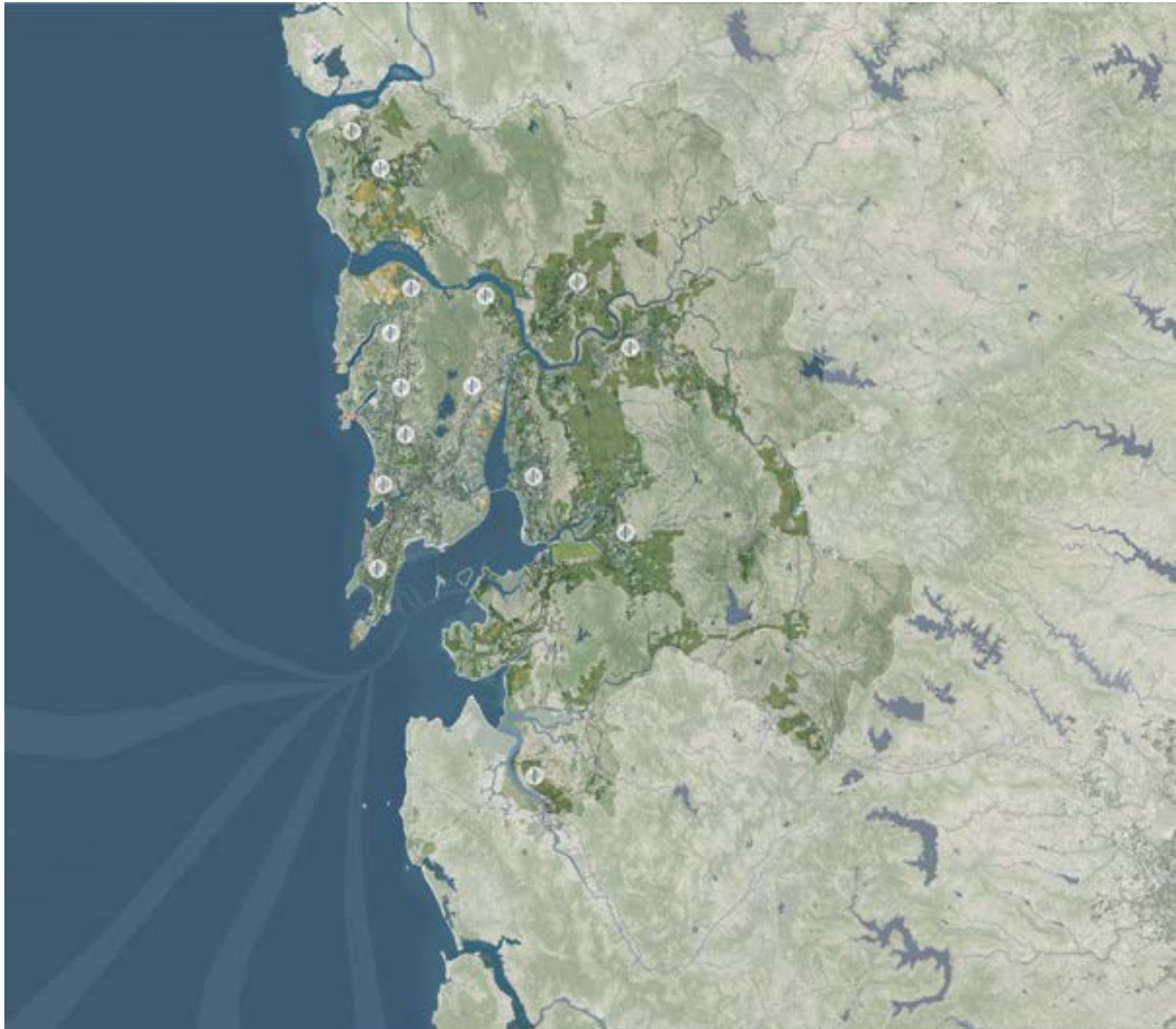


REGIONAL VISION

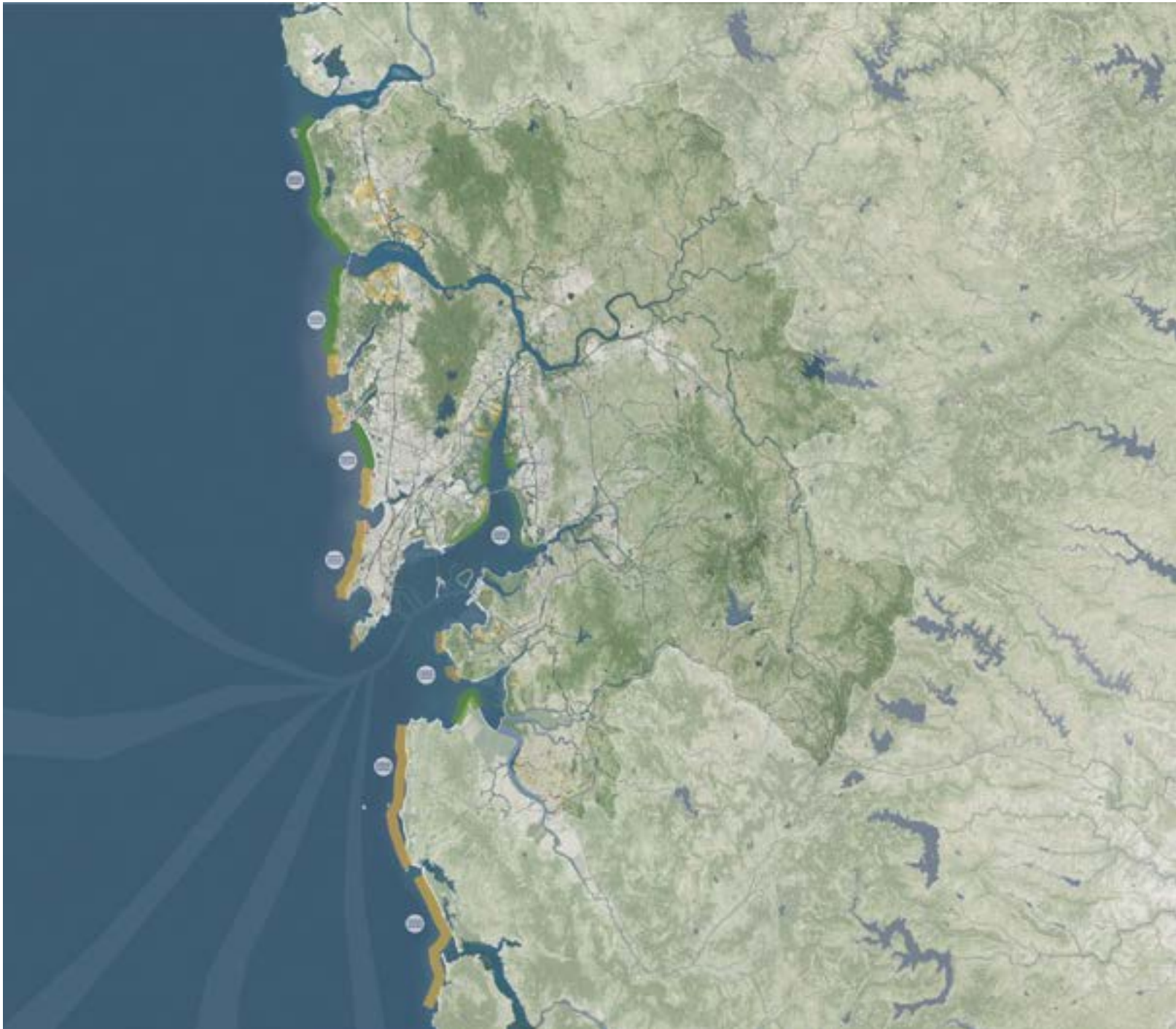
Extrapolating the 3 Principles on the Region



Ecological corridor : responds to Fluvial & Pluvial flooding



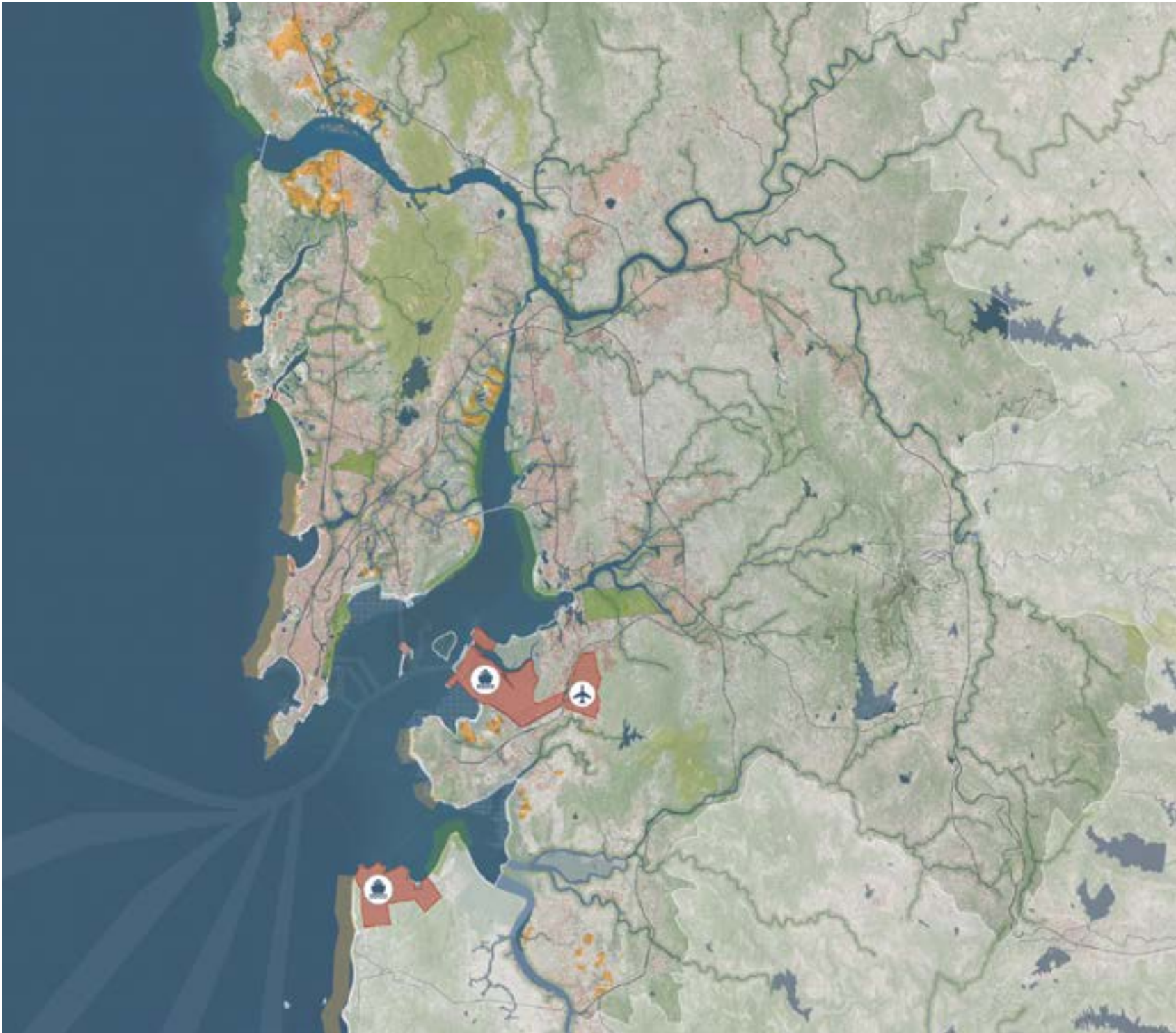
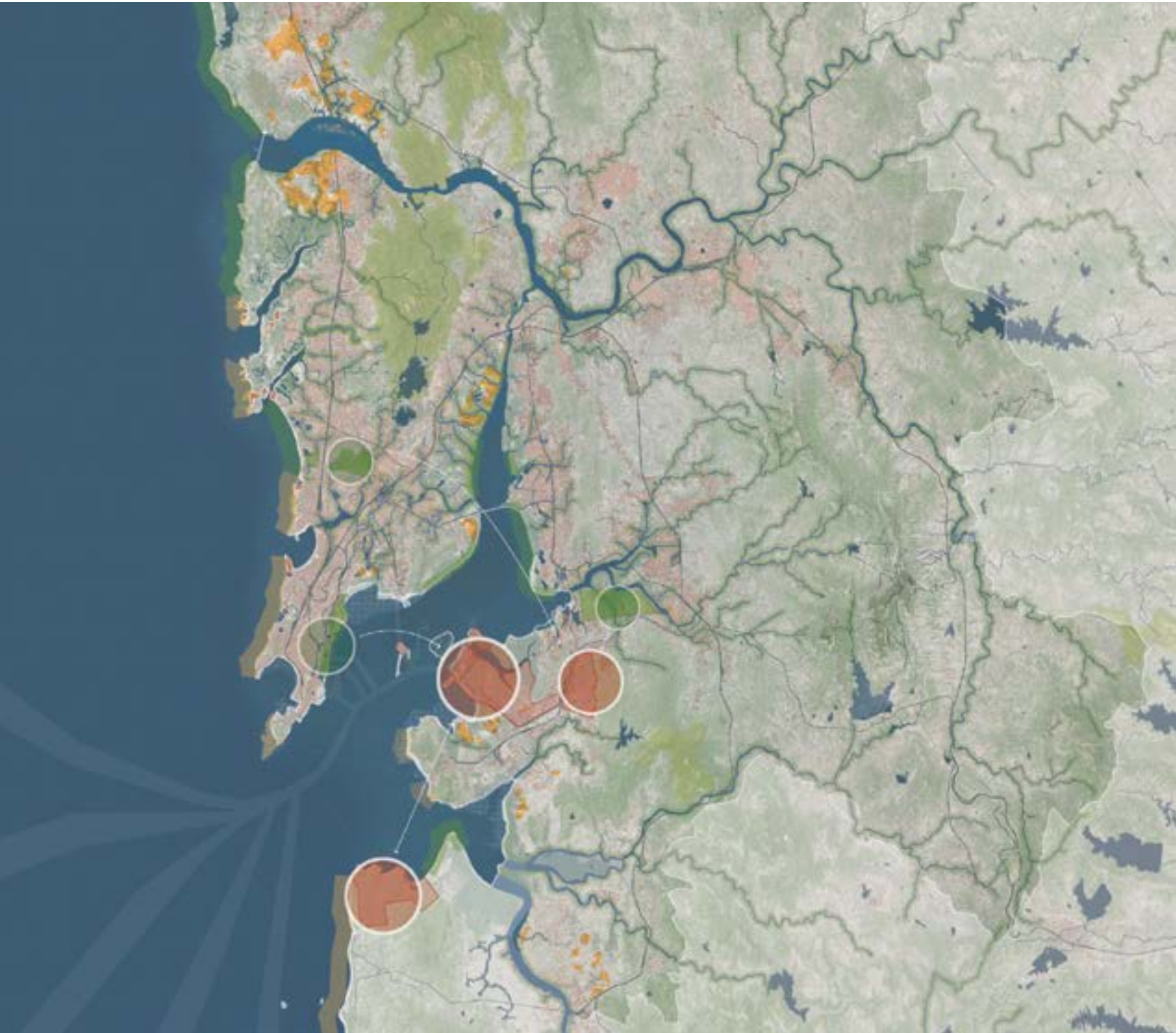
Capillaries : responds to Fluvial & Pluvial flooding



Coastal Protection : responds to Coastal flooding

REGIONAL VISION

Strategic Transformations



An aerial night photograph of a densely populated city, likely Mumbai, India. The city is characterized by a high concentration of tall, multi-story apartment buildings and commercial structures. The buildings are illuminated with warm yellow and orange lights, creating a vibrant urban glow. In the foreground, many buildings have blue-tinted roofs, possibly due to lighting or the color of the roofs themselves. The city extends to a large harbor area in the background, where numerous ships and boats are visible, their lights reflecting on the water. The harbor is bordered by hills and mountains, which are also visible in the distance under a dark blue night sky. A semi-transparent white rectangular box is overlaid on the center of the image, containing the text "Design & Planning framework".

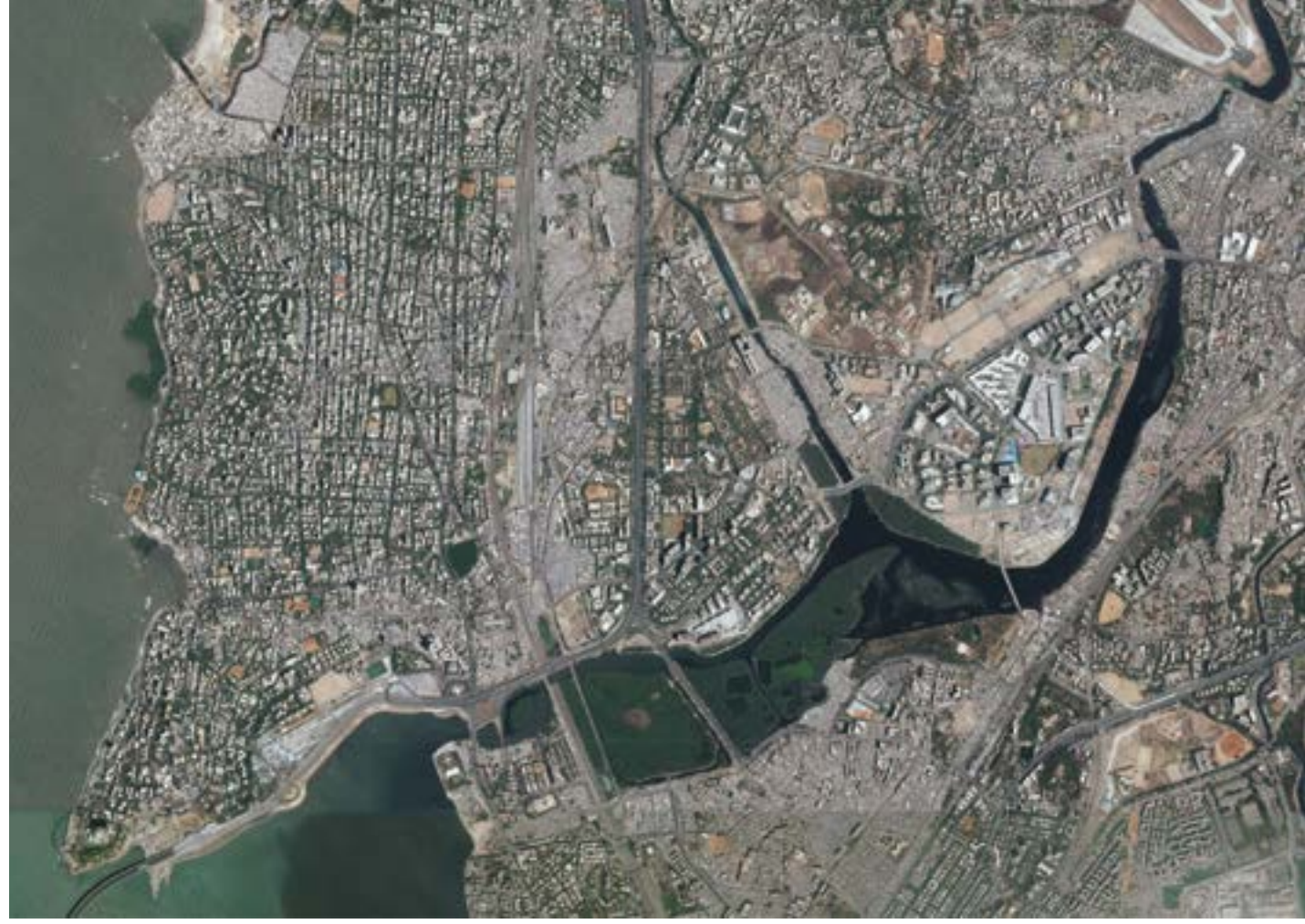
Design & Planning framework

Introduction to 3 cases



Introduction to 3 cases

Airport- BKC Area



Salt pan & Creek Area



Island City



Introduction to 3 cases

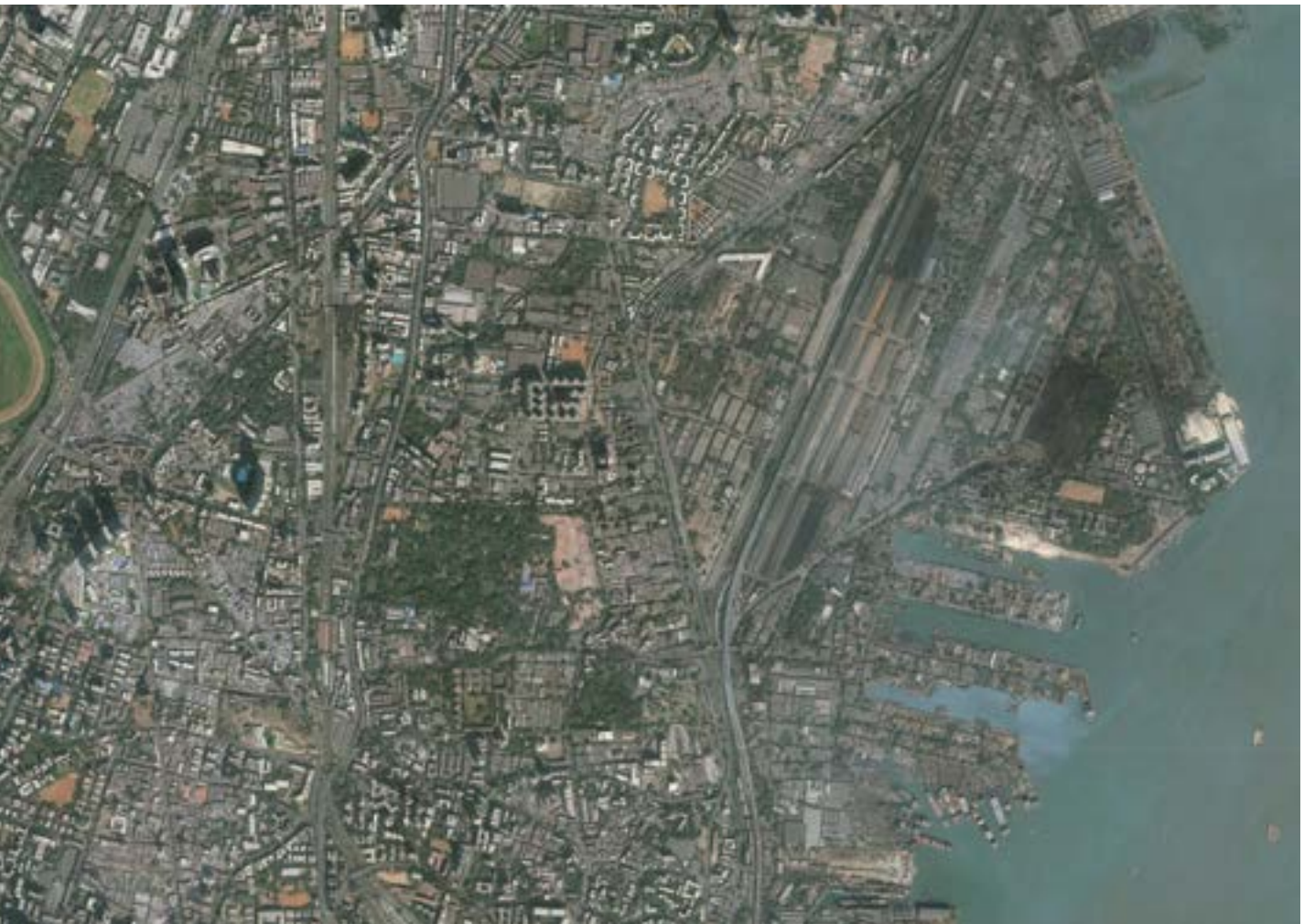
Airport- BKC Area



Salt pan & Creek Area



Island City



source: zoomearth; author

Introduction to 3 cases

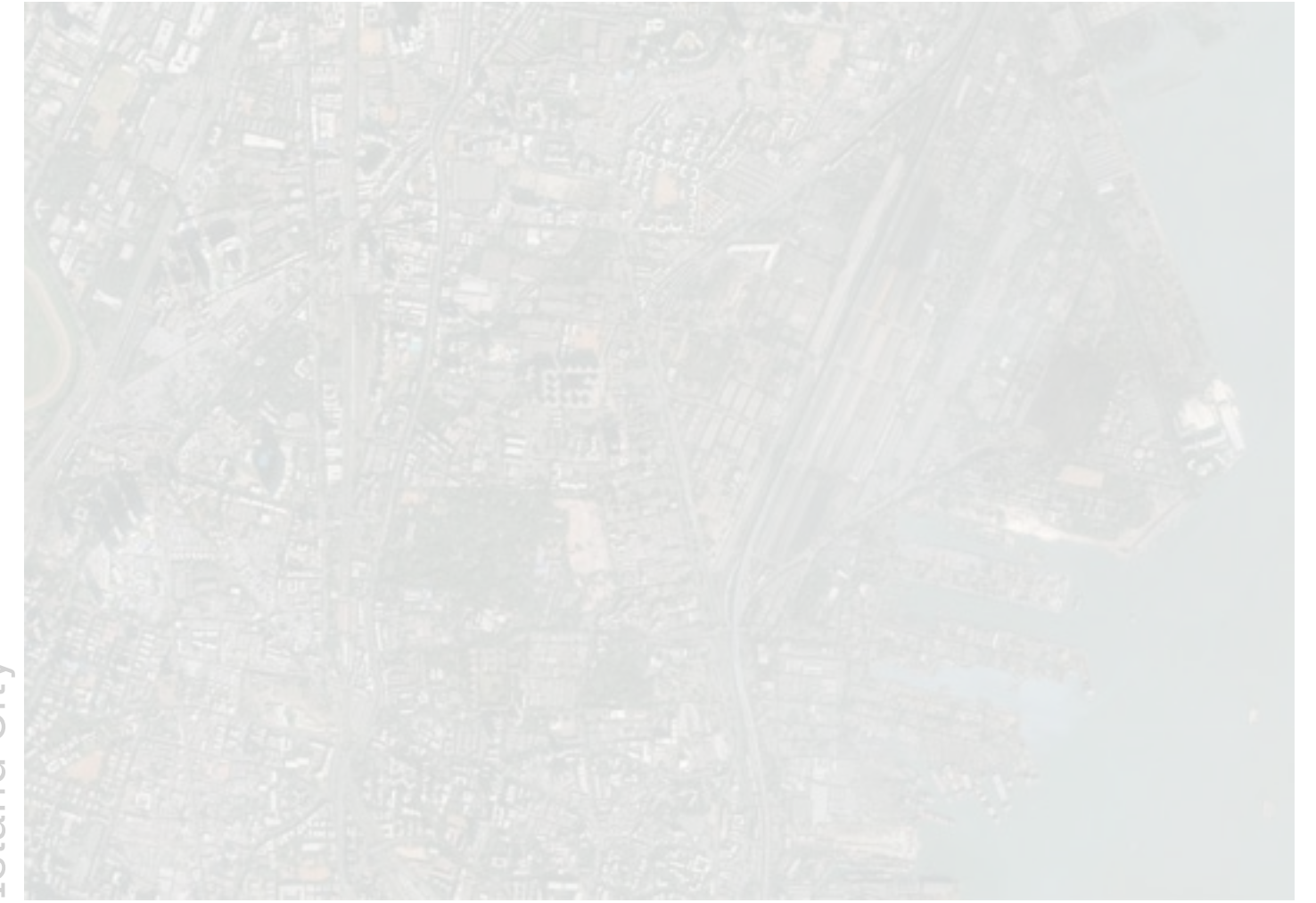
Airport- BKC Area



Salt pan & Creek Area



Island City



MESO



MICRO



MACRO



Airport-BKC Area



Airport - BKC Area

Existing Built & Natural system



Ecological Corridor Delineation



Ecological Corridor Design Interventions

- ① **Fish Ponds**- Creating fish ponds for the local fishing community to continue seasonal fishing



