

ADAPTIVE GEOGRAPHIES

Towards a Flood Resilient Mumbai Metropolitan Region

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I am ever grateful to get this opportunity to be a part of TU Delft and to have a wonderful experience as this and take my learning and make a positive impact in this world.

Report | Surabhi Khandelwal



FIG. 1.1 Climate action strike-Greta Thunberg.source- https://www.google.com/ .

An urgent plan of action

“It is only when the emergency becomes articulate that we can locate that willingness to serve.”
- Leonard Cohen, Canadian singer-songwriter

We are facing the biggest plight of our entire span of existence on this planet.We are fighting for the mere existence of our species. It is about time for us to rethink our practices and way of living and prepare ourselves for what awaits us. We live in a state of emergency which has articulated itself in forms that have detrimental repercussions to humans and requires impulsive actions to rethink and galvanise a necessary systemic change before the state of emergency is without no return. This brings our attention to the notion of ‘sustainability’ and how could that be applied in all walks of life.This poses a serious question for us that how do we as Urbanists, contribute in sustaining the future of our kind through spatial planning and strategy?

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1.

Introduction

Preface to the Research Project

This chapter sets the scene for the Research project giving a brief overview of the Research project. It concisely explains the overall theme of the endeavoured research and describes the structure of the project report.

Mumbai , the financial capital of Inida, history of being the ‘Gateway of India’ is a spatial manifestation of extreme social, cultural and economic construct with co- existence of extreme duality within the same shared space. The issue of dealing with Climate change would be a mammoth task and simplification of this complxe task is highly essential.

Mumbai’s history as a city that grew to service a colonial administration within the constraints of its geography,accounts for its extraordinarily high densities.It is time to understand that ‘slum’is as inappropriate a word for its informal communities as it was for Jane Jacob’s Greenwich village.

- Darryl D’ Monte, 2011

It is a city that, above all others, attracts India’s poor, but it is also the place that is the jumping off point for India’s migrationto Europe and America.It has become the key to understanding the nature of the emerging world city.

- Suketu Mehta, 2011

With a leap of imagination, Mumbai could escape its old geographical constraints and create a functioning metropolis that stretches over the boundaries set by its origins and allow it to function in a new way, bringing together exisitng settlements.

- Charles Correa, 2014

FIG. 1.2 Spatial disparity in the urban shared space scape (https://unsplash.com/)

Climate Change requires immediate actions and transformations necessary in spatial realities that could respond to the impacts of these new climatic realities. This project would attempt to propose spatial strategies to adapt Mumbai to tackle the issue of flooding through the integration of ecological infrastructure. Currently, in an economic-centred development, it is overwhelming to see the negative externalities that it brings with it, in society and ecology embodied as climate change vulnerability amongst others. It is important to stir a systemic change and develop these territories in an equilibrium, which would involve emphasising on socio-ecological development alongside economic activities.

The Research would begin with investigation of the context and problem field and further focalise it to the site in consideration-Mumbai Metropolitan region. The report is structured in different chapters based on the narrative but could be broadly categorised as four sections - Problem Definition, Guiding forces, Operationalisation and Design & Planning Framework.

The first section **Problem Definition**, from Chapter 2 to 5 would begin with contextualisation and problematisation of the challenge dealt in the research to put forth the issue of flooding in Mumbai Metropolitan Region. It begins with understanding the current context at multiple scales,firstly, setting the scene of climate crisis at a global scale and then analysing it at India(National), Maharashtra(provincial) and Mumbai City scale.It would then unfold the causes of flooding and would derive the hypothesis and research aim of the project.
The second section **Guiding forces**, from chapter 6to 8 unfolds the structuration of the whole process of the Research that would guide the study in the discourse. It delineates the methods, approaches and the philosophy steering the whole process and provides a framework to the research through a guiding plan of action.It explains the theory and concepts undergirding the research at different stages. In the chapter 8 , the analysis of the specific ecological elemnts and mechanism for flood protection would be explained.

The third section, **Operationalisation**,it includes chapter 9,that constitutes the comprehension of the territories on specific parameters and indicators which would guide the development of strategies and design for the region.It includes the development of **vision** to put forth the essential values and intentions necessary for the facilitation of the spatial design to achieve a resilient Mumbai metropolitan region. It would deal with city and region scale to explain the spatial strategy.

The fourth section, **Design and planning framework**, from Chapter 10 to 15 explains the translation of the vision in space and place. Through 3 case examples with varying degrees of urban and nature, it would exemplify the translation of the strategies to smaller scales. The planning framework would give an idea on the implementation of the design through different actors and coordination mechanisms required. It would project an alternate governance structure necessary to facilitate a resilient Mumbai Metropolitan Region.The section and the project would end with discussion and synthesising conclusion & reflection.



FIG. 1.8 Aerial image of Mumbai .source:DNA

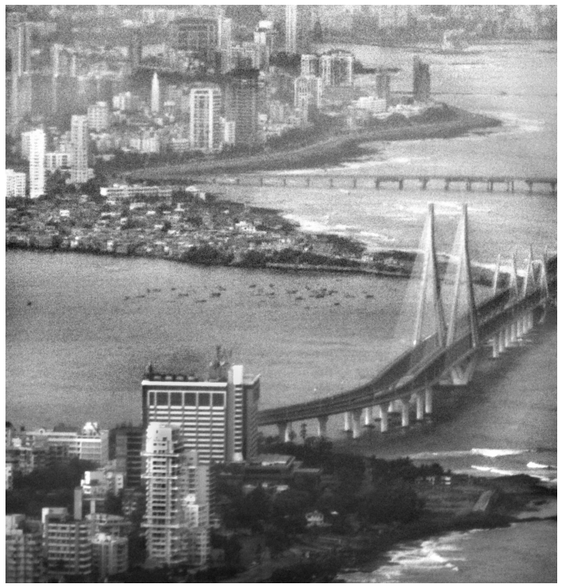


FIG. 1.9 Aerial image of Mumbai .source: the guardian



FIG. 1.10 Aerial image of Mumbai .source:pixeldo pixeldo .

2.

Climate Change

Climate Crisis to **New Conditions of existence**

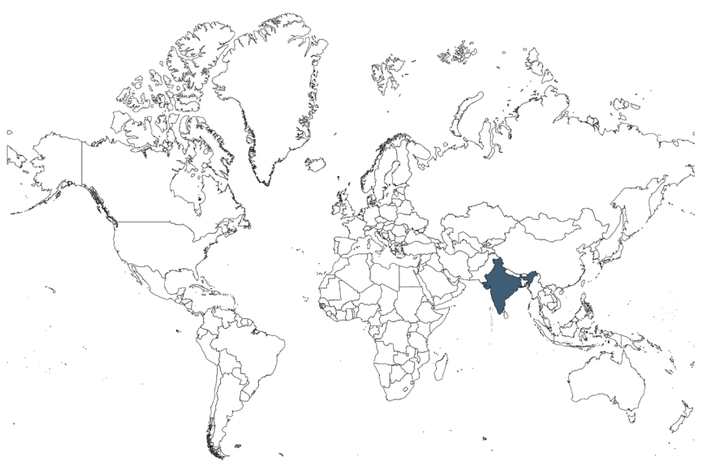
OVERVIEW

This chapter presents an understanding of the current context and problem at multiple scales to set out the frame of contextualisation and problematisation of the issue as our environments are not only a product of the processes in our proximity but also a product of global processes and phenomena. It is an aggregate/cumulative product of the processes and phenomena taking place at multiple scales.The chapter would first comprehend the situation at global scale and would further analyse the issues at National and then the Metropolitan scale.

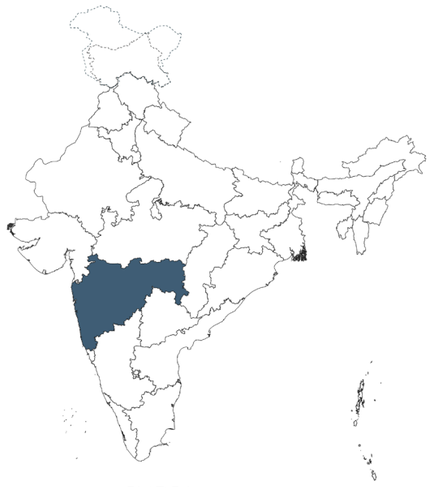


FIG. 1.1.1 Coastal Flooding .source:medium medium

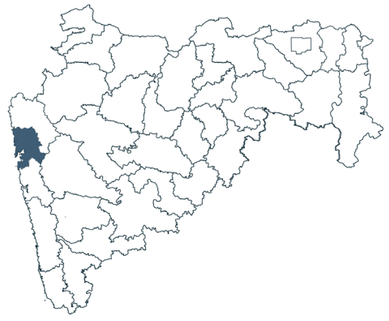
Climate crisis



WORLD



INDIA



MAHARASHTRA



MUMBAI METROPOLITAN REGION

Scalar Understanding of Climate crisis



FIG. 1.12 Glaciers melting. source:medium

More than 1 million species are at risk of extinction by climate change

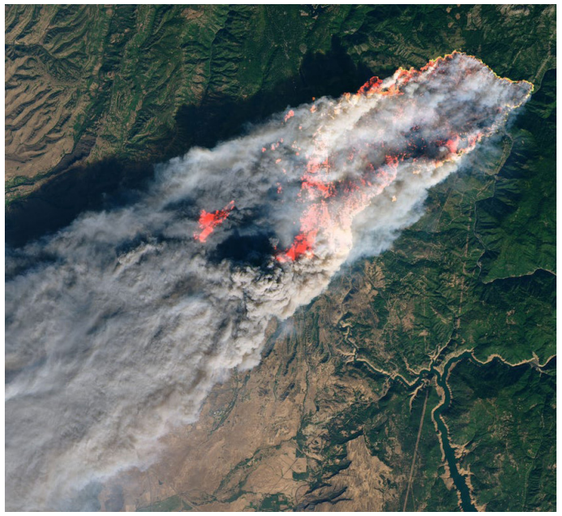


FIG. 1.13 California wildfires. source: independent.co.uk

Forest of the size of a football field is lost every second



FIG. 1.14 Dried Lake Chilwa in Malawi .source:people

2019 was the second warmest year on record



FIG. 1.15 Tornado in United States. source:people

800 million people are currently vulnerable to climate change impacts

Climate crisis in the World

Climate Change is one of the biggest crises that our world is dealing with currently (apart from the Coronavirus crisis,2020) which is challenging the existence of mankind. With ever increasing greenhouse gas emissions and land cover transformations, the changes in climate are happening at an unprecedented rate, whose effect is witnessed more than ever all across the globe. ‘Increase in global temperature, sea level rise, increased precipitation pattern, ocean acidification, cyclones and other climate change impacts are seriously affecting coastal areas and low-lying coastal countries, including many least developed countries and Small Island Developing States. The survival of many societies, and of the biological support systems of the planet, is at risk.’(2030 Agenda for Sustainable Development) The impacts of this crisis is seen as increased frequency and intensity of climatic disasters like flooding, cyclonic storms, forest fires, prolonged drought and increasing heat waves which have taken a huge toll on the socio- economic system with 1.3 million lives and 3 trillion dollars(direct economic losses) of recorded damage between 1998-2017.
The changing climatic system would impact the availability of basic necessities like fresh water, food security, and energy. The efforts to redress climate change, both through adaptation and mitigation, will similarly inform and shape the global development agenda. The links between climate change and sustainable development are strong. Poor and developing countries, particularly least developed countries, will be among those most adversely affected and least able to cope with the anticipated shocks to their social, economic and natural systems.



FIG. 1.3 Impact of hurricane Katrina. source: archinect



FIG. 1.16 Australian bushfire .source: vox

Climate crisis in the World

Impact of Flooding

Floods are the most frequent form of natural disasters due to climate change in the world with the most fatalities in the world. It is caused by the rising heat and changing rainfall patterns along with the snow cap melts or storm surge due to tropical cyclones. (WHO,2018) It caused mass-destruction of life and livelihood along with damage to infrastructure. There are three common types of floods which includes -pluvial floods ,caused due to excessive rainfall; fluvial floods, which are caused as a result of increased river capacity due to excessive rain or snow melts and Coastal Floods caused by storm surges associated with tropical cyclones or tsunamis. The changes in land use patterns with destruction of environment as a result of loss of vegetation has increased the flood risk in the past couple of years. At any time throughout the world a river somewhere is in flood and its waters are threatening communities, their property and even their lives.''(UN, 2002) While the world is dealing with a pandemic, the changes in climate have not halted and its impact continues. In April,a massive flood in DRC's South Kivu killed dozens and impacted 80,000 people. (UN,2020) Extreme flooding events would likely increase and continue in areas where human habitation has occupied flood plains or low lying coastal areas. We live in a world of 1.1 degree warming and with temperature rise ,record temperatures and record floods would not be an anomaly rather it would become a new norm and new records would be set year after year.(Hagelberg, 2019) Policy makers, businesses, society and each and every individual needs to be prepared to face more frequent extreme weather events as the climate continues to change at an increasing rate.Climate science must be taken into account to develop knowledge and action to how we build, adapt and protect and prepare our environment, society, businesses and infrastructure from the impending events (Hagelberg, 2019).



FIG. 1.4 Floods in Venice .source: archdaily

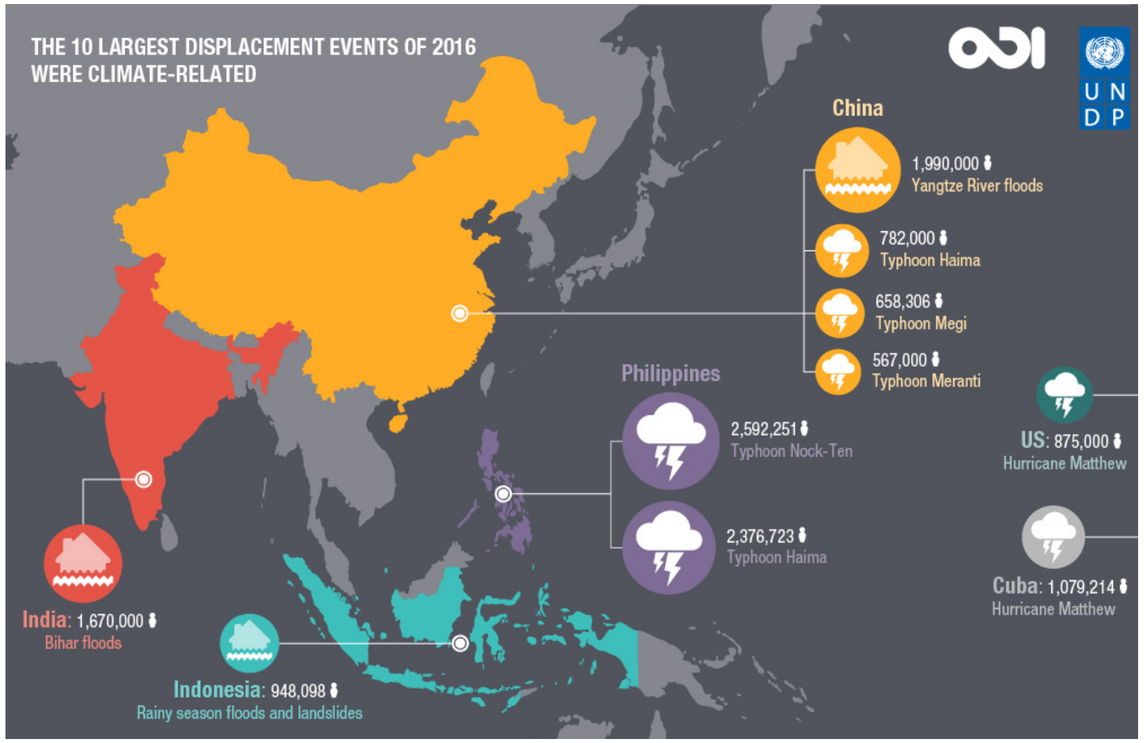


FIG. 1.17 Climate related displacement approx. 4.6 M people due to floods & 8.9 M due to cyclones .source:UNDP

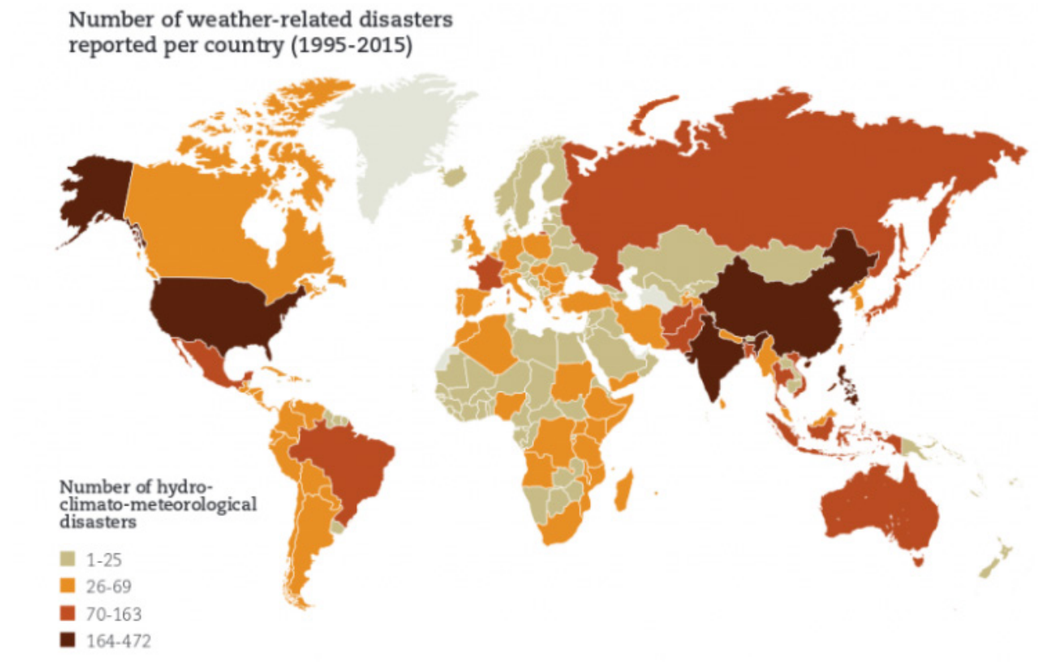


FIG. 1.18 In 1995-2015 ,flood affected 2.3 billion and killed 157,000 people, source: floodlist

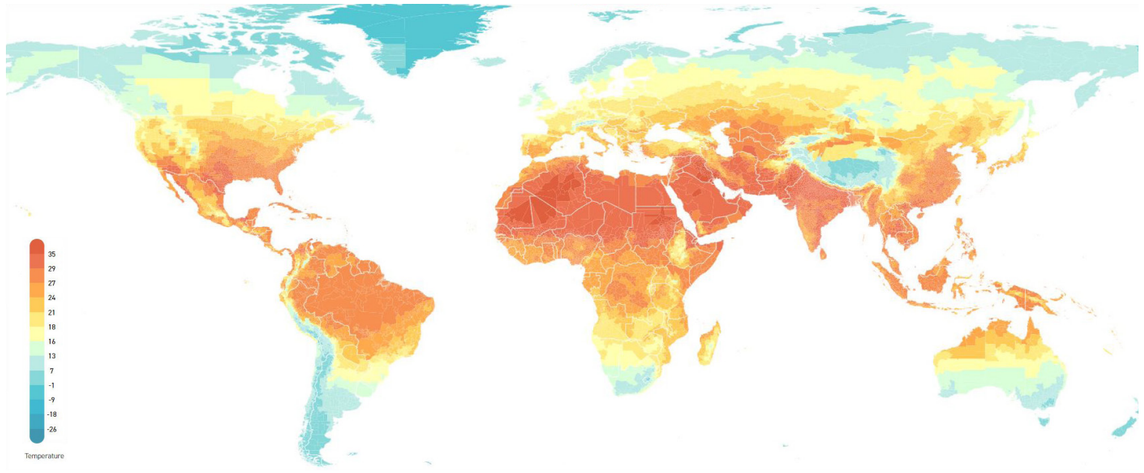


FIG. 1.19 Annual average temperature.source: impactlab.org

2.1.2. Global Actions and Partnerships

The international political response to climate change began at the Rio Earth Summit in 1992(Rio de Janeiro) , where the United Nations(UN) after accepting the effect of humans in the changes in Climate with 'Rio Convention' included the adoption of the UN Framework on Climate Change (UNFCCC). This convention set out a framework for action aimed at stabilizing atmospheric concentrations of greenhouse gases (GHGs) to avoid "dangerous anthropogenic interference with the climate system." The UNFCCC which entered into force on 21 March 1994, now has a near-universal membership of 197 parties.Over the years, the collaboration became stronger but the actions and targets were missing from the mission to tackle Climate Change. However at the 21st Session of the Conference of the Parties (COP21/CMP1) convened in Paris, France(in December 2015), the Paris Agreement was adopted. A universal agreement which aims to keep a global temperature rise for this century well below 2 degrees Celsius, with the goal of driving efforts to limit the temperature rise to 1.5 degrees Celsius above pre-industrial levels. Along with the Paris Agreement, the 2030 Agenda for Sustainable Development was adopted by the member states of the United Nations which provides a 'blueprint for peace and prosperity for people and the planet, now and into the future. The core of this Agenda includes the 17 Sustainable Development Goals(SDGs) which are an urgent call for action by all countries in a global partnership.

The SDG 13 aims to 'take urgent actions to combat climate change and its impact' while acknowledging that the UNFCCC is the primary international, intergovernmental forum for negotiating the global response to climate change. The associated targets of SDG 13 focus on the integration of climate change measures into national policies and planning, the improvement of education, awareness- raising and institutional capacity on mitigation and adaptation responding to climate change along with impact reduction and early warnings. The targets also include implementation of the commitment undertaken at the UNFCCC and for the promotion of mechanisms that would facilitate increase in capacity for effective climate change related



FIG. 1.20 UN Sustainability Goals .source: UN.org UN .

By the Numbers

407.6 parts per million

The concentration of CO_2 in the lowest layer of our planet's atmosphere. Compare that to 380 ppm just a decade ago.

2 degrees Celsius

The goal for maximum global temperature rise from pre-Industrial levels, as outlined in the Paris agreement. Unfortunately, a study published last summer determined that the chance of hitting that goal by 2100 is a mere 5 percent. The reality is, the rise could be as much as 4.9 degrees Celsius.

75 percent

The portion of humanity that could face deadly heat waves by 2100 if major cuts to CO-2- emissions are not made. By the middle of this century, the American South could see a tripling of days per year that hit 95 degrees.

1.5 degrees Fahrenheit

The rise in sea surface temperature between 1901 and 2015. Warming seas are a particular problem for coral, which release the photosynthetic algae they use to extract energy from sunlight when they're stressed and bleach to death.

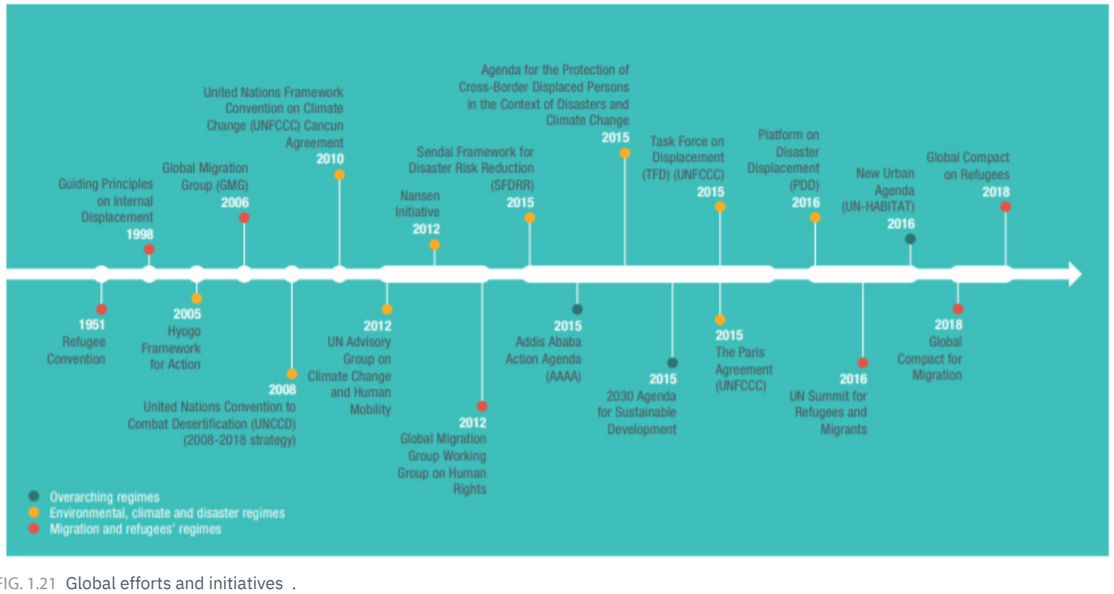


FIG. 1.21 Global efforts and initiatives .

planning and management in least developed countries and small island *developing states.*
While there are positive steps in terms of the climate finance flows and the development of nationally determined contributions, far more ambitious plans and accelerated action are needed on mitigation and adaptation (SDG,2019) Access to finance and strengthened capacities need to be scaled up at a much faster rate, particularly for the most vulnerable population.

Multiple other efforts and initiatives are being done to enable this adaptation to the changing climate by different levels of governments, large and small industries/ businesses and civilian groups.

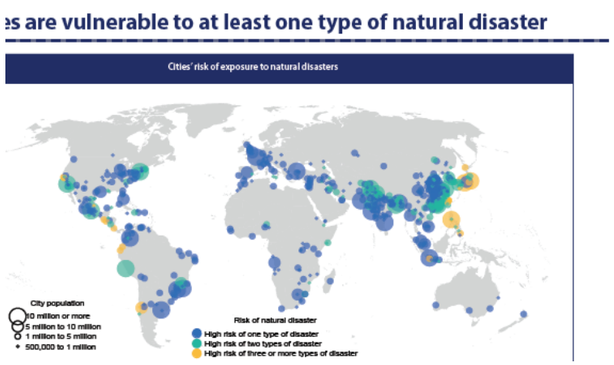


FIG. 1.22 Vulnerability of Cities .source:OECD



FIG. 1.5 Global Interconnectedness source: Nikos Katsikis

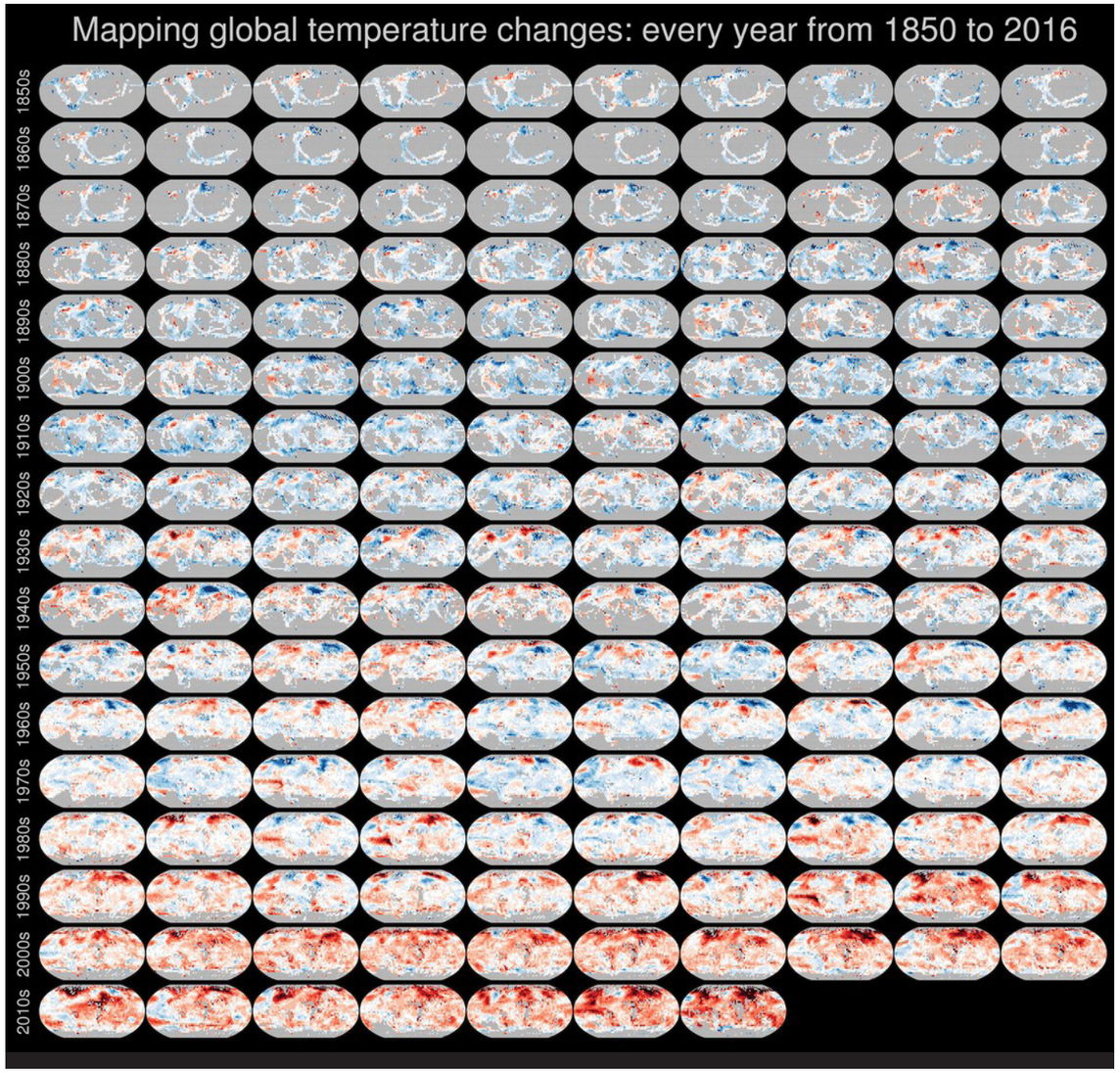


FIG. 1.6 Global temperature rise. source: wired

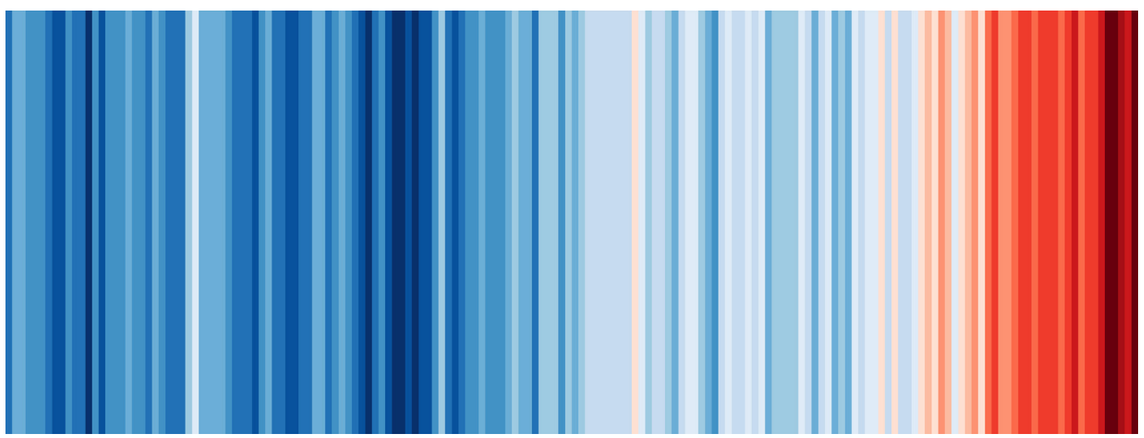


FIG. 1.23 Simplified visual stripes representing global temperature rise by Ed Hawkins. source: warmingstripes

Climate crisis in India

India with a landmass of 3.287 million square kilometres(excluding the disputed territories) and a population of 1.353 billion people (World Bank, 2018) is highly vulnerable to severe climate induced disasters. India experiences bouts of droughts, cyclonic storms, floods and heatwaves currently in different regions of the country. According to the data based on National Disaster Management Authority(NDMA) ,over 40 million hectares of land is prone to fluvial flooding and river erosion, approximately 5,700kms long coast out of 7,516 km long coastline is prone to cyclones and tsunamis, 68 percent of its arable land is susceptible to droughts and its hilly or mountainous areas are at risk from landslides and avalanches. The increasing urbanisation and development is increasing the emission levels and the rise in temperature is going to witness an increase in the frequency of these events. India ranked fifth in the Global Climate Risk index has been 'continuously facing one disaster after another and sometimes simultaneously.' (Khandekar, 2020)Therefore the task before India is mammoth as it is for the whole world , but the scale that India is dealing with needs all the forces that it can muster.