- ② **Mangrove State Park** - Development of a Mangrove forest recreational park with mangroves and other species which would protect from floods and serve as a recreational park for locals & tourists



- ③ **Urban forest**- Introduction and intensification of forest areas in the city to provide a dense rich habitat to support biodiversity, increase rainfall percolation

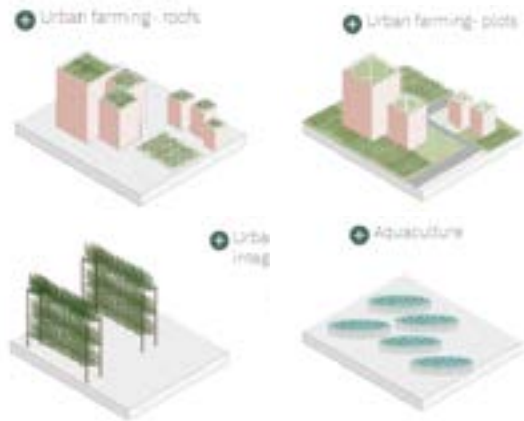
⑧

⑪



- ④ **Urban Farming** - Combination of Urban farming in the built areas- integration of aqua culture or crop farming within the built structure through redevelopment/ retrofitting

⑦

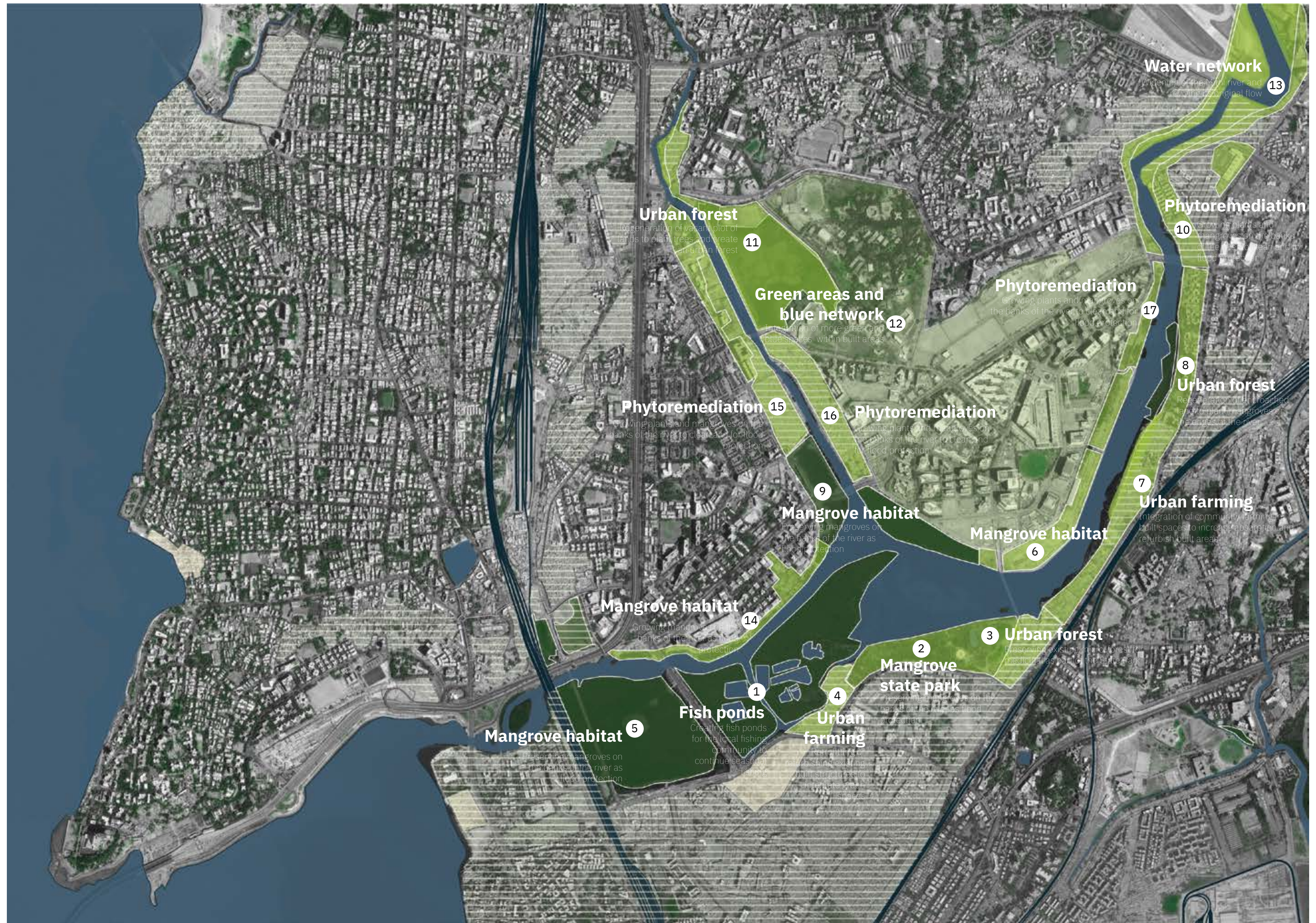


- ⑤ **Mangrove Habitat** - Preservation and intensification of Mangroves on the fringes of the banks of the river to provide natural flood barrier

⑥

⑨

⑭



Ecological Corridor

Design Interventions

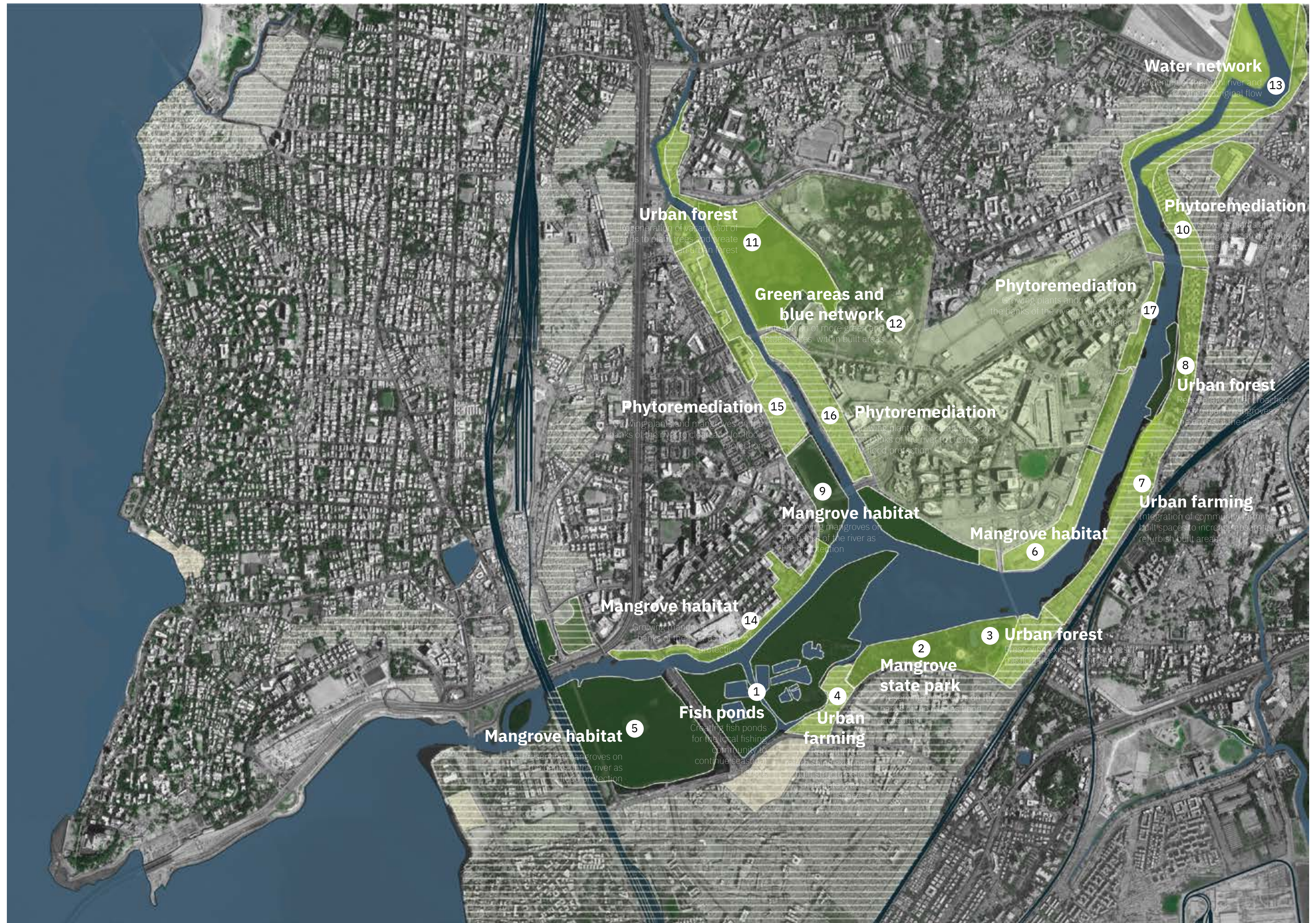
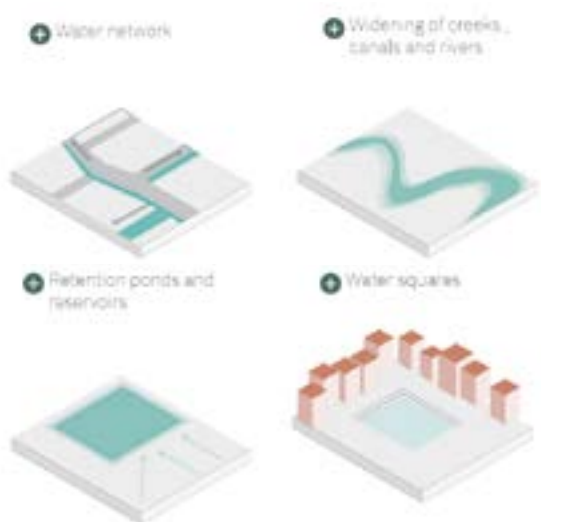
- ⑩ **Phytoremediation**- Preserving and regenerating to convert green areas/ vacant / unused plots into urban forest. Also this involves growing plants specifically for purifying the water and improving the water quality.
- ⑮
- ⑯
- ⑰



- ⑫ **Green blue network** - Combination of intervention with green or blue elements like green / blue roofs or green facades, addition of parks, permeable paving , increasing open green spaces or making room for water storage.



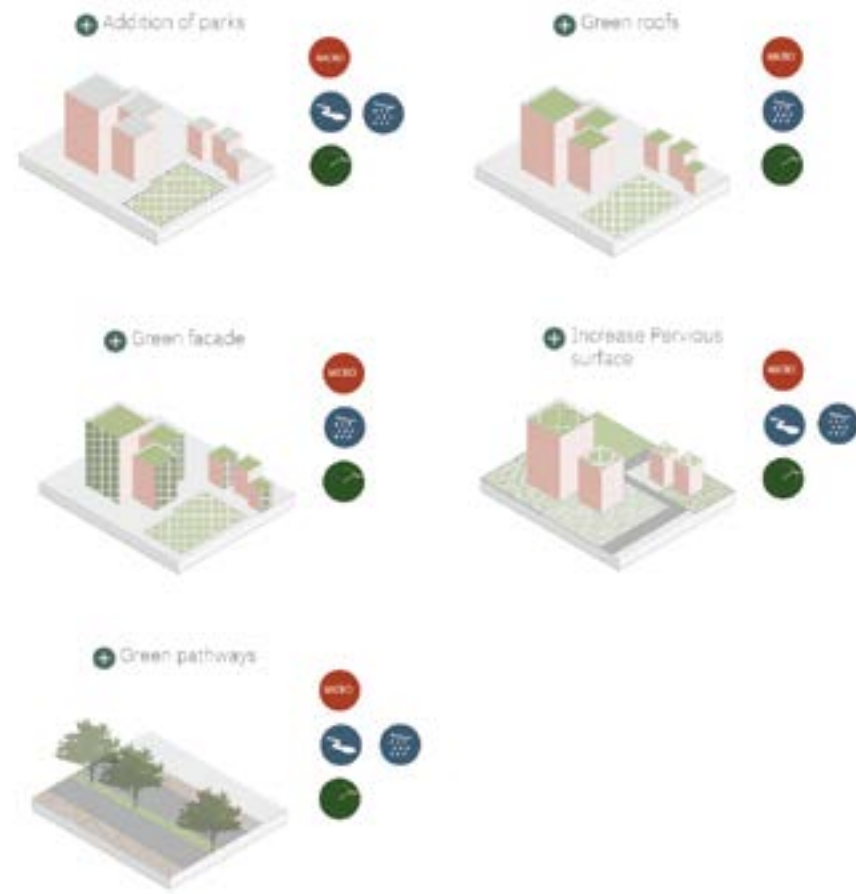
- ⑬ **Water Network** - Introduction of water or giving more space to water to be absorbed ,stored or drained. Creation of water channels, widening rivers , adding water square or reservoir.



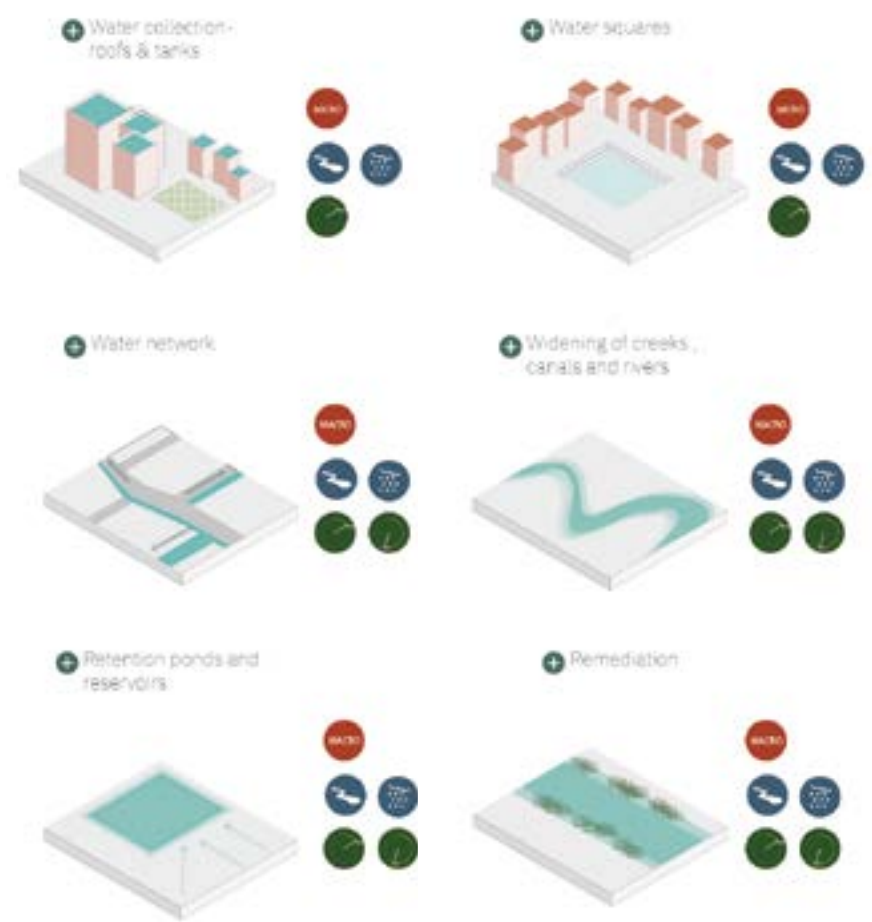
Capillaries

Design Interventions

Green Network - Possibilities of introducing green spaces on roofs and facades of buildings. It involves, permeable pavings, percentage reservation for green spaces, vacant plots to be turned into functional green spaces and

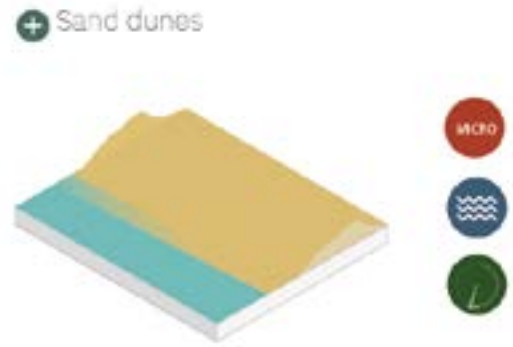


Water Network - Possibilities of increasing water storage capacity on roofs and facades of buildings. It requires collection of water in large spaces like creation of lakes, raingardens or water squares.

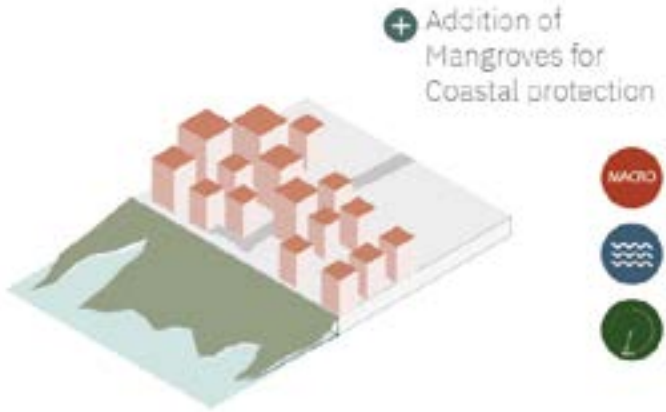


Coastal protection Design Interventions

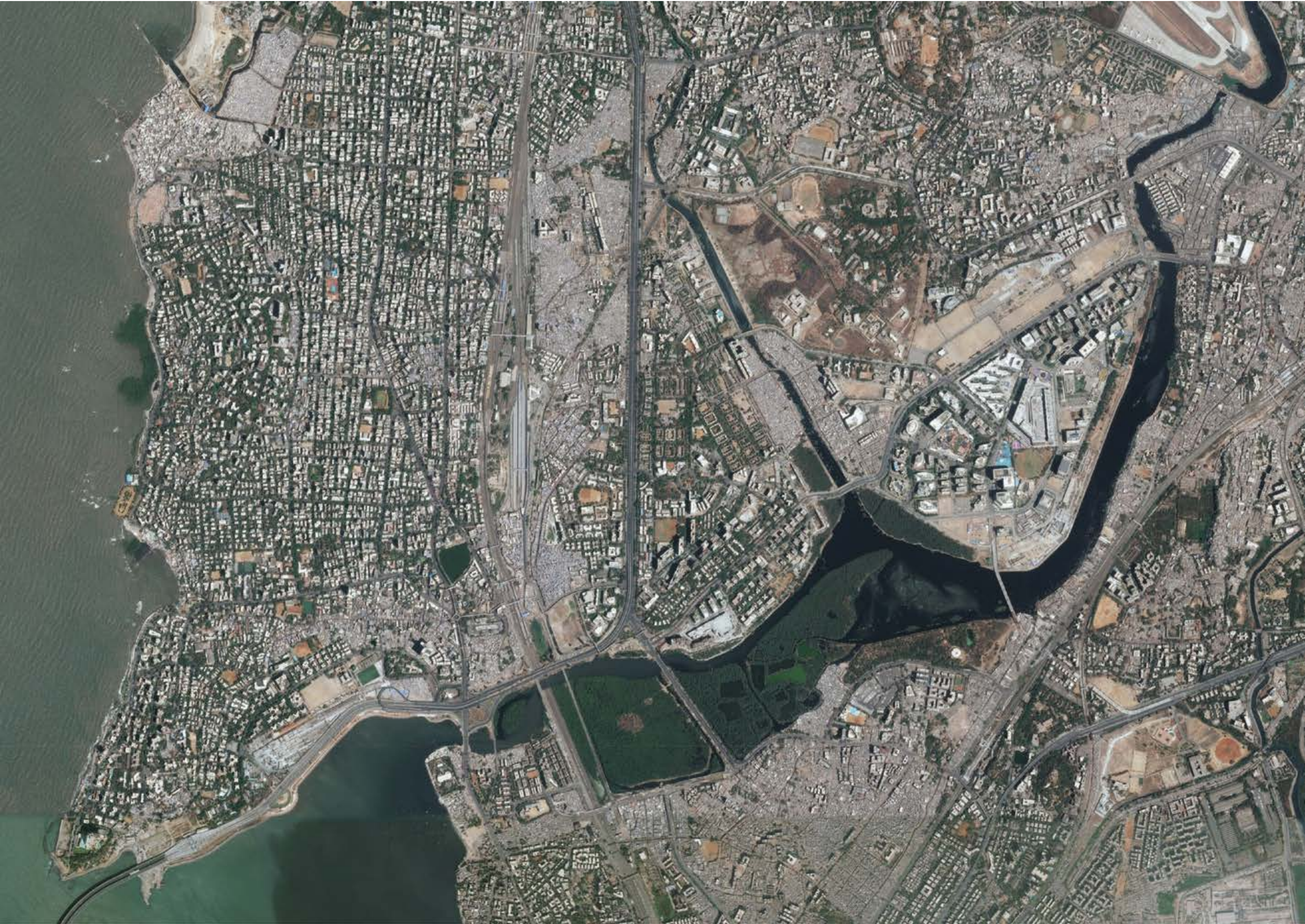
① **Sand dunes** - Introducing sand dunes in parts of the coastline with recreational beaches and areas for fishing communities



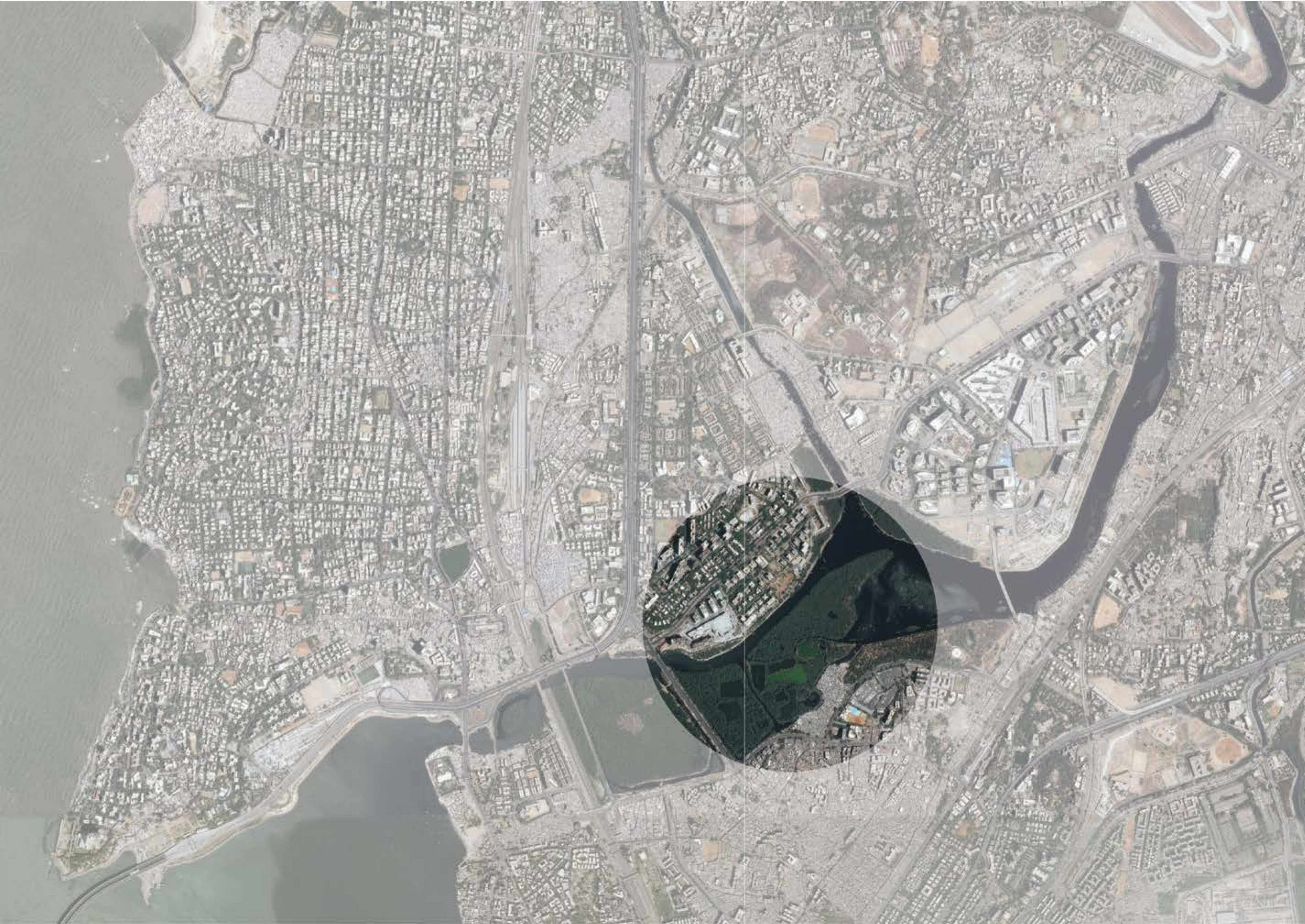
② **Mangroves**- Introducing mangroves for flood protection on the coastline areas where it doesn't obstruct fishing communities and could provide possibilities for variant fishing during high tides and provide flood protection



Looking at the micro scale



Looking at the micro scale



Looking at the micro scale



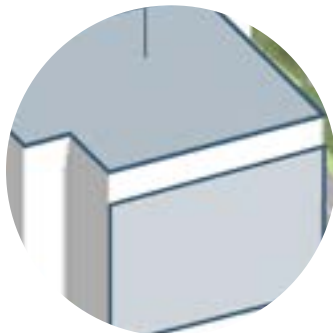
Looking at the micro scale



Capillaries

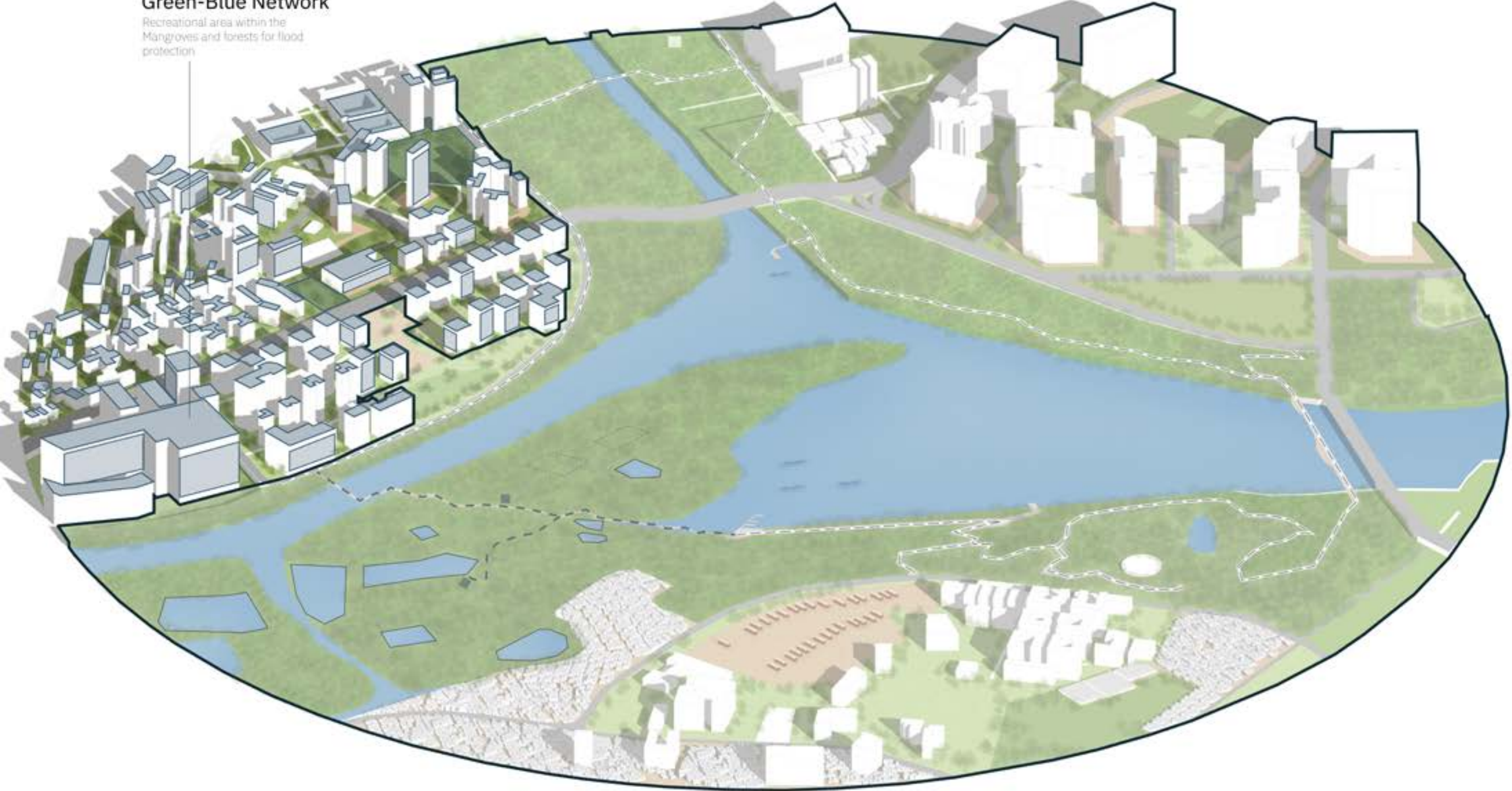


Capillaries

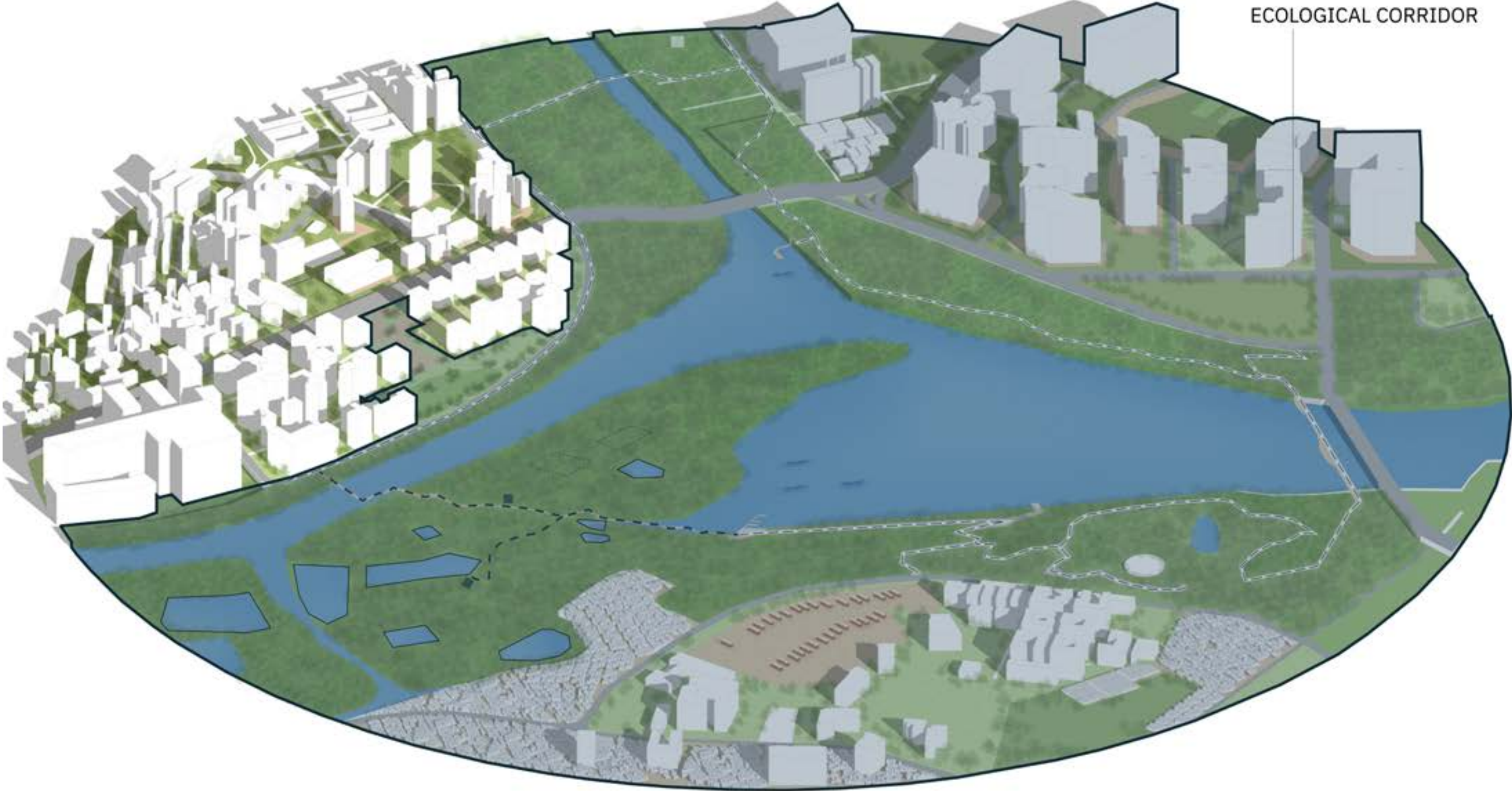


Green-Blue Network

Recreational area within the Mangroves and forests for flood protection



Ecological corridor

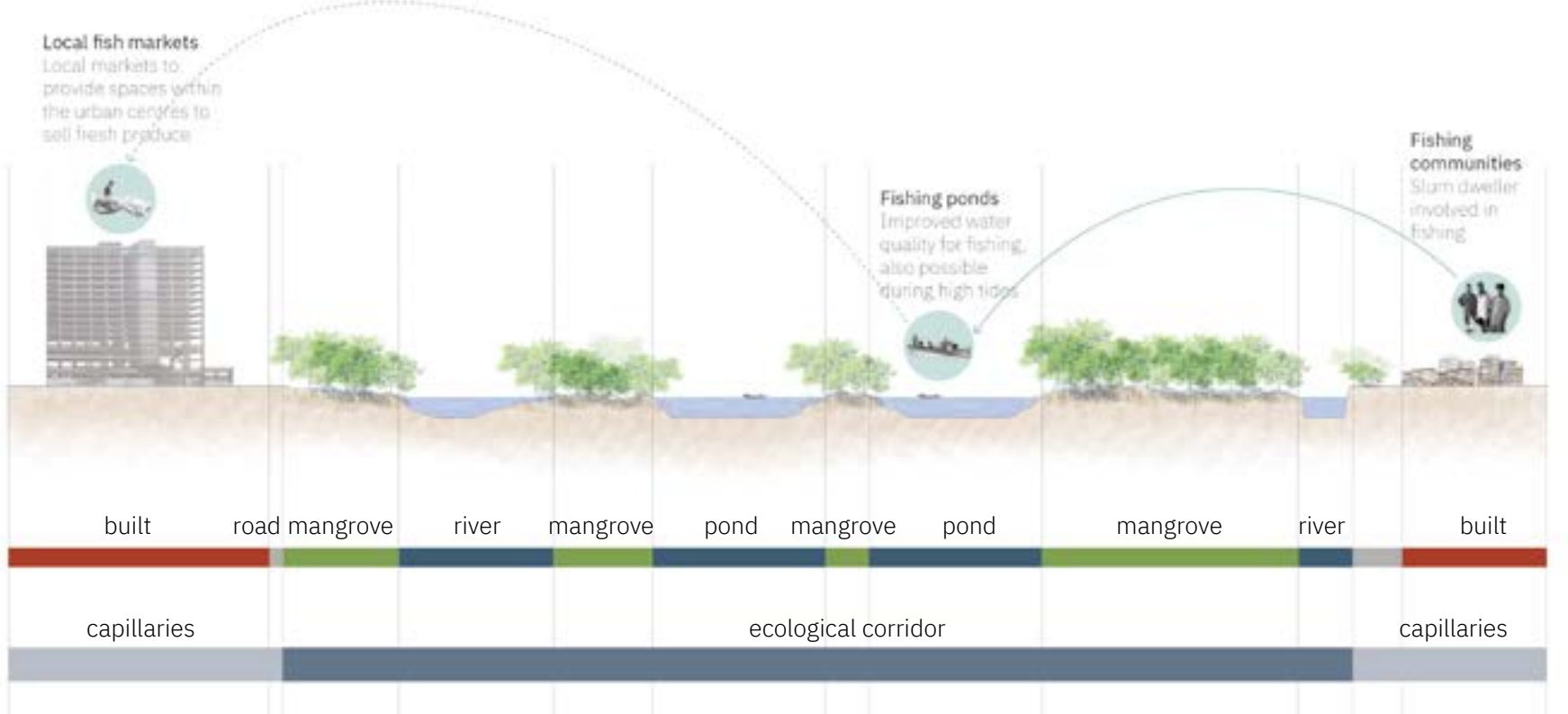
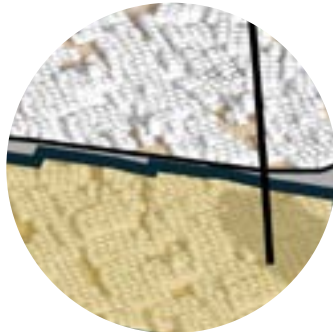
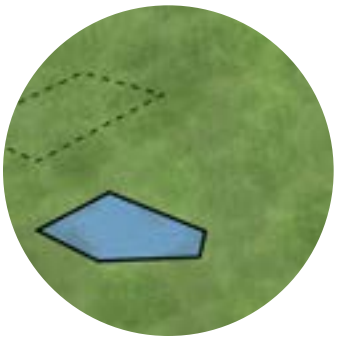
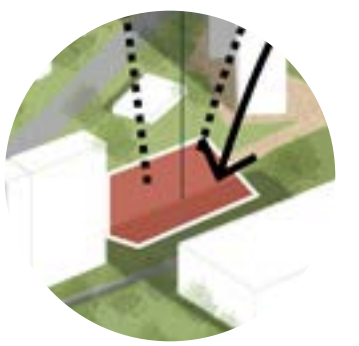
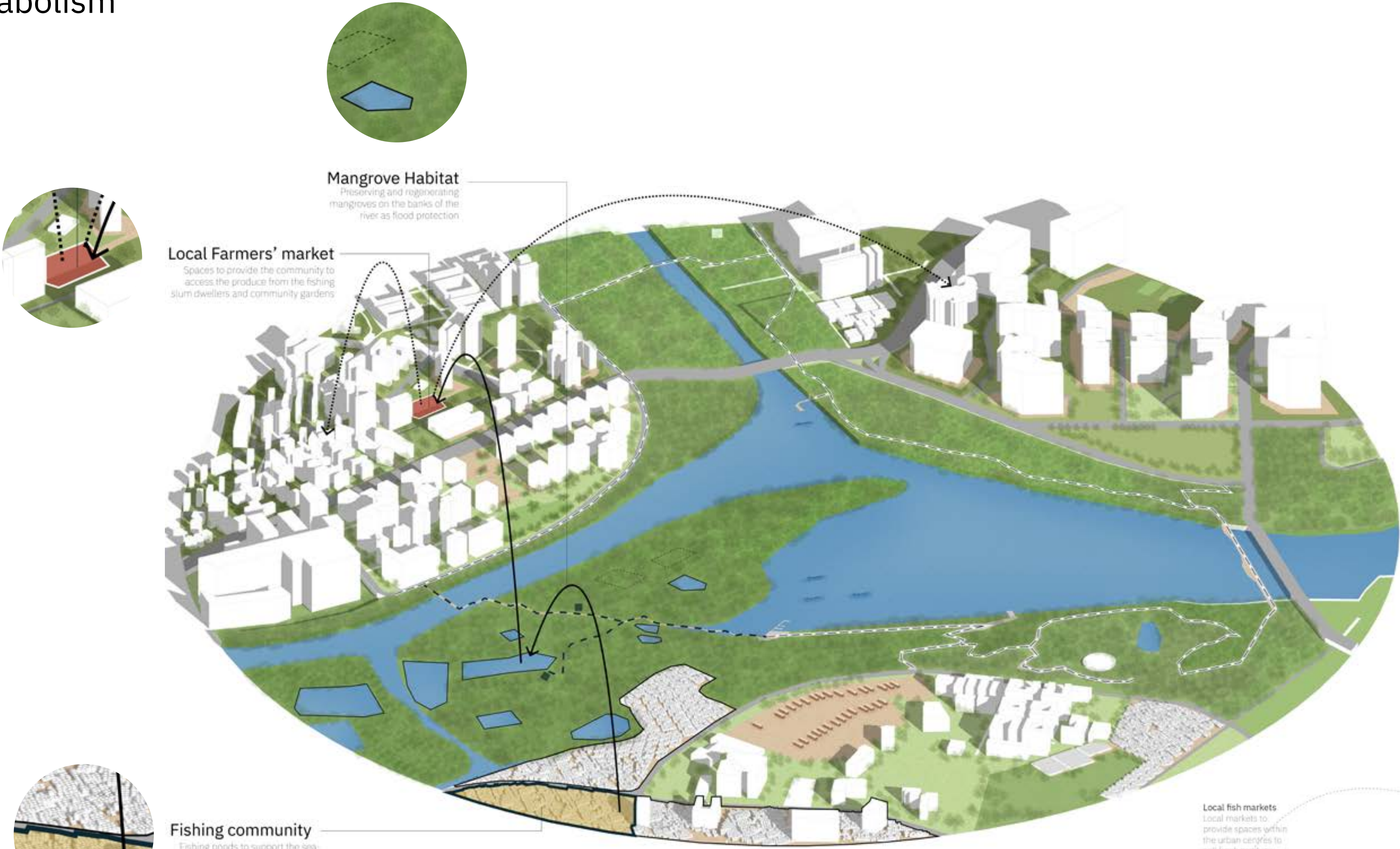