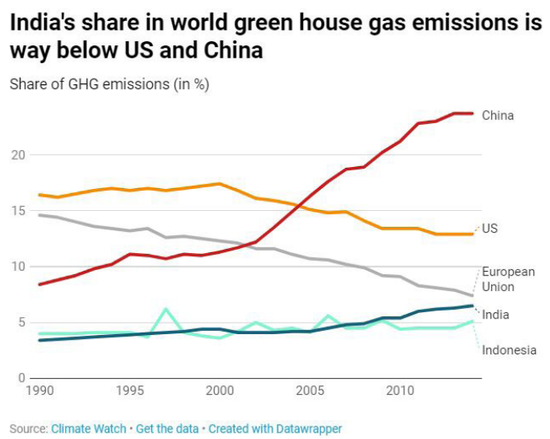


FIG. 1.7 India's share in Grenhouse gas emissions. source:climatewatch

'In the last two years, India has been hit by at least one extreme weather event every month.'

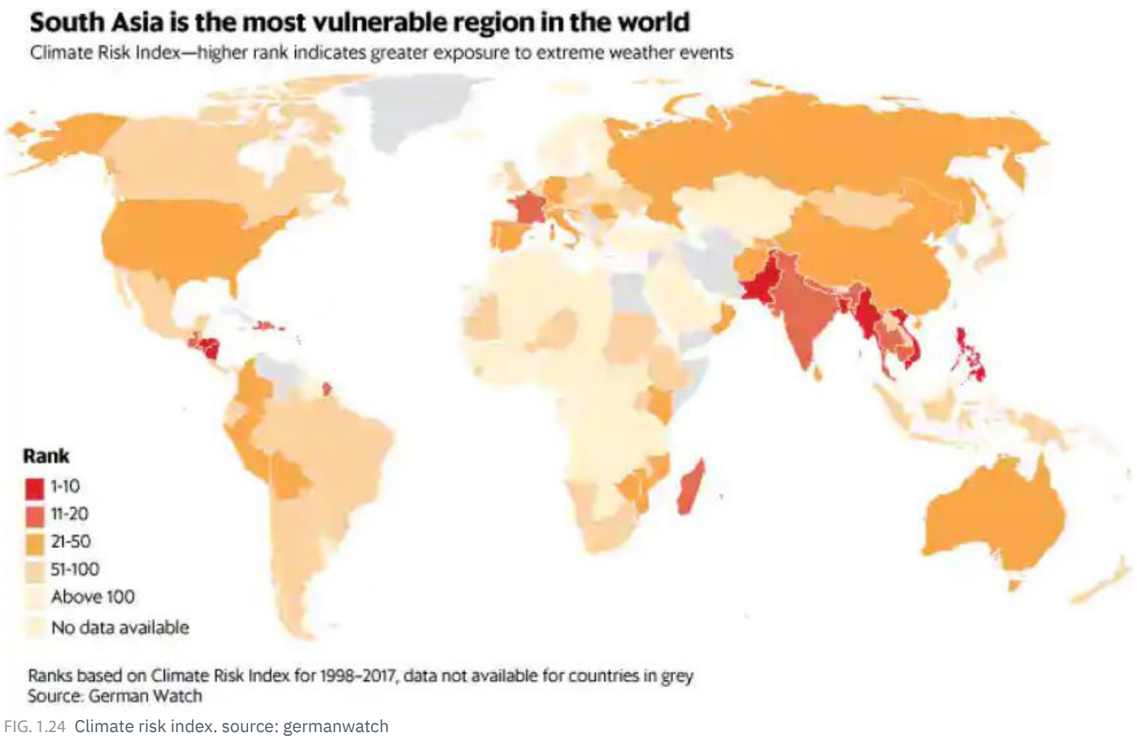


FIG. 1.24 Climate risk index. source: germanwatch

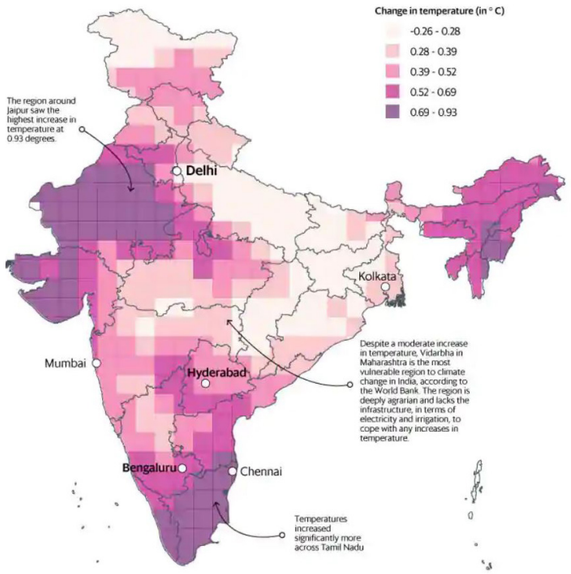


FIG. 1.25 Change in temperature .source:livemint .

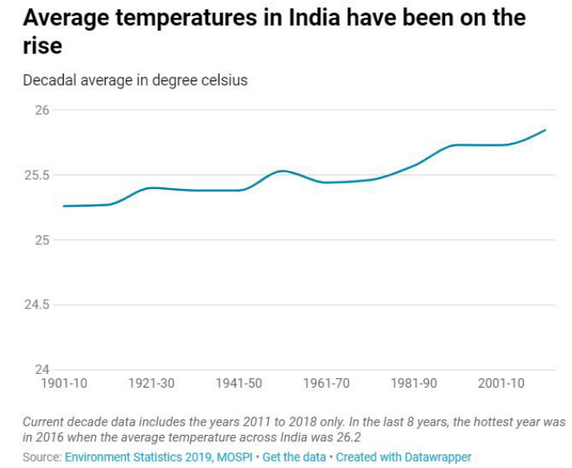


FIG. 1.26 Average temperature rise in India.source: livemint

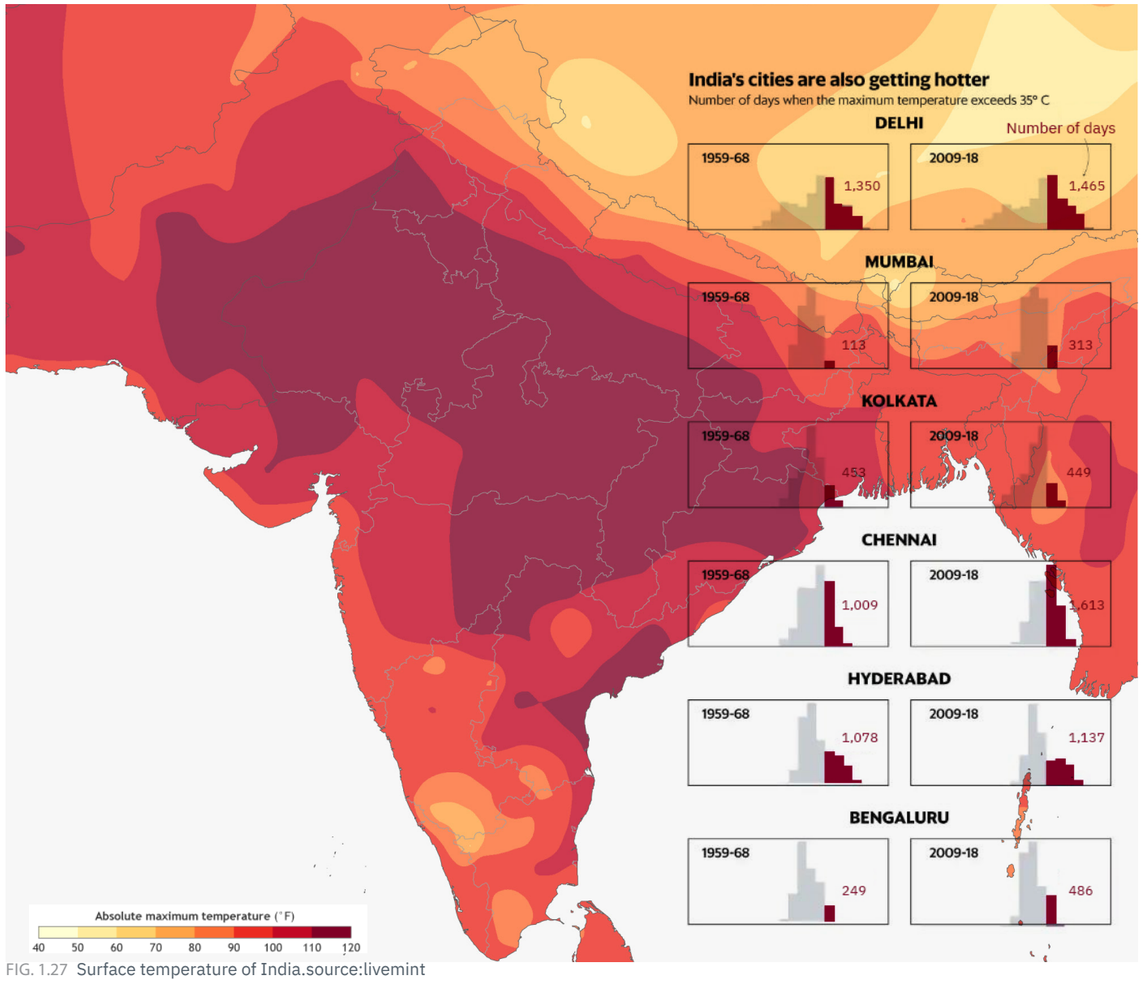


FIG. 1.27 Surface temperature of India.source:livemint

Impact of Flooding

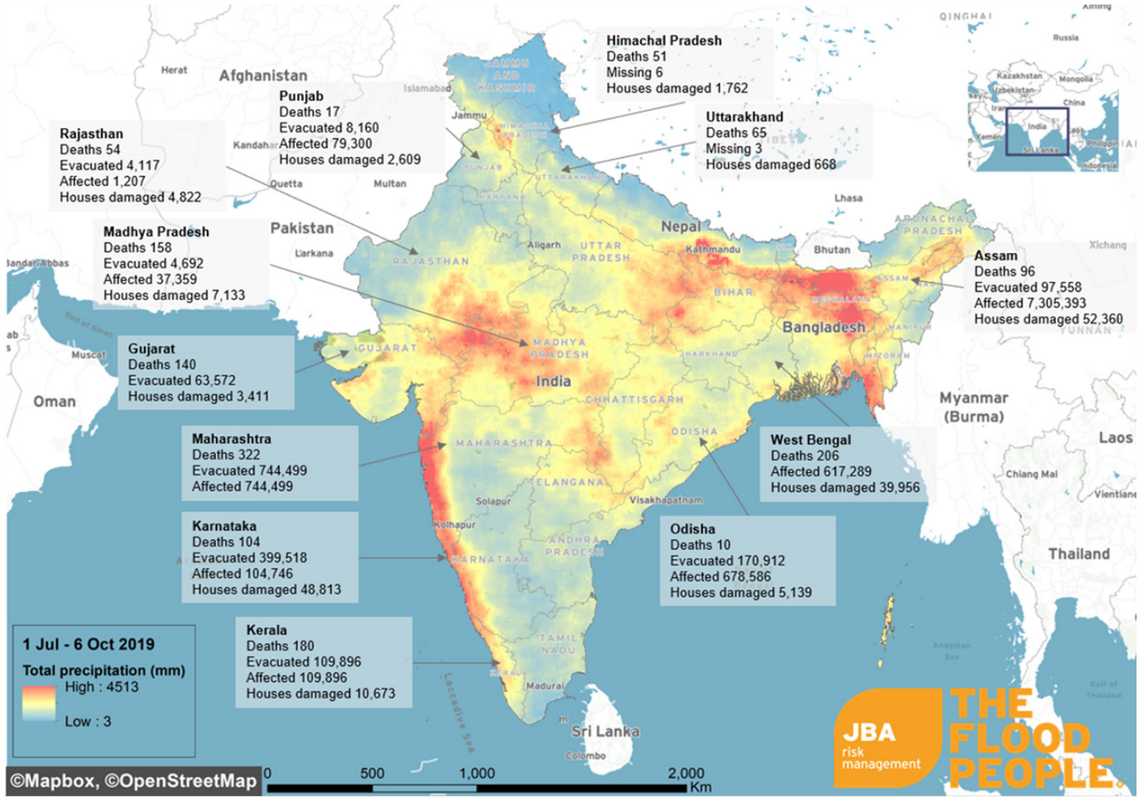


FIG. 1.28 Flood impact in India in 2019. source : iiac

India is one of the most disaster-prone countries in the world, with hydrological (water-related) disasters being among the most frequent and having high mortality and damage costs.(UNEP, 2020) According to the World Bank, “India is among the countries most vulnerable to climate change. It has one of the highest densities of economic activity in the world, and very large numbers of poor people who rely on the natural resource base for their livelihoods, with a high dependence on rainfall.” (Rawat, 2019)
India lies in a climatically sensitive zone and bears a heavy burden of a billion population.It is a nation where the impact of climate change can be seen as measured tangibly due to the scale of the impact.The major source of flooding in India are the Monsoon rains ,cyclone induced rains and melting of Himalayan ice caps.(Rawat, 2019) India has incurred massive damage to both life, property and livelihood due to floods in the past few decades. From 1953- 2017, India suffered a damage worth INR 3,782,470,470,000 and lost 107,535 people to floods.As per the recorded damage, 80,717,993

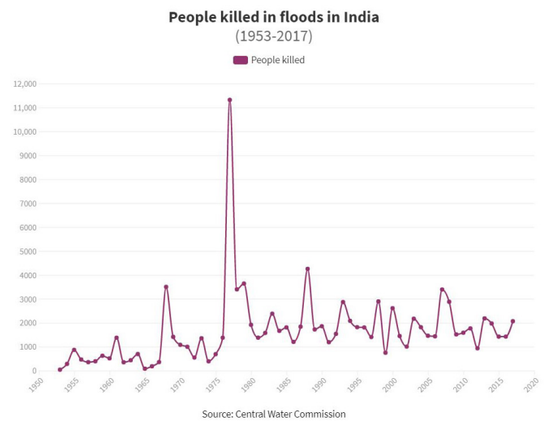


FIG. 1.29 People due to to floods in India (1953-2017). source:indiatoday

When skies rained death & destruction: India suffered Rs 3,78,247.047 cr loss due to floods in 65 yrs

Despite their annual nature, floods in India continue to maim states, claim hundreds of lives and ravage valuable resources worth thousands of crore year after year.

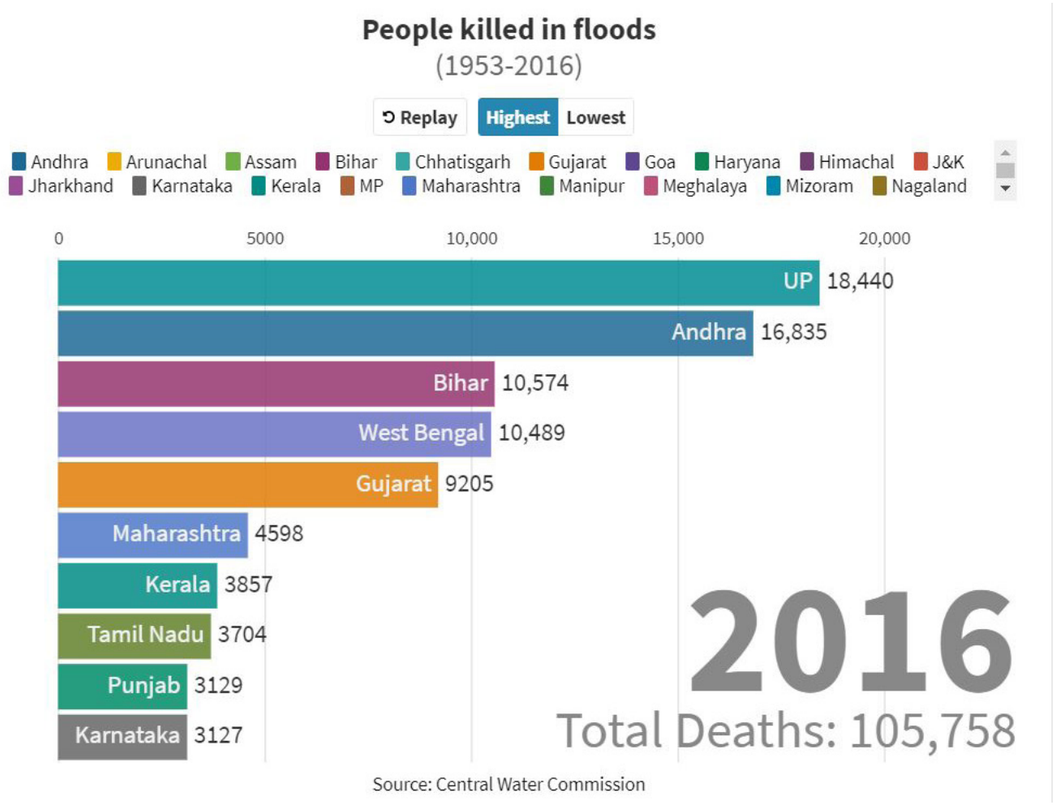


FIG. 1.30 Deaths in India in 2016 .source: indiatoday

houses have been destroyed with an area of approximately 466.335 million hectare affected in the past 65years.(Rawat, 2019) With increasing temperature ,the situation is going to worsen as the frequency and intensity of the flood would increase to an alarming rate. Therefore the human-induced climate changes need to be controlled by checking on the actions of the society. India is highly susceptible to coastal flooding in the future with its long coastlines and large parts of coastal communities at a low elevation level. It has already been projected that 7.1 million people are going to be affected only by one metre rise in sea level and approximately 36 million people will be affected by 2050 where the impact is concentrated in the coastal urban centres like Mumbai, Chennai, Kochi, Odisha and the coasts of Gujarat.(Chandrashekhar, 2019).
According to the World Migration Report (2020), at the end of 2018, there were a total of 28 million new internal displacements across 148 countries and territories. “Sixty one percent (17.2 million) of these new displacements were triggered by disasters (Joshi, 2020)

Therefore drastic changes in the way current socio-economic systems work along with urbanisation. Adaptation and mitigation are vital to the sustenance of the future of mankind.

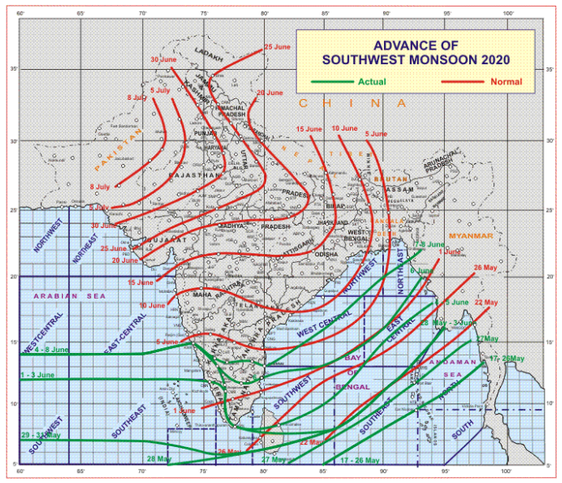


FIG. 1.31 Change in southwest Monsoon.source:IMD

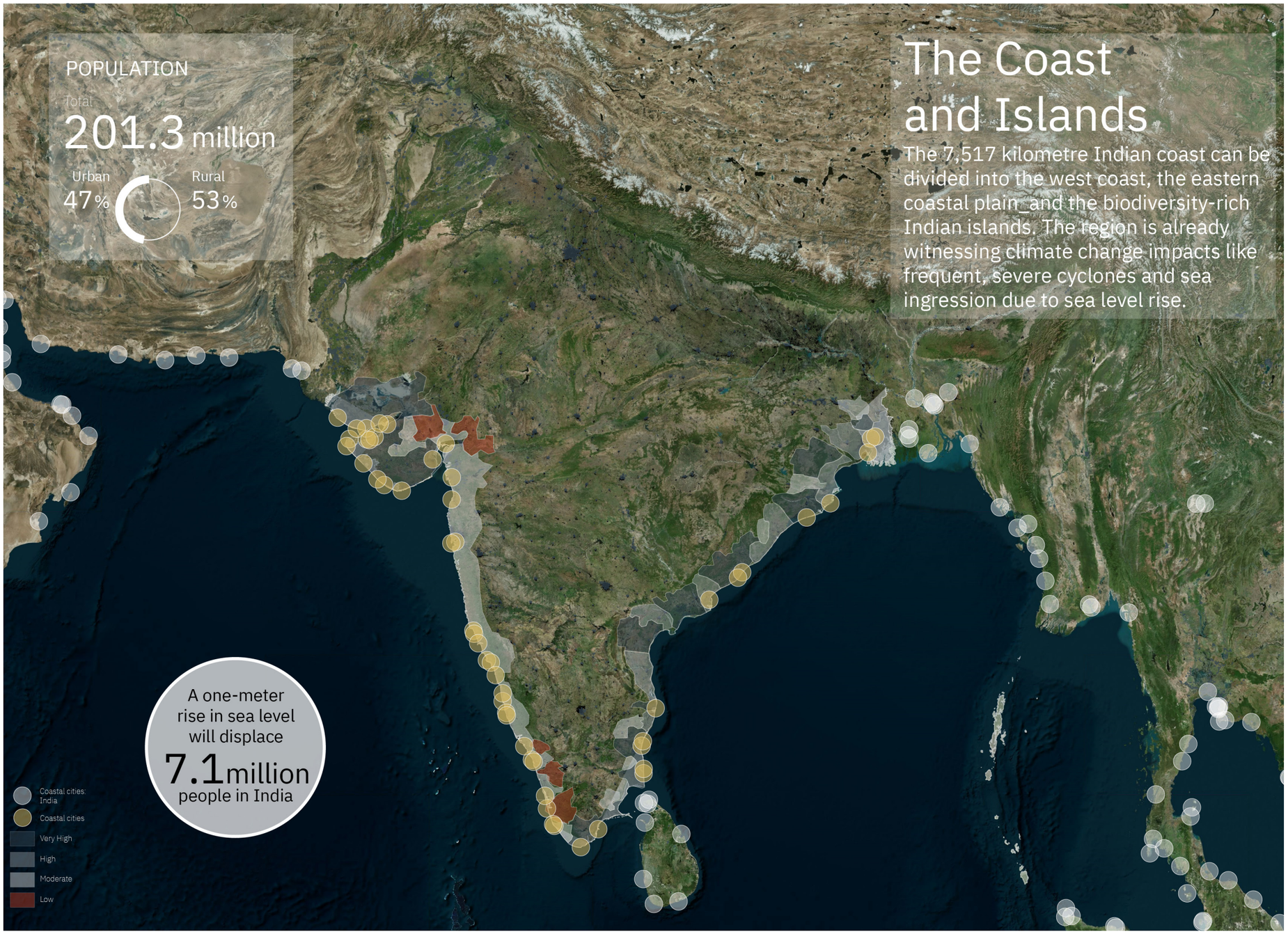


FIG. 1.32 Impact in caostal cities .source:author based on timesofindia

Figure1.1Megaregions in theWorld.source: https://qz.com/666153/

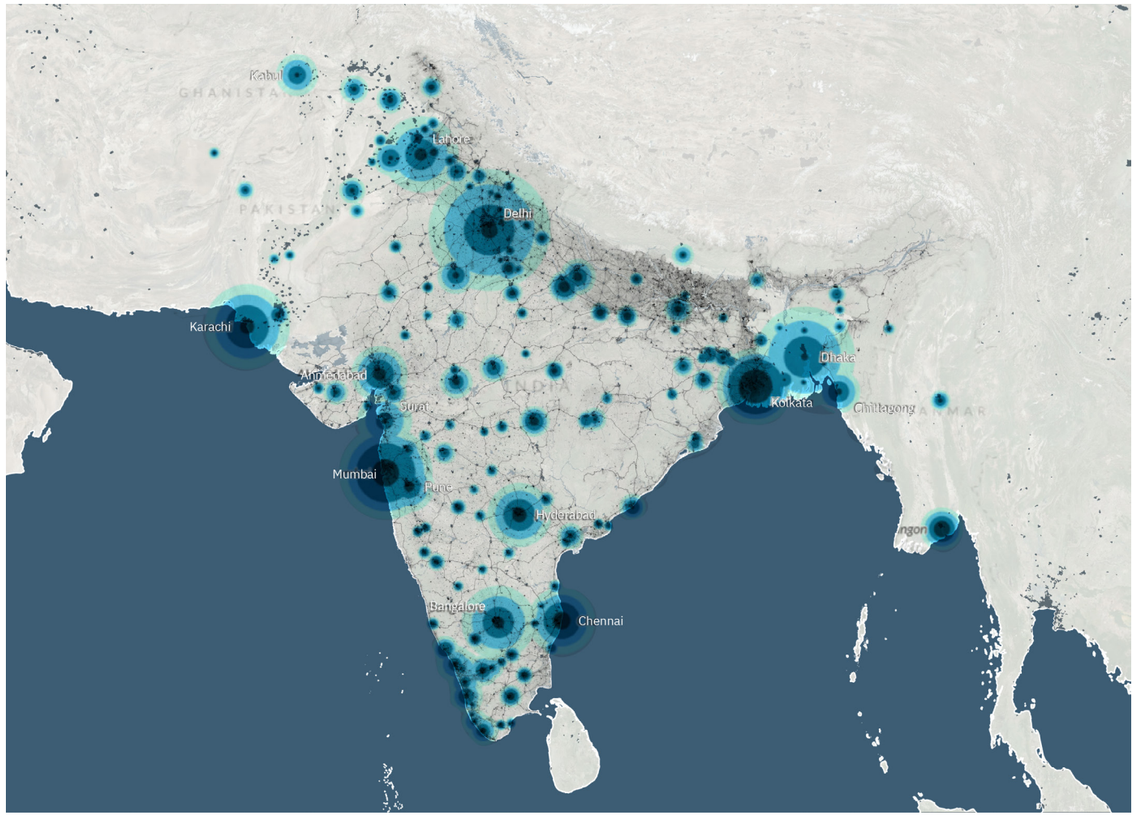


FIG. 1.33 Urban agglomeration in India .source:author based on https:/luminocity3d.org/world citylulum

But India with its massive population also deals with other rural-urban challenges like poverty, hunger, sanitation, access to water and energy etc. It is also one of the countries which is urbanising at a rapid pace. The transformation of the world from a predominantly rural to a predominantly urban world is being witnessed, but this transition has not yet fully occurred in India.(Sudjic, 2011)The 21st century is witnessing this transitioning with a rapid rate due to increment in population and internal migration. India's urban population is projected to grow from 410million to 814million by 2050.(UN, 2018)This requires planning and preparedness to ensure an overall sustainable development.

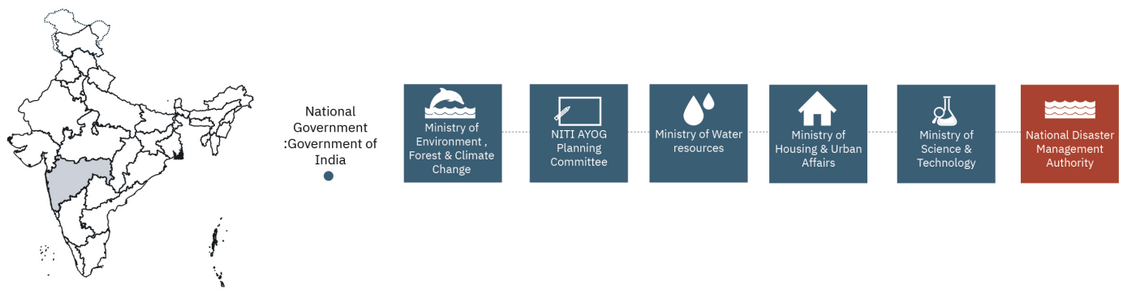


FIG. 1.34 Governance structure -Disaster Management responsible for flooding issue. source: author

India drafted its NAPCC- National Action Plan on Climate Change for the UNFCCC WITH 8 missions to tackle climate change like solar missions, green mission, water missions and others. But these Missions have not translated into a comprehensive and mandatory action list. Although it is not yet late and until now India is currently compatible with its indicated target to control emissions under 1.5 degrees as per IPCC but needs swift action in terms of adaptation of its highly vulnerable coast to floods.
Recently in 2020, industries like Tata, Godrej, Mahindra and others(approximately 40 industries) have joined hands through various philanthropic organisations, business schools, aid agencies, government advisory institutions, and academic think tanks have come together to cooperate on climate solutions with an umbrella organisation called India Climate Collaborative with an inclusion of International institutions like Bloomberg Philanthropies and MacArthur Foundation. The organisation identified three critical risk factors in india with one of them being the 7,500km coastline with several major cities, most importantly economic hubs, which includes the country's main ports which lie a metre or less above current sea level.(Khandekar, 2020) Therefore a disruption in supply and demand chain would also be disrupted. Such multiple narratives give different actors motive to come together for Climate action. This is a start but India needs more such scalable actions and cooperations to reduce the devastating impacts of climate change.

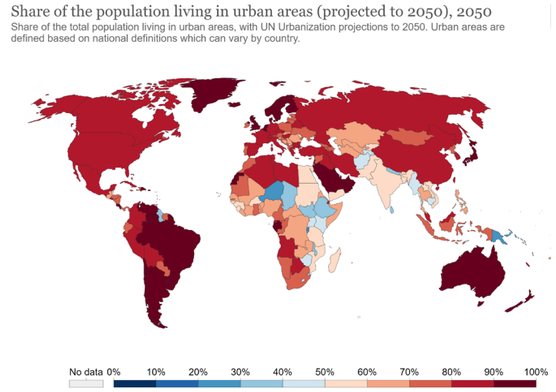


FIG. 1.35 Share of population in urban areas by 2050 .source: UN



FIG. 1.36 iUN Sustainable development Goals. source: UN.org

Climate crisis in the province of Maharashtra

The province of Maharashtra deals with destructive impacts of climate change ,with droughts in its rural areas and floods in its urban areas. The frequency of droughts in semi-arid regions in Marathwada and Vidarbha is now 5-6 years respectively and the destruction of floods along with frequency growing each year.(CDKN, 2018) Based on the study of the World Bank, the GDP per capita in the drought stricken districts of the state would shrink by nearly 10% by 2050. (Padmanabhan et al, 2019)
Maharashtra is attempting to deliberate Climate Change as an important issue of the state and plans to form a committee that deals with relief and disaster preparedness with a focus on impact of climate change. But the actions need to be extended to ‘adaptation’ inorder to safeguard the farmers from the detrimental impact on their produce and the urban centres from the losses in flood damage that already existing changes in climate would manifest.

Netherlands :
Area - 41,543 km²
Population - 17.28 million

Province of Maharashtra :
Area - 307,713 km²
Population - 114.2 million







FIG. 1.37 Geographic location of Maharashtra .source: author .

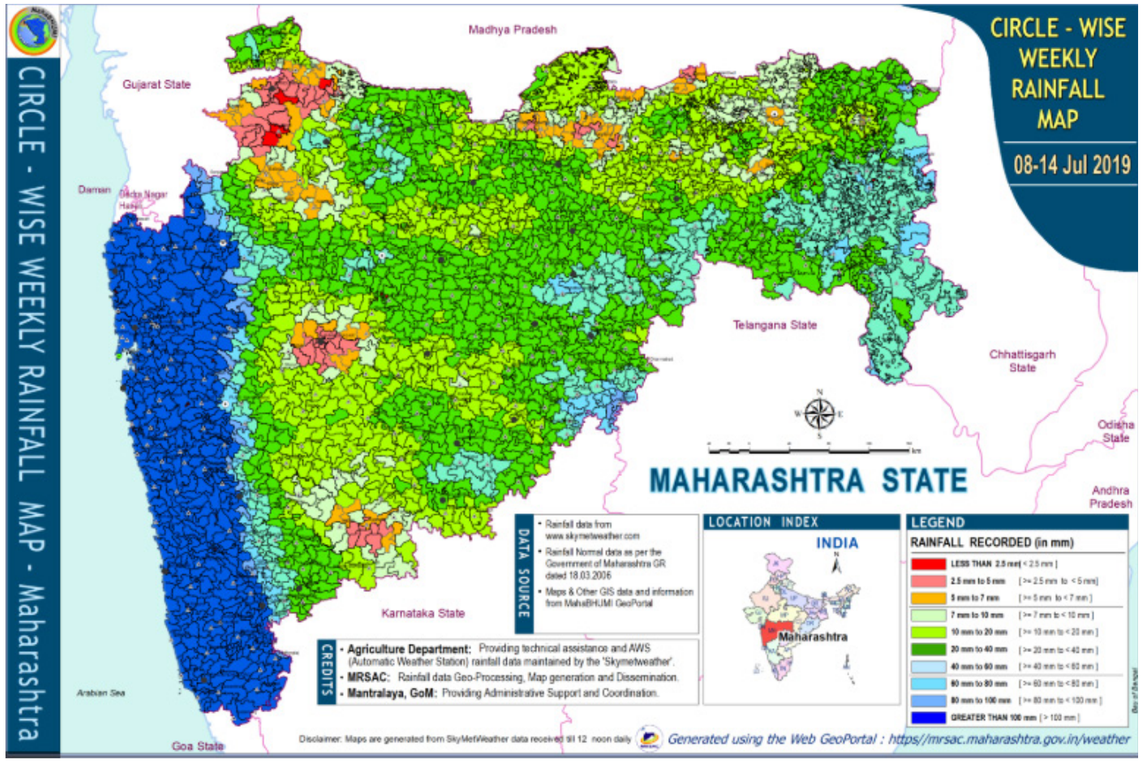


FIG. 1.38 Rainfall pattern.source:Moefff/ .



FIG. 1.39 Flooding in a district in Maharashtra.source:the quint

Climate crisis in Mumbai

Flood risk in Mumbai



FIG. 1.40 Flood in Mumbai .source:safwan patrawala

Mumbai , one of the 10 most populated urban agglomerations in the world, a metropolis of around 21million people is inundated at least once every year with heavy rainfall. The urban life comes to a standstill during the excessive rainfall days with railways, road transport inundated and incurs loss to life , livelihood and damage to infrastructure. (Srivastava & Tandon, 2019) In 2005 Mumbai witnessed the worst floods in its history, where more than 1,095 lives were lost as Mumbai was flooded by 945mm rainfall and high tides.

The past decades have shown a change in the rainfall pattern with a rise in extremely heavy rainfall events, not only in Mumbai but in the whole country. (Pinto, 2019)The year 2019 saw 344mm rainfall in 24 hours. Mumbai receives 60 percent of its rainfall in the months of July and August ,while 95 percent is received in four months between June to September. (SWD, 2019)

Many sources have suggested the flooding in Mumbai is attributed to outdated drainage systems, destruction of the natural barriers against climate change and unsustainable urbanisation which have taken a toll at the city's capacity to deal with heavy monsoons and climate change.This project would endeavour understanding the causes and exploring solutions to tackle this challenge.



FIG. 1.41 Floods in Mumbai 2005.source: timesofindia

Climate crisis in Mumbai



FIG. 1.42 Floods in Mumbai 2005.source: DNA

Year :2005

Death : 1,094 people
5.5 Billion Rs. direct economic loss



FIG. 1.43 Floods in Mumbai 2008.source: timesofindia

Year :2009

(data not available)



FIG. 1.44 Floods in Mumbai 2011.source: thehindubusinessline

Year :2011

Death : 12 people (across state)
Rainfall : 1,693 mm (Mumbai city) 1,908 mm (suburb)



FIG. 1.45 Floods in Mumbai 2014.source: theguardian

Year :2014

(data not available)



FIG. 1.46 Floods in Mumbai 2015.source: Agarwal, floodlist

Year :2015

Rainfall : 310mm(in 24hrs)
High Tide: 4.47m



FIG. 1.47 Floods in Mumbai 2017.source: urbanupdates

Year :2017

Death : 21 people
Rainfall :468 mm



FIG. 1.48 Floods in Mumbai 2018.source: indiatoday

Year :2018

(data not available)



FIG. 1.49 Floods in Mumbai 2019.source: mumbailive

Year :2019

Death : 30 people

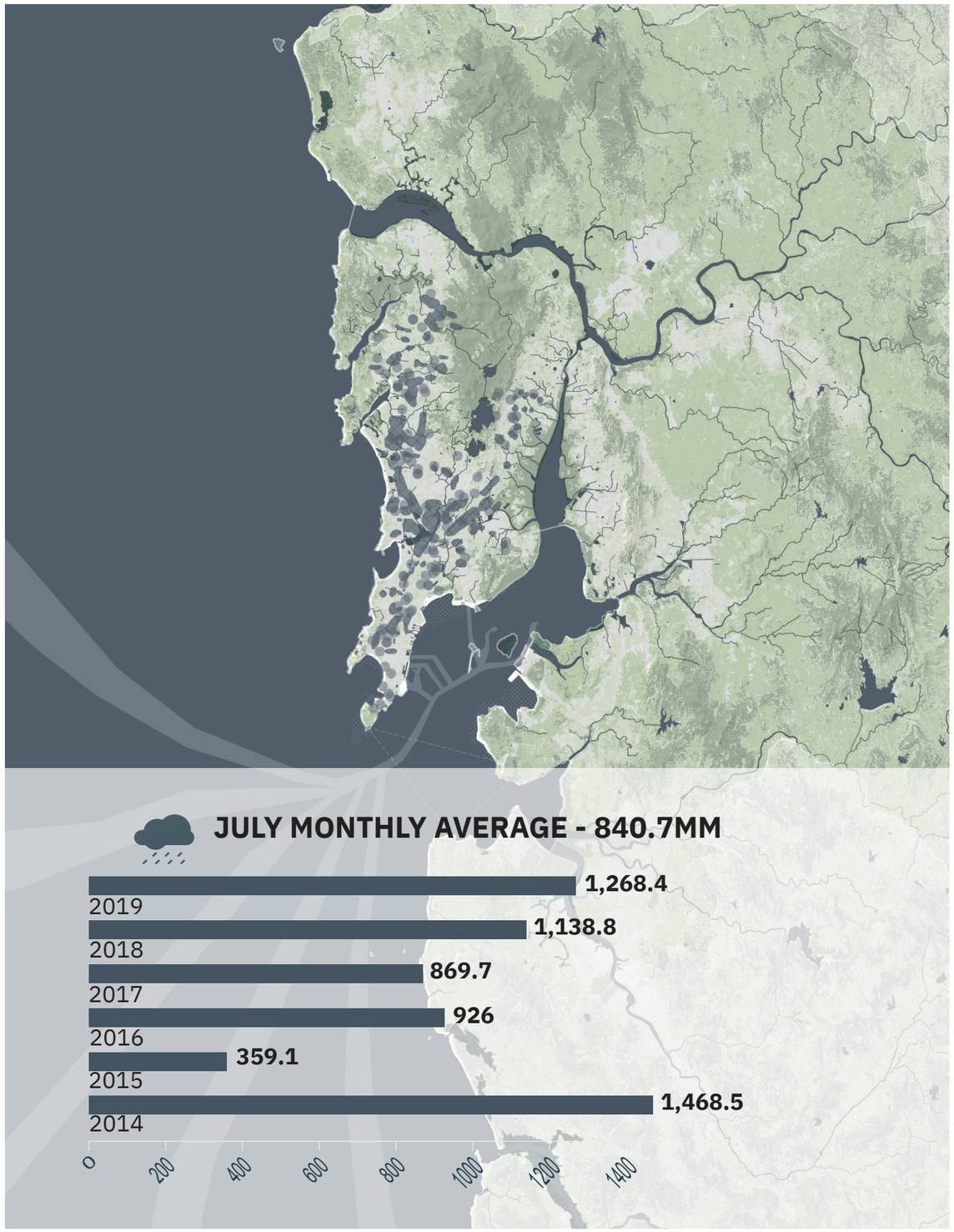


FIG. 1.50 Flooding spots in Mumbai with data of average monthly rainfall. source: author; based on times of india

Mumbai experiences pluvial, fluvial and coastal flooding. The erratic changes in rainfall patterns has been increasing over the past decade. With an average of 840.7mm rainfall in the month of July, in 2019 ,Mumbai experienced approximately 1,268.4mm of rainfall. the Meteorological department predicts the changes in the rainfall pattern increasign more and more in the next few years. Currently Mumbai has given charge the responsibility of flooding to Disaster Management and Storm water Department of teh Municipality of Mumbai. The city has a disaster management approach apart from the attempt to fix its century old drainage system.

With exacerbating climatic conditions, the city needs to be prepared for new conditions of existence. Climate change exposes people, societies, economic sectors and ecosystems to risk. Risk is the potential for consequences when something of value is at stake and the outcome is uncertain, recognizing the diversity of values. Therefore it

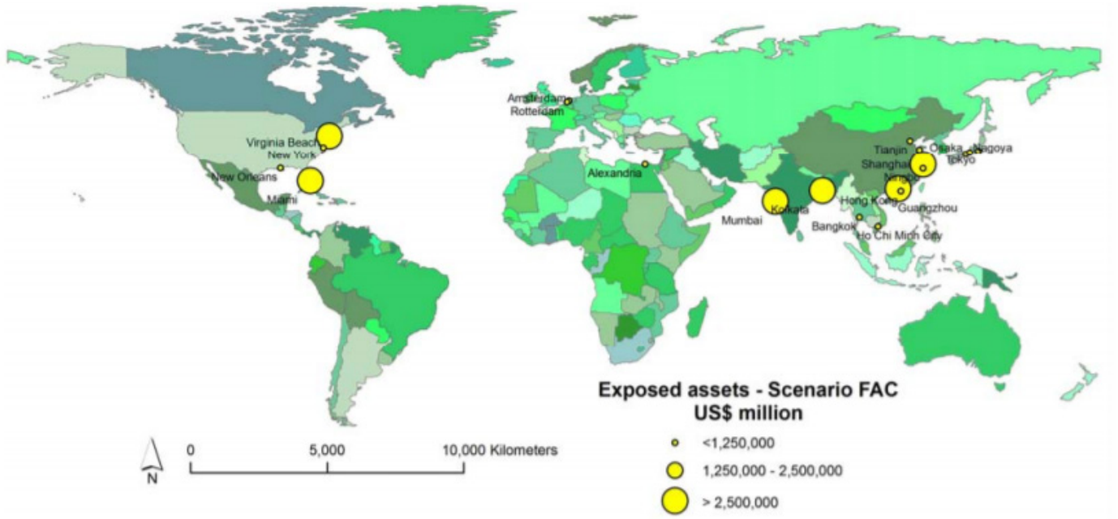


FIG. 1.51 Coastal flooding .source:author,based on climate central



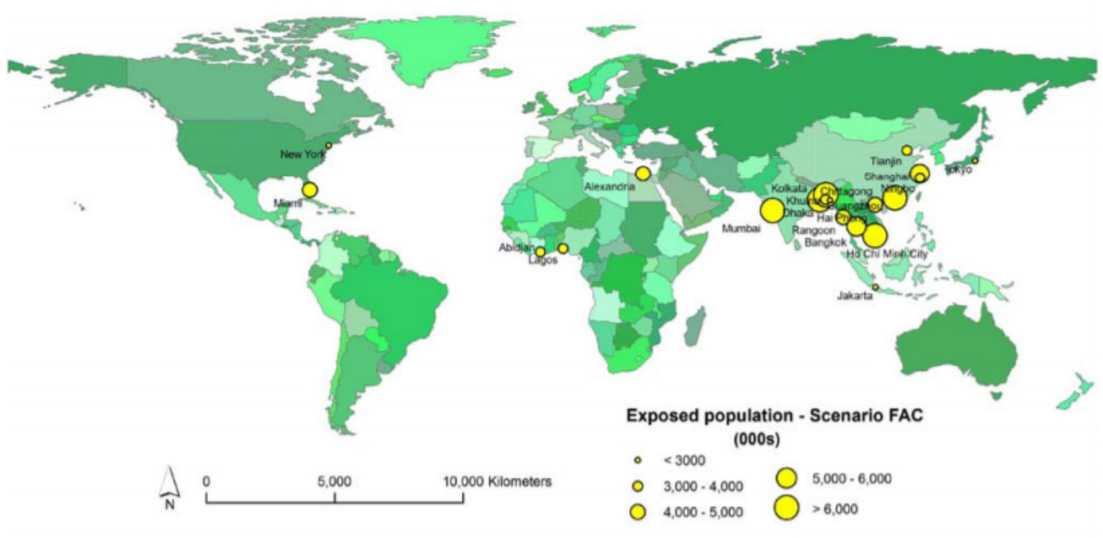
FIG. 1.52 Governance structure with respect to issue of flooding .source:author .

Climate crisis in Mumbai



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

FIG. 1.53 Highest Asset Vulnerability in the world.source: OECD



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

FIG. 1.54 Highest Population vulnerability in the world .source: OECD

is important to understand the future climatic conditions of Mumbai and adapt its urban landscape to withstand the impacts of those changes. In thsi process it is important to understand the other challenges that Mumbai faces like slums upgradation, poverty, economic inequality, access to resources, drinking water supply and other urban challenges. Sustainable development would involve a solution which not only tackles flooding but also responds to the other chanllenges that the city face. But to explore the solution, the project would first comprehend the cause of this annual event of lfooding in Mumbai.



FIG. 1.55 Cartoon on the situation in Mumbai. source:indianexpress .

IF WE DO NOTHING.
MILLIONS OF PEOPLE WOULD BE DISPLACED BECAUSE OF CLIMATE CHANGE.

WHAT CAN WE DO? HOW DO WE PREPARE OURSELVES FOR THE NEW REALITY?

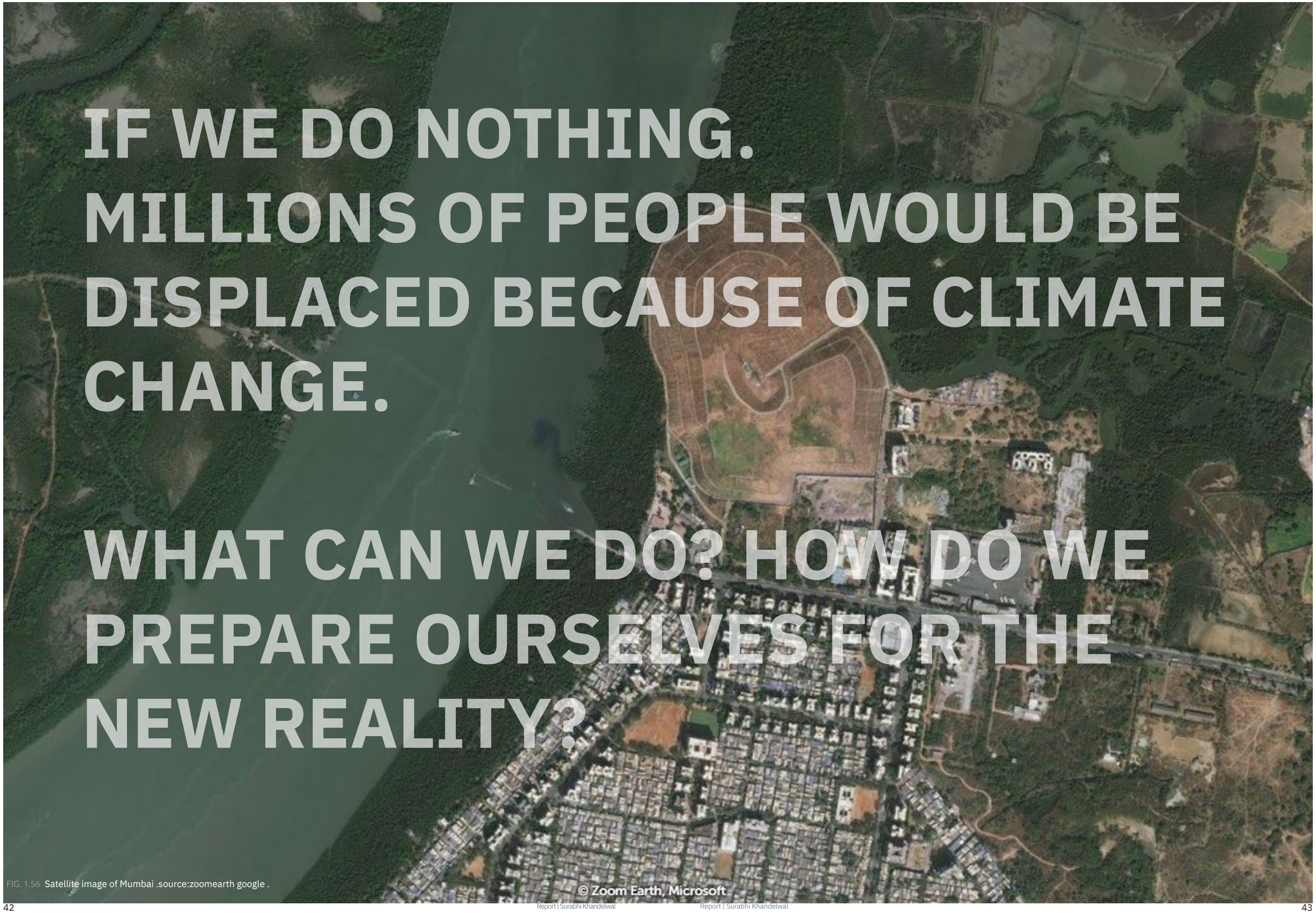


FIG. 1.56 Satellite image of Mumbai .source:zoomearth google .

3.

Why does Mumbai Flood?

Natural & Anthropogenic causes



FIG. 1.57 Bus submerged in the floods in Mumbai.source: pri

Context - Mumbai Metropolitan Area

Geography, context & problem focus

Mumbai, the financial capital of the country is also the capital of the province of Maharashtra in India is situated on the west coast of India.It is the second-most populous city in India with a population of 19.98million. The Mumbai city, also called as Greater Mumbai, has an area of 403sq.km which is the centre of the larger territory called the 'Mumbai Metropolitan Region' which includes an area of 6,355 square kilometres and a population of over 25 million. The Mumbai Metropolitan Region consists of 9 Municipal Corporations and 15 smaller Municipal Towns.



FIG. 1.58 Mumbai archipelago of 7 islands . source : author

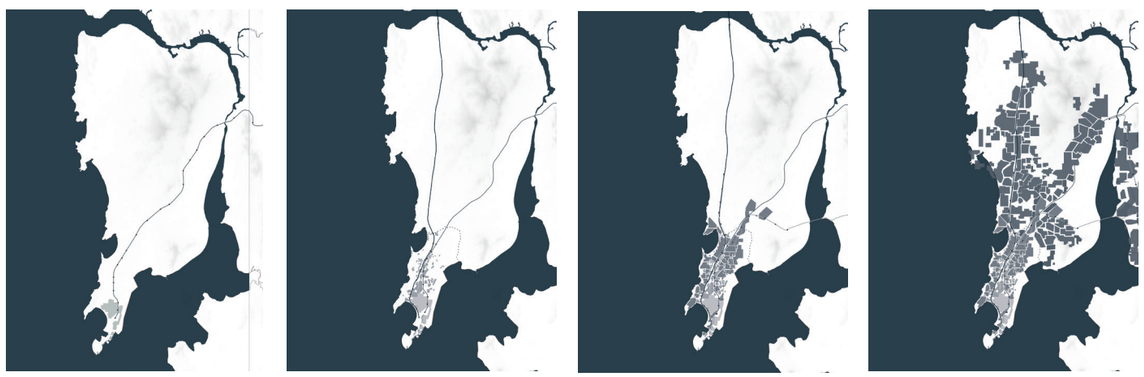


FIG. 1.59 Urban expansion of Mumbai .source:author

Greater Mumbai was once an archipelago of 7 swampy islands which were inhabited by small fishing communities which went through a succession of indigenous rulers and was later ceded to Portuguese and subsequently to British. Mumbai's physical history comprises of a series of reclamations-additions which were spontaneous and not set in a preconceived pattern or master plan. Each addition was a struggle by successive generations to recapture their position on the sea edge which forced the process of renewing the physical expression of the city in response to contemporary needs and aspirations and created a significant transformation in the urban landscape moulding the city edge to its present form. (Mehrotra, 2001)

Significance of Infrastructure

Railway infrastructure was a major instrument in reorganising the urban and rural space in India and all across the globe with the Industrial revolution. In 1853, the first railway line in India was laid between Mumbai and Thane. This defined the urban spatial form of the subsequent growth of the city. The infrastructure like Railways and Highways -industrial and technological interventions act as an instrument for cohesion and segregation.(Jain, 2016)
The railways fueled the growth and development of Mumbai. 'Concurrently, and undoubtedly springing from the development of Railway was the development of a new growth that was another blissful use of the steam technology: the cotton textile industry.' The first mill had started in 1854 and in a span of two decades, the number grew to 15 mills which daily employed 11,000 workers. By



FIG. 1.60 Expansion of the territory of Mumbai .source: author .



FIG. 1.61 Expansion of the territory of Mumbai and its relation with transition in infrastructure and economy.source: author; alamy; indiatoday

1900, another two and a half decades the number of cotton mills had risen to 76 (an increase of five folds) and the daily employment had increased eight times. This was an impetus for migrants from the hinterland to settle in Greater Mumbai. Thus the same infrastructure that shaped the economy of the city also shaped and reshaped the morphology of the city. Starting from the water infrastructure for the fishing village to port and water for ports and railways for industries and further on the technological infrastructure shaped Mumbai as a financial & commercial centre. Also, there was a constantly growing demand for new space for the City's growing economic base—the port, the railway infrastructure, the cotton mills, government offices, financial establishments. Migrants and settlers needed housing. A complicated synergy started spurring the city's population and spatial limits. This led to the re-territorialisation of Mumbai and then began this sequential series of expansion due to its limited land resource, that once Greater Mumbai, has now been redefined to Mumbai Metropolitan Area.

Natural Causes

Geograhich sensitivity-Rainfall & Topography



FIG. 1.62 Elevation below sea level .source: author based on DEM

Mumbai was once an archipelago of 7 islands which were inhabited by the people of the fishing community. Due to its strategic location, it was inhabited by the British East India Company to set up a port as a gateway to India. The port led to a series of reclamation in the consequent years as railway infrastructure arrived in this area as well. The reclamation of these group of islands, therefore, led to the elevation of the land not being very high above the sea level and still includes parts of the land which are below the sea level making it geographically susceptible to flooding. Also, the rainfall pattern on the west coast of India is high where most of the rain received by the city falls in two months amounting to almost 60- 70 % of the total rainfall in the year and the recent changes in climate have led to higher precipitation patterns in this coastal city since the past few decades.