Ecological corridor



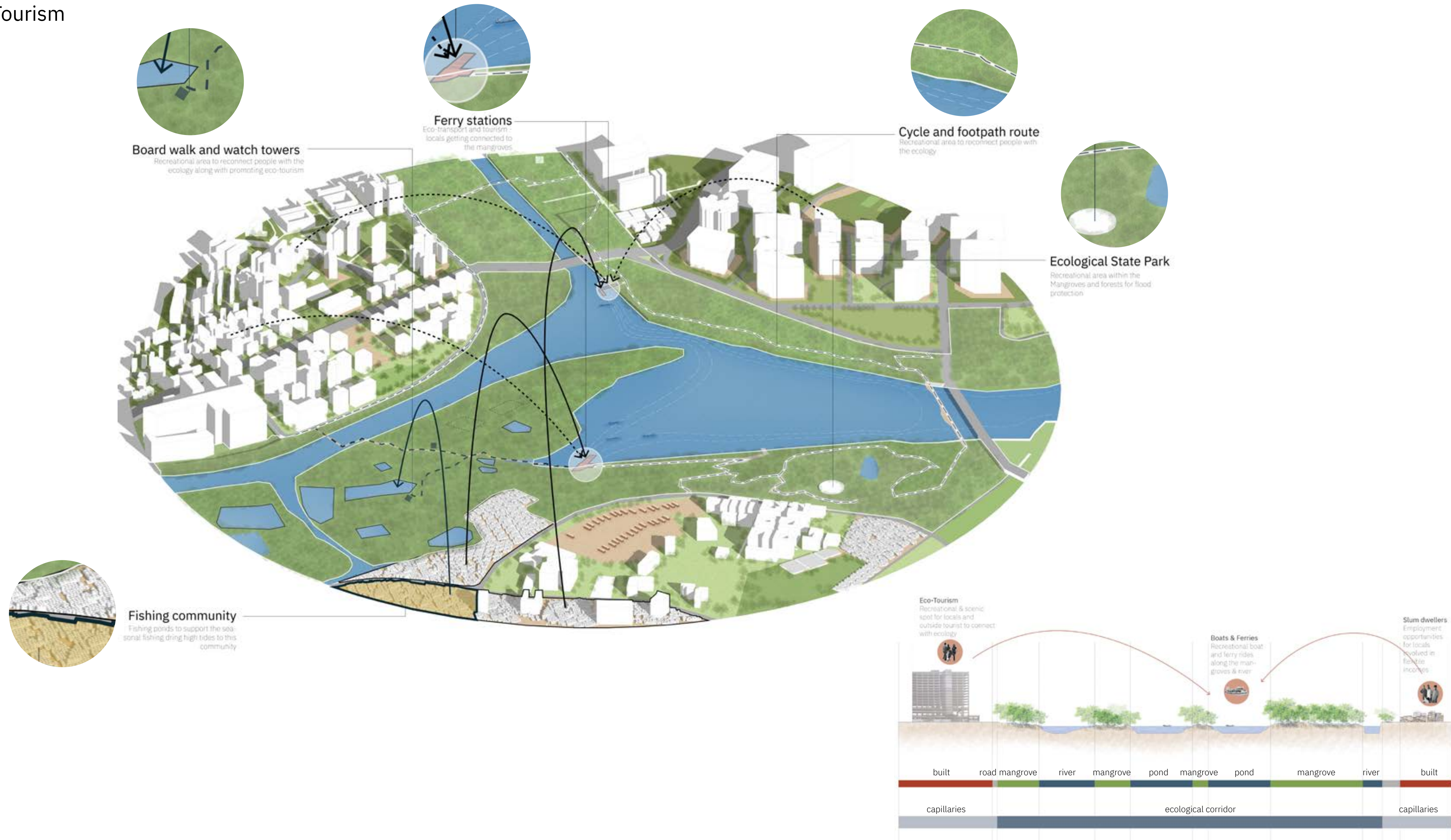
Urban metabolism

Fishing



Urban metabolism

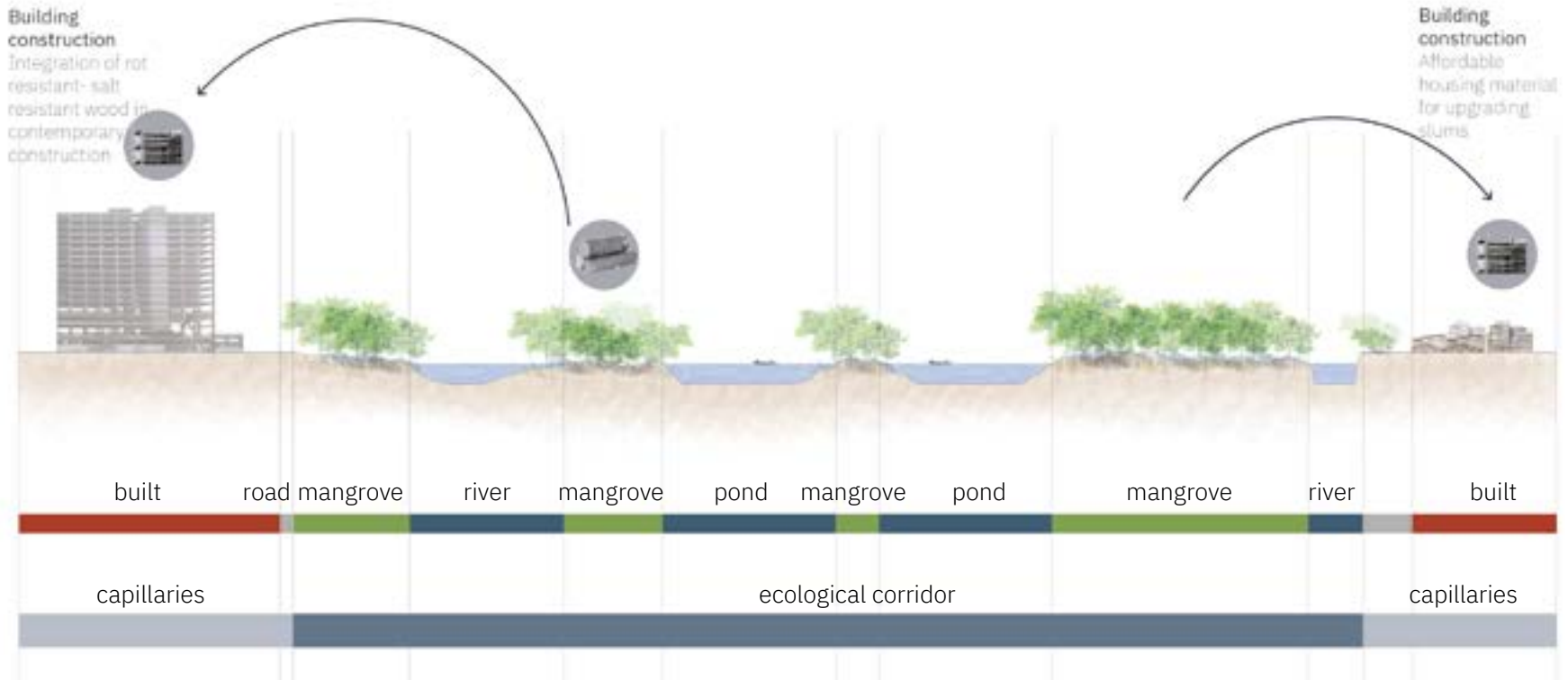
Recreation & Tourism



source: author

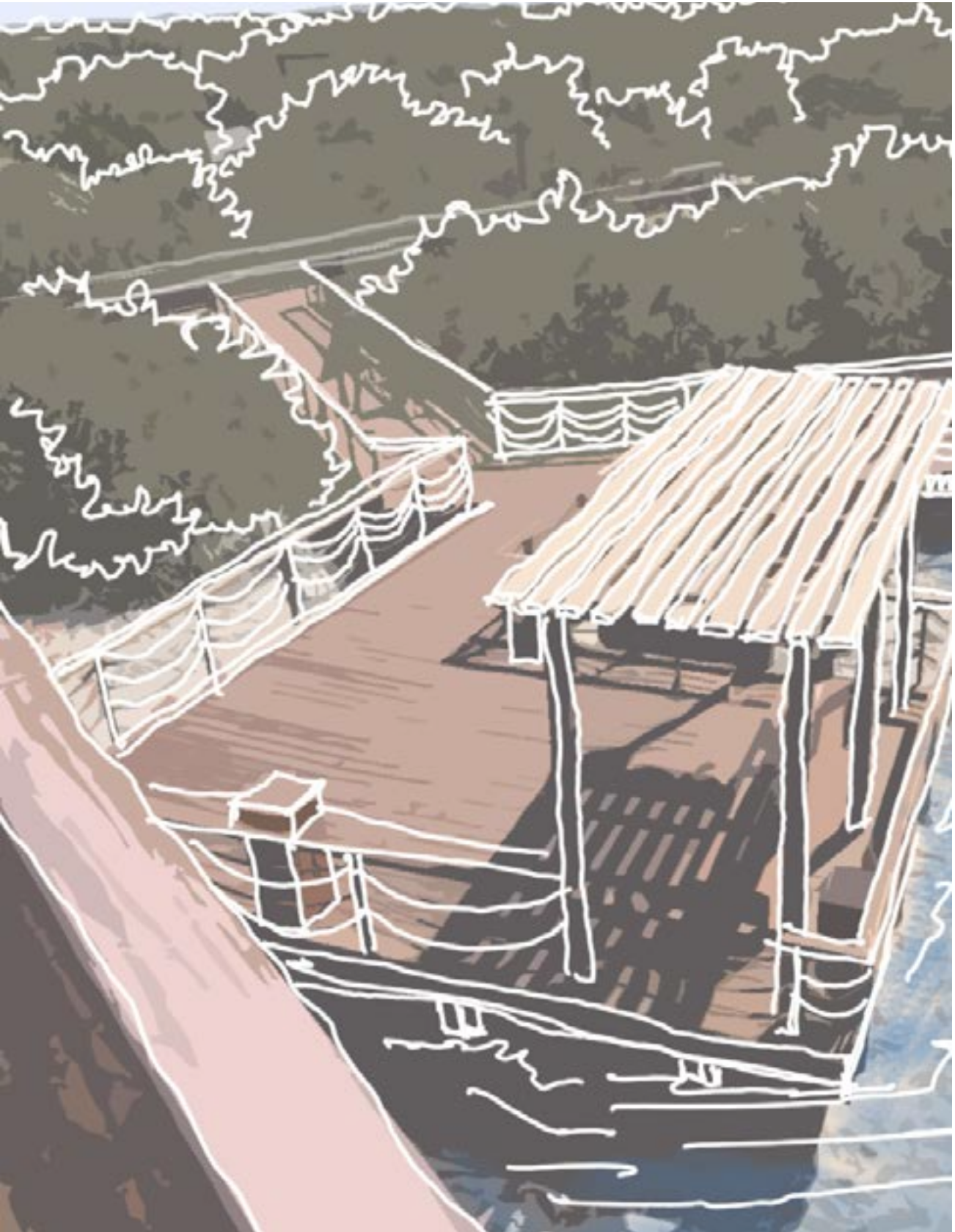
Urban metabolism

Construction

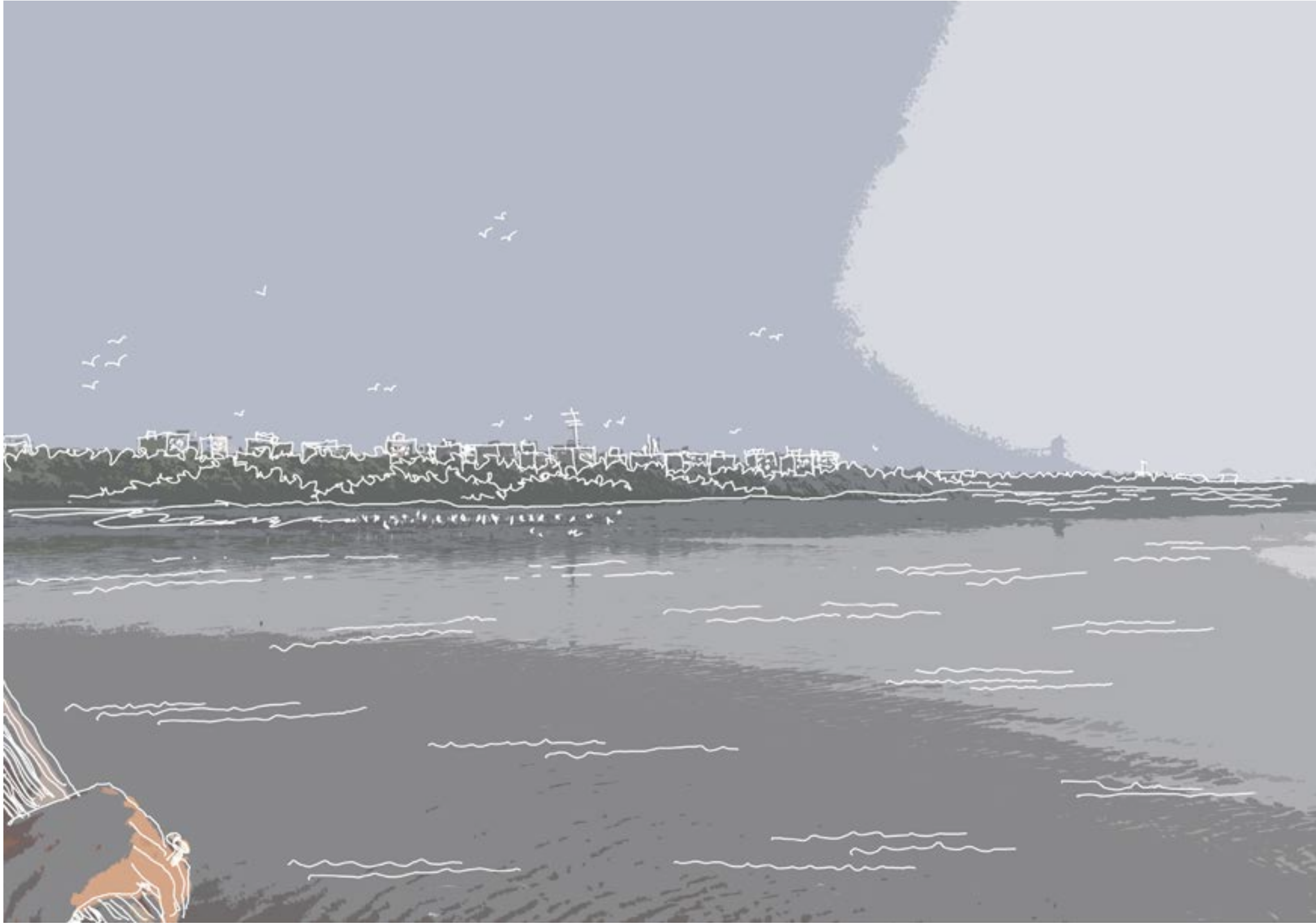


source: author

Spatial Experience



Spatial Experience



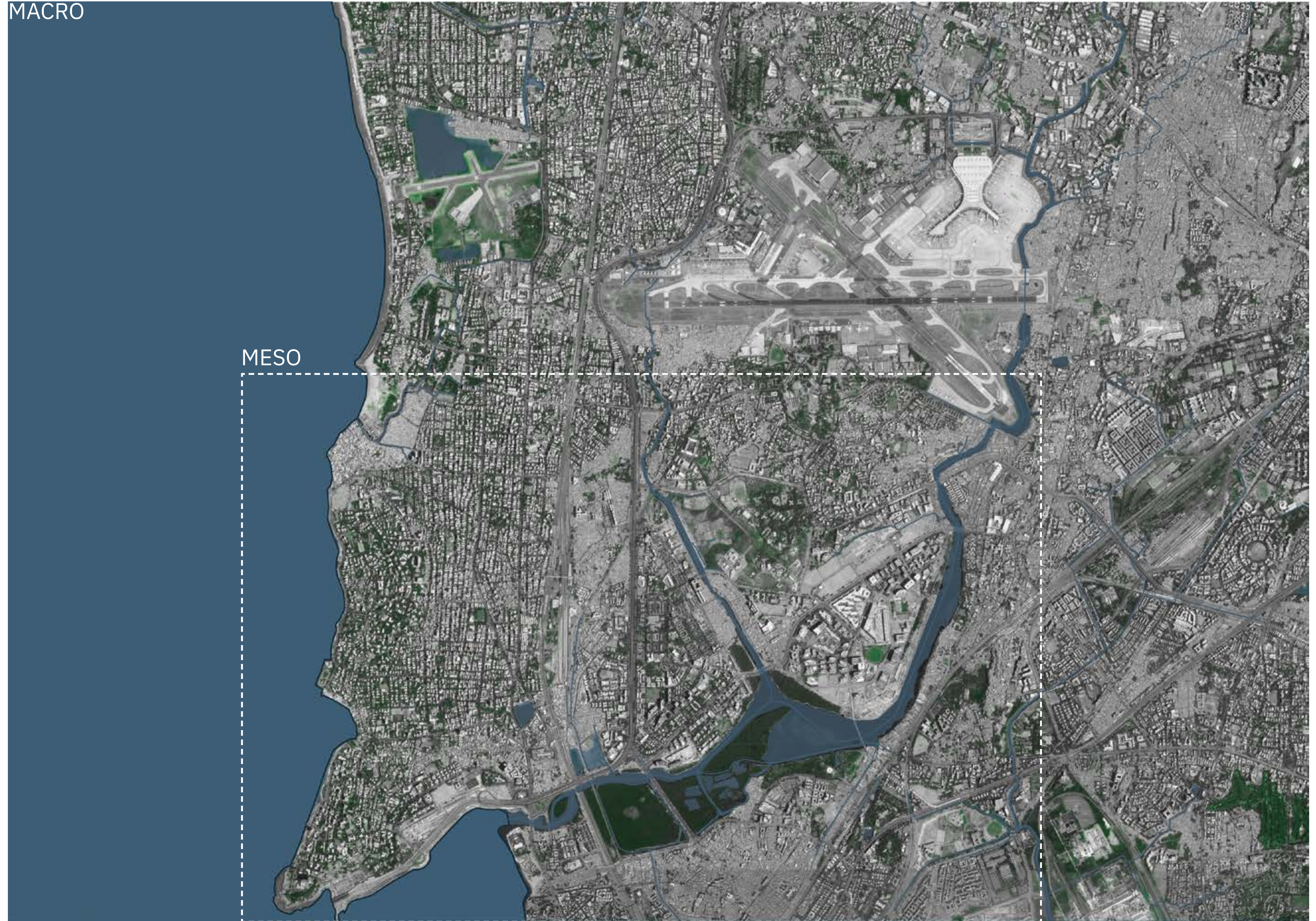
Looking at macro-scale



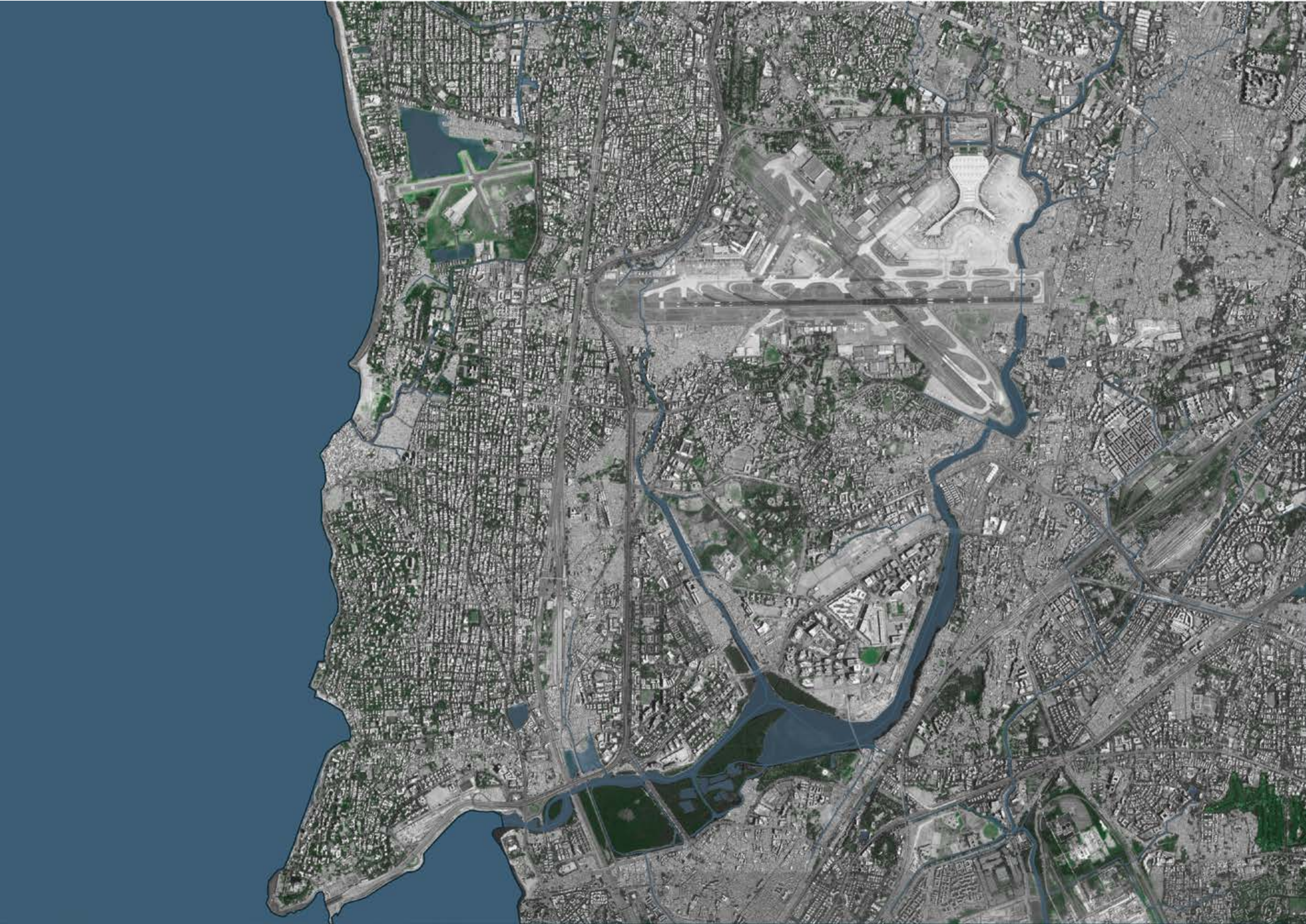
Looking at macro-scale

MACRO

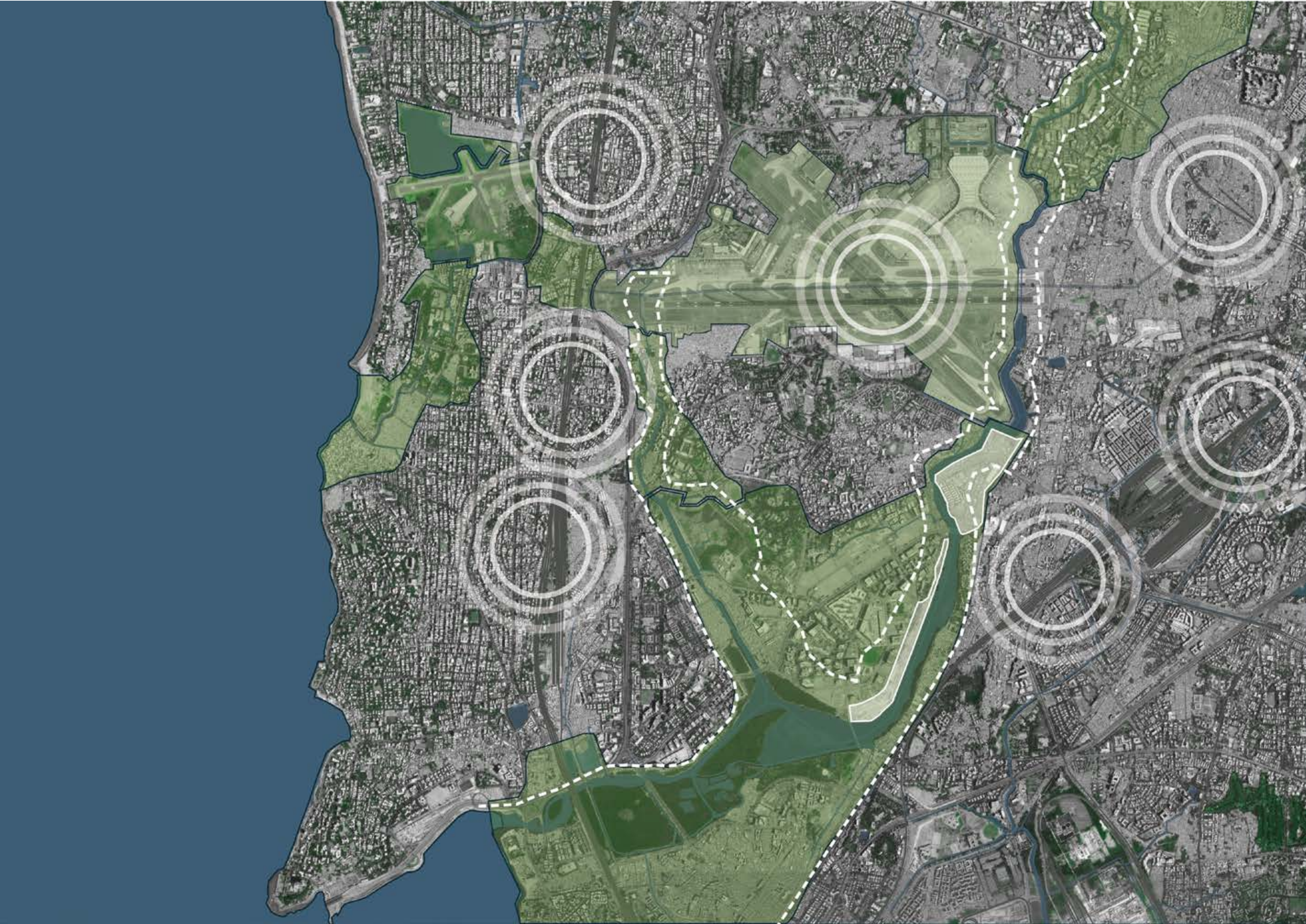
MESO



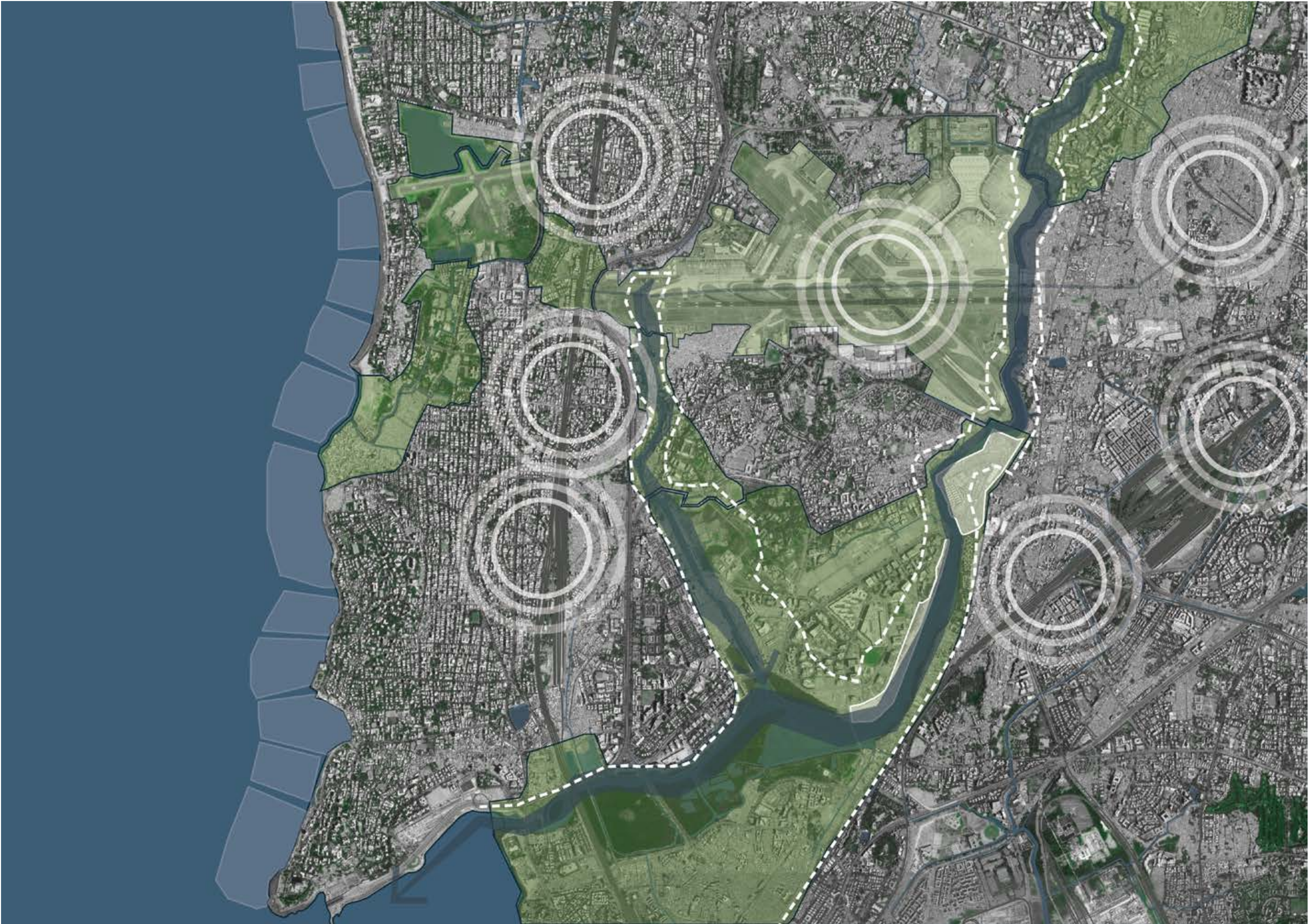
Looking at macro-scale
Synergies



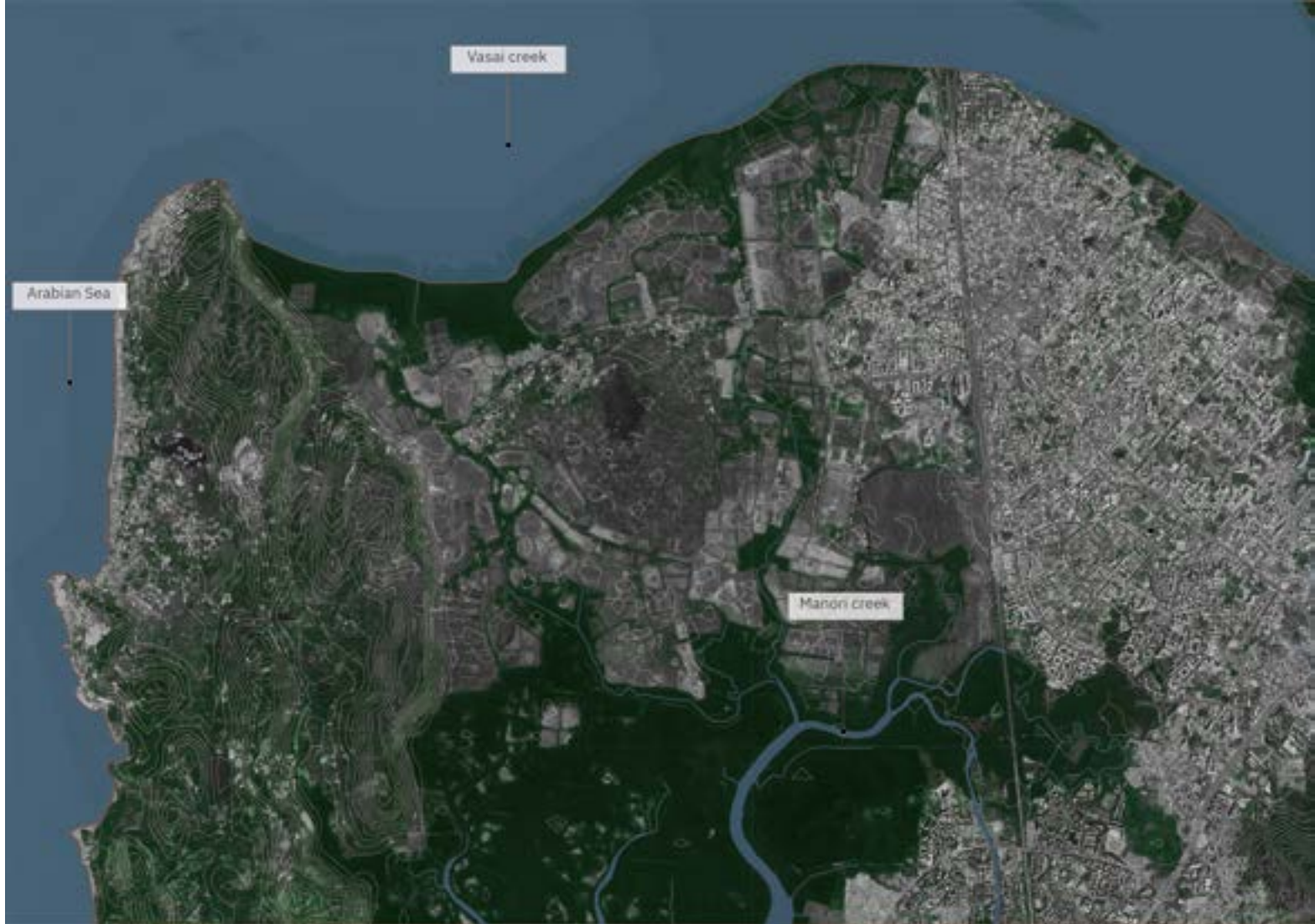
Looking at macro-scale
Synergies



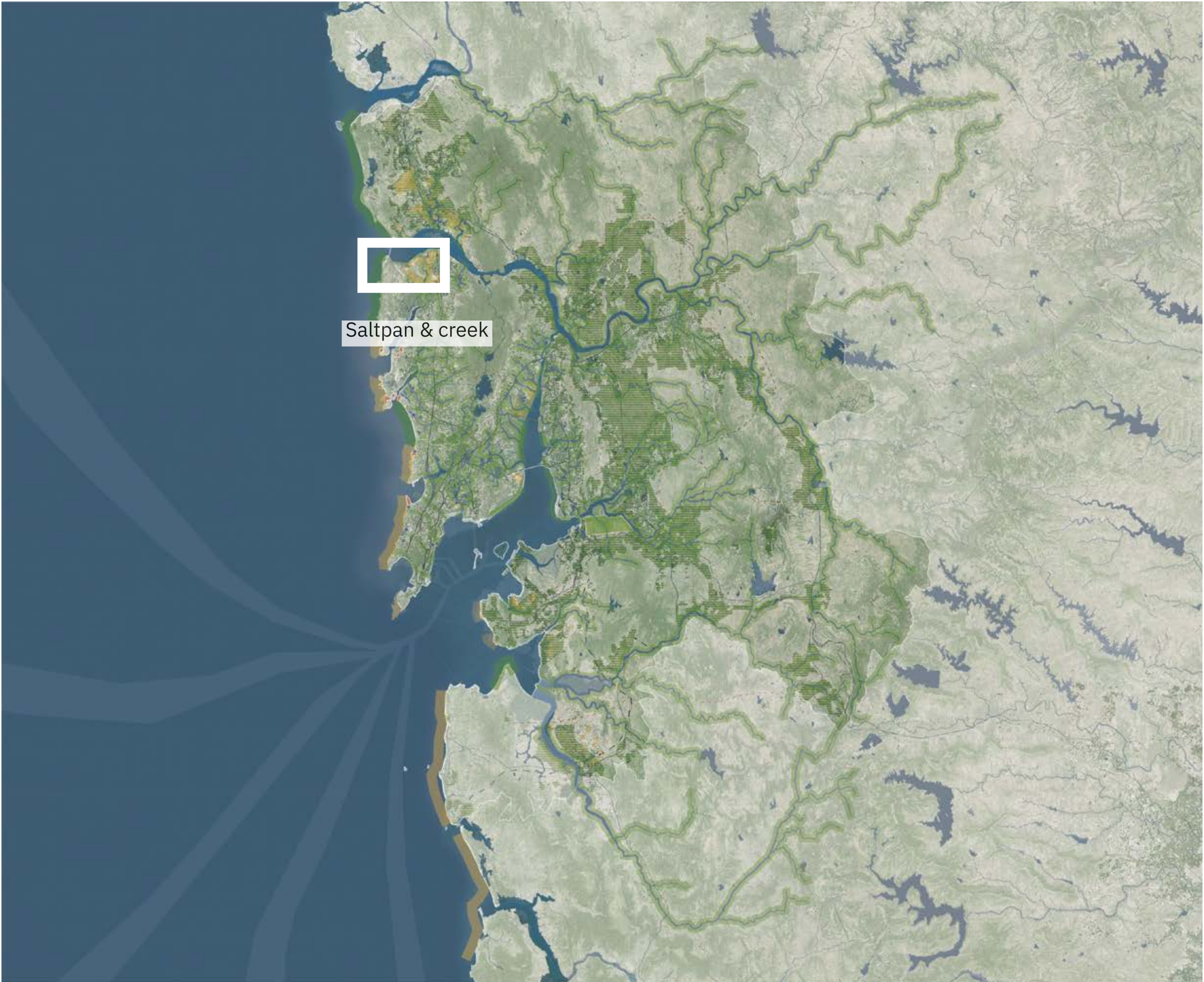
Looking at macro-scale
Synergies



Saltpans & Creek area

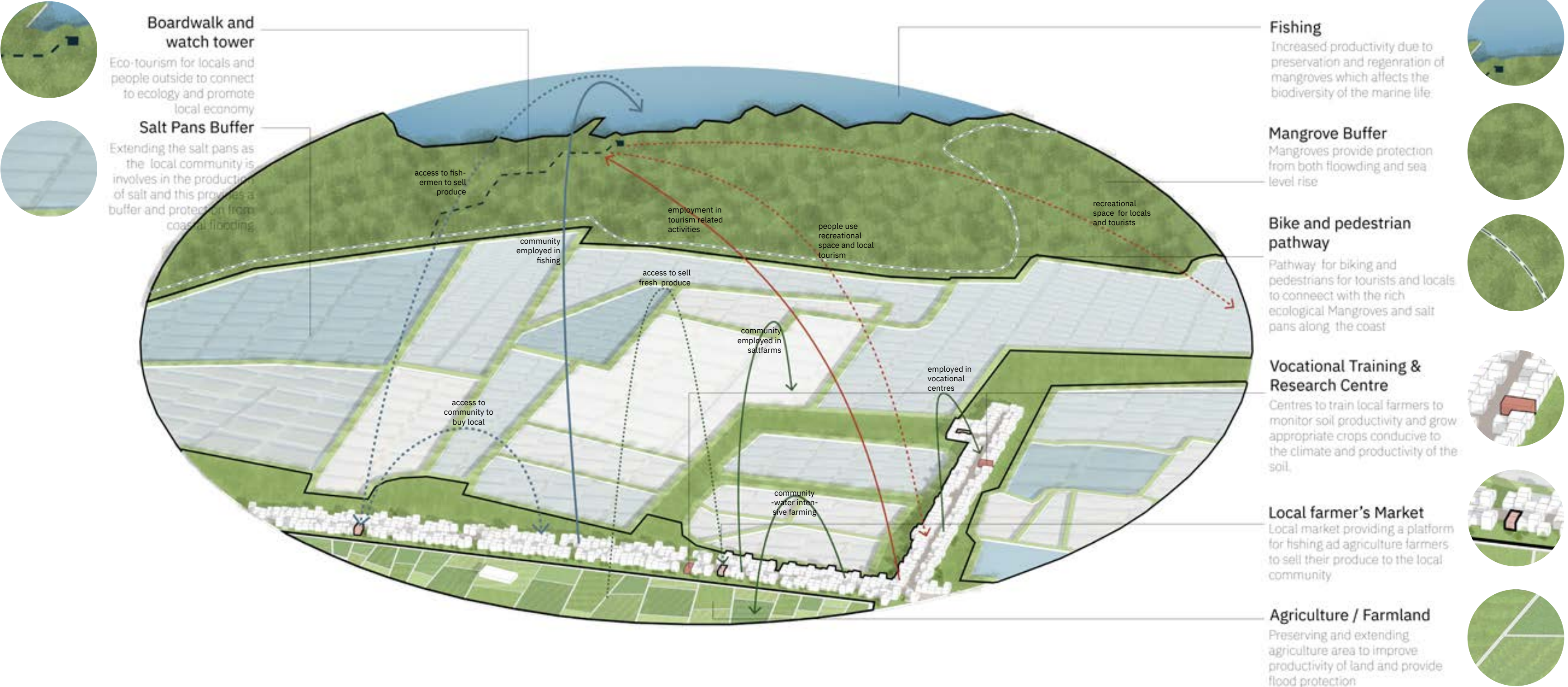


source: author ; zoomearth

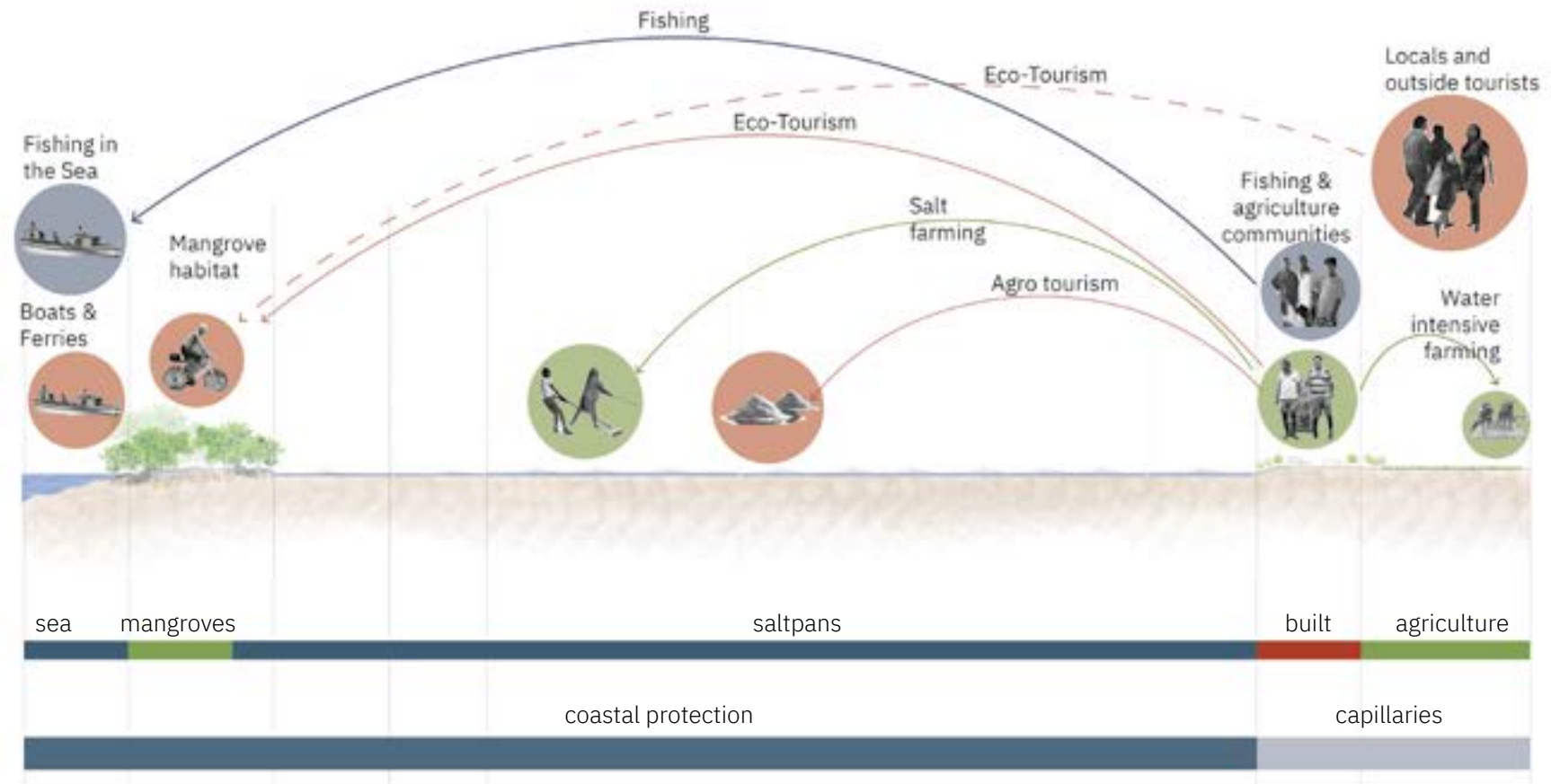


Urban Metabolism

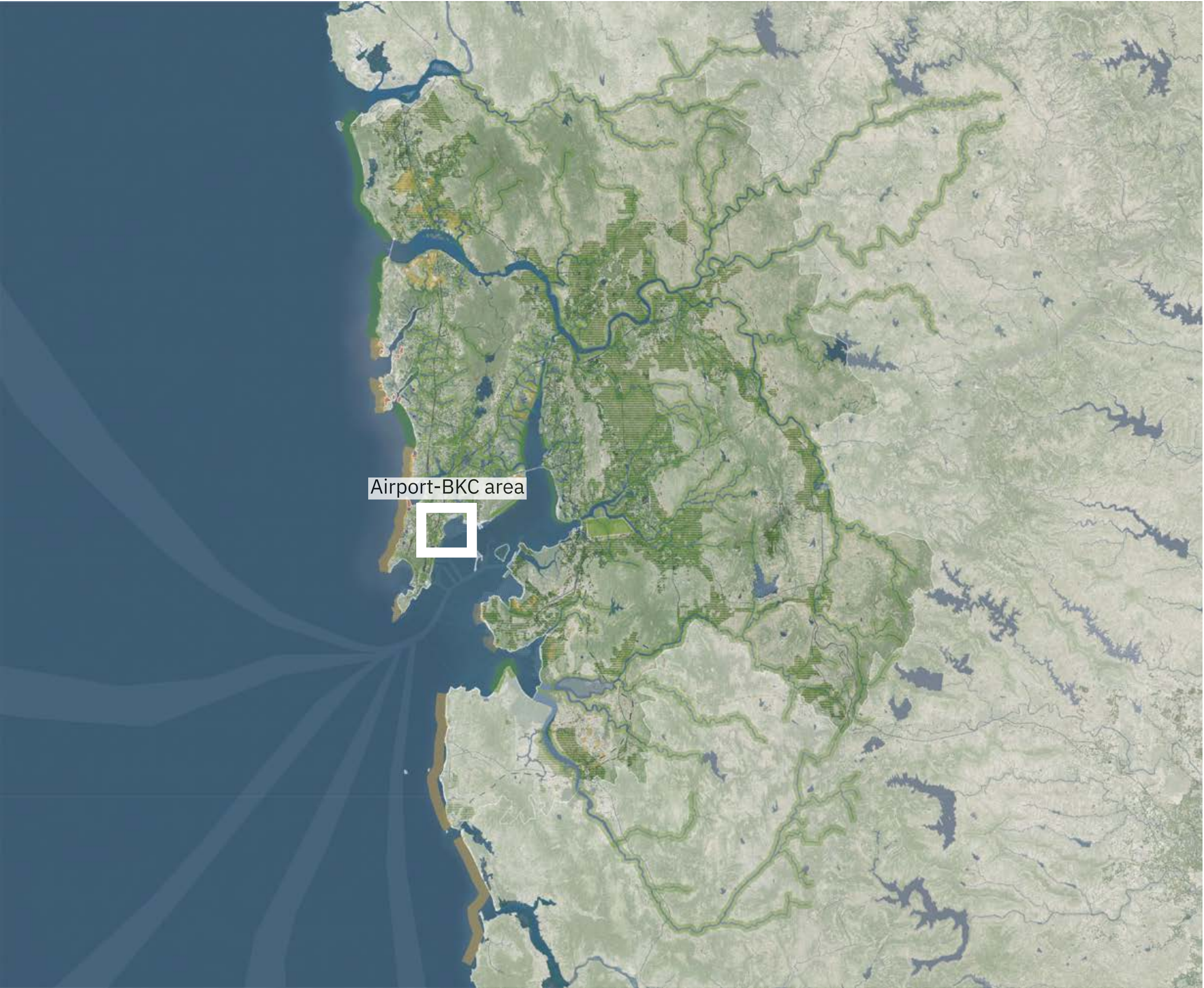
Farming, fishing & Agro-/Eco-tourism



- Tourism- employment generation
- - - → Tourism- service provision
- Farming- employment generation
- - - → Farming- service provision
- Fishing- employment generation
- - - → Fishing- service provision



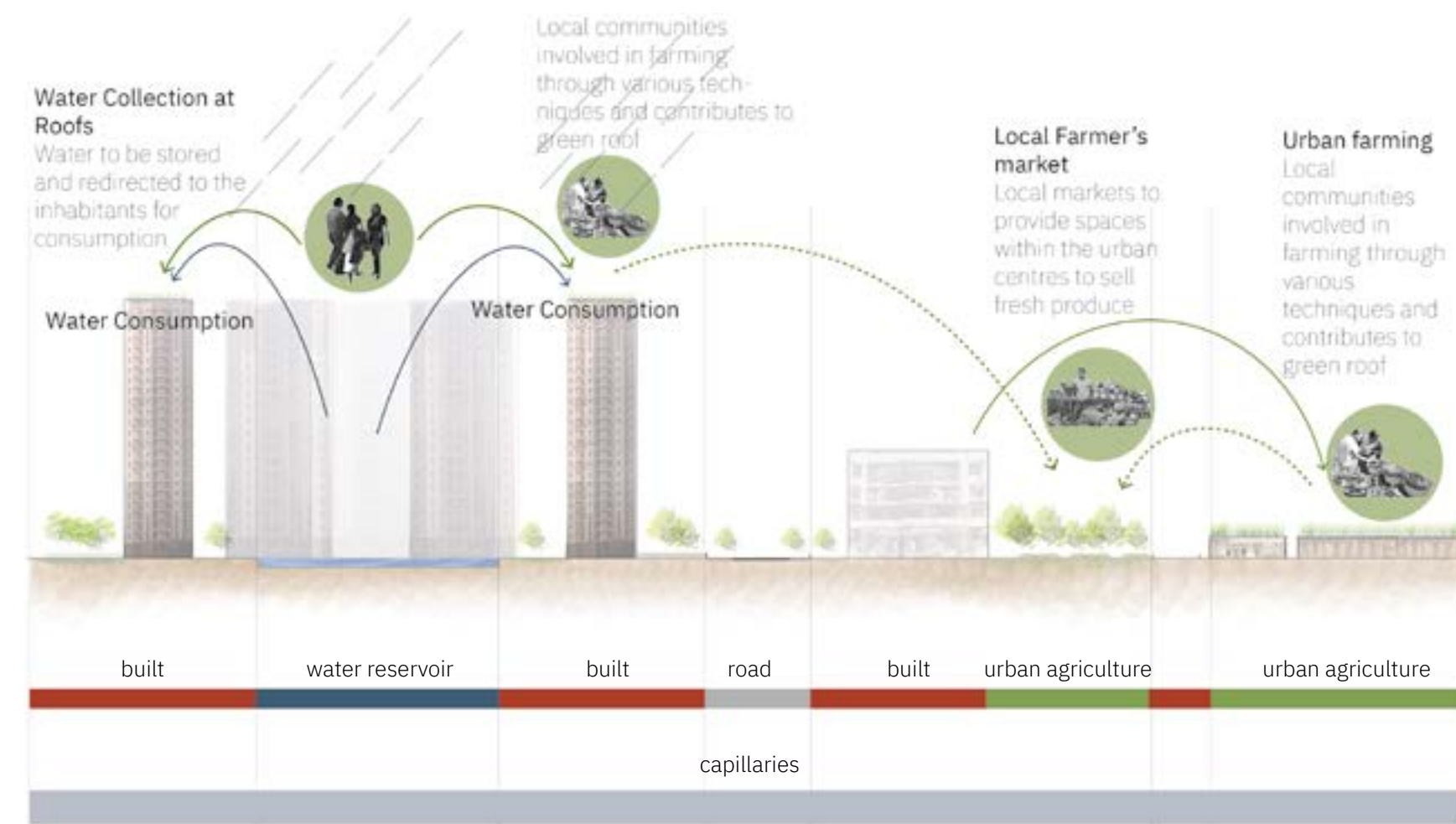
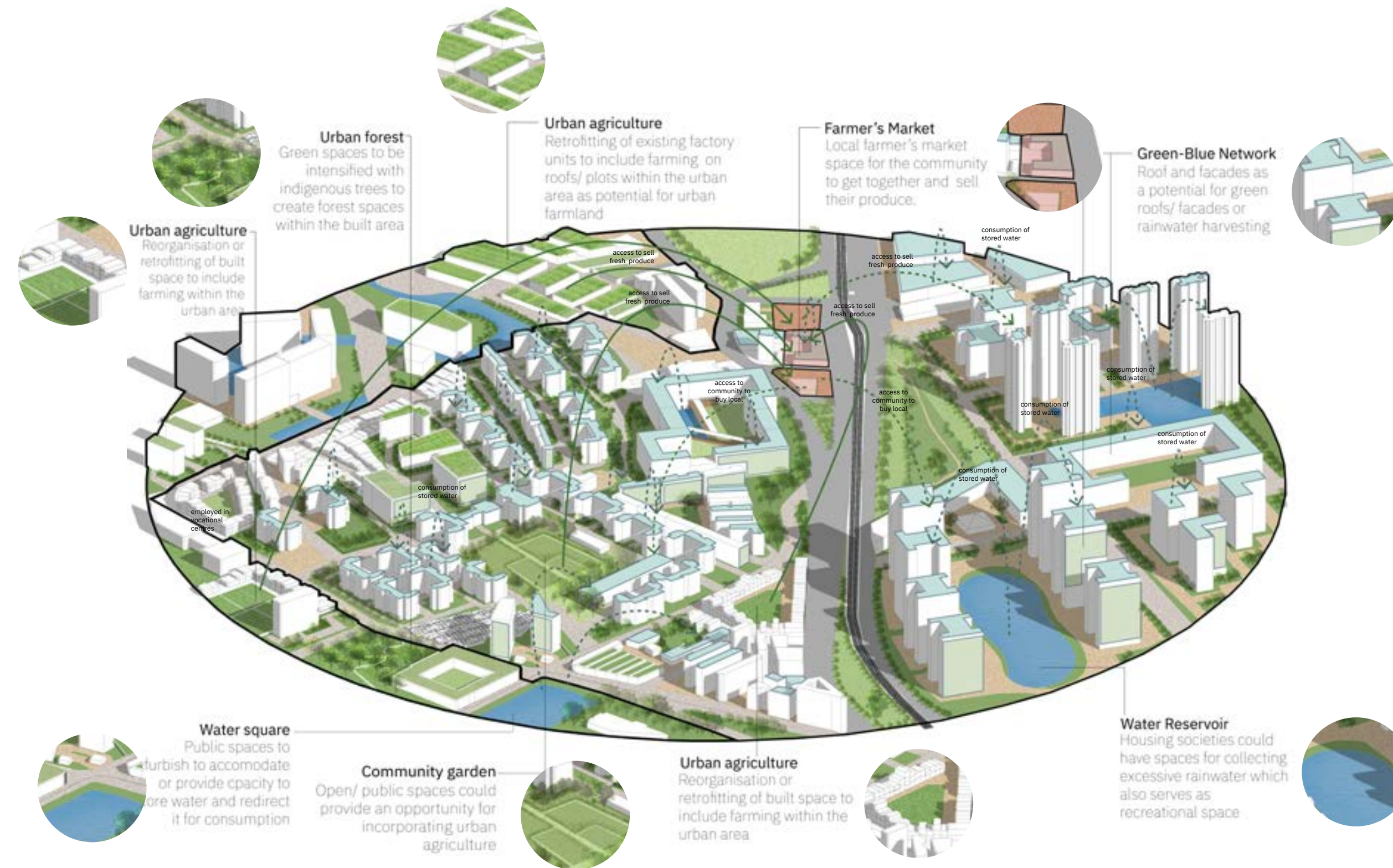
Island City



source: author ; zoomearth

Urban Metabolism

Urban Farming & rainwater harvesting



An aerial photograph of a dense urban area. The image shows a central green park area with a road intersection. The surrounding area is filled with buildings, mostly multi-story residential or commercial structures. The buildings are arranged in a grid-like pattern, with narrow streets and alleys. The colors are somewhat muted, with a lot of grey and brown tones, suggesting older buildings or a specific urban style. The overall impression is one of a highly populated and developed city center.