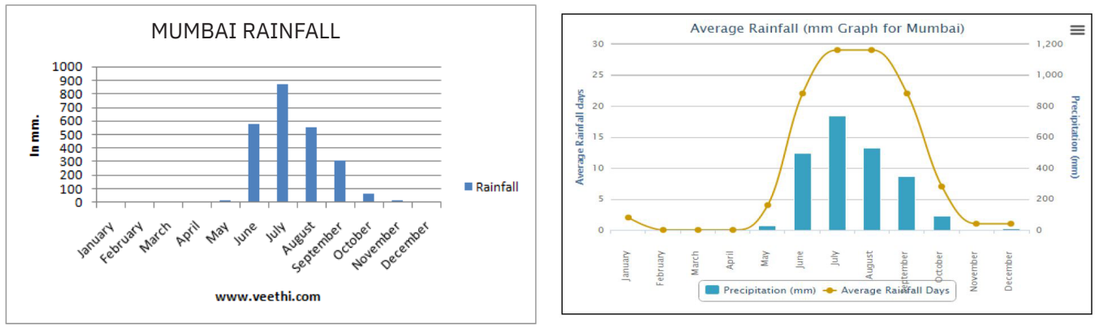


FIG. 1.63 Rainfall pattern in Mumbai .source: IMD



FIG. 1.64 Flood in Mumbai .source: stackumbrella

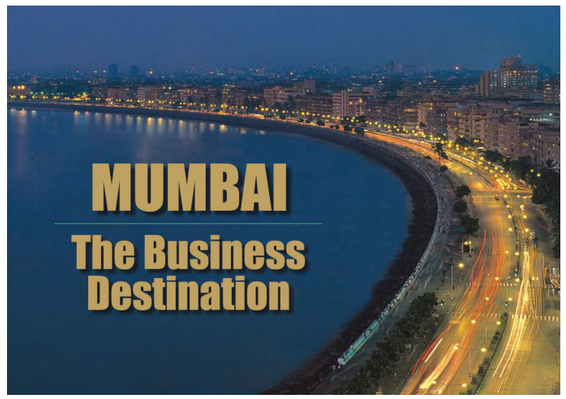
Anthropogenic Causes

I. Focus on Global economic concentration

Mumbai has gone through sequential transitioning in its economic phases, starting from fishing to trading ,in the 19th Century being the textile mill cluster to now being a diversified hub of finance, commerce, technology, entertainment and innovation.Mumbai has become one of the global cities in the world and this neoliberal development has been uneven.The emergence of Central Business districts and infrastructural developments focussed on efficient monetary gains in this neoliberal setting, this has lead to negative externalities both in society and ecology. It leads to urban challenges that needs immediate spatial measures.



FIG. 1.65 Mumbai branding-The business destination .source: MCGM



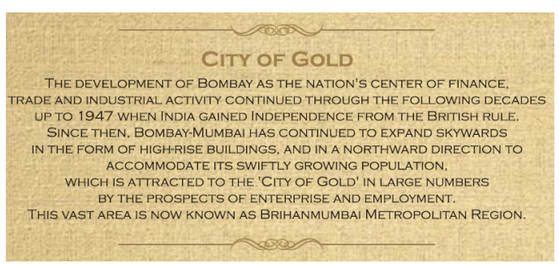


FIG. 1.66 Global economic concentrations.source: author based on open streets maps



Anthropogenic Causes

II. Infrastructure serving the global economic concentration

Although the current infrastructure has been a product and an instrument in this uneven growth. The railway lines were meant to connect the important global economic centres. A careful analysis of the distribution of the railway lines and stations show the clustering of these stations closer to the global economic centres and the wide distribution of the same in the suburb area with lesser economic centres. The east-west was also earlier not of priority as it did not benefit in the global economic trade. Later with the growth in urban population and development, there became a necessity to make these east-west connections which still remains an issue in the city.

III. Urban development oriented towards infrastructure

The urban growth in Mumbai follows the same logic as the railway infrastructure . The connection of port and industries in the hinterland guided the urban settlement which occurred as the city became a popular economic centre in the consequent years. Therefore Mumbai has two linear arms like urban plan along these railway lines.



FIG. 1.67 Infarstructure serving global centres.source: author

FIG. 1.68 Urban expansion along these infrastructures in Mumbai .source: author based on MMRP



Anthropogenic Causes

IV. Conflict of space with Ecology



FIG. 1.69 Expansion of built along with reduction of Mangroves in Greater Mumbai over the years. source: silentmaj

A. Encroaching /Depleting Mangroves

The conflict of space between the environment and urban has been an ongoing contest which has always been won by urban development in the interest of economic benefits but these gains have come at a detrimental cost to both ecology and society and now a cost to the existence of mankind.
Mumbai inhabits a rich ecology of Mangroves which have been in continuous conflict with urban reclamation due to a crunch of space leading to a loss of almost 70 per cent of the Mangrove cover with now 35 to 45 square kilometres of Mangrove cover left in the world's fifth-most densest cities in the world. (Goenka, 2017) Mangroves flank the river, creeks, sea and other waterways running in the city, wherein these havens include— short, shrubby trees with waxy leaves and tangles of finger-like roots that rise out of the swampy, sandy areas. In this global city, India's largest, mangrove forests have historically been overlooked with large extents of them being removed as part of land reclamation projects, and most of the remaining ones becoming dumping grounds for garbage and are seen as interstitial spaces between land and water to be occupied by developers and squatters. (NASA,2017)
Environmentalists and experts have argued that Mangrove forests are one of the few ways for 'a city starved of open spaces to breathe.' Mangroves act as natural flood barriers to tidal flooding and encroachment of these mangroves have led to frequent events of flooding in these areas. (Goenka, 2017) The failure of improvement in the drainage system along with urban development that disregards both ecology and society has fractured the capacity of the region to absorb, store and drain water. The 1980s and period after that witnessed a surge in population, with a doubling of the number of inhabitants in no time. This growth has led to the reclamation of natural areas without a comprehensive understanding of the system it embodies.
The Mangroves in Thane and Malad exemplifies instances of mindless annexation of the ecological territory. Other instances of their destruction are visible in the area around the Manori creek (North-West Mumbai Suburb) where large parts of mangrove forests have been massively encroached upon. In recent years CRZ regulation has been relaxed as a result of the developer's lobbying, posing a further threat to mangroves and in turn to the city.









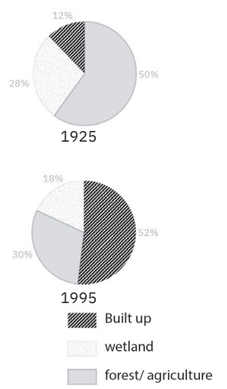




FIG. 1.70 Satellite monitoring of Mangroves-reductionf from 1988 to 2017. source :NASA

FIG. 1.71 Expansion of built along with reduction of Mangroves in Greater Mumbai over the years.

FIG. 1.72 Land use change from 1925 to1995



Anthropogenic Causes

IV. Conflict of space with Ecology

B. Encroaching Biodiversity Hotspot

gi The Western Ghats enlists as one of the 31 biodiversity hotspots in the world housing a range of flora and fauna which are unique to the habitat. Mumbai Metropolitan Region is ap part of this biodiversity hotspot but the new development plan as proposed by the Mumbai Metropolitan Region Development Authority has ignored the presence of this rich biodiverse habitat and the future urban development is in conflict with this ecosystem. In recent years, Environmental Impact Assessment has been gradually reformed to ensure that development could occur without hindrance any hindrance by Nature. This poses a threat to this rich ecology that would be uprooted for future urban development.

The images on the right shows this conflict of space between the western ghat and Regional Plan of Mumbai Mteropolitan Region. It poses a serious question of how do we develop in a compact way without taking up the space of the ecological system. How can we develop sustainably to ensure both existence of human and nature in the future world.

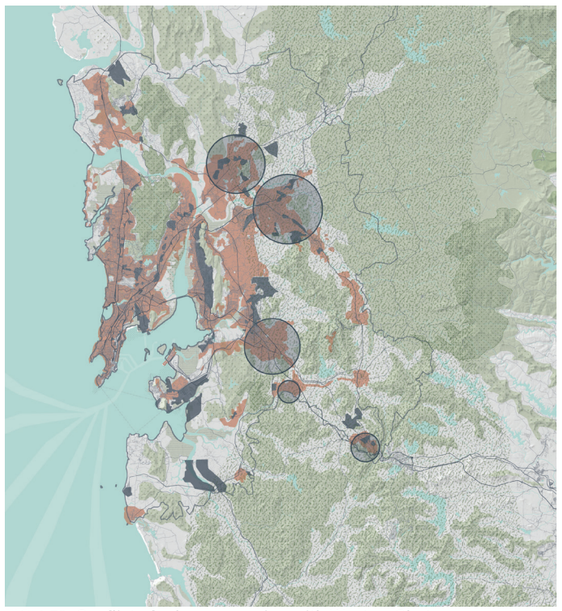


FIG. 1.73 Conflict of urban expansion with WesternGhats. source: author



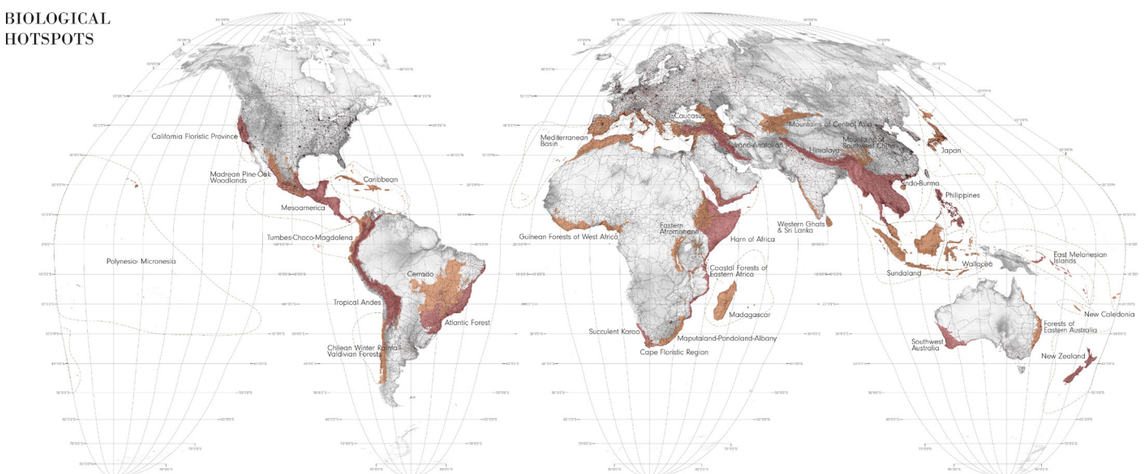


FIG. 1.74 Biodiversity Hotspots in the world. source: atlas for the end of the world

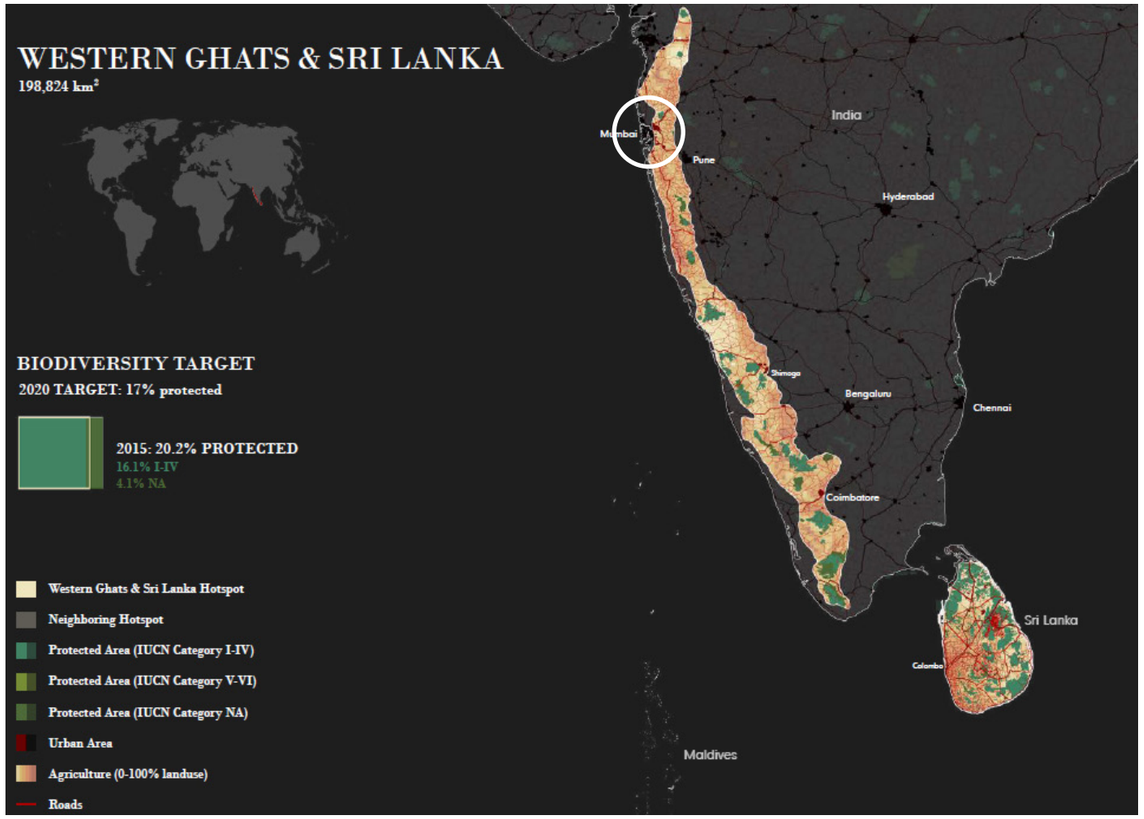


FIG. 1.75 Biodiversity hotspot -Western Ghat in India .source: atlas of the end of the world

Anthropogenic Causes

IV. Conflict of space with Ecology

C. Encroaching Saltpans

Saltpans are few of the remaining land untouched by the brunt of the real estate developer until now by strict Coastal Regulation zones(CRZ) safeguarding them. But recently in the wake of popular political support, the saltpans have been recently opened for development by changes made in the CRZ regulations. In total Mumbai houses 5,300 acres of salt pans which acts as an ecological barrier to coastal floods. They also host a set of biodiverse species which thrive on these saltpans. Changes in the laws were made subsequently to remove restriction from development on these saltmarshes. First, in 2017 it was removed from the category of wetland in order to open up a possibility of development. The next step which is already in action is to impose relaxation on the coastal regulation zones regulation where saltpans which are ecologically sensitive area falling under CRZ-1B could be developed under a special arrangement of a public-private partnership with Floor space index in line with the prevailing regulations for the city. This would open up 1,781 acres of saltpans for development. (Dixit,2019) Salt pans are situated in Mulund, Bhandup, Ghatkopar, Chembur, Wadala, Trombay, Jogeshwari, Malwani, Gorai, Bhayandar and Virar.

Environmentalists have tried multiple narratives to argue for this action and the response by ecology would be detrimental to society. Some people have argued that the low-cost housing project would not be feasible on this land as in order to make this land buildable, an additional cost of investment would be needed to make this land good for construction with infrastructure to be planned and built with additional coasts and difficulty making it an expensive project than its former purpose. (Dixit,2019)

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

By Nikhil S Dixit • October 16, 2019



FIG. 1.76 New paper article about saltpans being opened up for development . source: quartzindia

hindustantimes

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Home / Mumbai News / Mumbai will drown if development is allowed on salt pans

Mumbai will drown if development is allowed on salt pans

The state's move has come at a time when it also declared plans to set up an expert committee to identify the reason behind floods in the state.

MUMBAI Updated: Aug 21, 2019 05:41 IST

Faisal Malik
Hindustan Times, Mumbai



FIG. 1.77 Newspaper article about the issue of development on saltpans . source: hindustantimes .

MONGABAY
NEWS & INSPIRATION FROM NATURE'S FRONTLINE IN INDIA

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Mongabay Series: Environment and Elections

Salt pans save Mumbai from floods. So why are they under threat?

by Nikhil S. Dixit on 14 October 2019



FIG. 1.78 Saltpans saves from flood. source:Mongabay Mongabay .

Anthropogenic Causes

IV. Conflict of space with Ecology

D. Coastal Regulations

Coastal Regulation Zone in 1991 was defined as the coastal land(does not include the oceanic part) up to 500m from the High Tideline (HTL) and a buffer of 100m along the banks of rivers, creeks, estuaries and backwaters subject to tidal fluctuations. The Environment Protection Act of 1986 has restricted activities in these buffer areas due to the risk of flooding and environmental threat, for instance setting up and expansion of industries or processing plants which is issued by the Ministry of Environment and Forest(MOEF)(Environment department, MCGM)
These zones can be categorised in four categories- CRZ-1, CRZ-2, CRZ-3, CRZ-4 with the following definition:
'CRZ-1: Ecologically sensitive areas which are essential in maintaining the ecosystem of the coast. They lie between low and high tide lines. Exploration of natural gas and extraction of salt are permitted
CRZ-2: these areas are urban areas located in the coastal areas. Now under new coastal zone regulations 2018, the floor space index norms have been reinstated.
CRZ-3: rural and urban localities which fall outside the 1 and 2. Only certain activities related to agriculture even some public facilities are allowed in this zone
CRZ-4: this lies in the aquatic area up to territorial limits. Fishing and allied activities are permitted in this zone. Solid waste should be let off in this zone. This zone has been changed from 1991 notification, which covered coastal stretches in islands of Andaman & Nicobar and Lakshadweep. ' (MOEF,2013)

The first CRZ notification of 1991 signified the government's intention to protect the coastal environment and its resource-dependent population by regulating land use along the coast.' (Chouhan, Parthasarthy & Pattnaik, 2016) With the liberalisation of the economy in the subsequent years, the notification experienced multiple amendments, where provisions were bypassed to promote economic benefits. In 2018, the Indian government called the CRZ notification an opportunity to "see and enjoy the beauty of the mighty seas," where enhanced economic activity would "rejuvenate coastal activity while also reducing their vulnerabilities." (Chouhan, Parthasarthy & Pattnaik, 2016) Also in 2019,Mumbai witnessed an amendment in the CRZ which reorganised the CRZ1,2 and areas due to which land earlier marked as 'No Development Zones' were converted into zones which allowed urban development in the name of 'economic growth'. This poses a threat to activities that could exacerbate the problem of climate change and worsen the impacts of flooding in Mumbai.



FIG. 1.80 Negative externalities on society due to changes in Coastal Regulation Zone. source: engage

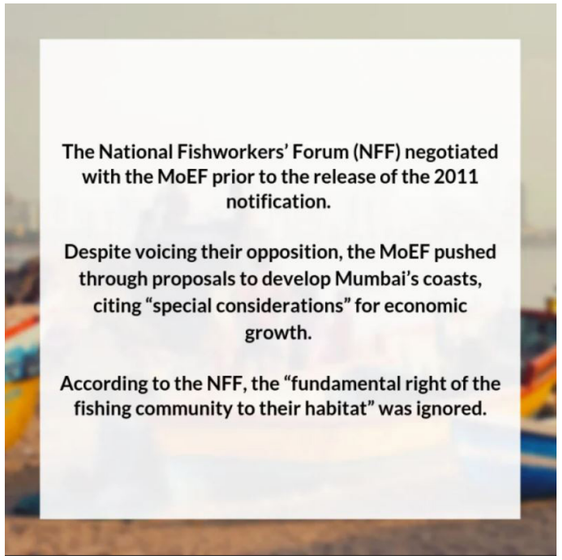
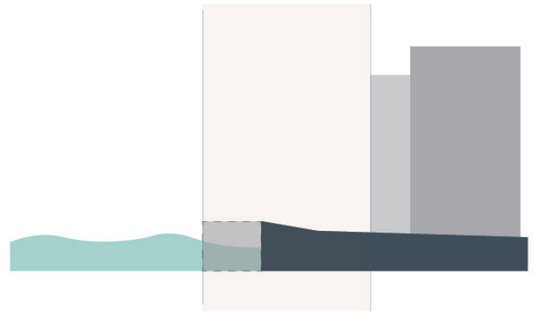


FIG. 1.79 Negative externalities on society due to changes in Coastal Regulation Zone. source: engage



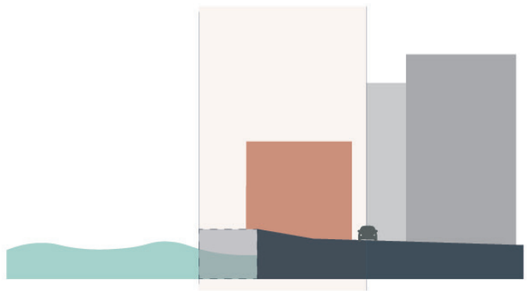


FIG. 1.81 Cause of flooding due to violation of Coastal regulation zone .

Anthropogenic Causes

IV. Conflict of space with Ecology

E. Compensation Afforestation over preservation

Trade-offs and compensations are a market strategy to negotiate, and it is important to perform a cost-benefit analysis in such cases to ensure the benefits of the project is more than the cost.
But recently the politicians have employed a narrative to ensure uncontestation of their development plans harming ecology to silent the environmentalists. The Japanese technique of creating micro forest which can be implemented in dense urban environments to create a new green ecosystem in the dense urban environments.
But this needs to be careful examination and assessment as afforestation cannot be an argumentation for deforestation. The health and ecological benefits of trees which have been there for years cannot match the new plantation created in place of them somewhere else as compensation. Also, it is difficult as of now to say that the complex forest ecosystem can be artificially replaced and if the transferability of the technique from Japan to India, a tropical country makes sense or not.
Some people view it as a 'good way to improve the green cover, especially in pockets of congested cities like parks and hospitals' while at the same time questioning the extent of its application as forests are a natural ecosystem which could be supplemented by them but not replaced. (Kaushik,2019)



FIG. 1.82 Newspaper artcile describing the protest against this compensation gimmick. source: mumbailive



FIG. 1.83 Construction on the banks of Mithi river. source : author

Anthropogenic Causes

V. Stormwater drainage network

Incapacitative planning - Human-made infrastructure

Mumbai's incapacity to drain floodwater is partly due to its century-old drainage system that is unable to cope with the capacity of rainfall that the city witnessed in the current times.It is a network of surface drains across 2000 km and underground drains of about 400km but they are heavily silted and damaged at many parts. Their outfall to the sea is blocked in some cases and 42 out of the 45 outfalls lack flood gates to avoid reverse flow during high tides and many of them are also at an elevation below the high tide line. The drains planned and constructed would have a capacity of 25mm per hour but this does not withstand the rainy days when the capacity needed is more than 50mm per hour. (Srivastava & Tandon, 2019) The city currently has 6 pumping stations where at several places the 'flooding' is solved by diverting the water to flood another area.

'The Brihanmumbai Storm Water Disposal System (BRIMSTOWAD) project to fix Mumbai's drainage system was proposed in 1993 after the 1985 floods and was intended to be a longterm road map for the city's vulnerability to flooding. However, no action was taken due to the financial cost of the project until the 2005 floods after which the department was under pressure by people and other authorities with a committee formed to analyse the deluge that made recommendations to upgrade Mumbai's old stormwater drainage system.(Srivastava & Tandon, 2019)

Pumping stations incapacity

incapable storm water drains



FIG. 1.84 Stormwater drainage network under streets with pumping stations. source : author



hindustantimes

Monday, Jan 13, 2020

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Home / Mumbai News / 14 years on, drainage system still unfinished

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

FIG. 1.85 Article about the ongoing work on drainage system. source: hindustantimes .

Anthropogenic Causes

VI. Impervious built environment

Incapacitative planning - Human-made infrastructure - Imperviousness of the socio-economic system

The current dense built environment of Mumbai is highly impervious and concretized. The regulations like FSI have made permissible prescription for the built area but the regulations necessary to safeguard open green space are still missing. This leads to both private open space being built as driveways, parking lots and rarely leaves green spaces for the city to breathe. In a recent study by HCP planning firm in India, it was observed that 52 per cent of a 1kmx1km of land comes under private open spaces which generally form driveways or parking spaces and are inaccessible to the public. Therefore when one looks at the land surface temperature of the city, the temperature is quite high and needs interventions to cool down the urban heat in the city.

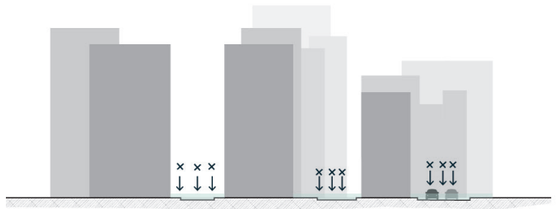


FIG. 1.86 Impervious surface. source : author

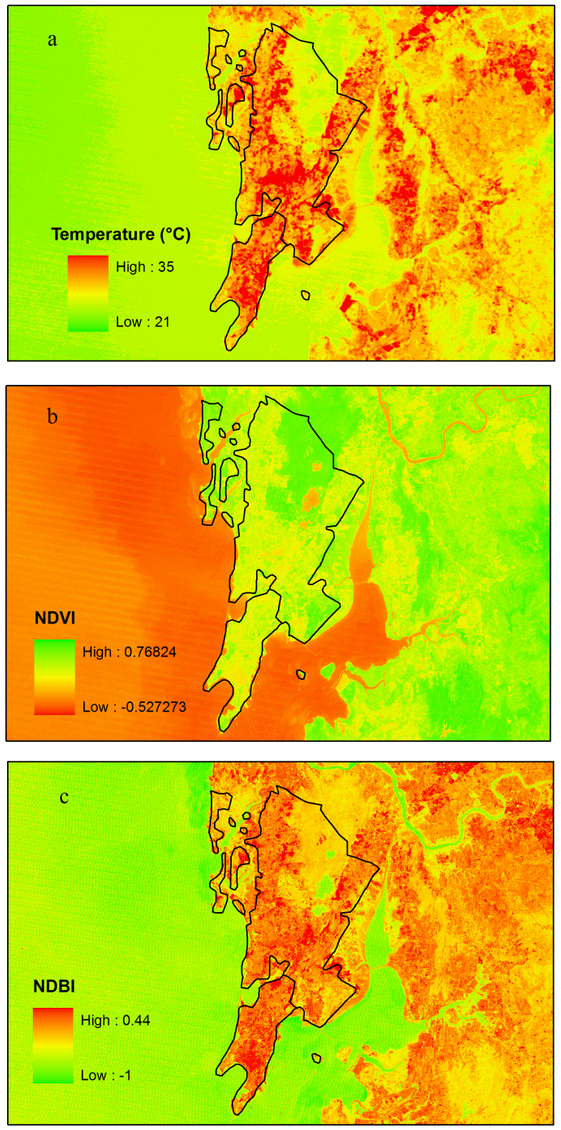


FIG. 1.87 Land surface tempearature with NDVI & NDBI source : Singh & Grover, 2015

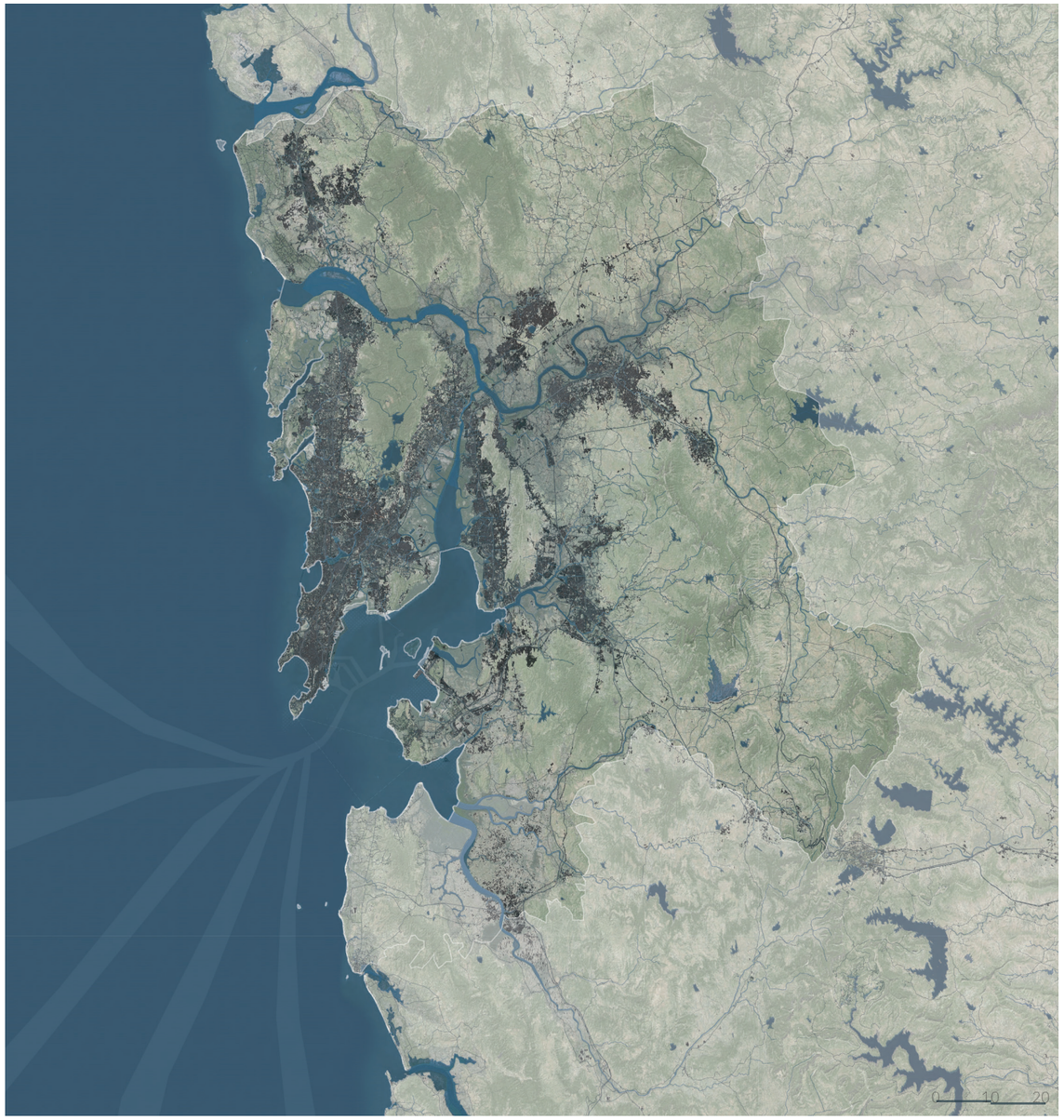


FIG. 1.88 Impervious built environment. source : author

water
nature reserve
forest
biodiversity hotspot
grassland
grassland
building

Anthropogenic Causes

VII. Planning framework- Regional Plan

Inconsideration of climate change impact

The current Mumbai Metropolitan Region Plan has not brought the issue of climate change to the forefront and does not take the issue of flooding as a serious threat in the future. It ignores the issue as being taken care of by the storm waterdepartment which seems enough for the autorities in terms of action to tackle climate change.
It is a matter of great concern to see that flood risk zones are not mapped since the 2005 catastrophic event. The storm water departement has prepared a list of 336 flooding spots but hasnt identified these on the map of mumbai spatially. Flood risk modelling is a technology which needs to be integrated within the system of analysis and action apart from other measure that needs to be taken up by the authority to bring this issue at the forefront as climate change is as real as it can get.