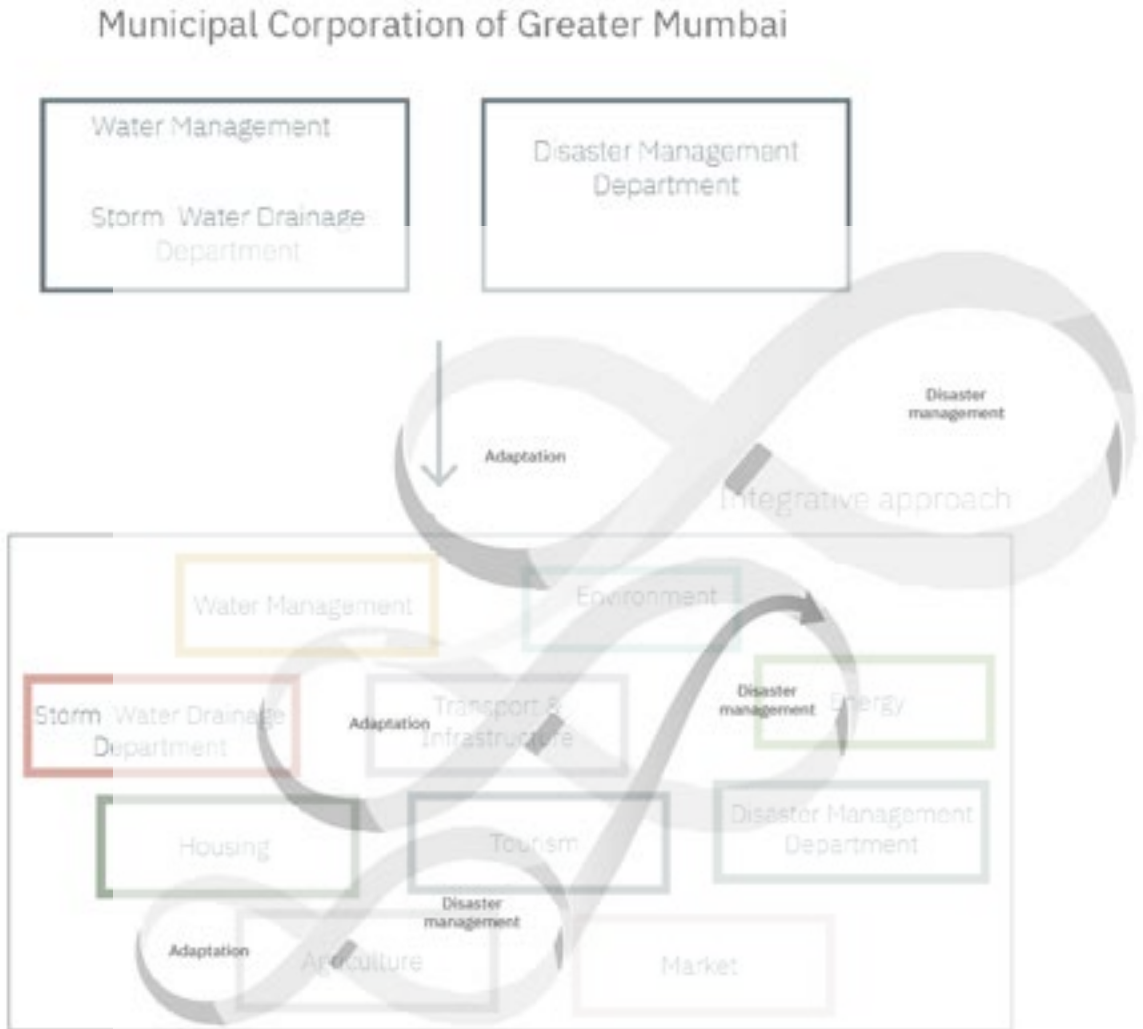
Planning framework

Actors, institution, processes and instruments

Planning framework



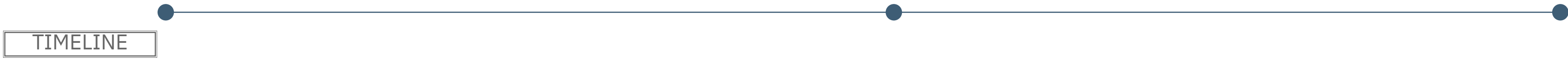
Planning spatial strategies



Planning Approach



Governance structure



TIMELINE

PLANNING INSTRUMENTS

Fiscal Instruments •



Regulating Instruments •



Informative Instruments •



STAKEHOLDERS

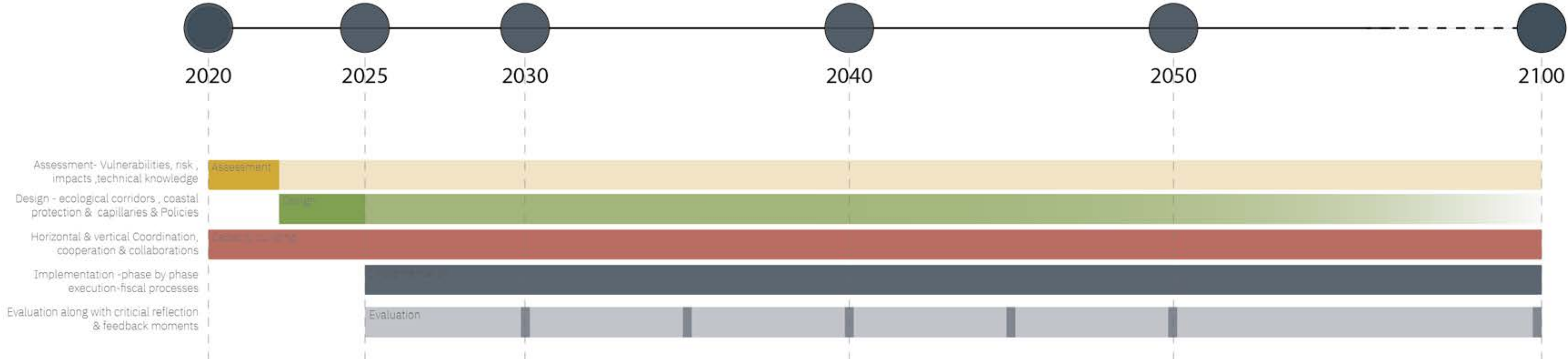


Planning of the Spatial strategies

Steps involved



Process

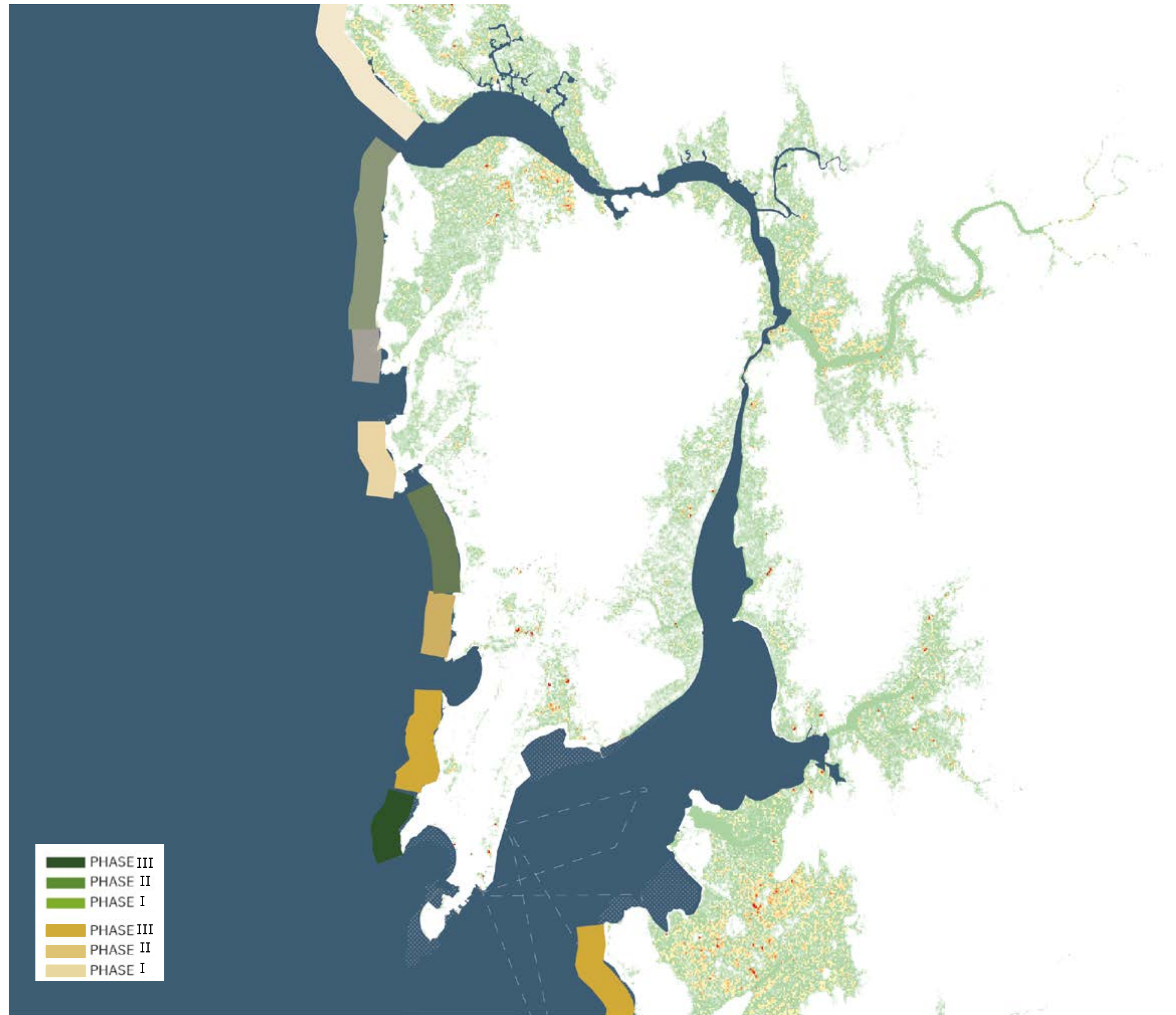


Timeline Ecological Corridor



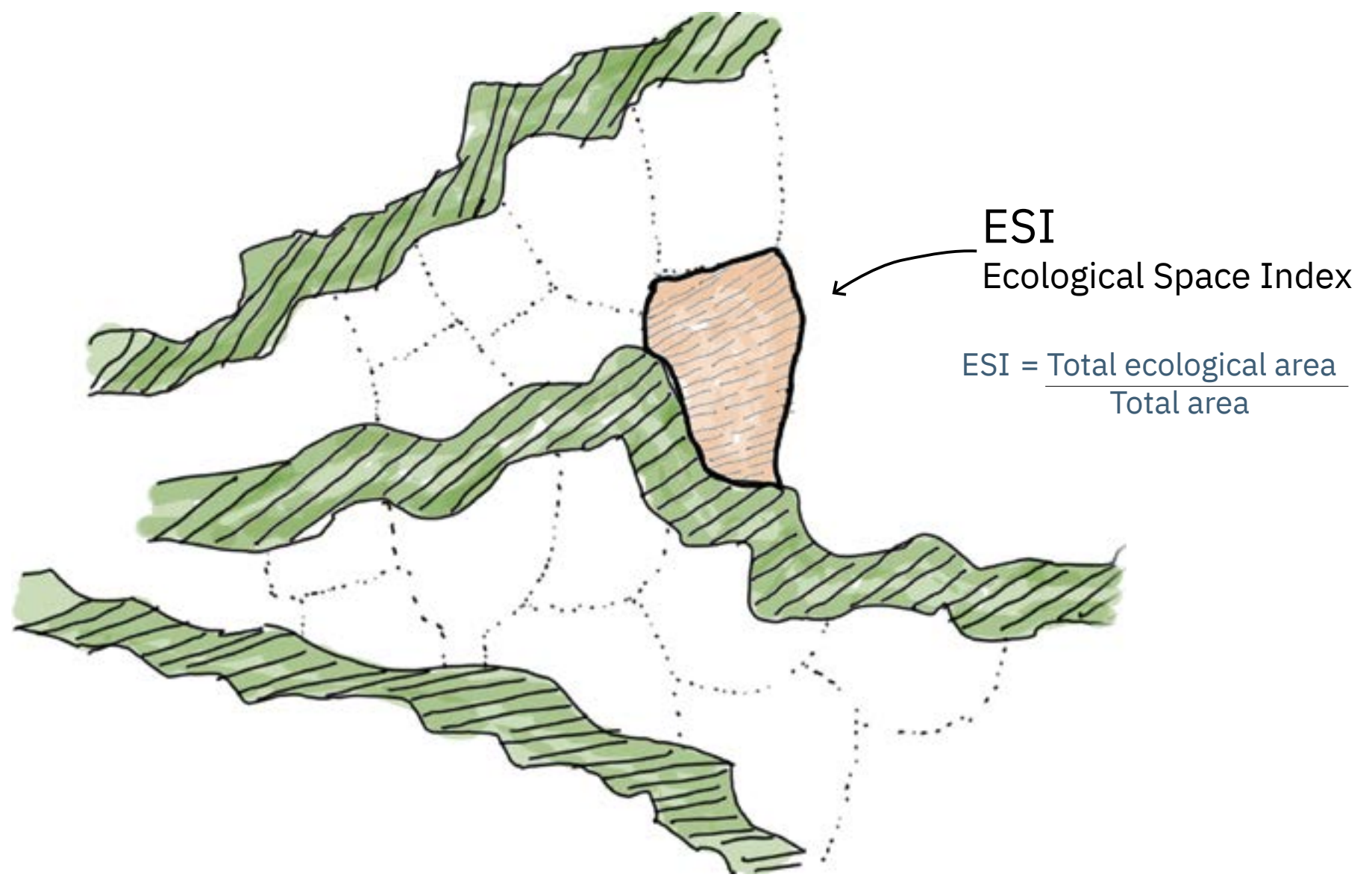
Timeline

Coastal protection

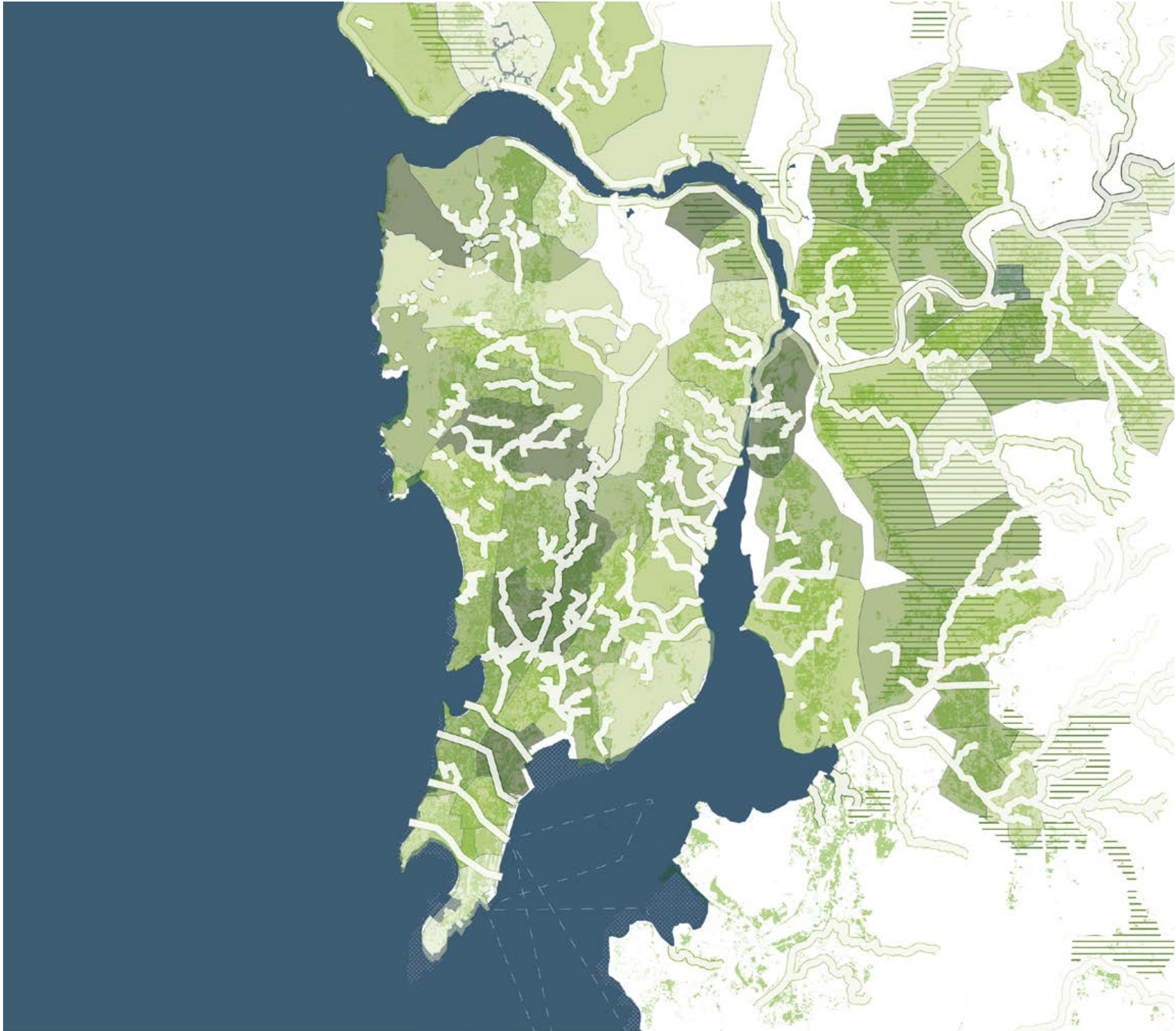
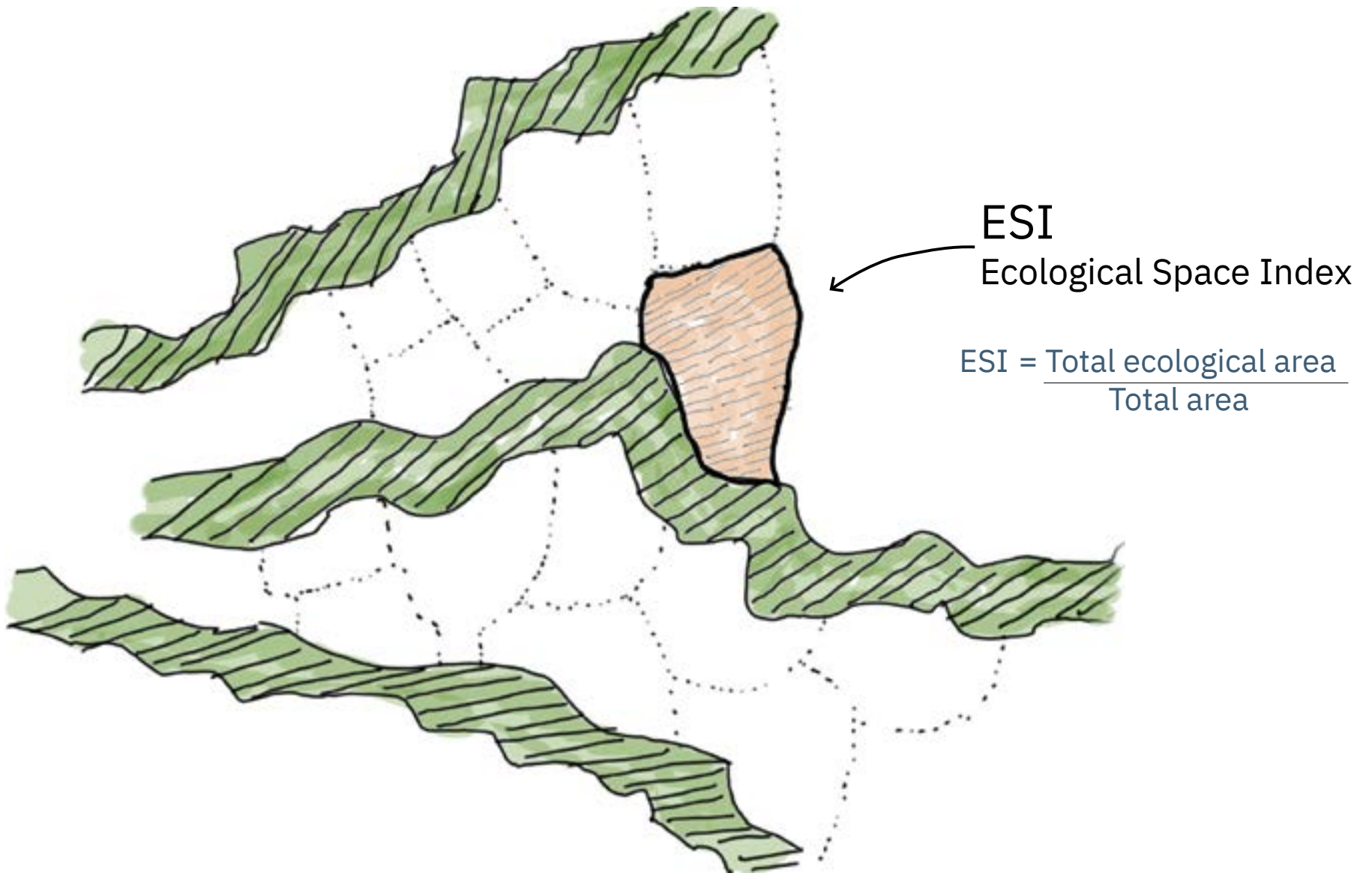


Timeline

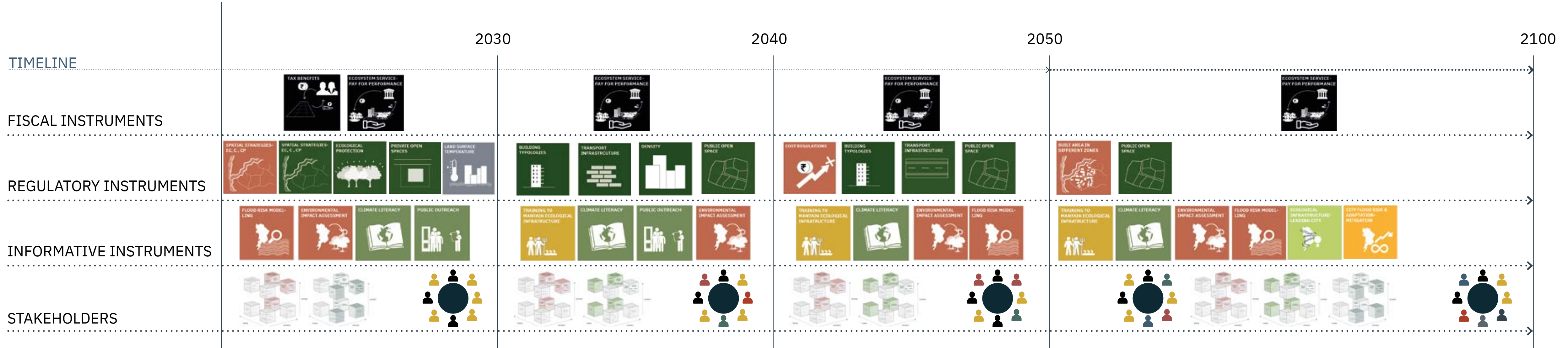
Capillaries



Timeline
Capillaries



PLANNING CAPILLARIES

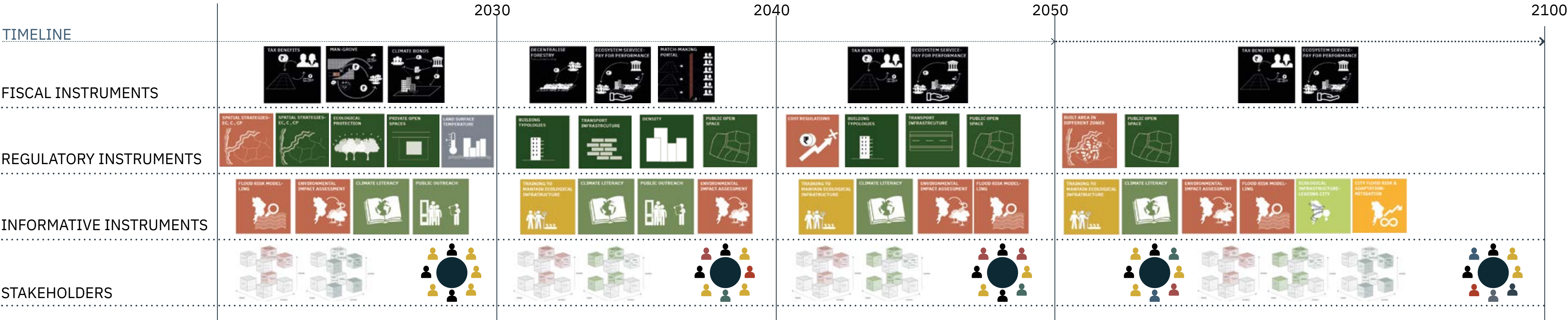


ECOLOGICAL SPACE INDEX



Gradual transformation with community participation to match up to the ecological space index on the target decided by each ward / administrative unit for ESI

PLANNING CORRIDORS

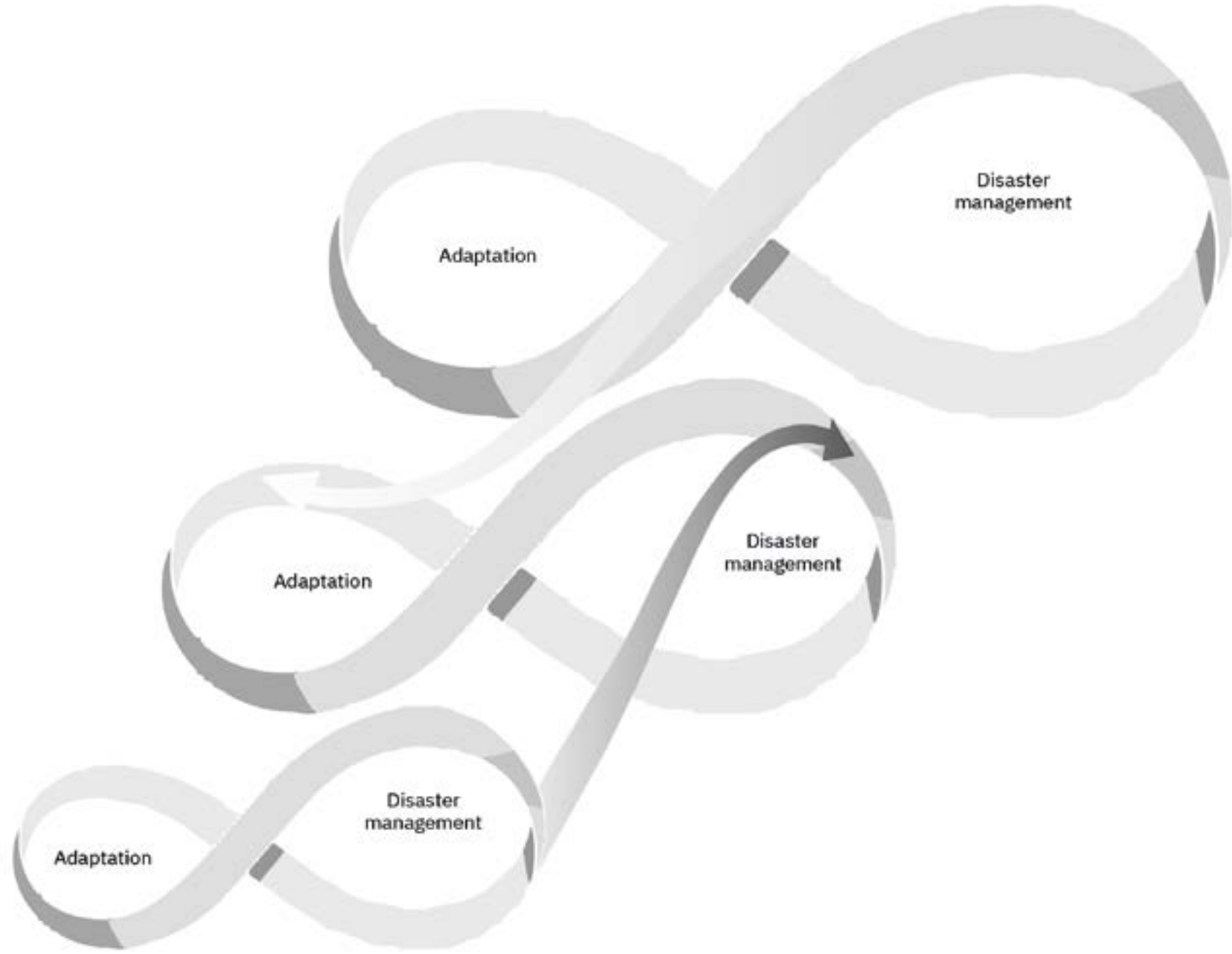
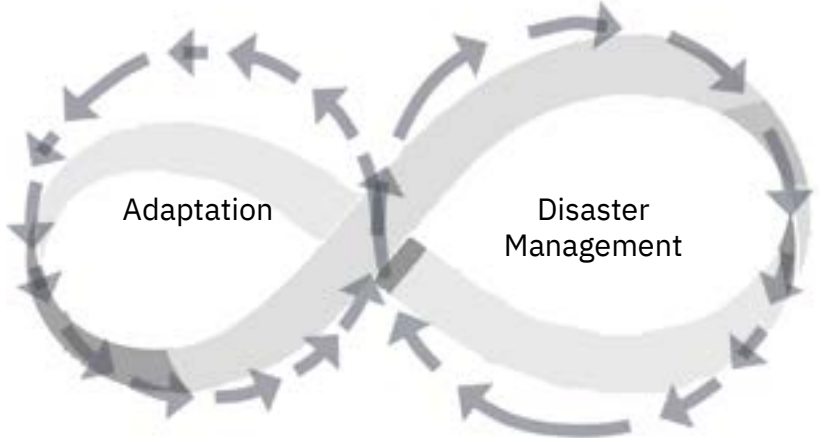
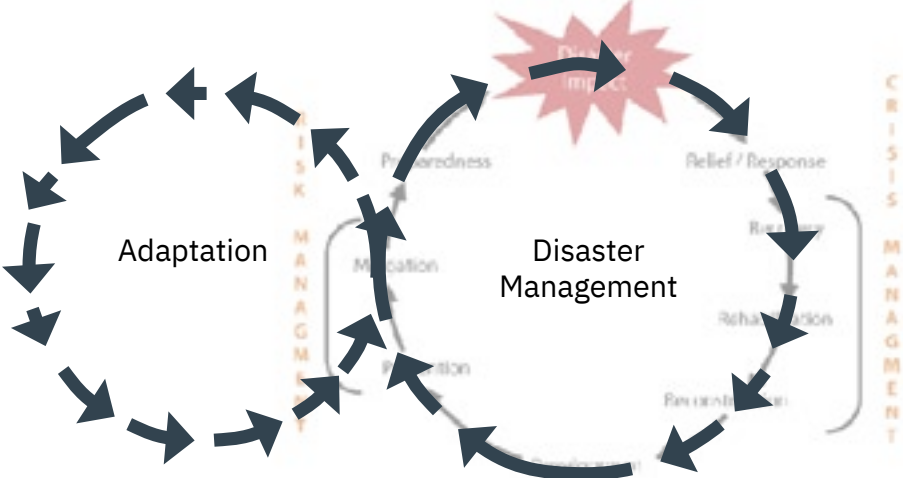