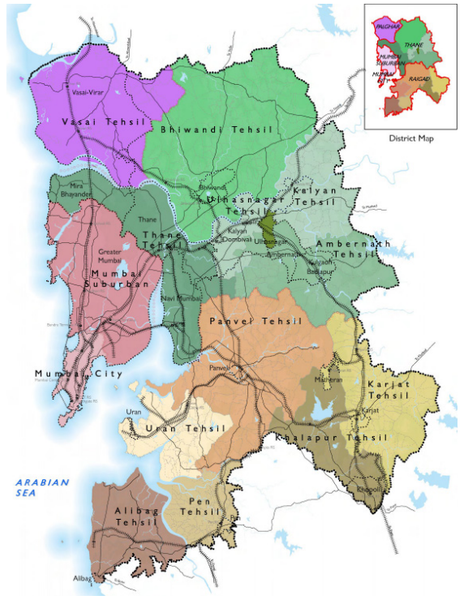


FIG. 1.89 Mumbai metropolitan region-Districts source ::Mumbai metropolitan region plan

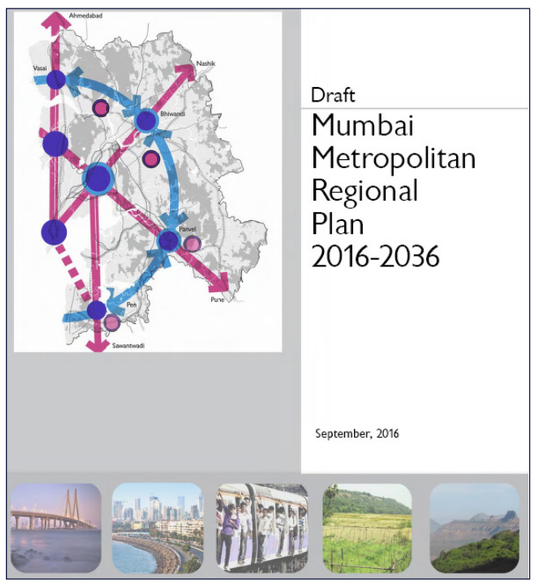
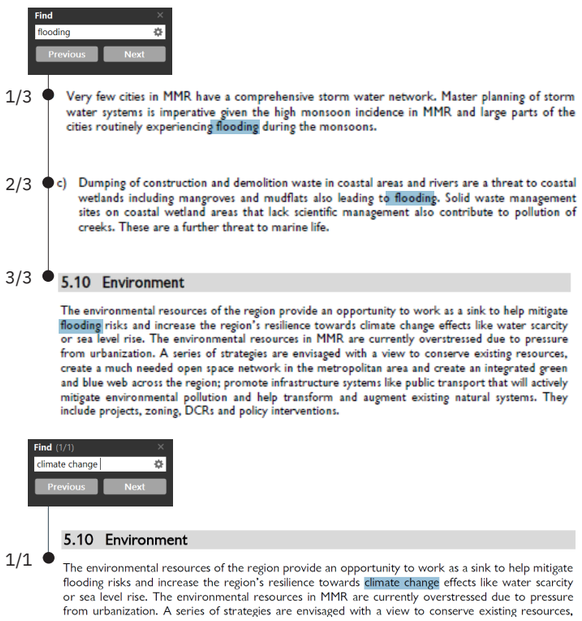


FIG. 1.90 Snapshots of document with climate change and flooding mentioned 1 & 3 times respectively. source :MMRP



Flood-risk zones not mapped even after '2005 deluge: Supreme Court panel

Clara Lewis | TNN | Sep 11, 2019, 5:17 IST

A- A+



A swollen Ulhas River had flooded Badlapur in July

MUMBAI: The BMC and Mumbai Metropolitan Region Development Authority (MMRDA) did not prepare flood-risk zone maps even 12 years after the 2005 deluge that was caused by a swollen Mithi river, according to a Supreme Court-appointed committee which submitted its report on the river's status to the apex court in March 2018. The committee had also observed that while a trapezoidal section was suggested for widening Mithi, a rectangular section was adopted, which reduced the river's carrying capacity.

FIG. 1.91 Flood risk zone not mapped- news article.source: TNN

Anthropogenic Causes

Exemplification of Urban development & Planning

Case examples I

Airport runway extension :
The International Airport Authority of India diverted the river to extend the runway of the airport. According to law,the course of a river cannot be changed except for dams, which also needs to be restored back. The river has been diverted by 90degrees at 4 places within a kilometer stretch. River would naturally flood during monsoon as it has an organic flow. (Gupta,2015)

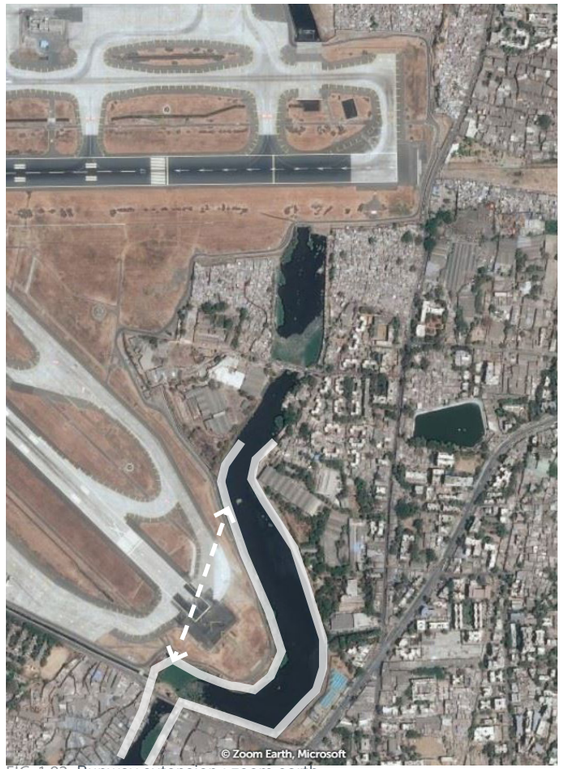


FIG. 1.92 Runway extension : zoom earth

Case examples II

Bandra Kurla Complex Reclamation :
Reclamation of 600 acres of land for creation of Bandra Kurla Complex since 1973 has resulted in Mithi river overflowing which was occupied by landfill in river, mangroves and wetlands. (Lewis, 2019) The river which is one of the world's oldest surviving river systems has been encroached upon gradually in the name of development'' leading to floods. (Gupta, 2015)



FIG. 1.93 BKC reclamation : zoom earth

Case examples III

Aarey colony-Metrocar shed :
The Sanjay Gandhi National park which is an ecologically sensitive area adjoins aarey colony which was once a part of this area ,has recently been opened up for development to house a metro car shed. This would disturb the hydrology of the area and cause future floods in the neighboring areas.



FIG. 1.94 Aarey colony : zoom earth

Case examples IV

Coastal Road Project:
This is a recent controversial project in Mumbai ,which is still under public litigation but with reclamation work already started on certain parts of the coast. It is an eight lane 29.2 km long freeway that would run along the west coast of the city. It would disconnect the city with its coastline and impact both society and ecology negatively.

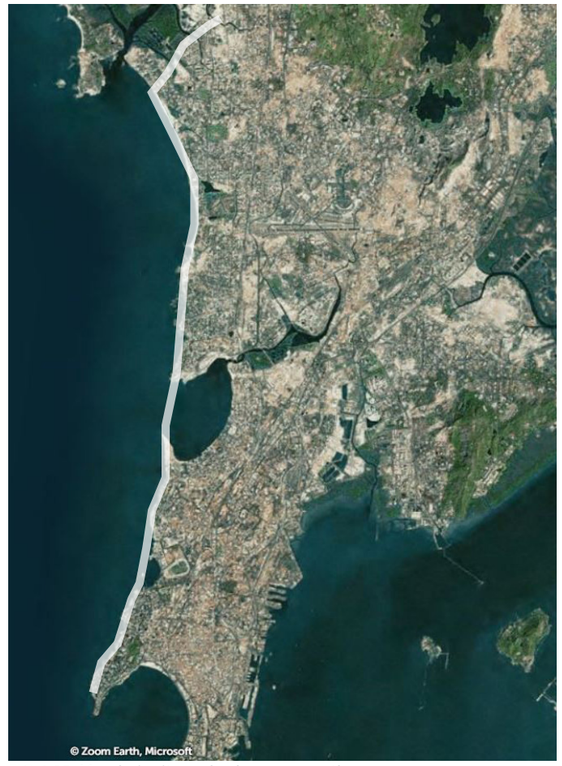


FIG. 1.95 Mumbai- city -suburb : zoom earth

4.

Understanding the socio-economic structure

A street in borivali Mumbai. source: author

Urban development & Planning

Existing Built Area

This shows the current urbanisation pattern in Mumbai Metropolitan Region through built and industries layers. Mumbai Mteropolitan Region consists of 8 Municipal Corporations, few councils and villages. The Regional plan is drafted by the Mumbai Metropolitan Development. The current developemnt has been defined by infrastructure and has a linear morphology.

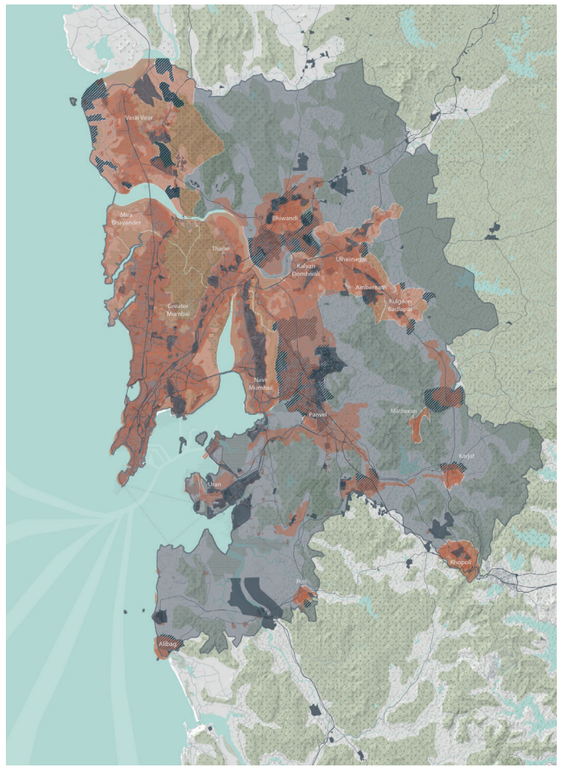


FIG. 1.97 Mumbai-Urban and Rural area. source: author based on MMR

FIG. 1.98 Existing built area . source: author

- water
- nature reserve
- forest
- biodiversity hotspot
- grassland
- grassland
- building
- port
- wetlands
- shallow depth sea
- commercial
- flooding
- sewage plant
- roads-smaller
- highway
- railways

Urban development & Planning

Urban Growth

Considering the case of Mumbai in India, which locates itself between global and local identity being a global megalopolis with a post-colonial reality. Mumbai as a global city region and the financial capital of the country has developed at a tremendous pace with adapting its economy to the quicksilver global economy resulting in the concentration of jobs that have created a centripetal force and mobilised human resources through large scale internal migration within the country. The future of Mumbai is projected to inhabit about 24 million people and has to be taken into account for when planning for the future. The incapacity of this topographic coastal geography to absorb this large number of migrants with limited land resources and uneven allocation of resources and capital has led to huge disparities in social processes. Especially leading to the proliferation of slums which constitutes fifty-five per cent of the population and the informal sector jobs.

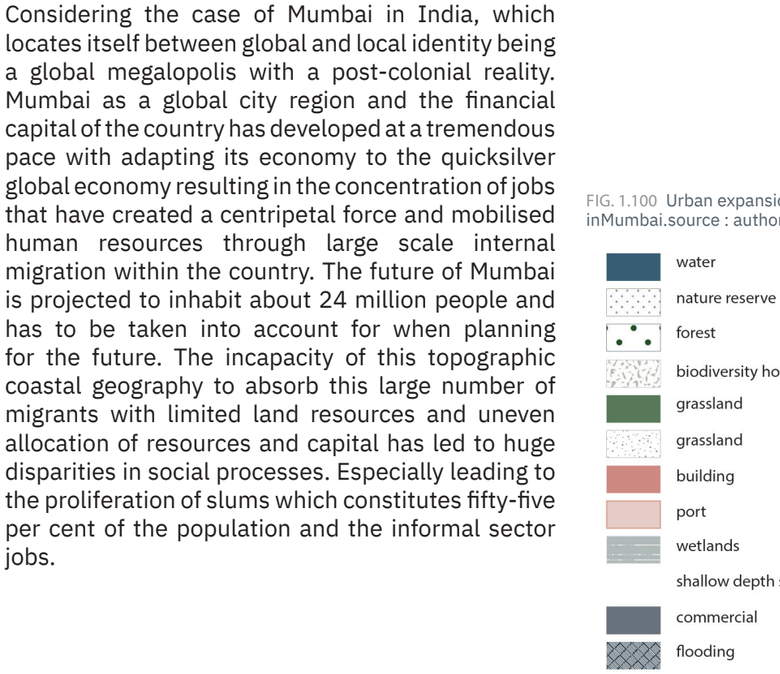
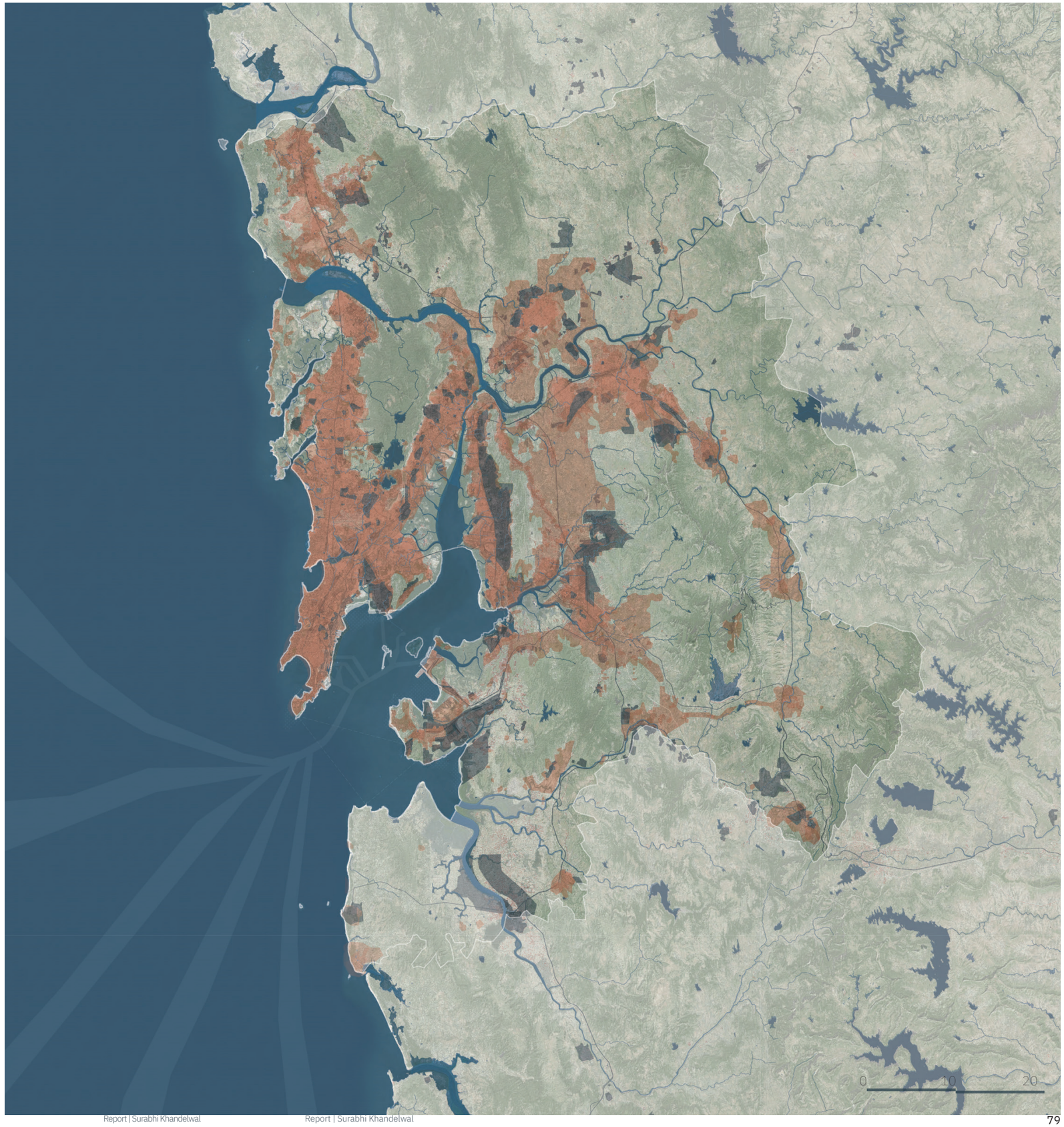


FIG. 1.99 Population growth in major global cities- Mumbai 25 M.source: UN DESA DESA

FIG. 1.100 Urban expansion inMumbai.source : author



Socio-economic system

Global City- Kinetic City

Mumbai is a varied landscape, occasionally called ‘One Space, Two worlds’. (Mehrotra, 1991) One city One world is supposedly static and monumental in its nature while the other is kinetic, sprawling in the interstitial spaces it finds. Mumbai city is the physical manifestation of these socio-economic forces in play. As discussed earlier in the history of the city, the economic transformation of the city has led to-this varied socio-ecological system as of today. It houses a population of over 20 million people where approximately 55percent of the population resides in slums and are largely absorbed in the informal economy. At the same time, it is counted amongst the megacities and aspires to be a leading global city with its financial centres, it hubs, banks and institutions in place. The socio-ecological system provides great potential for steering the development in a more sustainable pattern but this involves challenges as it also constitutes a large vulnerable population and the current pattern of growth disregards the social and ecological vulnerabilities in the city. It is essential for the planning bodies to recognise that both population especially the migrants are making the culture and physical form of the city as much as they are adjusting to the same.

The city is projected to expand to a population of approximately 25million people by 2030 (According to UN Desa) which increases the percentage of prospective vulnerability if the future with comprehensive rhythms of change is not accounted for. Mumbai with its suburban railway lines, metro lines planned, monorail, diverse population and economic welfare although unequal provides a great opportunity for tapping the current system and to combine it with the ecological system to create a resilient socio-ecological system. The current practices to provide flood resilience is using the storm-water drainage which would resolve the problem to a limited extent and only for a limited time. This system needs a combination of the ecological system which can provide the capacity to the city to cope with frequent flooding in the future. The economic and social capital together with the natural capital can mobilise an adaptive system for the future.

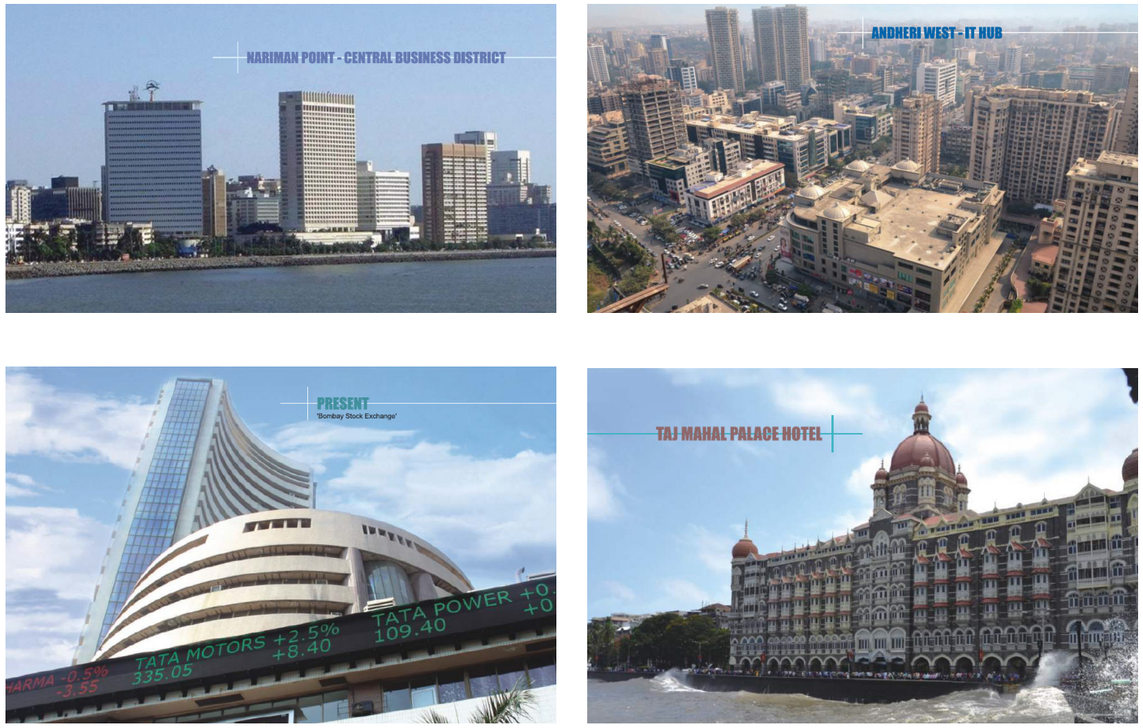


FIG. 1.101 All images are Mumbai branding -a business destination. source: MCGM destination

Socio-economic system

Migration-Population growth

A workshop by an urban research think tank once made an interactive exhibition in Mumbai asking people to connect where they migrated from in India and the result was extraordinary as seen in the image below. The urban economic forces mobilises a large population of the the country to move towards these financial hubs, where people from rural or less urban area or sometimes second tier urban centres some to this city permanentallly , temporarily or seasonally. The lack of planning of this migration results in creation of slums in ceratin sections of the society while it also employs a large workforce in informal incomes. Thus the population growth in future would involve such dynamic forces and planning in future would require taking this in account and ensuring social and ecological justice.



FIG. 1.102 Migration to urban economic centres. source: author destination

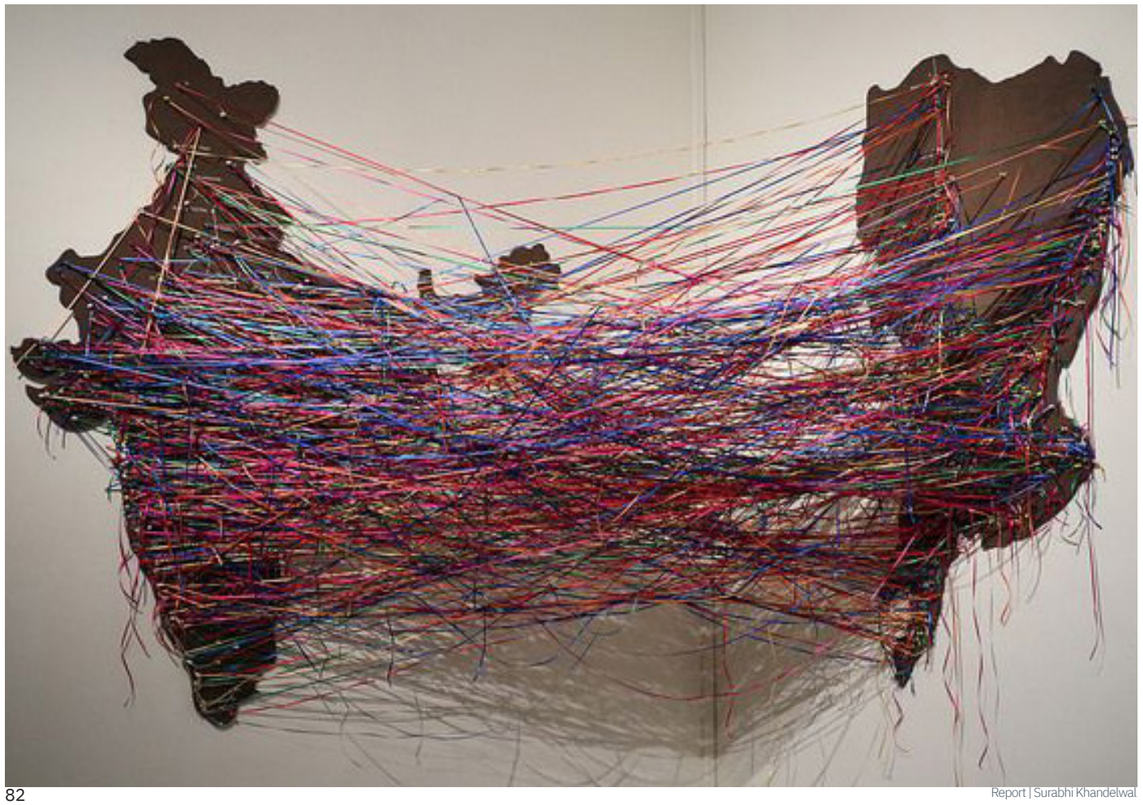


FIG. 1.103 Exhibition on Migration to Mumbai. source: urbz



FIG. 1.104 Informal economy in Mumabi. source: author

Socio-economic vulnerability

Social Vulnerabilites- slums

Mumbai has one of the largest slum population in the country with almost 55 percent of Mumbai's population being slum dweller.With Mumbai growing at a tremendous rate and competing in the world market to be a global city, the allocation of resources and capital invested has been exclusive to certain groups of people in the society leading to social segregation.The limited land resource, dictated by Mumbai's peculiar geography and heightened by the competition from other economic activities, is one factor that has made formal housing unaffordable for most locals/migrants in the city.In addition,Slums have mainly proliferated in the city due to incompetent housing policies and political reasons.

In Mumbai today, the economic relationship of exploitation and dependence is giving the city 'Two Worlds in One ' character with their distinctive physical shapes and specific locations. (Mehrotra, 2011) 'One world is static, monumental in its presence and exploitative of high spots in the city;the other sprawls along the transport lines and into interstices or crevices it finds. There now exists equivalents for all systems in the ' urban' city - places and means of recreation, markets, techniques of constrcution, sources for supply of material, and different physical manifestations- the 'kutcha' city.' (Mehrotra, 2011)

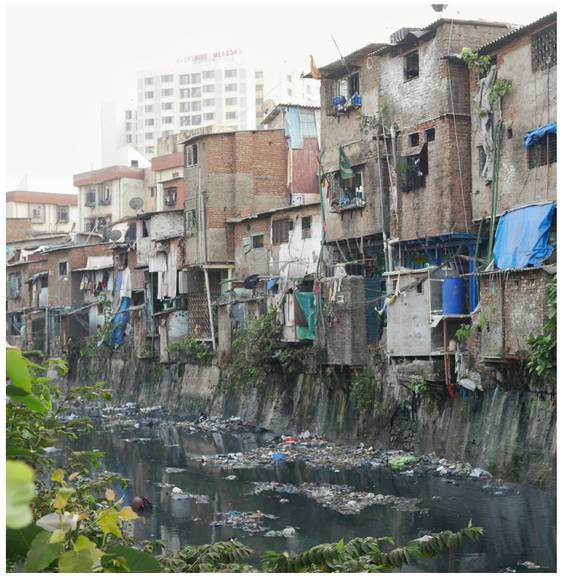


FIG. 1.105 Slums in Mumabi. source:

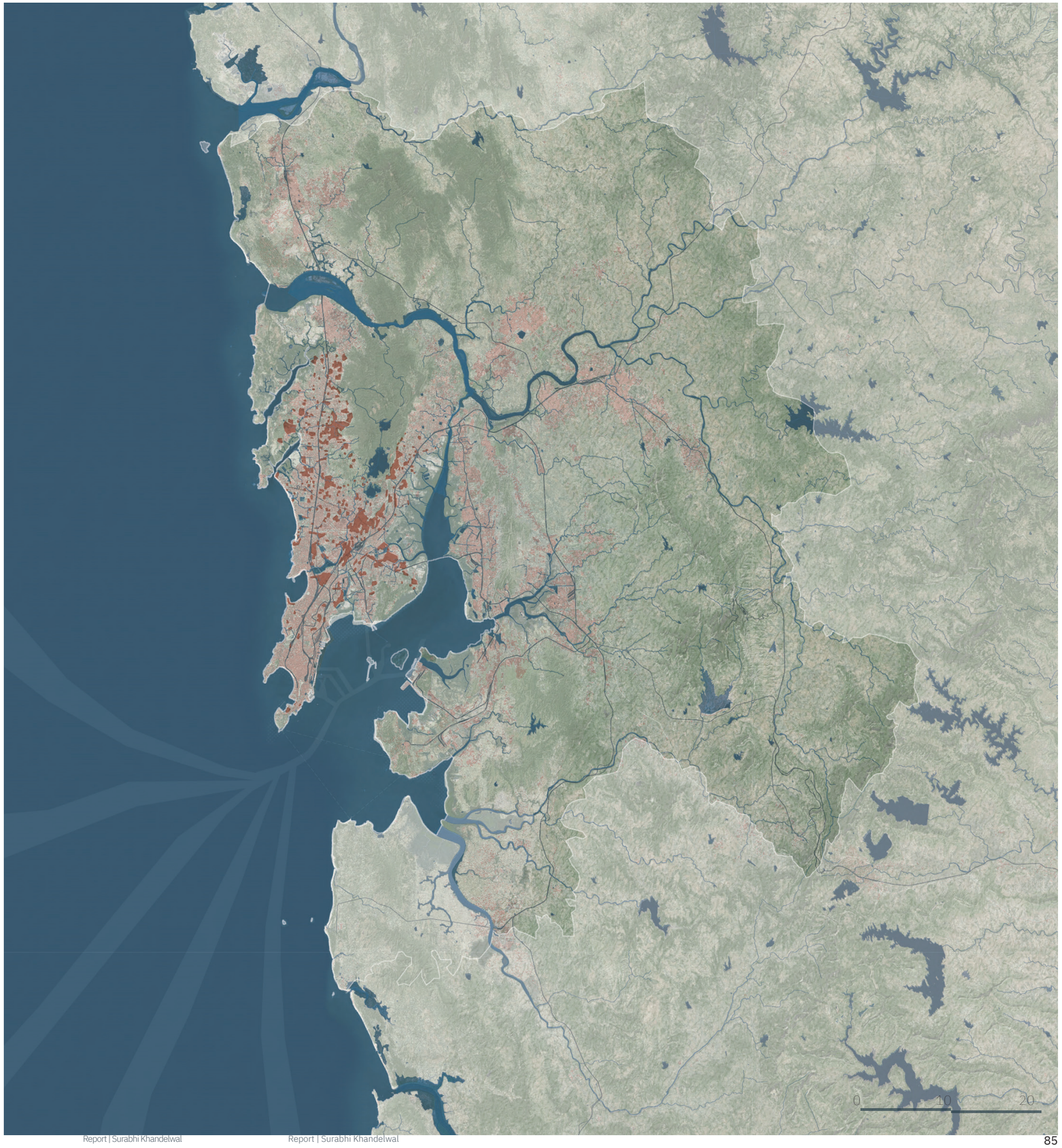


FIG. 1.106 Slums in Mumbai. source: author

Ecological Vulnerability

Flood risk

MMR is vulnerable to 3 types of flooding that includes the coastal, fluvial and pluvia flooding. The problem in MMR is the lack of capacity of both man-made and natural infrastructure to fight against floods.

Mumbai is at an average elevation of 10-15 meters above sea level and receives an annual rainfall of 2,200 mm out of which 50% is in the month of July. On 26 July 2005, Mumbai got a record single day rainfall of 944mm (42% of the city's annual rainfall). This coupled with a high tide of more than 4.8m, overwhelmed the drainage systems and flooded the city. Mumbai lost close to $200 million of revenue and over 1,000 lives. The floods also caused serious damage to property, infrastructure and left serious diseases in its wake. Many were even traumatised.
The 2019 Indian floods were a series of floods that affected over thirteen states in late July and early August 2019, due to incessant rains. At least 200 people died and about a million people were displaced. Karnataka and Maharashtra were the most severely affected states. It was the heaviest monsoon in last 25 years. More than 1600 people died between June and October 2019.

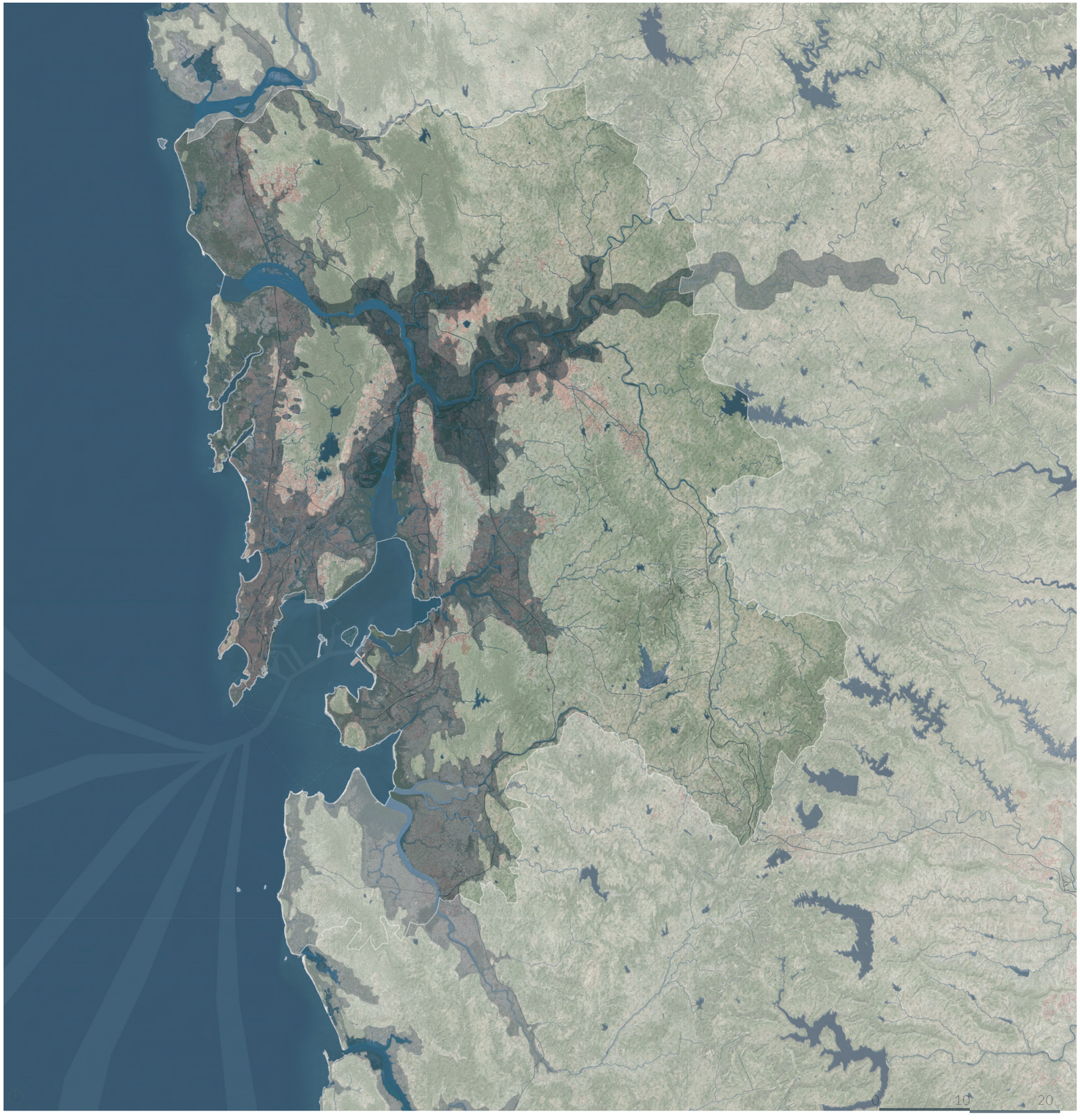


FIG. 1.107 Flooding in Mumbai . souce :author based on climate central, SWD data, WRI author

Ecological Vulnerability

Coastal Flooding

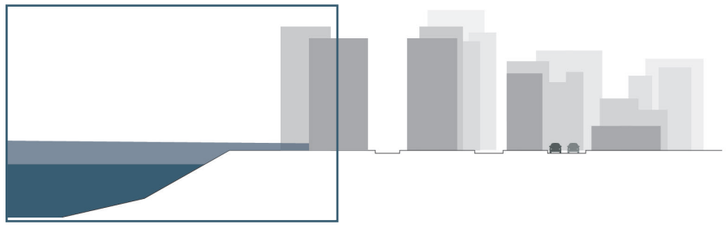




FIG. 1.108 Coastal Flooding in Mumabi. source: author based on climatecentral Climatecentral

The Arabian Sea could begin entering and flooding most of Mumbai at least once every year by the year 2050, according to a new study that paints an alarming picture of what global warming-induced sea level rise could do to the world's biggest coastal cities.

Pluvial Flooding

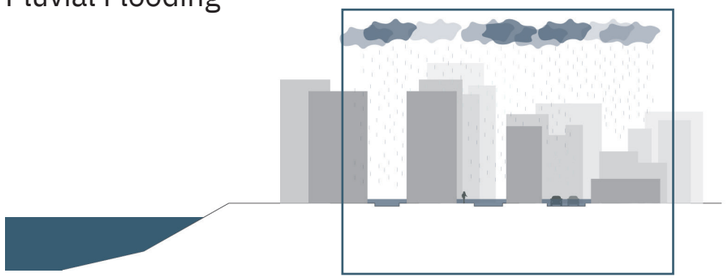




FIG. 1.109 Pluvial flood in Mumabi. source: author based on SWD, Gupta,2005.

Lack of comprehensive planning perspective with development has lead to narrowing down of some creeks and natural drainage basin along with the reduction in Mangrove cover that exacerbates the situation created due to climate change and causes disruptive rainfall in the city.

Fluvial Flooding

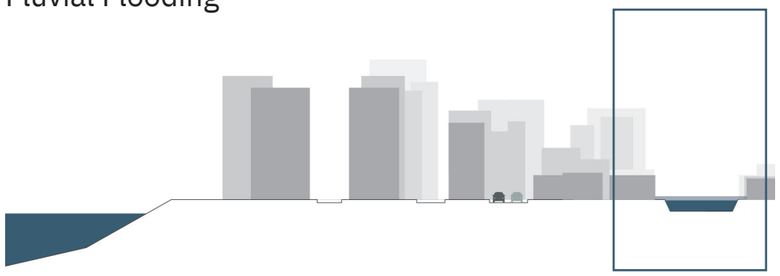




FIG. 1.110 Fluvial Flooding in Mumabi. source: author based on WRI

The drainage capacity of the drains recently increased from 50mm to 100mm but the avergae rainfall that falls is way beyond the capacity. Also the land surface in the region has not been carefully made into porous paving inorder to provide its absorptive capacity.



FIG. 1.111 Flooding in Mumbai. 2018 source: reliefweb



FIG. 1.112 Flooding in Mumbai. source:



FIG. 1.113 Flooding in Mumbai. source: twitter



FIG. 1.114 Flooding in Mumbai. source: indianexpress

5.

Research aim

Research question, problem statement

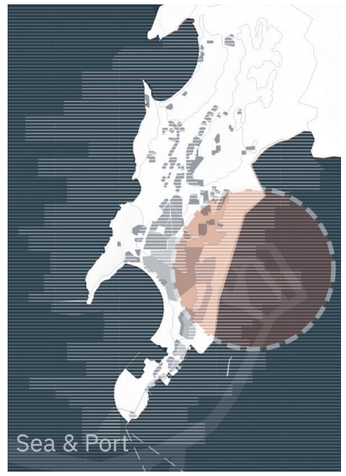


FIG. 1.115 Floods in Mumabi. source: thequint

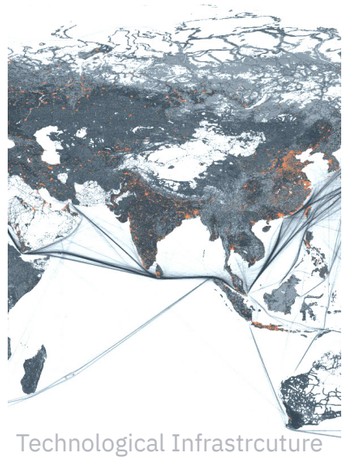
Hypothesis

PARADIGM SHIFT









Ecological Infrastrcuture

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.

Problem Statement

The economy and morphology of Mumbai Metropolitan Region has been shaped by the physical infrastructure (human-made) and made Mumbai, a global city region as is known today. But the current pattern of infrastructure development has neglected the ecological and social aspects in planning. This has lead to the extreme vulnerability of the region to ecological and social negative externalities. The region experiences urban flooding every year disrupting the daily lives and inflicting loss to both life and livelihood of many. Also, the state of emergency due to climate change that the world deals with fighting for the sustenance of humankind is a serious challenge. Mumbai, also one of the largest cities in the world, is at risk of being wiped out. It was formed from an archipelago of seven islands which includes the city's historic downtown core that is particularly vulnerable along with most of the suburban districts. This leads to an urgent need for providing resilience to the socio-ecological system in the region by providing climate adaptive capacity against floods.



FIG. 1.116 City of Mumabi. source: safwan patrawala

Research Aim

The above-sketched situation of the problem focus demonstrates how infrastructure has restructured and strengthened the economy (global) but lead to socio-spatial and ecological negative consequences / vulnerabilities. With time, society, once a part of ecology has become a co-existing separate system. The current form of development is oriented towards physical human-made infrastructure co-existing with ecology next to it. The aim of the project is to identify the ecological infrastructure within the ecological relational geography in the Mumbai Metropolitan Region in order to provide resilience to the socio-ecological system of the region against flooding and this would contribute in achieving the following objectives over this discourse:

•Identifying the significance of ecological infrastructure to provide adaptive capacity against flooding.

•Identifying the interactions between ecology and society that would contribute further to attain a resilient system.

•Understanding the role of regional planning and design to achieve a resilient system.

•Understanding the spatial scales of interventions of strategies to provide the adaptive capacity to urban(human) development.

•Understanding the aspects of planning frameworks that could facilitate coordination and collaboration amongst stakeholders.

•Position macroregions in the field of regional planning.

•Understanding how macroregions could be used as a spatial analytical tool and a spatial strategic tool.

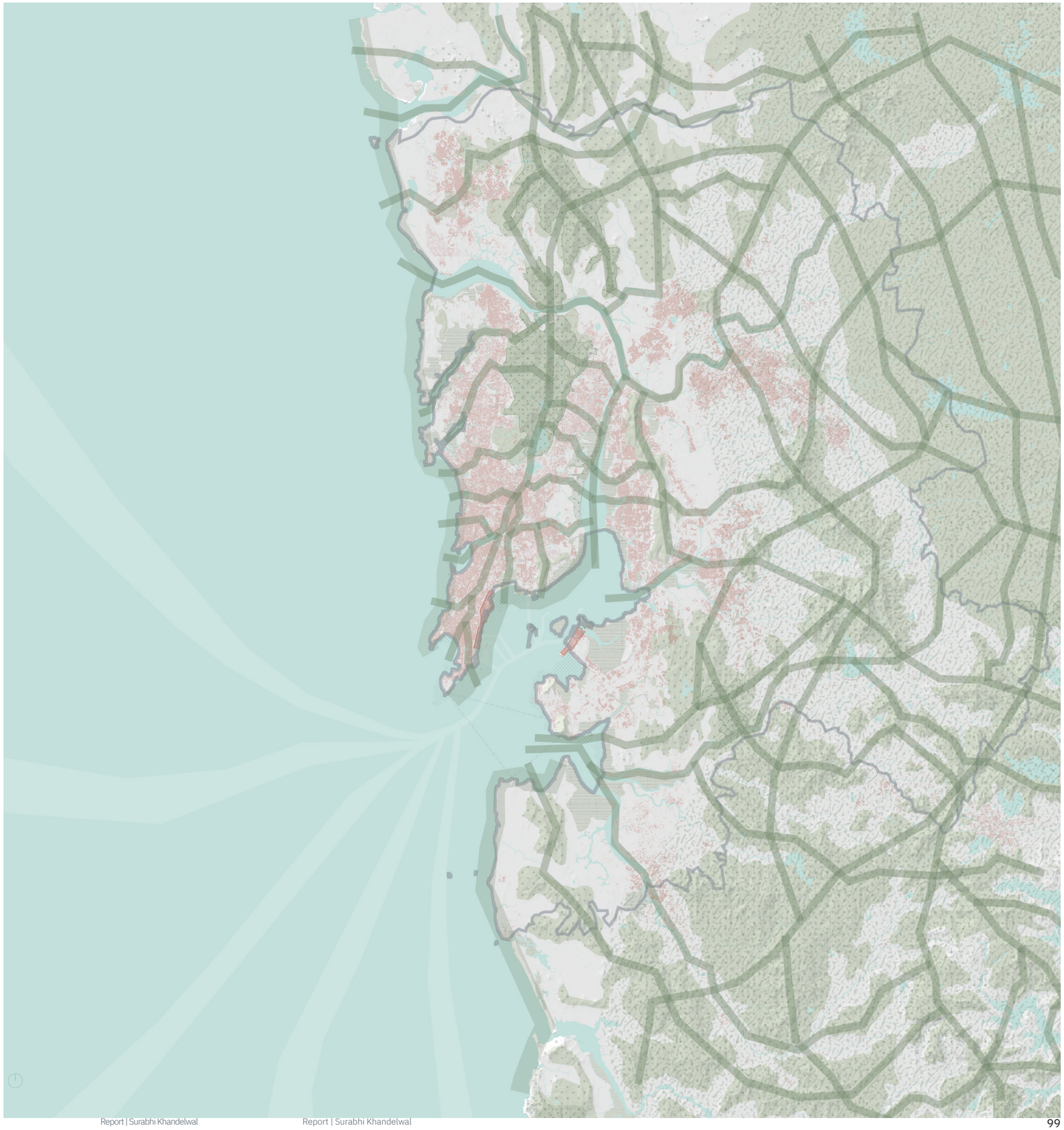


FIG. 1.117 Mumabi with ecological infrastructure . source: author

Research Question

In accordance with the main aim, the central research question guiding the Research would be :

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

sub- questions

In accordance with the secondary aim and leading to the solution for the central question, the sub-research questions are:

1) What are the current ecological infrastructures present in Mumbai Metropolitan Region?

2) What are the current ecological and social vulnerabilities in the MMR?

3) What are the strategies needed to respond to different types of flooding?

4) What are the interactions between ecological structure and society currently and how can that be strengthened?

5) What are the other physical infrastructures (man-made) to provide capacity against flooding?

6) What is the current planning framework to tackle climate change and flooding?

7) How to operationalise resilience through ecological infrastructure? What would be the critical strategies at a regional scale to provide the adaptive capacity to the region?

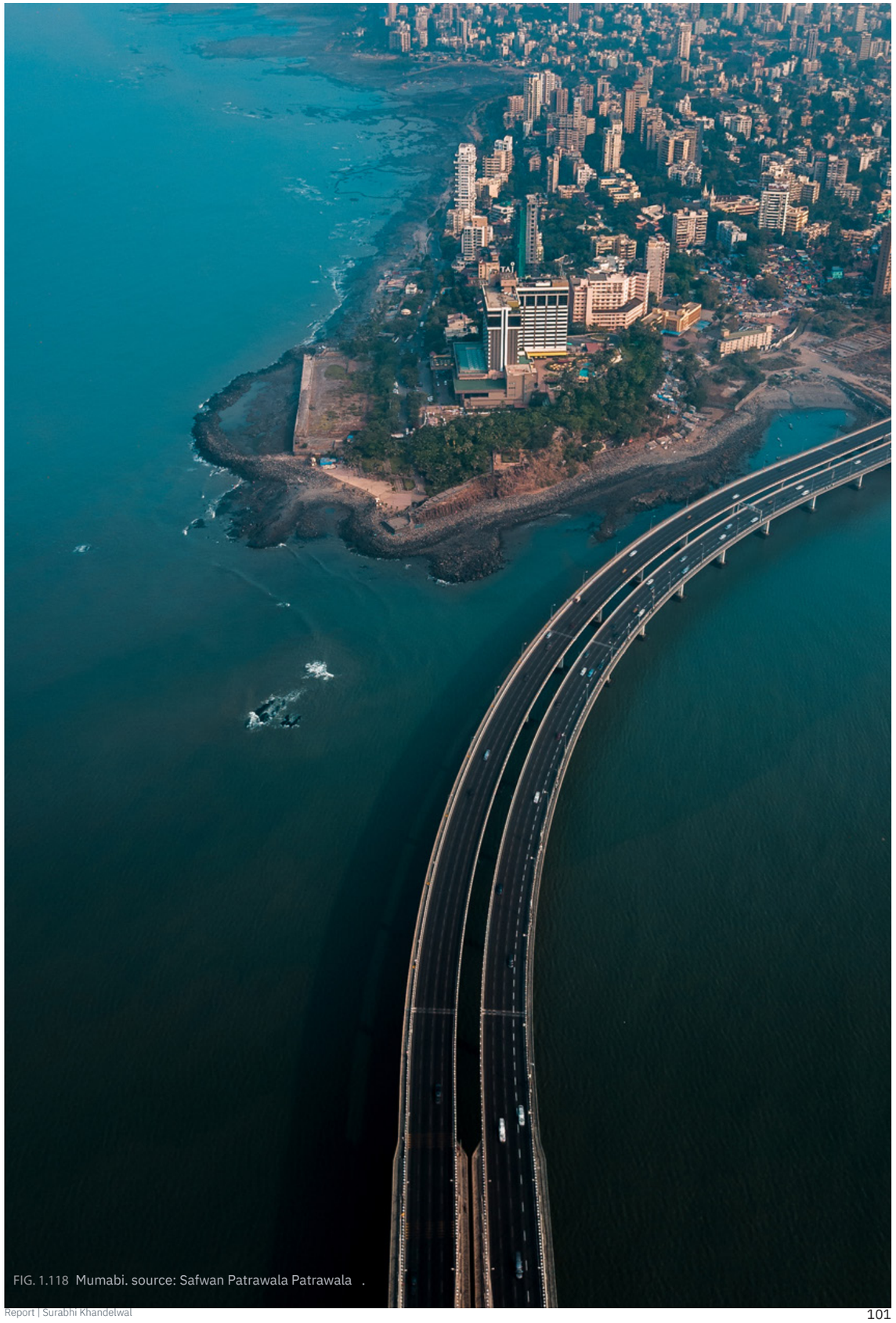


FIG. 1.118 Mumabi. source: Safwan Patrawala Patrawala .

6.

Resilience to Flooding

Theories and Concepts

Mumabi, source: thequint

I.

Theoretical Framework

conceptualisation and theorisation

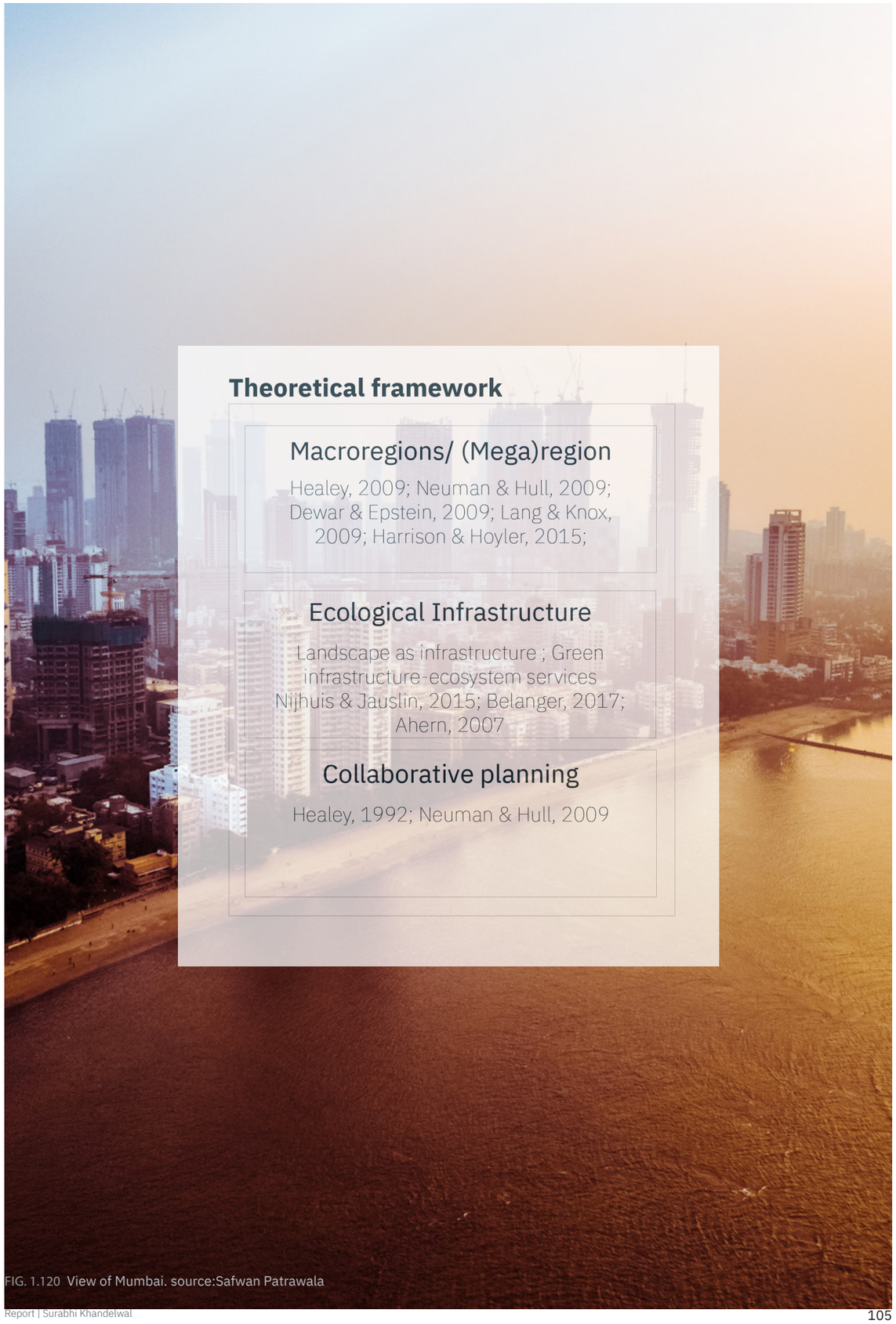


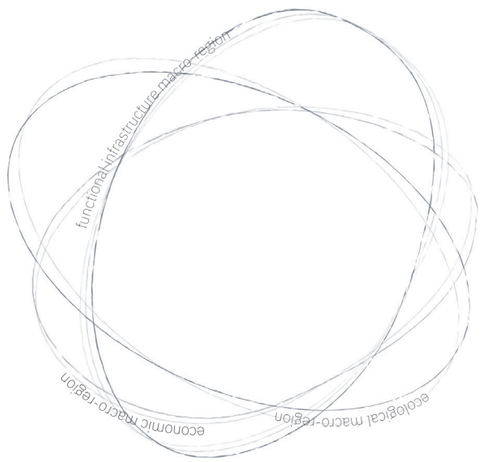
FIG. 1.120 View of Mumbai. source:Safwan Patrawala

A. Macroregion/[mega]region - a relational geographical construct for future development

The current world embodies a multiplicity of differential webs connecting people, firms and non-human processes through space and time which transects and intersects across geopolitical borders. (Healey, 2009) With these changing processes, our lens of scale for understanding the same needs to be adapted concomitantly leading to an emerging understanding of a restructured spatial scale called ‘Megaregions’. The extent of urbanisation in a technologically advancing globalised world is inordinately expanding until the dissolution of the dichotomy or urban/rural or city/country-side. Geographers and planners have been comprehending this phenomenon of sprawling urbanised landscapes comprising functional networks through: ‘ megalopolis, archipelago economy, galactic city, string city, limitless city, endless city, liquid city, global city-region, world city-region, mega-city region, polycentric metropolis, new megalopolis, megapolitan region, metro region, polynuclear urban region, super urban region, super-region...megaregion.’ (Harrison & Hoyler, 2015) Each variant is intended to make this macro-region more intelligible and to help one grasp the rapidly changing realities. The author comprehends this ‘imagined’ spatiality of relational geographic construct through a comprehensive understanding of selected works of literature in this urban regional discourse which would be constructive in this processual understanding.