source: author

Planning approach

Integrate Adaptation

Disaster Management Cycle



source: author based MCGM; Gudenrson & Holling, 2002

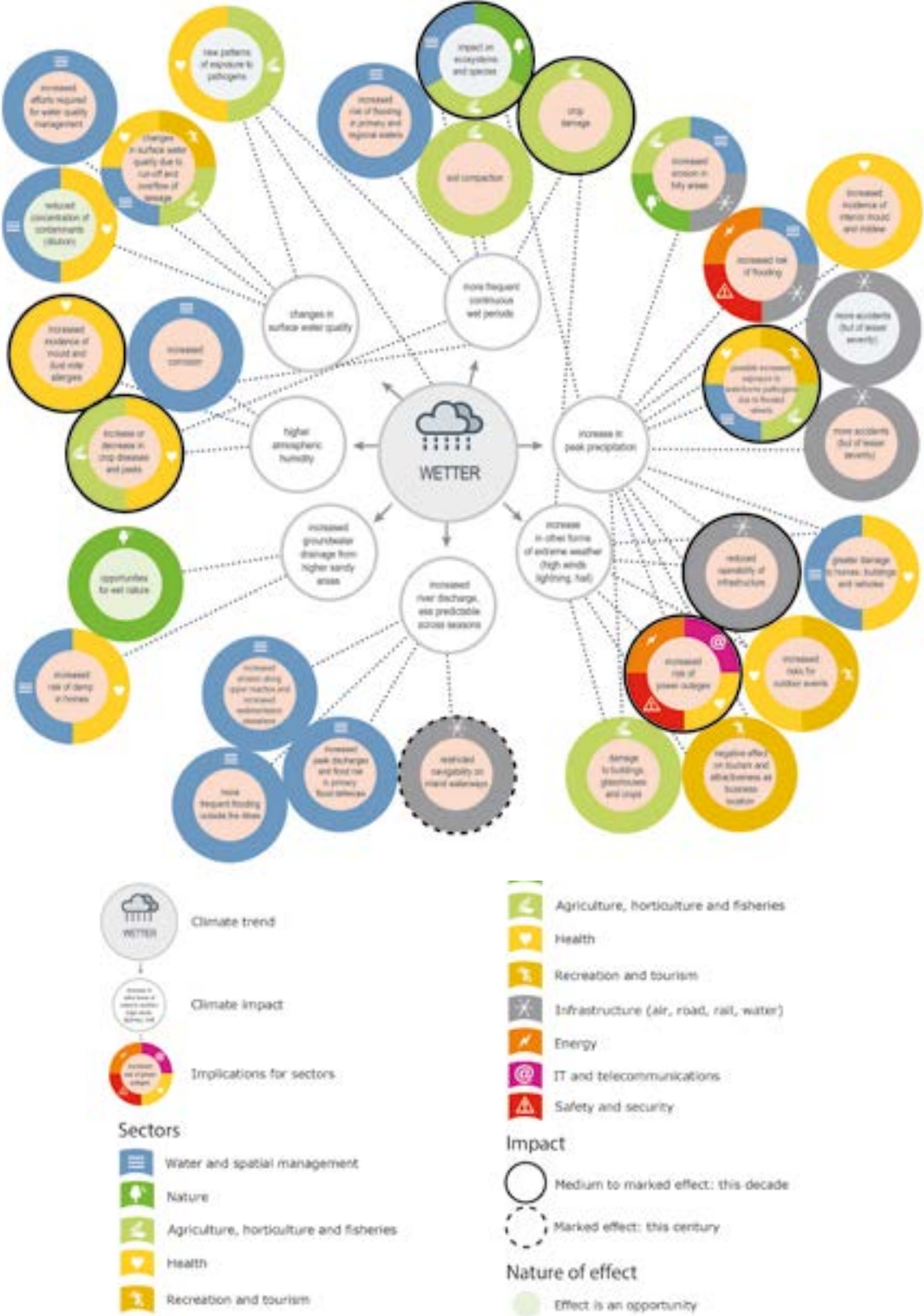
Governance structure -Adaptation

Integrated approach

Municipal Corporation of Greater Mumbai



Integrative approach

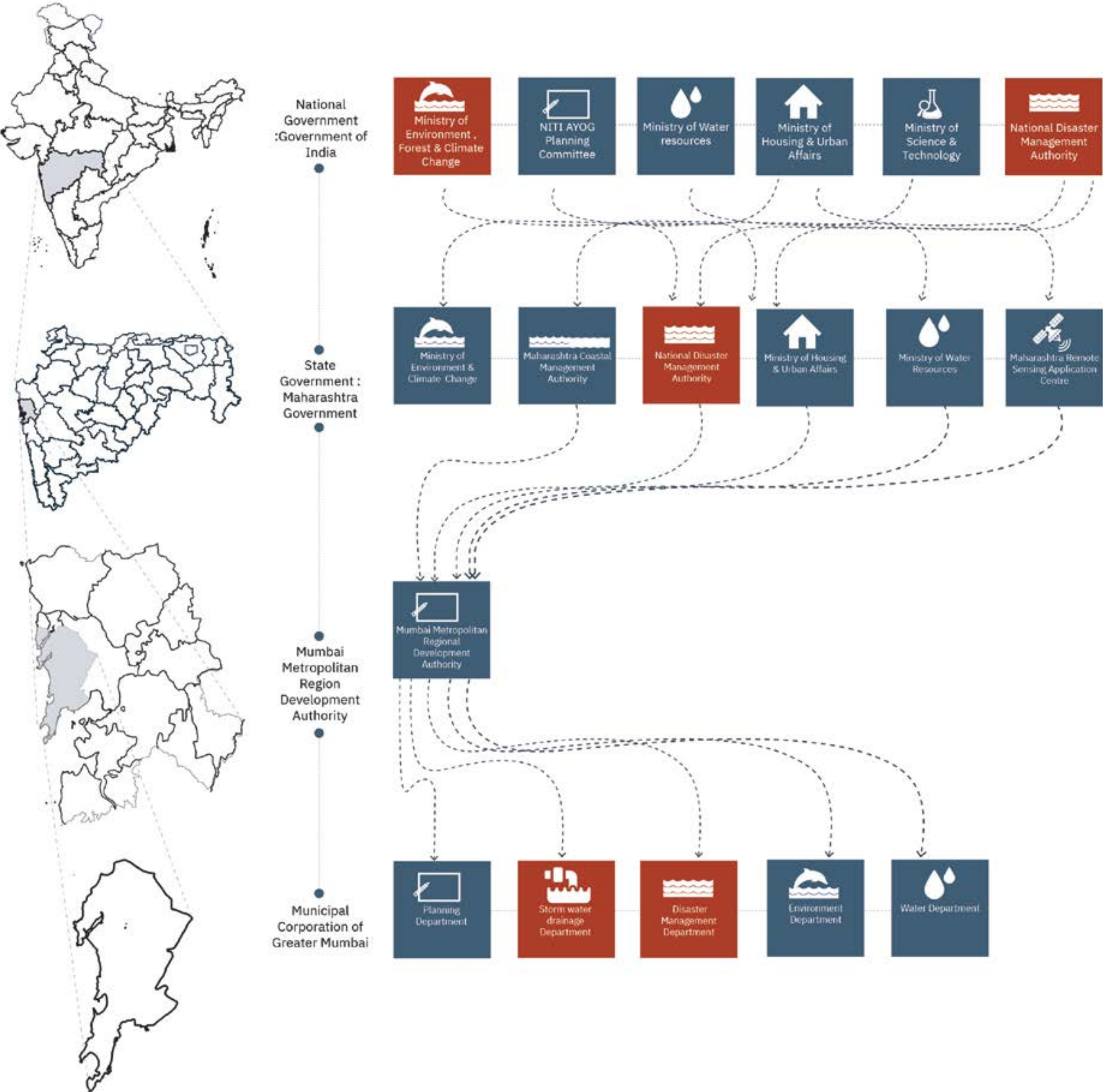


Governance structure -Adaptation



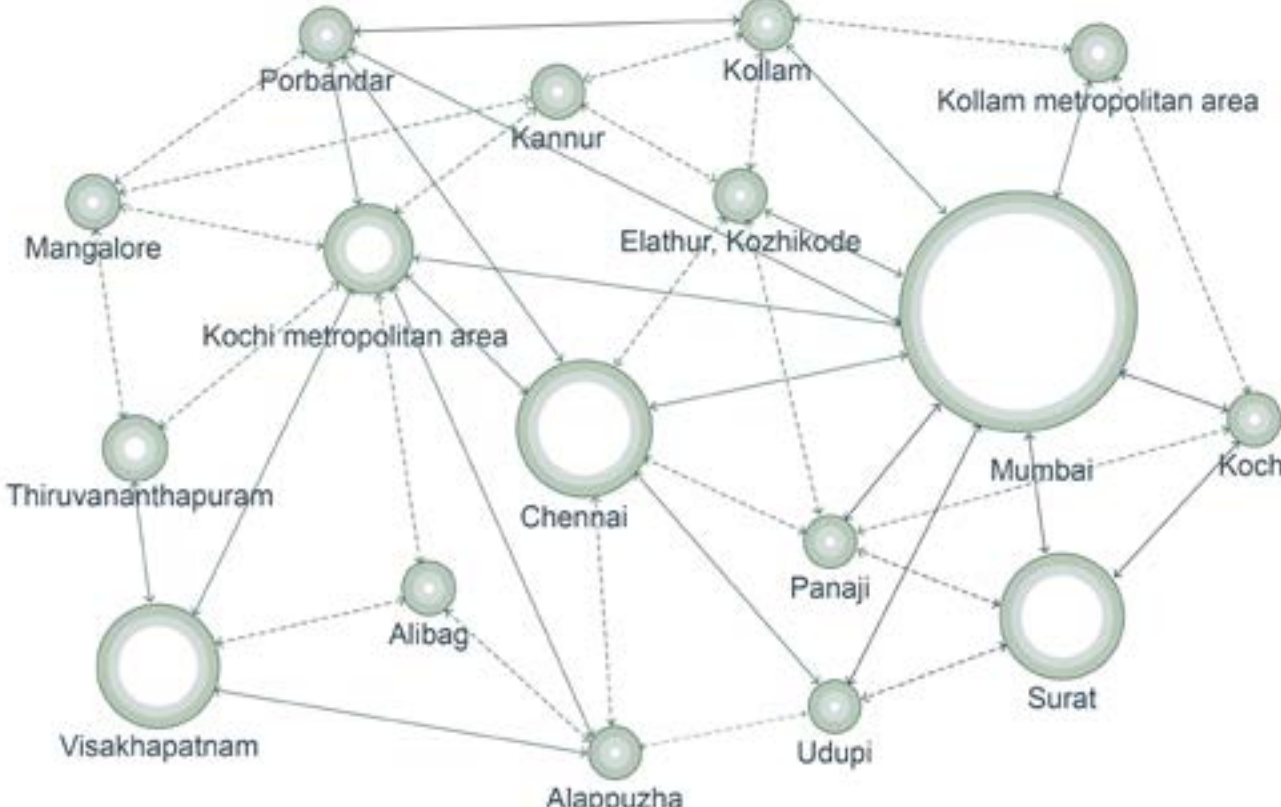
source: author

Governance structure -Adaptation



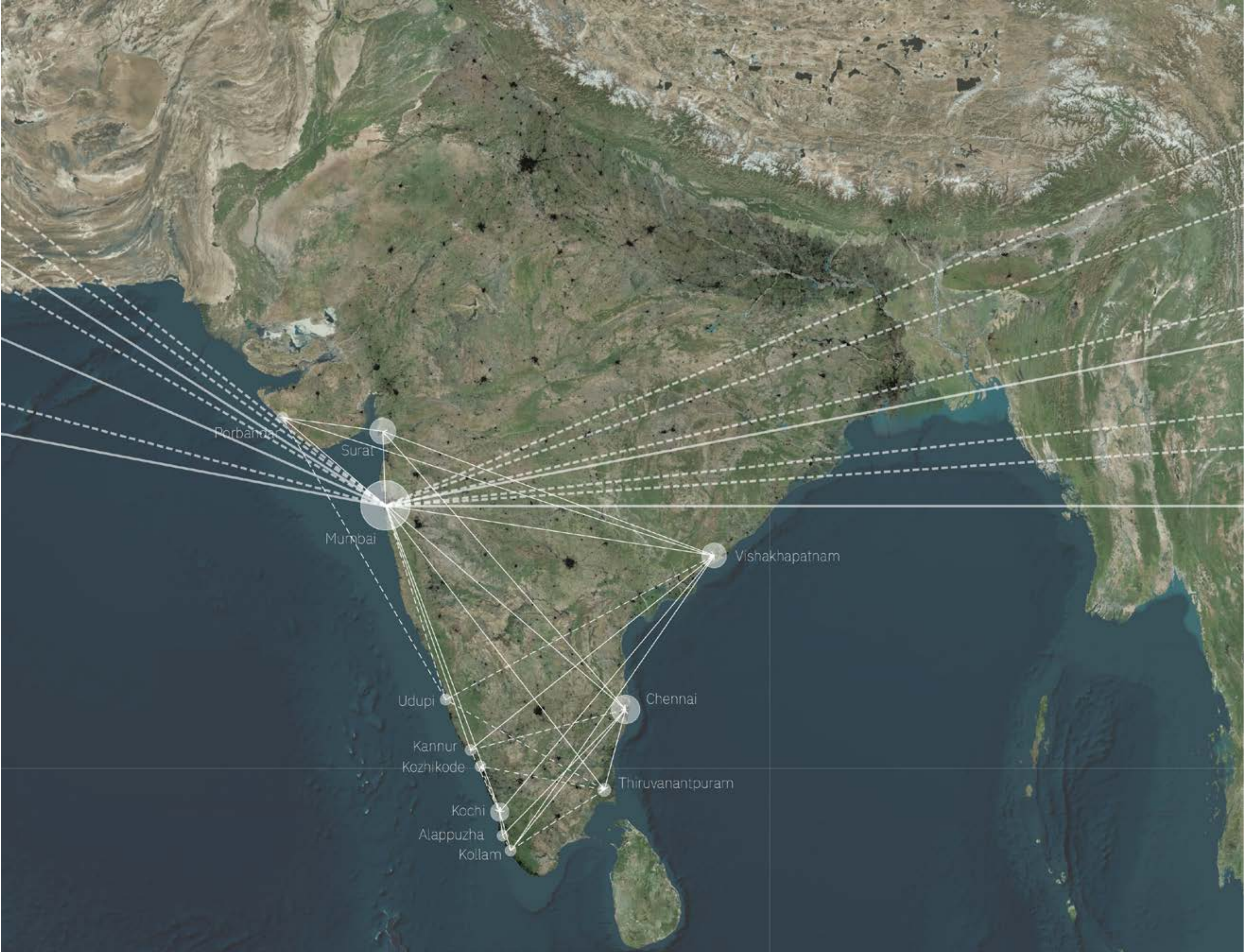
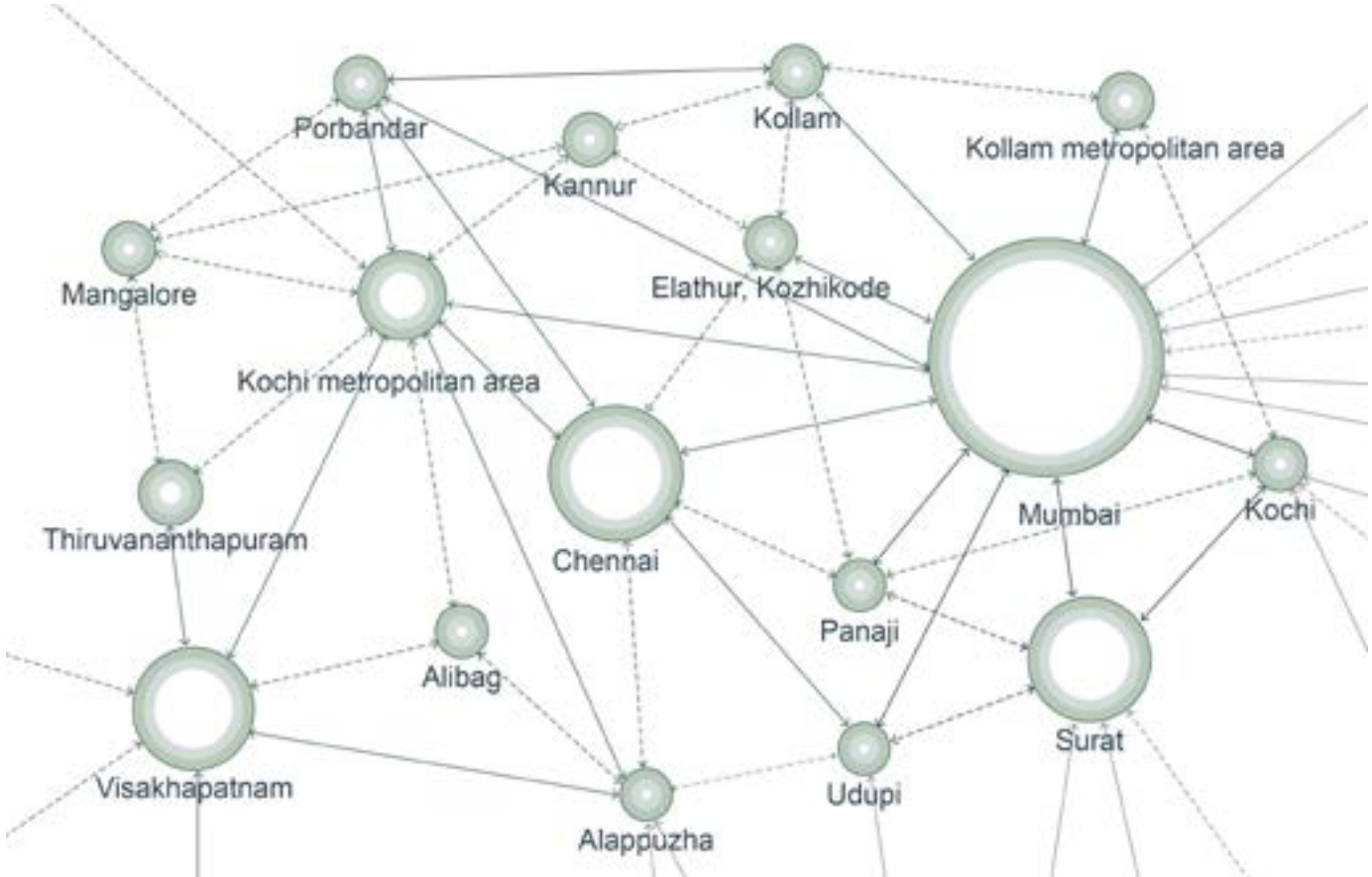
Governance structure

Collaboration across Coastal Cities



Governance structure

Global Collaboration



An aerial photograph of a dense urban neighborhood, likely in a tropical region, characterized by numerous multi-story buildings with flat roofs and a high density of palm trees. A central roundabout is visible, surrounded by a circular green space. A semi-transparent white rectangular box is overlaid on the center of the image, containing the word "Conclusion" in a black, sans-serif font.

Conclusion

Conclusion & Discussion

- **Confluence of Socio-economic system with ecology**
- **Transferability**
- **Ecological Space Index**
- **Adaptation and Collaboration is the key to tackle Climate Change**
- **Climate Literacy**



Reflection

- A Ray of Hope



Reflection

- A Ray of Hope

- Mitigation is not forgotten



Reflection

- **A Ray of Hope**

- **Mitigation is not forgotten**

- **Rethinking Scales**

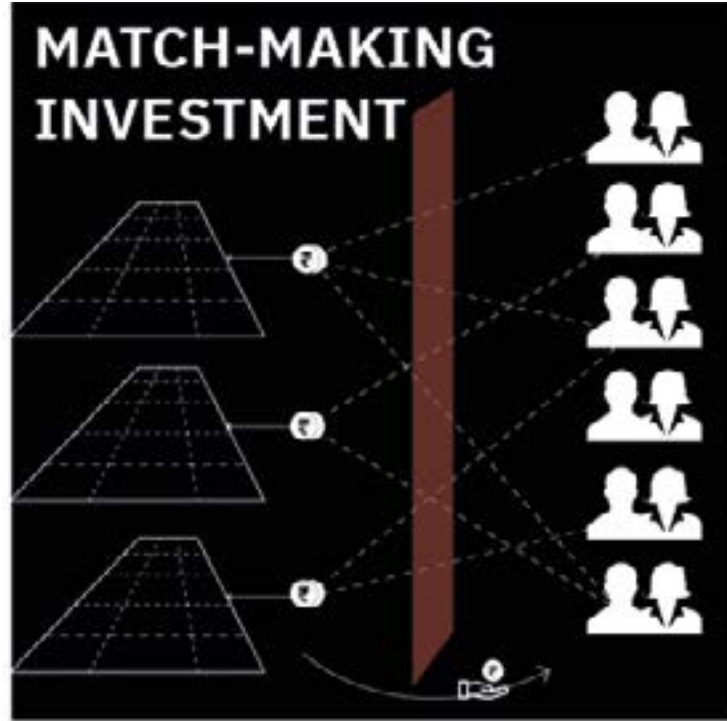
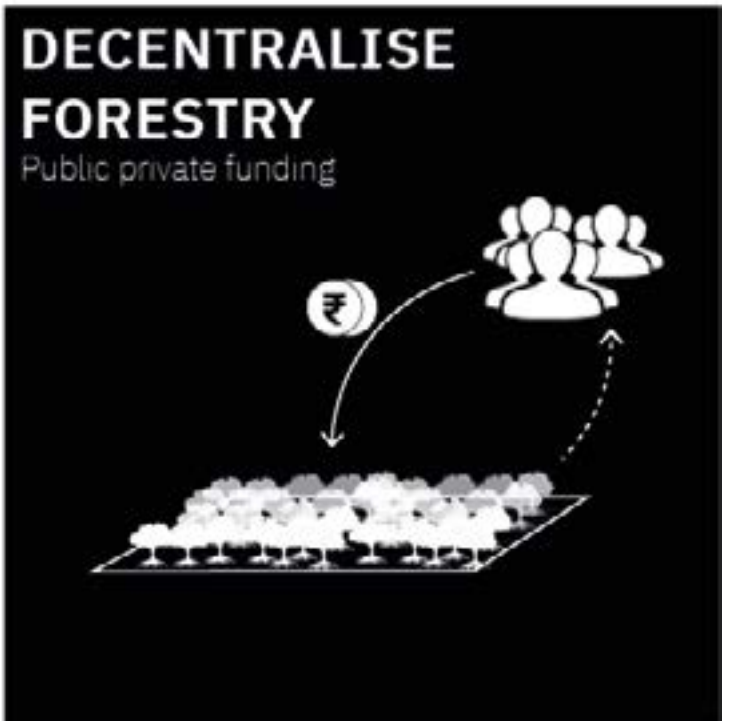
On a concluding note, the design and planning framework depicts the rethinking of scales necessary to tackle urban challenges in current times. Any action at one scale has a cascading effect on the others and the adaptive geographies would require an iterative process of spatio temporal rescaling to assess the impacts and implications of the strategies to deal with ClimateChange.