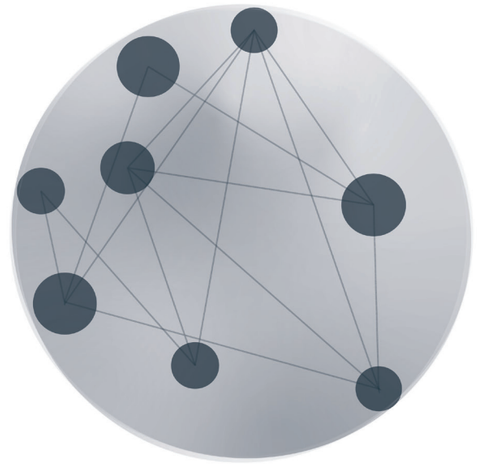
The author would expand on a certain understanding of ‘megaregion’ and position it in this wide range of terminology and definitions of this common spatial concept. The author would use the theory of Megaregions, city-regions and Megalopolis by experts and scholars like Michael Neuman, Patsy Healey, Peter Hall, Robert Lang & Knox and Dewar & Epstein to understand the multidimensionality and interactional nature of the construction of this space. (Healey, 2009; Hall, 2009; Lang & Knox, 2009; Neuman & Hull, 2009)

It is a trans-metropolitan landscape which involves a large combination of urban agglomerations-cities and metropolitan areas but along with it the ‘operationalizing landscapes’ as theorised by Planetary Urbanisation. (Brenner, 2013) This has been an outcome of the new forms of networks and spatial connectivity that reintegrates urban spaces through advanced infrastructure defining patterns of spatial-economic integration. (Lang & Knox, 2009)The urban infrastructure and communication networks spread across national landscapes extend urbanisation beyond city boundaries which correspond to the perceived ‘functional’ regions. (Healey, 2009) These regions coincide with a ‘functional reality’ of integrated economic, political and social relations and have a potential for harnessing critical socio-environmental relations to develop strategies for steering a sustainable urban development. (Ravetz, 2000). The layers of infrastructure, economic, ecological, topographic, cultural and historic linkages that together define a shared space can be used to organise policy decisions. (Dewar & Epstein, 2009). Regional planners and development analysts have pursued the idea that ‘functional’ realities should be



Relational geography- processes in urban space- multiple macro-regions

FIG. 1.121 Relational geography. source: author aaauthorauthorg .



Relational construct- process in urban space

FIG. 1.122 Relational construct . source : author a‘author .

aligned with administrative jurisdictions, to create planning areas – functional urban areas or megaregions, which engenders future development trajectories. (Healey, 2009) Although these regions could take multiple forms from these ‘spatially overlapping or convergent urban areas with a surrounding hinterland’ or ‘geographically distinct but proximate urban centres working together to harvest benefits of mutual cooperation.’(Scott, 2001) Nonetheless, multiple actors in different contexts have tried to define the specificity to delineate these boundaries with various methods. The major three categories implemented in the United States describe the distinction in boundary limits: fuzzy boundary plans, multiple-boundary plans, and single boundary plans (Dewar & Epstein, 2007); however, it leads to the conclusion that the details of the boundaries are insignificant for a better understanding of the development of this huge concentration. These boundaries of megaregions should be adaptable to the purpose of the plan. (Dewar & Epstein, 2007) The advent of defining these ‘megaregional spaces’ also lead to researchers prioritising megaregional form to start marking out space by investigating the physical landscape, whereas others prioritising megaregional function by identifying less visible or even invisible patterns in the physical landscape, for example, flows of knowledge and capital. (Harrison & Hoyler, 2015) Both macro and micro-level analysis of megaregional space begin to depict the unevenness of megaregionality processes over megaregional space. (Sassen, 2007) The processes of megaregionality impact different spaces, places and people unevenly across megaregional space induced by the complexity and diversity of the socio-spatial relations that synergise in space and time. (Healey, 2009). This leads to an important question of how the megaregion concept could help in analysing the different processes that are played out in local spaces? (Harrison & Hoyler, 2015)

Megaregions are heterogeneous in terms of being a concept as well since an array of economy, state, civil society, ecology and other external actors come together at varying scales of action to produce multiple regions and regional collaborative mechanisms. (Söderbaum, 2015)

References:

B. Ecological Infrastructure - Landscape as Infrastructure

In this era of the human-dominated geological epoch(Sijmons, 2014), the architecture of the urban landscape has evolved into a complex system, extending far into the hinterland and deep into the environmental systems. Infrastructure by virtue of its scale and its impact constitutes an important element of the urban landscape. (Neijhuis & Jauslin, 2015) Natural landscapes have been transformed into urban, logistics, industrial and waste landscapes. Though often successful in geopolitical and economic terms, the tendency to engineer single-purpose infrastructure has led to neglection of the ecological system leading to disrupted landscapes and erasure of the cultural and natural values. (Strang, 1996). Today infrastructure projects play a key role in global policy. Infrastructure is considered the primary field of investment of public authorities (European Commission, 2011, 2012). It is regarded as a backbone in which the increasingly privately financed urbanisation can be grafted. (Shannon & Smets, 2010). The potentials of infrastructure for performing the additional task of shaping urban landscapes are largely unexploited. (Nijhuis & Jauslin, 2015) Urban landscape infrastructure as a design concept is considered as an armature for the development of urban systems which facilitate social and ecological interactions. It seeks to redefine infrastructural design as an interdisciplinary design effort to establish a local identity that has tangible relationships to the region. The space of flows is introduced as an impetus to develop the concept of landscape infrastructure into a more comprehensive form of urban landscape architecture. (Nijhuis & Jauslin, 2015)

References: Landscape as infrastructure ; Green infrastructure-ecosystem services
Nijhuis & Jauslin, 2015; Belanger, 2017; Ahern, 2007

C. Collaborative planning

The concept of megaregion being an imaginative construct comes from the epistemology which recognises that ideas of the city, city-region, of place, as not objectively ‘there’, but are imagined concepts, constructed in particular times and places for specific reasons (Healey, 2002) This raises questions about the intentions of such construction and the institutional work carried out by them. Healey analysed the relations and identities that are carried within the concept of ‘region’ associated with the mobilisation forces and with the potential consequences. She assimilated that this concept contributes to the form and content of place development. (Healey, 2009; Neuman & Hull, 2009)
Economic and administrative interests have dominated the deliberations of Megaregions and it has been interpreted as a step towards the search for sub-national re-configuration. (Healey, 2009) In regard to the institutional structure, this means devolving state power to regional and local levels, and developing horizontal collaborations between actors, to replace the vertical hierarchical institutional structure. (Healey, 2009) ‘Megaregion’ could become the crucial institutional arena both for identifying and selecting projects in a new configuration of government and for encouraging the promotion of endogenous economic development where the focus shifts from government to governance. (Healey, 2009) A ‘megaregion’ arena may be promoted to draw the different networks of provision together, to enable better coordination and delivery of services and infrastructures in the region. (Healey, 2009) How could insertion of ‘megaregion’ institutional arena reconfigure governance and help to create institutional spaces for an assertive ‘politics of place’ which draws attention to the relational nexuses that intersect and co-exist in localities? (Healey, 2009) Healey explains with the example of The Netherlands, where a flexible informal regional arena emerged as a locally developed response to change national funding arrangements, in which prioritising projects became a critical activity. The development of this arena was fuelled by an understanding of a ‘network society’ where ‘soft institutional form’ was developed based on the functional linkages considered for a project. (Healey, 2009) This would mobilise the dynamics of the complex intersecting and co-existing multiple relations in particular places for potential development. Therefore, government reconfiguration needs to build upon the ‘locally specific, endogenously grounded but exogenously positioned place development strategies.’ These place development strategies mobilise and coordinate forces in developing more horizontal governance forms, open to influences from economic and civil society relational nexuses. (Healey, 2009)
The relational geography with the interplay between urban spaces and processes that produce that space involves interactions at multiple scales. The patterns of interactions within regions and between individuals and institutions in an attempt to govern regions occur through networks in physical and non-physical(digital) environments. This shows that the institutionally networked space reflects the urban network space, a phenomenon called ‘spatial-institutional isomorphism’ by Neuman & Hull. Spatial-institutional isomorphism can be comprehended as the dynamics of spatial, institutional, and virtual network phenomena which influences the space-society relations and indicate on a reconfigured analytical approach. (Neuman & Hull, 2009) Institutional networks govern infrastructural networks that are the eventual shapers (and shapes) of space at all scales. This implies a relational approach to institutional design and points to the relational agency where the process mechanisms include coordination, collaboration, consensus building and facilitation. (Neuman & Hull, 2009)

II.

Conceptual Framework

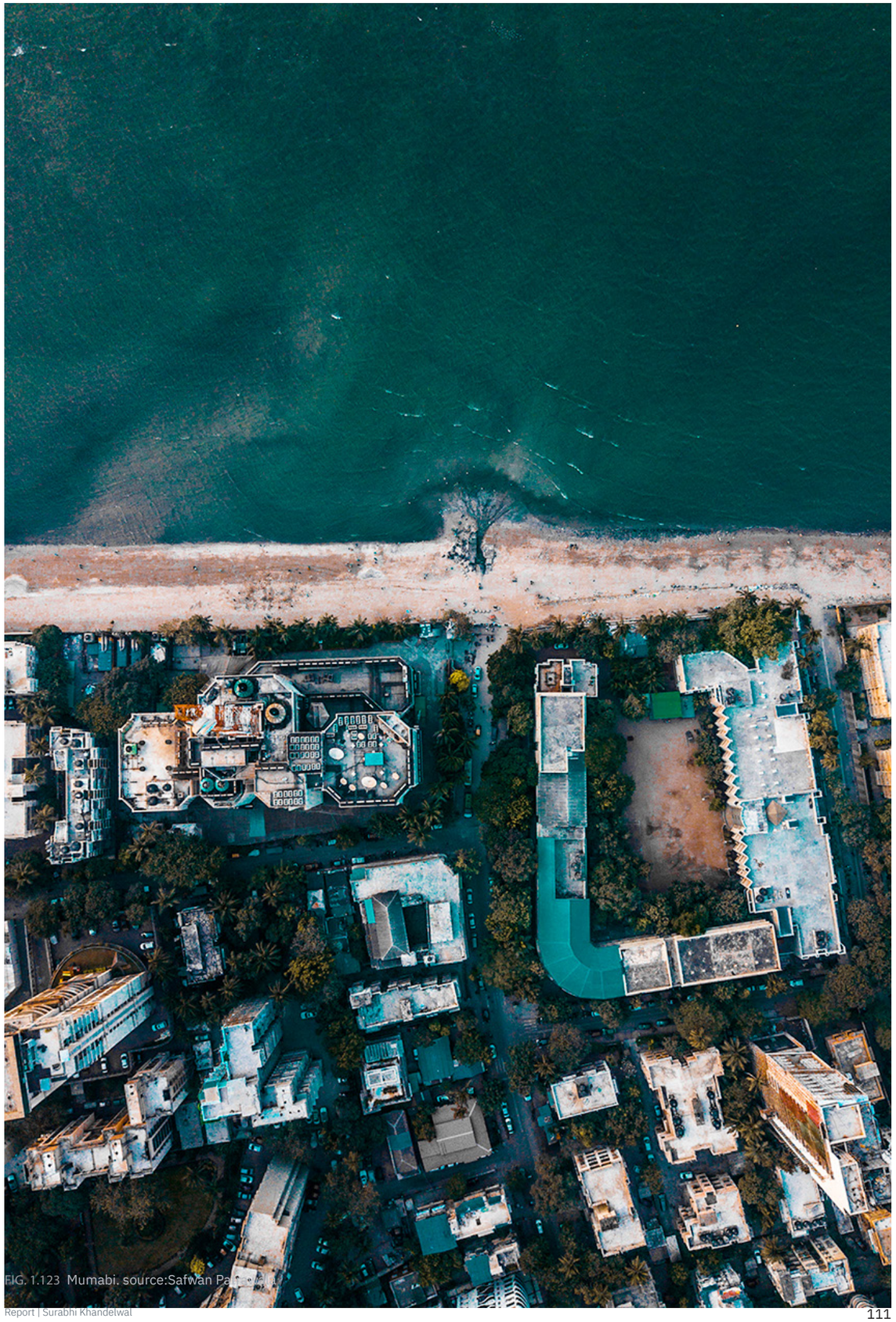


FIG. 1.123 Mumabi. source:Safwan Pa[illegible]

Conceptualisation

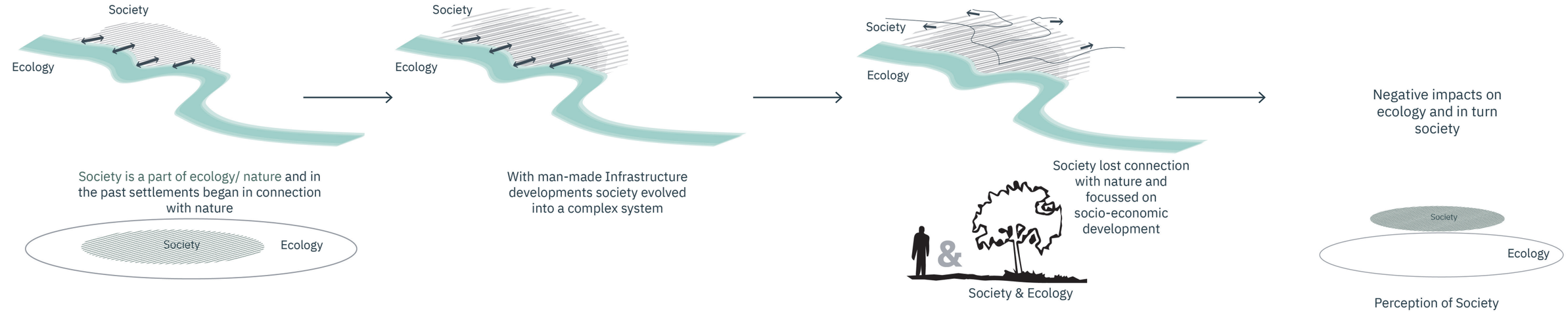


FIG. 1.124 Man in Nature to Man & Nature-1st Concept diagram. source: author .

The conceptual framework is a guideline that includes the key concepts, understanding of processes, variables in the project and the philosophical orientation of the author which would guide the project in the research project.
In order to comprehend the complex task, the conceptual framework has been systematically split into multiple diagrams. The first one simplifies the processes and phenomena involved and has sequentially abstracted the understanding of the pattern of development which form part of this causal effect, where the current state of development is unsustainable and creates negative externalities forming the problem and then suggests the shift needed to achieve a sustainable development pattern which is indicated as the desired outcomes in the course of the project. The second and third diagrams suggest possible concepts and theories that would be significant to attain balanced development in Mumbai, India. The development of these concepts is an iterative process which includes a rigorous process of concrete research followed by concept refinement and back again.

The **first diagram** explains the understanding of the socio-ecological system where society is a part of the ecological system. The society subsumes the socio-economic system where the economy is a construct of our society that becomes a part of it and this society (socio-economic) is a part of the ecological system. Earlier society understood the importance of ecology and began settlements close to rivers/elements of the ecological system with a close connection to the same, understanding the significant exchange/ interactions between the social and ecological systems. With time as the settlements developed, and evolved into a complex system the socio-ecological system began to lose its connection and began to be perceived as Society and ecology rather than society in ecology. The development of society turned towards the physical(human-made) infrastructure and focussed on the socio-economic system. This form of development pattern led to negative impacts on both society and ecology. For sustenance, we need to bring back the connection between society and ecology reviving the understanding of ‘Society in Ecology’ rather than ‘Society & Ecology’. There is an urgent need to re-introduce ecology in the pattern of development of the society, the current societal development oriented towards man-made infrastructure needs to shift its orientation towards ecological infrastructure where the connection of society and ecology is restored.

The **second diagram** explains how the perception/

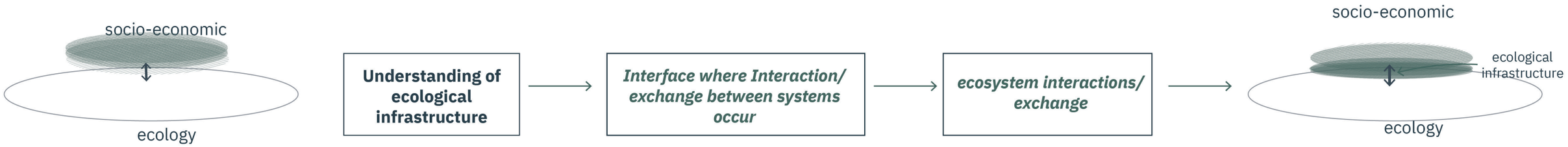


FIG. 1.125 Ecosystem interaction. source: author .

orientation of societal development could shift towards ecology. Infrastructure as we know it, and as understood constitutes the basic systems and services that the society needs to function properly. It includes the physical systems such as the road and railway networks, utilities, sewage, water, telephone lines and cell towers, air control towers, bridges, and others along with services including law enforcement, emergency services, healthcare, education, etc. In order to introduce the connection between the ecological system and social system, we need to introduce a tangible understanding of ecology as infrastructure and extend it as an ecological infrastructure for the society to reconnect with ecology. The ecological infrastructure could be seen as an interface between ecology and society through which the interactions or exchange between the two systems occur. Ecological infrastructure could be understood as the spatial constituent of ecology forming the spatial pattern and the processes which occurs within it. This understanding of ecological infrastructure through patterns and processes would help to guide the project further in its analysis. The author seeks to redefine infrastructural design as an interdisciplinary design effort to establish a local identity that has tangible relationships to the region where the strategic design of infrastructural ecologies, describing a synthetic landscape of living, biophysical systems operate as urban infrastructures shape and direct the future of urban economies and cultures into the 21st century. (Belanger, 2017; Nijhuis & Jauslin, 2015) Infrastructure being important technological utilitarian features in the urban landscape influencing both society and ecology lacks the permeation of landscape and societal connotation within them. The author suggests the appropriation of ecological infrastructure with ecology and society that has the potential to gain operative force in territorial transformation processes and to explore the dynamic between structure and process. Ecological infrastructures can be used as a tool to re-establish the role of design as integrating activity in contemporary urban development
and transformation. The theory of landscape as infrastructure helps to extend the concept of ecological infrastructure as an urban landscape infrastructure which implies that multi-functionality, connectivity, integration, long term strategies, ecology, social-inclusive and interdisciplinary design processes are at the core of the spatial design. It aims to create landscapes from a perspective of sustainable development, so as to guide and shape changes which are brought about by socio-economic and environmental processes. It aims to create infrastructure which is economically-driven in terms of the capital and resources required to mobilise it but at the same time is society-based and landscape-cased which facilitate functional, social and ecological relationships between natural and human systems and provide conditions for spatial development.

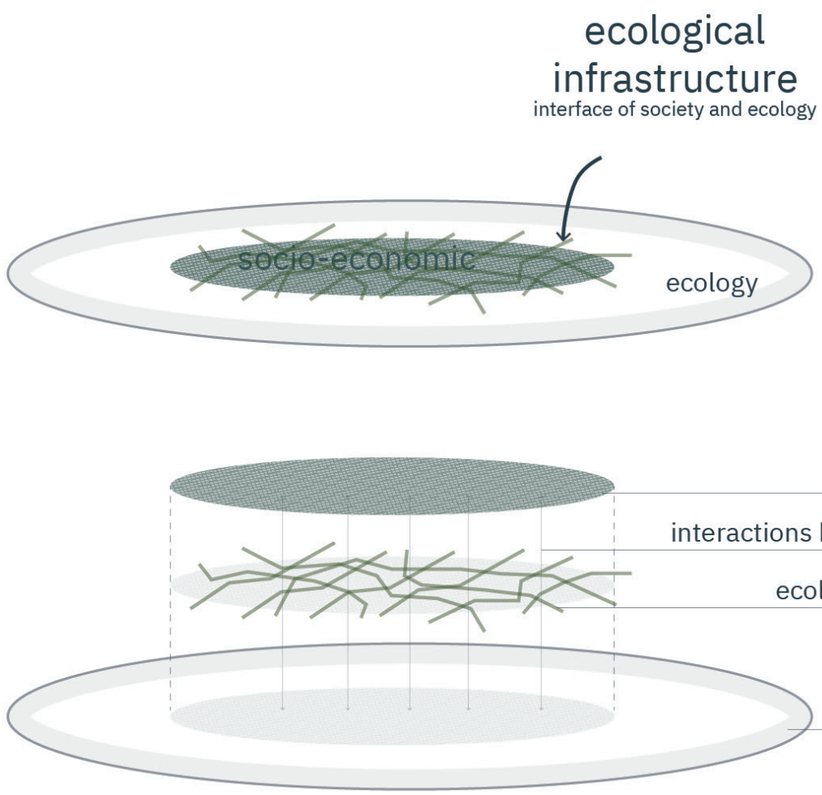


FIG. 1.126 Concepts ‘second’ diagram -ecological infrastructure . source: author .

Conceptualisation

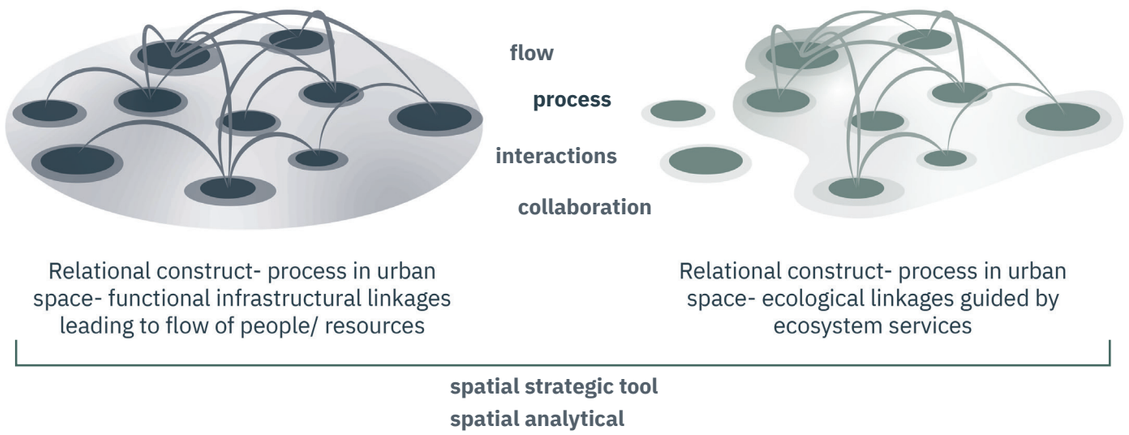


FIG. 1.127 'Third' diagram of the concept. source: author .

The **third diagram** indicates to the understanding of the spatial scale of analysis for this system. It proposes the concept of [Mega]region or macro-region as a tool to tackle this challenge with a strong belief and recognition of [Mega]region as this new potential entity. The author hypothesized that Megaregion in place of megalopolis 'stands indeed at the threshold of a new way of life, and upon [the] solution of its problems will rest civilization's ability to survive".(Gottmann,1961,p.16)The theoretical framework explains the author's understanding of this spatial relational construct and the potential of it being used as both a spatial analytical and strategic tool. First, ecological infrastructure can be analysed at a macro-regional scale where the flows could be analysed to see the economic, social and ecological implications over the territory. Further, the concept of macro-regions can be used as a strategic scale of implementation for ecological interactions and mitigating climate risks by strengthening the ecological structure of the macro-region to provide a climate adaptive capacity. This concept would also help in developing governance which responds and facilitates these interactions through collaboration as discussed in detail in the collaborative planning chapter of the theoretical framework.

The **fourth and fifth diagrams** are the author's comprehension of the tool- ecological infrastructure and its link to the goal to provide socio-ecological resilience to achieve sustenance and the concepts that it would entail. The concept of resilience is inter-related to provide the adaptive capacity to the system in order to counter vulnerability or the impacts on society. The diagram illustrates the process of external pressure on the system and how a resilient social-ecological system gets affected and reacts to it. It interlinks the concept of vulnerability and resilience to the social-ecological system.

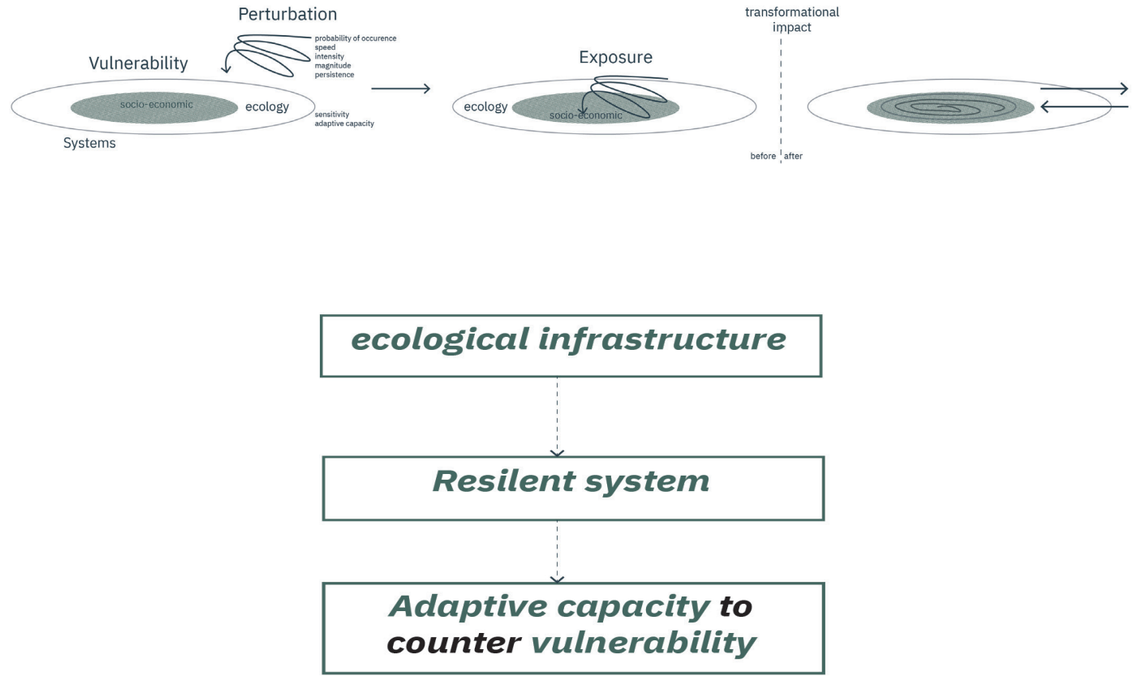


FIG. 1.128 'Fourth' diagram of the concept. source: author

7.

Methodological Framework

Path planning of the Research process

FIG. 1.129 Image of a fisherman tying his net. source: Safwan Patrawala .

Introduction

Research is critical to advancing a field and helps to reach the next level - in pedagogy/ practice.As aptly stated by Mau, *"Process is more important than outcome. When the outcome drives the process we will only ever go to where we've already been. If process drives outcome we may not know where we're going, but we will know we want to be there."(Mau, 1998)*
Thus it is essential to this process to have a guided structure and progress steadily to reach the goal.
The research involves an iterative and recursive process in which there is a steady need to cocnstantly reflect and revise the research design and attain the best results.

The methodological framework defines the plans and procedures for research that span the decisions from broad assumptions to detailed methods of data collection and analysis. This plan involves several decisions taken at different moments of the research process. The overall decision involves which research design should be used to study a specific topic.

As an Urbanist, I aspire to be an instrumental member in shaping society and bring a positive impact in the world. Thus, for my thesis, I plan to deal with the Megaregion of Mumbai which is one of the most populous megaregions in the world. With the current shift in the global mindset, due to the highly clustered knowledge economy, the global economic drivers have become a combination of cities and metro areas called the megaregion. Due to an economic centred development, it is overwhelming to see the negative externalities that it brings with it in the society and the environment. Therefore it is important to develop these megaregions in an equilibrium, which would involve emphasising on socio-ecological development alongside economic activities. Also, this region becomes a role model for development for the rest of the country and the world which needs to shift the focus of development from economy to society and ecology for human sustenance by tackling the issue of flooding.

In conclusion the main purpose of this chapter is to develop the framework of the methods and approaches that have been selected to guide the imperative goal of this research.