Fiscal Instruments



Regulating Instruments

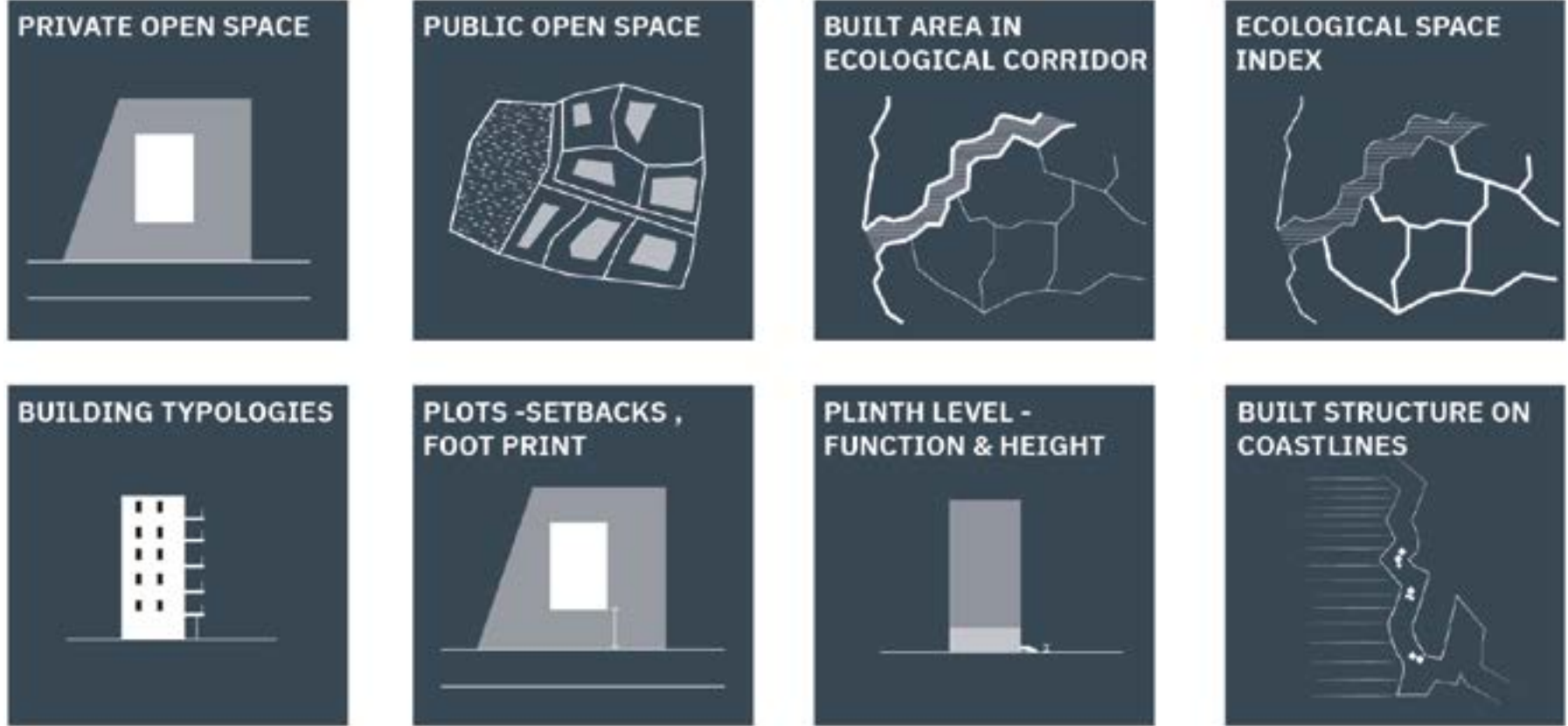
Compulsory regulation



Bans

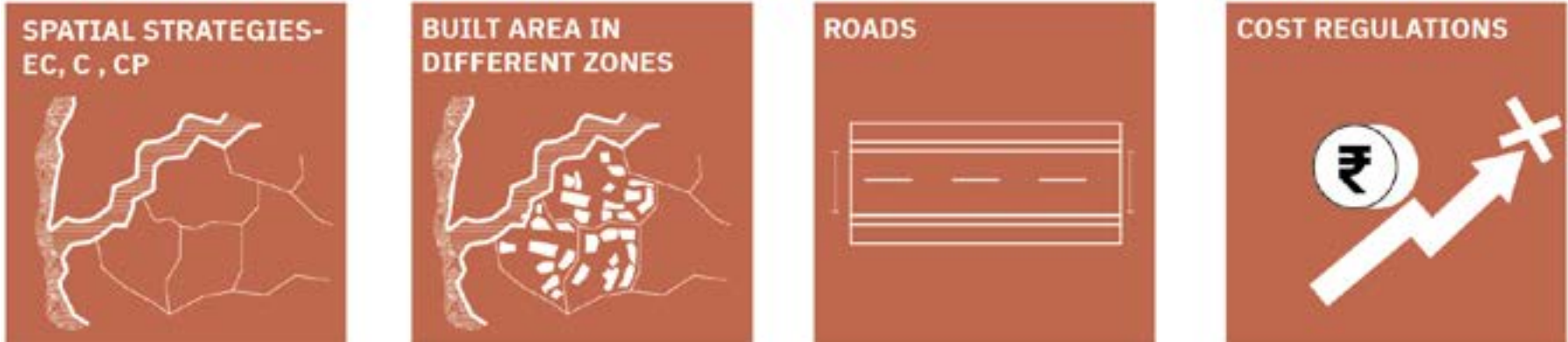


Codes and Standards



Regulating Instruments

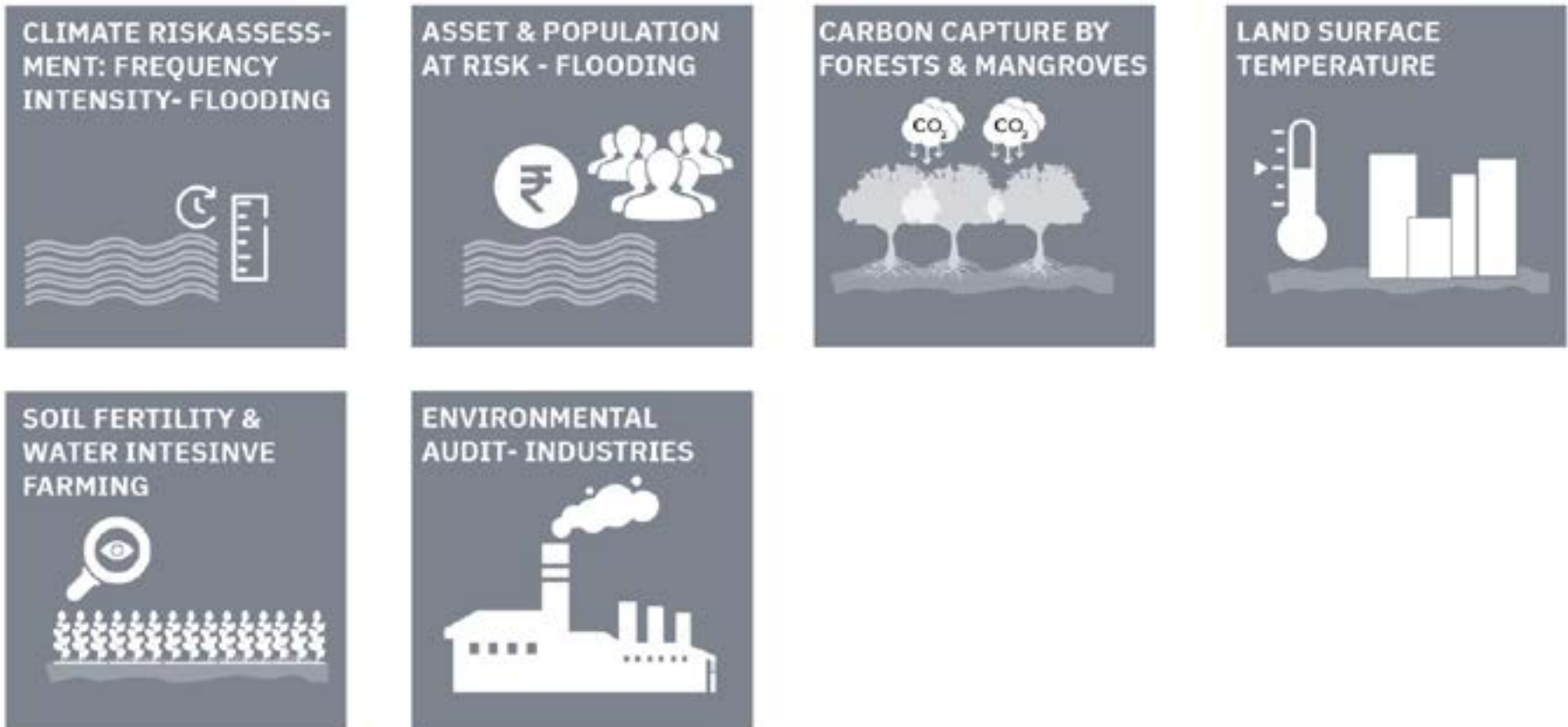
Limits



Other Mandatory Requirements



Monitoring & Auditing



Informative Instruments

Education



Advisory Services & Capacity Building



Information Campaigns



Environmental Monitoring & Reporting



Performance Labelling



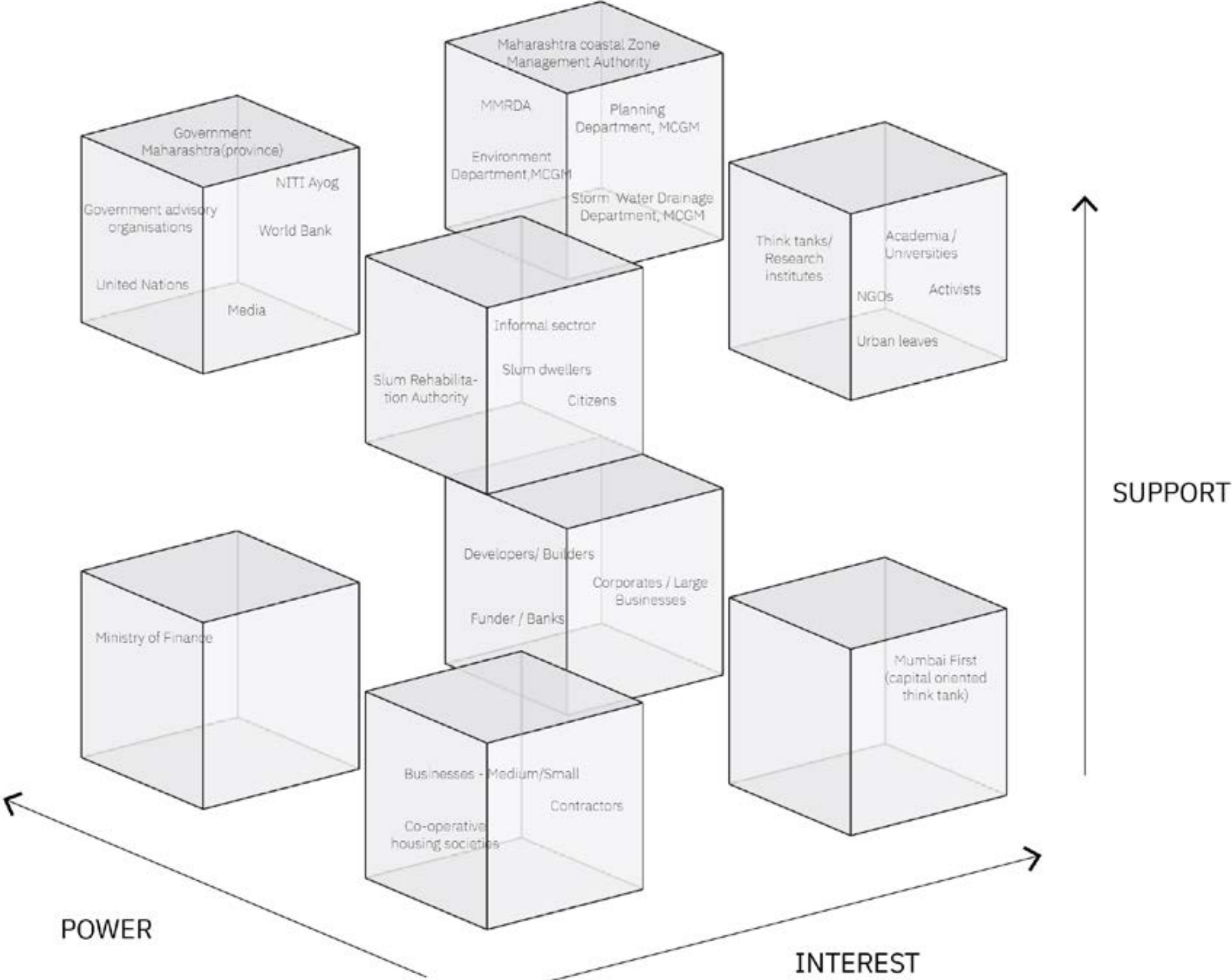
Access to Information/ Justice Rights



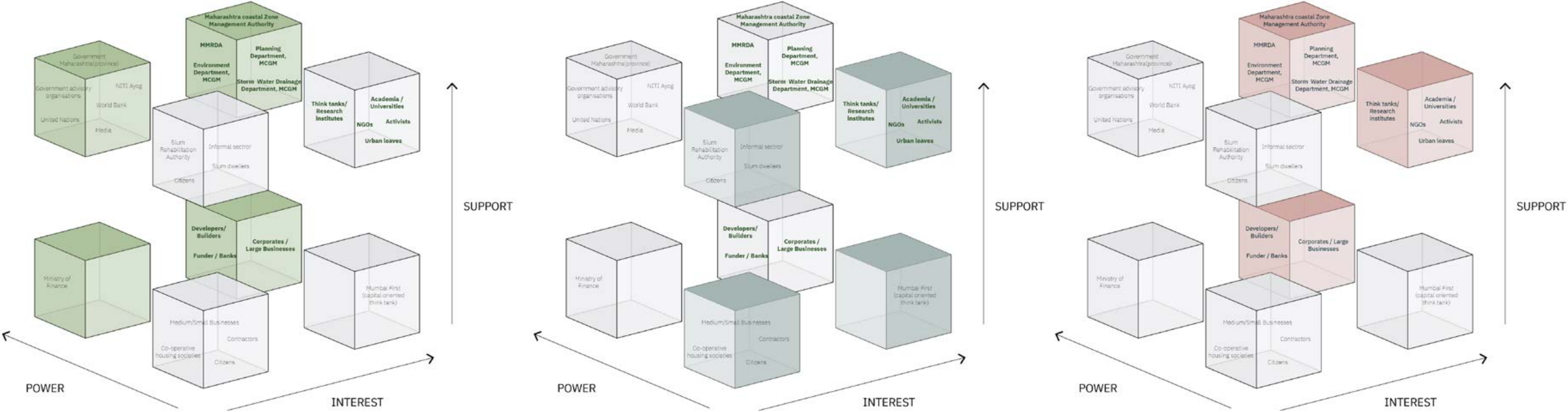
Labelling /Branding



Stakeholders



Stakeholders





'The State'

Desired : **promoters - support - collaborate**

Why? **Acceptance & sustainability**

- effective implementation
- proper enforcement
- political acceptability
- ownership of decisions & outcomes



'The Big Business'

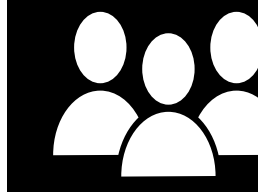
Desired : **support - collaborate - involve**

Why? **Economic efficiency**

- cost saving
- broader benefits

Social cohesion & equity

- fostering corporate social responsibility

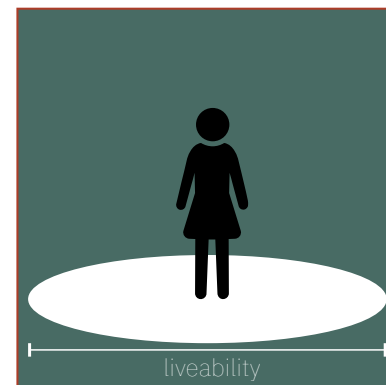


'The Citizens'

Desired : **inform - consult - aware - empower**

Why? Capacity & Knowledge development

- awareness raising
- information sharing
- Social cohesion & equity**
- building trust & confidence
- satisfaction



Increase recreational spaces



Opportunity for slum upgradation



Improve image of Mumbai city



Economic investment at risk



Economic benefits



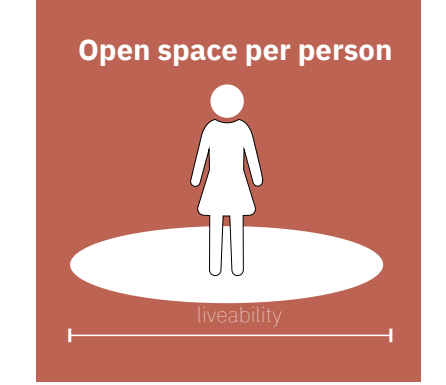
Economic benefits



Flood protection



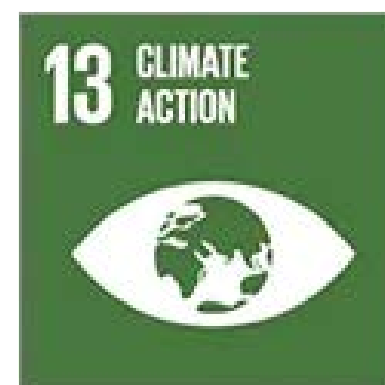
Opportunity for economic growth



Improve liveability



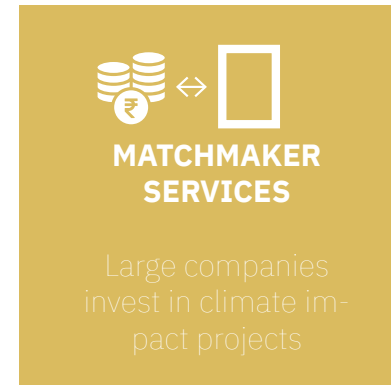
Expenditure/ investment at risk



Flood protection



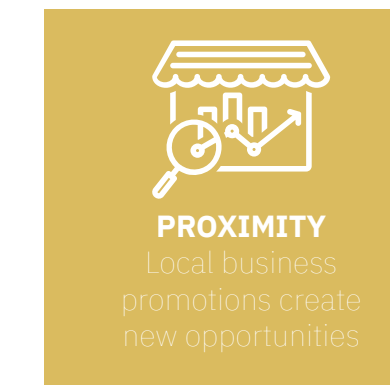
Improve biodiversity



Economic benefits



Social responsibility



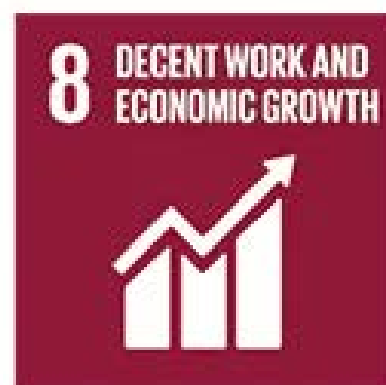
Expenditure/ investment at risk



Flood protection



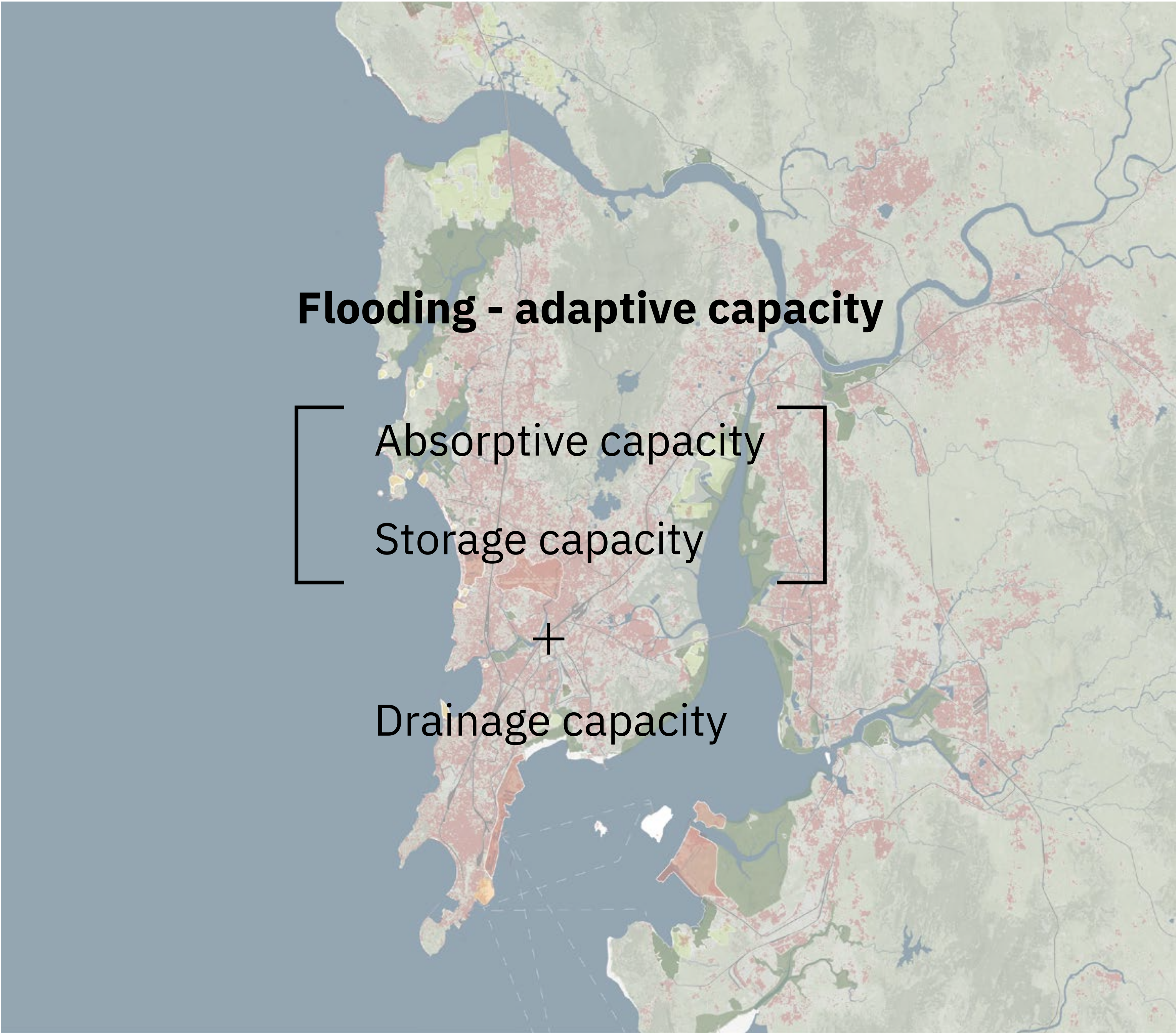
Improve biodiversity



Income generation

Regional Vision in Development

Adaptive Capacity



Socio-economic vulnerability

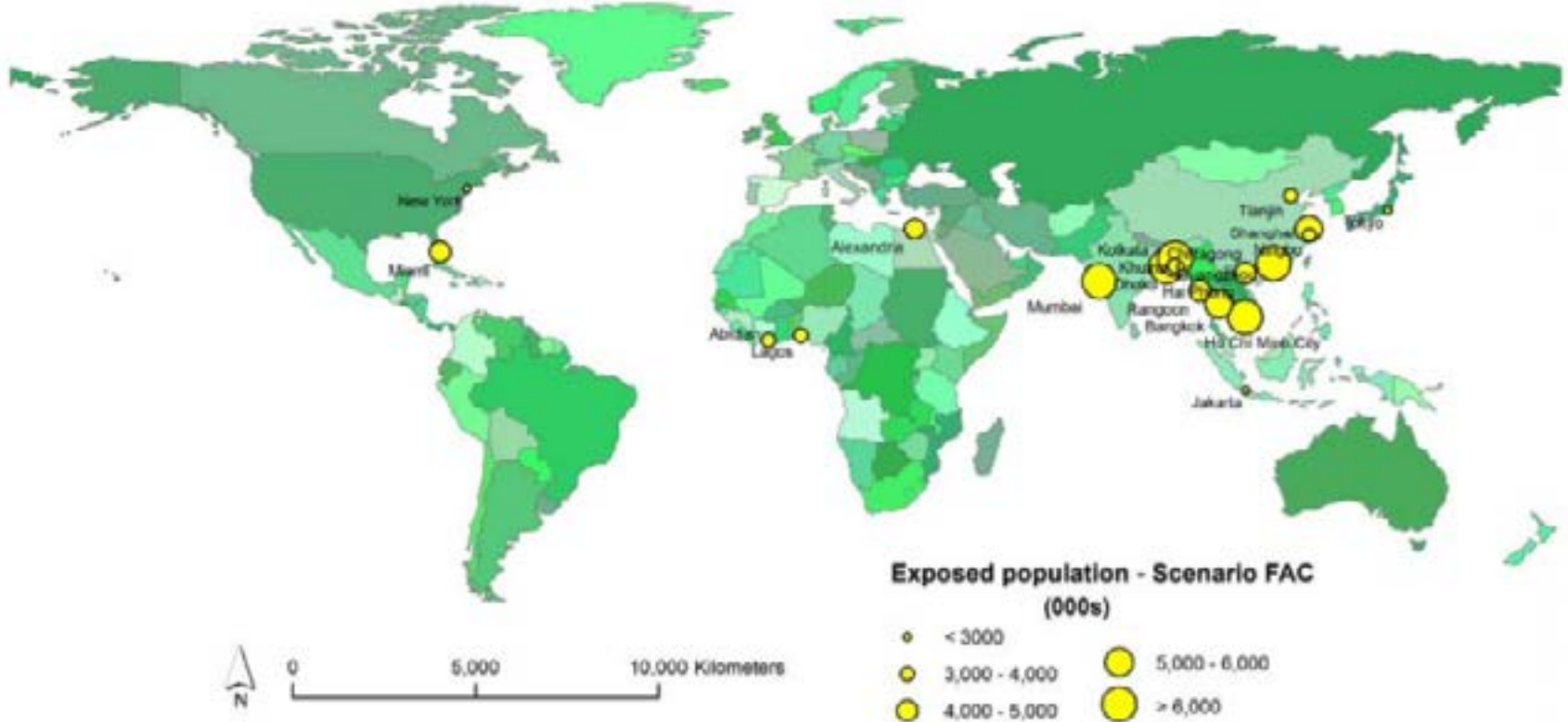


Figure 2: Map showing the Top 20 cities for exposed population under the future climate change and socioeconomic change scenario (Source: Nicholls et al (2007), OECD, Paris)

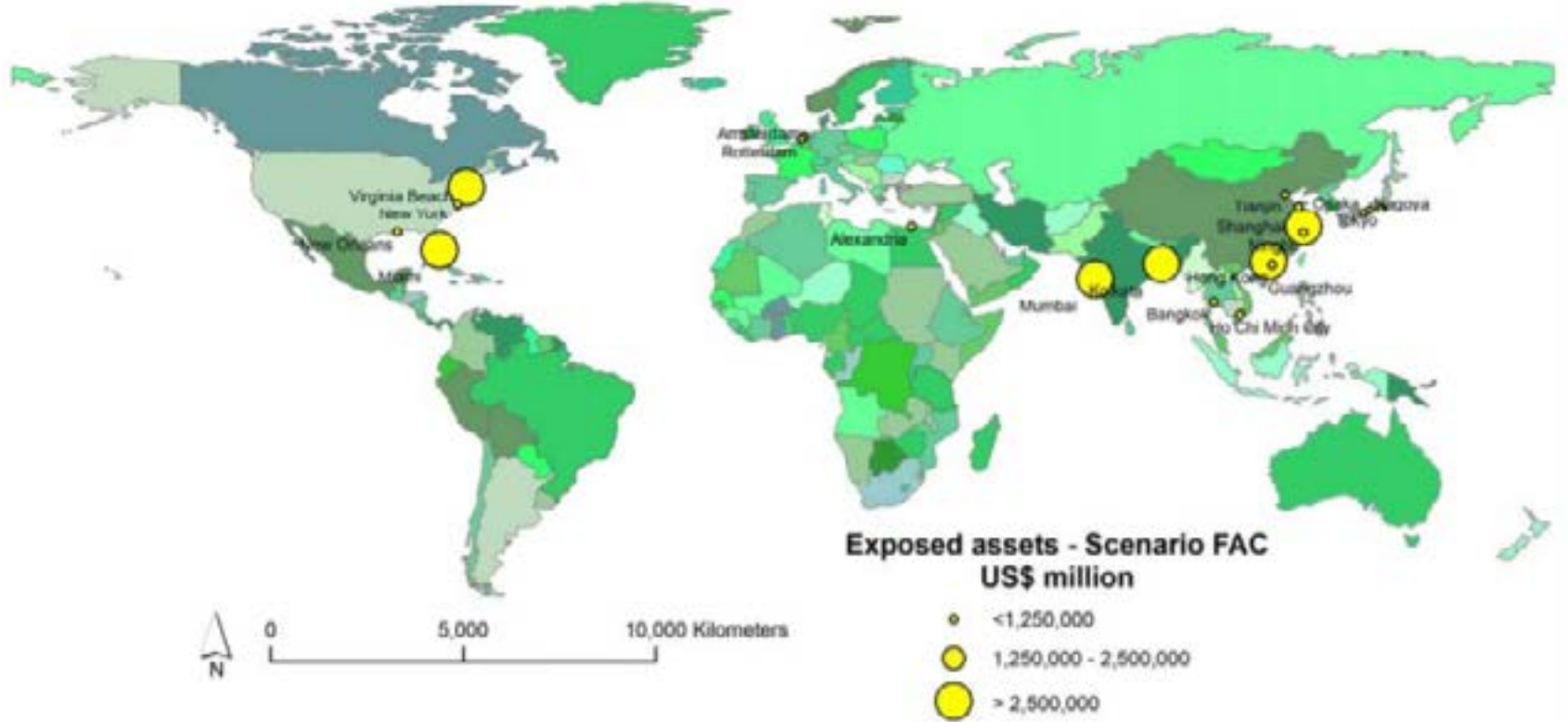


Figure 3: Map showing the Top 20 cities for exposed assets under the future climate change and socioeconomic change scenario (Source: Nicholls et al (2007), OECD, Paris)

Rank	Country	Urban Agglomeration	Exposed Population Current	Exposed Population Future
1	INDIA	Kolkata (Calcutta)	1,929,000	14,014,000
2	INDIA	Mumbai (Bombay)	2,787,000	11,418,000
3	BANGLADESH	Dhaka	844,000	11,135,000
4	CHINA	Guangzhou	2,718,000	10,333,000
5	VIETNAM	Ho Chi Minh City	1,931,000	9,216,000
6	CHINA	Shanghai	2,353,000	5,451,000
7	THAILAND	Bangkok	907,000	5,138,000
8	MYANMAR	Rangoon	510,000	4,965,000
9	USA	Miami	2,003,000	4,795,000
10	VIETNAM	Hai Phong	794,000	4,711,000
11	EGYPT	Alexandria	1,330,000	4,375,000
12	CHINA	Tianjin	956,000	3,790,000
13	BANGLADESH	Khulna	441,000	3,641,000
14	CHINA	Ningbo	299,000	3,305,000
15	NIGERIA	Lagos	357,000	3,229,000
16	CÔTE D'IVOIRE	Abidjan	519,000	3,110,000
17	USA	New York-Newark	1,540,000	2,931,000
18	BANGLADESH	Chittagong	255,000	2,866,000
19	JAPAN	Tokyo	1,110,000	2,521,000
20	INDONESIA	Jakarta	513,000	2,248,000

Table 1: Top 20 cities ranked in terms of population exposed to coastal flooding in the 2070s (including both climate change and socioeconomic change) and showing present-day exposure (Source: Nicholls et al (2007), OECD, Paris)

Rank	Country	Urban Agglomeration	Exposed Assets Current (\$Billion)	Exposed Assets Future (\$Billion)
1	USA	Miami	416.29	3,513.04
2	CHINA	Guangzhou	84.17	3,357.72
3	USA	New York-Newark	320.20	2,147.35
4	INDIA	Kolkata (Calcutta)	31.99	1,961.44
5	CHINA	Shanghai	72.86	1,771.17
6	INDIA	Mumbai	46.20	1,598.05
7	CHINA	Tianjin	29.62	1,231.48
8	JAPAN	Tokyo	174.29	1,207.07
9	CHINA	Hong Kong	35.94	1,163.89
10	THAILAND	Bangkok	38.72	1,117.54
11	CHINA	Ningbo	9.26	1,073.93
12	USA	New Orleans	233.69	1,013.45
13	JAPAN	Osaka-Kobe	215.62	968.96
14	NETHERLANDS	Amsterdam	128.33	843.70
15	NETHERLANDS	Rotterdam	114.89	825.68
16	VIETNAM	Ho Chi Minh City	26.86	652.82
17	JAPAN	Nagoya	109.22	623.42
18	CHINA	Qingdao	2.72	601.59
19	USA	Virginia Beach	84.64	581.69
20	EGYPT	Alexandria	28.46	563.28

Table 2: Top 20 cities ranked in terms of assets exposed to coastal flooding in the 2070s (including both climate change and socioeconomic change) and showing present-day exposure (Source: Nicholls et al (2007), OECD, Paris)