Research framework

WHY? ***WHAT?*** ***HOW?***



FIG. 1.130 Streets of Mumbai, source: Safwan Patrawala

Process of the Research

Problem Definition

Context & Problem

current trend of development - oriented towards man-made infrastructure - Society & ecology

Climate change
Human sustenance - Natural hazards - urgent attention
Coastal, Pluvial & Fluvial Flooding in Mumbai
Metropolitan Region

Rapid urbanisation
context in India

Migration
focussed on global economic concentrations
GDP high

Social & ecological vulnerabilities

Aim

Resilient Mumbai Metropolitan Region

Adaptive capacity

Flooding

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** ?

Guiding forces

Theory & Concepts

macro-region / regional
Healey, 2009; Neuman & Hull, 2009; Dewar & Epstein, 2009; Lang & Knox, 2009; Harrison & Hoyler, 2015;

Adaptive capacity
Adaptive capacity, vulnerability
Adgers, 2000 ; Smit and Wandel, 2006 ; Walker et al., 2004 ;

Ecological infrastructure
Landscape as infrastructure ; Green infrastructure-ecosystem services
Nijhuis & Jauslin, 2015; Belanger, 2017; Ahern, 2007

Collaborative planning
Healey, 1992; Neuman & Hull, 2009

Operationalisation

Analysis

ecological infrastructure - **patterns & processes**

- Spatial pattern
- ecosystem interactions/ services
- design strategies for adaptive capacity
- stakeholder analysis
- built- population density

Tools & Instruments

to analyse & design strategies for both regional , meso & micro scale

Expected Outcomes

Regional Design & Planning framework

Macro- Meso-micro scale

Validated design proposal

Design & Planning Framework

The research project framework has been inspired by the guidelines of 'Design research Methodology' developed by Blessing and Chakrabarti which includes the structuration of the project into 4 stages- Research Clarification, Descriptive study I, Prescriptive study and Descriptive study II. (Blessing, & Chakrabarti, 2009) but that has been contextualised to the relevance of the spatial planning and design project. It helps to divide the phase of the whole process of research into 4 stages called - Research clarification, Analytical study, Projective study and Evaluation study. The figure shows the comprehended structure adapted for the research project with the contents and methods involved in the process. In general, this applied research commenced with a deductive approach, coming from the broad concept of [Mega]region to investigate the hypothesis to the specific case of Mumbai [Mega]region but during the processs of the research, the trajectory deviated from the idea of macro region being central to being an embedded theory. The protagonist of the narrative became Climate change and the issue of flooding at the end of the research which projects to shift the research to an inductive research where the strategies could be further simplified and applied as a concept to adaptation in coastal communities. Also, the research would involve a constant iteration/ recursion of the research framework at definite reflection points in order to attain a comprehensive project.

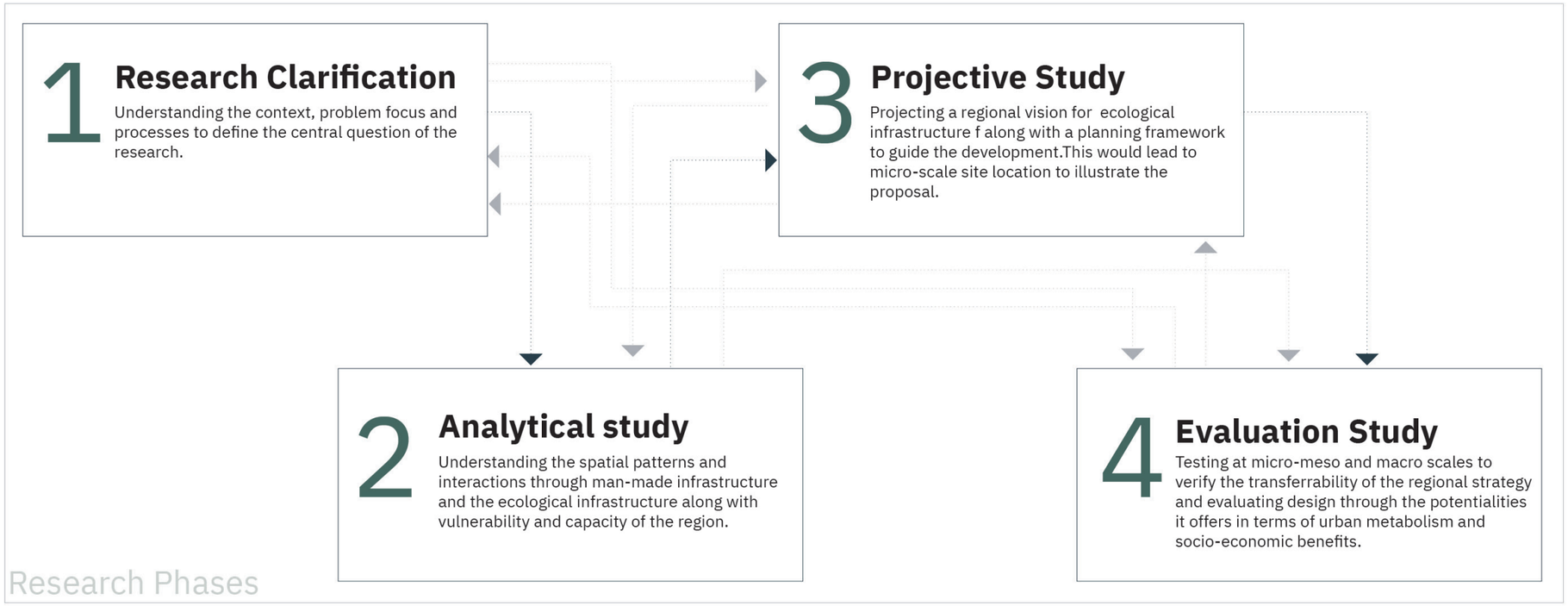


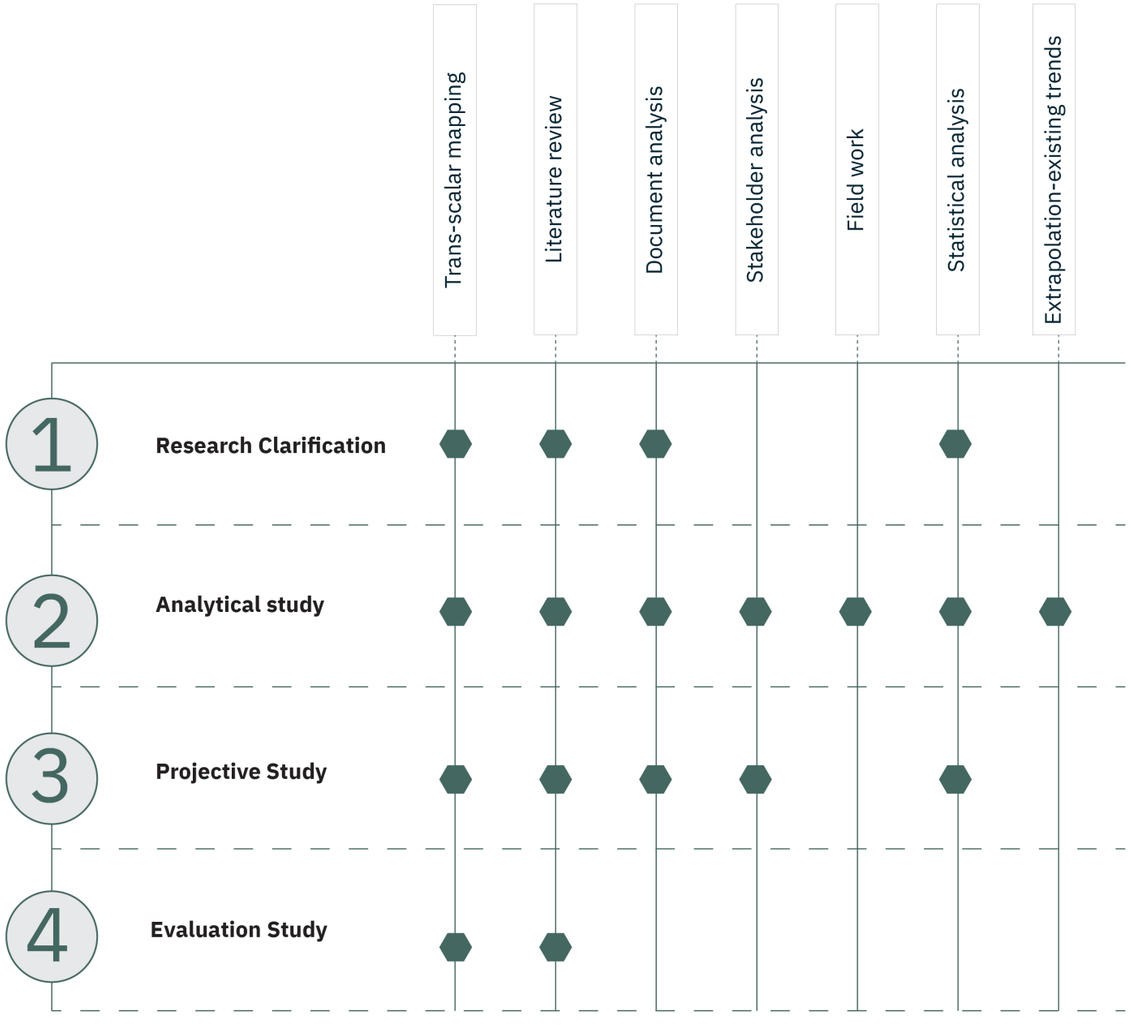
FIG. 1.131 Research Process. source: author .

Research Clarification -
This stage involves the process of resolution of the purpose of the study, problem field and focus, research questions, hypothesis, acknowledgement of world views and philosophical stances that would guide the research. The aim of the stage is to be aligned in thoughts to delve into the next stage of analysis and comprehending the processes and constructs involved in the issue. The method undertaken at this stage involves a literature review for clarification of the broader concepts, documents examination to quantify and qualify the issue along with both primary and secondary mapping and statistical data.

Analytical study -
After clarification of the aim of the research, the next stage deals with the identification of variables, processes and inter-relationships to move further in the process to project scenarios. This stage involves the development of theoretical framework, conceptual and analytical frameworks. The theoretical framework helps to define the key terminologies- [mega]regions, parameters for analysing ecological infrastructure and its impact, urban landscape infrastructure and Resilience which will be guiding the project with scientific arguments that underpin the conceptual and analytical frameworks. The conceptual framework developed will define key concepts, variables and processes with their inter-relationship. While the analytical framework would provide a lens to investigate the [Mega]region by closely analysing the ecology through a set of parameters that would guide the research. The methods to tackle this stage includes literature review, documentary examination, deconstructing the region through mapping (primary & secondary), statistical analysis to quantify the constructs in the study, stakeholder analysis, fieldwork which would involve data collection through observation, visual imagery, interviews, vignettes and surveys.

Projective study -
This stage involves understanding the construct of the Region and to project future ecological infrastructure. It involves the projection of an integrated urban landscape infrastructure responding to economy, society and ecology. This would include the construction of projection through the production of mapping and visual imagery. This process would also entail the projection of functional ecological region on Mumbai Region. This stage would involve proposing governance structure responding to the infrastructure projects that include collaboration with different actors involved.

Evaluation study -
The intention of the author at this stage is to evaluate the projections and test the hypothesis on achieving resilient Social-ecological system in Mumbai region through an alternative approach in regional planning. It would involve testing the transferrability of the strategy on meso, micro and macro scale to explore the benefits and opportunities it offers. It is also a stage for reflection to realise an extended scientific relevance, societal relevance, ethical consideration, limitations, research design, methodological design and personal and professional growth.



Methods

The project would primarily involve seven methods that would be used in the course of the research. These methods and approaches are incorporated at different stages of the research as discussed below:

Trans-scalar mapping

Objective - This method would develop an understanding of the ecological structure of the region and also its implications on a micro-scale. It would help to gain a spatial understanding of the impacts of lack of ecological infrastructure planning on the mitigating ecological and social vulnerabilities through trans-scalar mapping across multiple scales- macro-region scale, micro-region scale, administrative boundary scale.

Stage - This is a continuous process that would be extensively carried out in the Analytical Study and Projective Study stage in the project.

Process - The mapping in the Research clarification stage of the project helped to gain insights on the social-ecological and economic impacts of current infrastructure development. The mapping in the analytical stage would involve a deeper understanding of the nodes of infrastructure and micro-level analysis of the social impact, ecological hotspots, flooding zones through web scraping and unconventional mapping methods. It would involve mapping ecosystem services to understand the ecological structures to be strengthened and the strategic projects to be proposed for providing a climate adaptive capacity to the region. The mapping would also continue in the phase of projecting proposals and testing the hypothesis to achieve the research aim.

Database/ Source - https://www.geofabrik.de/; https://www.worldpop.org/geodata/summary?id=92; https://www.diva-gis.org/datadown; googlemaps; googleearthpro; https://dataforgood.fb.com/tools/disaster-maps/; https://developers.google.com/earth-engine/datasets/catalog ; http://luminocity3d.org/WorldCity/#2/35.2/28.1

Literature review

Objective - To develop a theoretical and contextual understanding of [mega] regions, urban ecological infrastructure in order to clarify the research aim, to develop a conceptual and theoretical framework, and to identify the critical gaps in the contextualisation and extension of the concept of [mega]region. It would also provide insights on formulating the concept of ‘Resilience’ and formulate an evaluation framework to test the hypothesis.

Stage - Literature review is a continuous process in the research although varying in degree of its indulgence. It would be included in all 4 stages- Research Clarification, Analytical study, Projective study and Evaluation Study.

Process - An in-depth study in the topic of the [mega] region for writing a paper was conducted. With a vast amount of deliberations and implementation over urban and regional understanding both in pedagogy and practice, it is essential to mention here, that due to the limitation of space and time, the author focussed only on a few of the relevant (pedagogical) theories on the topic and position the concept of [mega]region in this wide range of terminology and definitions of this common spatial concept by using the theory of Megaregions, city-regions and Megalopolis from experts and scholars like Michael Neuman, Patsy Healey, Peter Hall, Robert Lang & Knox and Dewar & Epstein to understand the multidimensionality and interactional nature of the construction of this space. Following this, a detailed review of selected academic work on ecological infrastructure and collaborative planning would be made to gain a theoretical understanding of the landscape as infrastructure. This method was important in developing the project aim, conceptual frameworks, and would be instrumental in further developing an analytical and evaluation framework. It would also entail the inclusion of an understanding of resilience to gain an understanding of climate adaptive capacity to urban development.

Database/ Source - https://www.researchgate.net/; https://link-springer-com.; https://www.jstor.org/; google scholars; https://www.academia.edu/

Document review

Objective - This method is undertaken to collect quantitative data and to gain a contextual understanding of Mumbai. It would help to understand the governance system by understanding the structure of the government and the policies formulated and implemented. Contribute to analyse the regional development plans of the Mumbai metropolitan region for future growth & development and ecology, also for flood risk planning. It would also involve examining the CRZ regulations, ENVIS document and other institutional documents to understand policies, projects and methods of implementation.

Stage - This method has been helpful in building a contextual understanding during the Research Clarification stage but also would be a primary method for quantitative analysis and investigating the lags in planning and governance in the Analytical study stage.

Process - The documentary review is a part of the process to understand the global and context-specific situation related to ecological infrastructure The documents would give practical, quantitative insights on the scope of development, data on the flow of people and resources, policies and projects by the regional planning committee, and future development plans. This method would also need an analytical framework to critically study the documents and find the gaps and lags of governance in terms of ecological infrastructure planning and planning for flooding.
Database/ Source - https://mmrda.maharashtra.gov.in/; https://portal.mcgm.gov.in/irj/portal/anonymous; http://www.udri.org/resource-centre/; https://www.worldpop.org/tabs/gdata/html/92/India_100m_Population_metadata.html; http://sezindia.nic.in/cms/seepz-special-economic-zone.php; http://mumbaiport.gov.in/writereaddata/linkimages/spareport.pdf; http://crit.org.in/projects/gis

Stakeholder analysis

Objective - This method would help to understand the power, interest and support of different actors influenced by this project in order to formulate planning strategies in the proposal.

Stage - This method would be primarily carried out during the Analytical Study stage of the project.

Process - The analysis of stakeholders would be carried out through both primary and secondary source of data collection- document review and fieldwork.
It would include creating an inventory of actors related to infrastructure and ecological development in Mumbai macro-region. The plan would further include understanding the collaborative actors needed to create a spatial-institutional isomorphic arena for the macro-region which would be project-driven and this analysis would help in developing specific strategies for planning and design in macro-region.

Fieldwork

Objective -This method would involve conducting an empirical study on the context of the study, i.e., Mumbai Metropolitan Region. It would help to gain first-hand information about the ecological infrastructure like mangroves and the Mithi river to see the on-ground reality of the plans, as well as engage with the stakeholders with power and interest to the project to analyse their stance on current and future development.

Stage - The fieldwork will be a part of the analytical study stage and would be carried out after P2 with a well-scheduled visit to the site for 3 weeks.

Process - The fieldwork would be carried out in the month of February with a precise plan of action. It would include visual documentation, interviews, surveys and workshops if necessary. This method would help to gain first-hand information to verify certain data gathered through secondary sources. It would also provide an opportunity to engage with multiple stakeholders varying in power, interest and support to understand their intentions on the current and future development and help to formulate planning strategies for the proposal. (The author is currently developing an elaborate fieldwork plan)

Statistical analysis

Objective - This method helps to quantify the data necessary in the project which would involve- flows of interactions in the ecosystem, development patterns, population growth, flood risk calculation.

Stage - It would primarily be used in the Analytical Study stage and the Projective Study stage.

Process -
It would Provide a quantitative measurement of the impacts of current transport infrastructure development in the Mumbai region. The method intends to analyze how the ecological infrastructure has evolved in the Mumbai metropolitan region with its impact in society, economy and ecology. The method will carefully explore both descriptive and inferential analysis and would provide argumentation and inform decisions in the design and planning phase.

Database/ Source -

Extrapolation-existing trends

Objective - This method would help to project the future if the existing pattern of development continues. It helps to further the argumentation for the research proposal.

Stage - This method would be carried out in the Analytical Study stage

Process - In this method, the existing rate of population growth, infrastructure development plans and status quo in processes would be considered to extrapolate the future scenario to demonstrate the unbalanced development practices and what would it result in the future. This would also help in informing the crucial or the most vulnerable aspects which needs immediate attention and would guide the timeline for the proposal.

Database/ Source - https://ourworldindata.org/indias-population-growth-will-come-to-an-end; https://data.worldbank.org/indicator/SP.POP.GROW?locations=IN; https://mmrda.maharashtra.gov.in/documents/10180/8037283/B.+Proposed+Land-use+Plan+for+MMR%2C%202036+%28eng%29/17810e21-b83e-474c-9063-be4961d33005
will-come-to-an-end; https://data.worldbank.org/indicator/SP.POP.GROW?locations=IN; https://mmrda.maharashtra.gov.in/documents/10180/8037283/B.+Proposed+Land-use+Plan+for+MMR%2C%202036+%28eng%29/17810e21-b83e-474c-9063-be4961d33005

Research scope and limitation

Due to the limitation of time and capacity that Masters graduation project has, the research would focalise only on using infrastructure and ecology as the major relations dominating the approach of [mega] region/macroregion planning to operationalise macroregion planning in order to achieve balanced development. This would help in establishing the role of regional planning in achieving balanced development. For the understanding of [mega]regions/macroregions, selective literature which aligns with the authors understanding and implications of macroregions has been used.
Data unavailability on certain aspects due to limited accessibility of data
The project would primarily involve seven methods that would be used in the course of the research. These methods and approaches are incorporated at different stages of the research as discussed below:

Expected Outcomes

Expected research outcomes :

The outcomes by the end of the project which would answer the research question and accomplish the purpose of the study includes design and planning framework at multiple scales.
Inorder to achieve resilience in the region, I foresee the following strategies developing:

In the process and in conclusion,the research project would formulate projections and proposals at multiple scales by dealing with the concept of Ecological infrastructure. The outcome would include the

A. Regional design strategy based on 3 types of flooding and the built/ unbuilt area
•Includes the Ecological infrastructure layer and built area layers.
•Possible combination of other physical infrastructure interweaved with ecological infrastructure based on spatial patterns and processes.

B. Collaborative governance-
Planning framework to facilitate collaboration and coordination for implementation of regional strategies amongst the authorities, municipalities and other stakeholders involved.

C. Translating the strategies at smaller scales- Meso-,micro- and macro-scale using ecological infrastructure

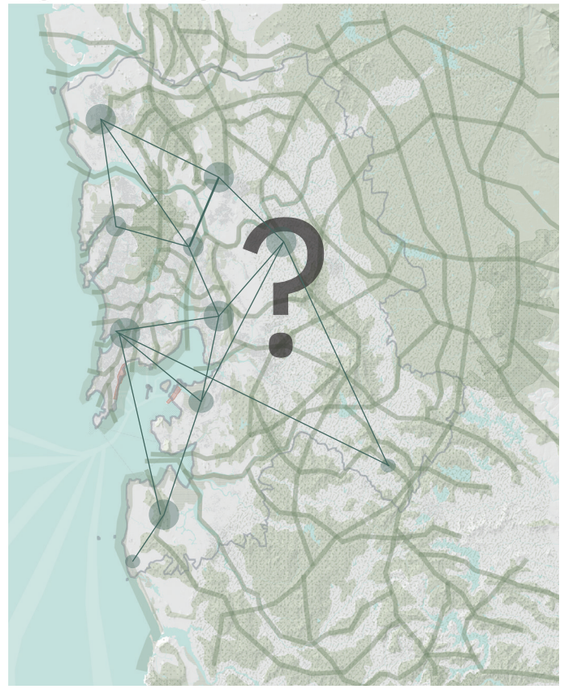
D. Timeline and policy recommendations to achieve a resilient system to provide a capacity against future flooding.

E. Planning framework
Key stakeholders, governance structure and planning instruments

Regional design



Regional planning framework



Macro-scale



Meso-scale



Micro-scale



Research scope and limitation

Due to the limitation of time and capacity that Masters graduation project has, the research would focalise only on using ecology as the major relations dominating the approach of [mega]region/macroregion planning to operationalise macroregion planning in order to tackle the issue of flooding in Mumbai. This would help in establishing the role of regional planning in achieving balanced development. For the understanding of [mega]regions/macroregions, selective literature which aligns with the authors understanding and implications of macroregions has been used.
Data unavailability on certain aspects due to limited accessibility of data

Ethical consideration:

Ethical consideration is critical in order to protect our personal, professional and institutional integrity. Ethical considerations in research projects include three issues(NIH, 1979): a) do not harm- benefits of the research outweigh the risks; (b) respect—maintaining an awareness of intellectual integrity and personal responsibility for the impact that research processes have on participants; (c) Fairness and justice—who bears the burdens; who receives the benefits.(NIH, 1979)In the process of the research, while carrying out the methodology- honesty, intellectual property, use of human subjects, confidentiality, and social responsibility must be taken into consideration(Resnick, 2010; Trochim, 2006).
Ethical considerations also accounts for the credibility of the research,the researcher and the institution associated with the project.Several areas of ethical behavior are included in the research process, some of these include:
(1) data—collection, maintenance, sharing, and ownership; (2) training— responsibilities of research mentors and trainees; (3) publication—practices and responsibilities of authorship; (4) bias—conflicts of interest in research; (5) professional conduct; (6) rights and protection of human subjects (respect for persons); (7) protection of animals used in research; (8) peer review; and (9) collaboration with sponsors and client populations. Some of the ethical violations that could occur, either consciously or unconsciously include: (1) violating agreements of disclosure; (2) violating confidentiality of participants; (3) invoicing for work not done, or excessive charges; (4) misrepresentation of the results of the study; (5) deceptive interactions with participants (ignoring informed consent); (6) disregarding legal liability for risks.

Scientific and Societal Relevance:

The graduation project would contribute to the research needed for providing resilience for our future urbanization to deal with uncertain climatic events and contribute to sustenance. The project would try to fill in a small amount of research gap in developing solutions for Climate Resilience in the Mumbai Metropolitan Region using ecological infrastructure and how the processes in the biophysical system could be used to create a socio-ecological system. The project would contribute to the scientific knowledge of regional planning in India and contribute to an approach of systemic resilience in regions in the discourse. The projections of the future illustrate that most of the city of Mumbai would be wiped out by 2050, which makes it an urgent social issue along with the short term impact and contribution to the regular flooding that occurs every year damaging the houses, livelihoods and threat to life for a large part of the society since 55% of Mumbai’s population are slum dwellers who are the most vulnerable section of the society in events of natural disaster. Thus, the project also tries to deal with the question of spatial justice and provide solutions for just development.

8.

Analysing Mumbai

Potential and opportunities



fig.1.132 Flooded Mumbai. source: timesofindia

Framework for Design

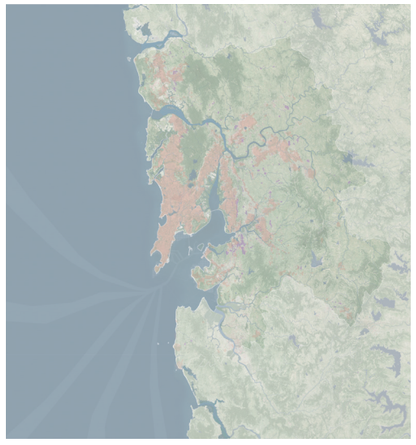
Socio-economic construct

Development of a future urban plan and design responding to current and future flooding would be informed by the existing socio-economic construct of the city inorder to integrate social challenges within the design along with using the social capital as a strength to operationalise the strategies. This would necessitate an understanding of the social construct within the city along with dominant economic activities and the social class divide. Future design strategies and planning framework would incorporate an understanding of the existing extent of urbanisation and the project future growth. An overview of the socio-economic vulnerability could provide an insight in planning mechanisms that could be developed to bring adaptation towards flooding in the forefront of the planning process.

Ecological Infrastructure and mechanism for flood protection

The critical aspect of the analysis of the city would involve studying the Pattern, Processes & Interactions of the ecological infrastructure. Firstly the Ecological infrastructure needs to be defined for the scope of the project. The elements included as a part of this infrastructure requires a study based on the ecological processes which could be developed as a mechanism for flood protection. The existing spatial extent needs to be analysed along with the built environment to explore possibilities of extending the ecological infrastructure in the current built and future built environment in order to provide an adaptive capacity to the city of Mumbai.
The strategy development also involved comprehending the three types of flooding -pluvial

Understanding the socio-economic system



Pattern, Processes & Extent

- What is the extent of urbanisation? Future urban growth?

- what is the current infrastructure for flood protection?

- What is the social constitution? What are the dominant economic activities in the Region?

Identification of ecological system



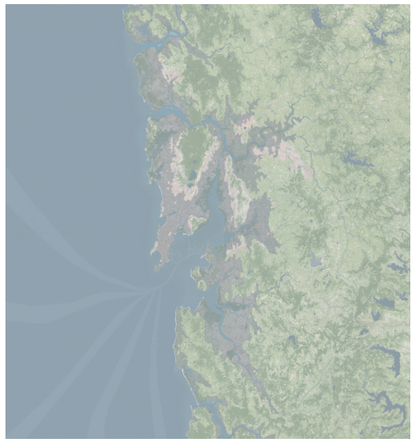
Pattern, Processes & Interactions

- Mechanism- How does it help in flood protection?

- What are the elements of the ecological system?

- What are the ecological processes involved?

Based on Flooding in the Region



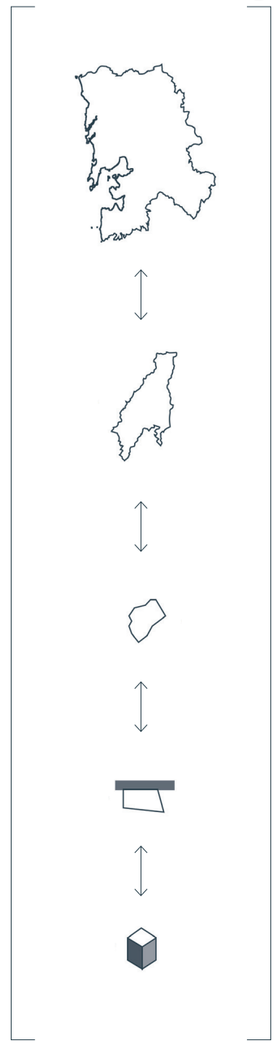
Vulnerabilities-geographic-socio-economic

- Which areas are at high risk?

- Types of Flooding ?

- Vulnerabilities in the region

scalar understanding



ecological processes at different spatial temporal scales along with the built grain and extent

spatio-temporal

, fluvial and coastal flooding in Mumbai in order to deepen the strategy development based on short term and long term planning. The ecological vulnerability due to flooding would inform the planning process of the design.

Scalar approach

The ecological processes vary at different spatial temporal scales along with the built grain and extent and this synergy needs to be articulated in the design through exploration of the strategies at multiple scales. Thus the strategic design would chronologically be developed first at the city scale and then the transferability at a regional scale. A case of three locations are chosen to further exemplify the transferability of the strategies in actual space and place. These case examples vary in their urban and natural systems and the interventions need to be strategically designed in a way that the ecological elements integrated in the built environment not only responds to the flooding issue but also maximizes the social and economic growth in an equitable manner.

Ecological Performance and Hydraulic performance

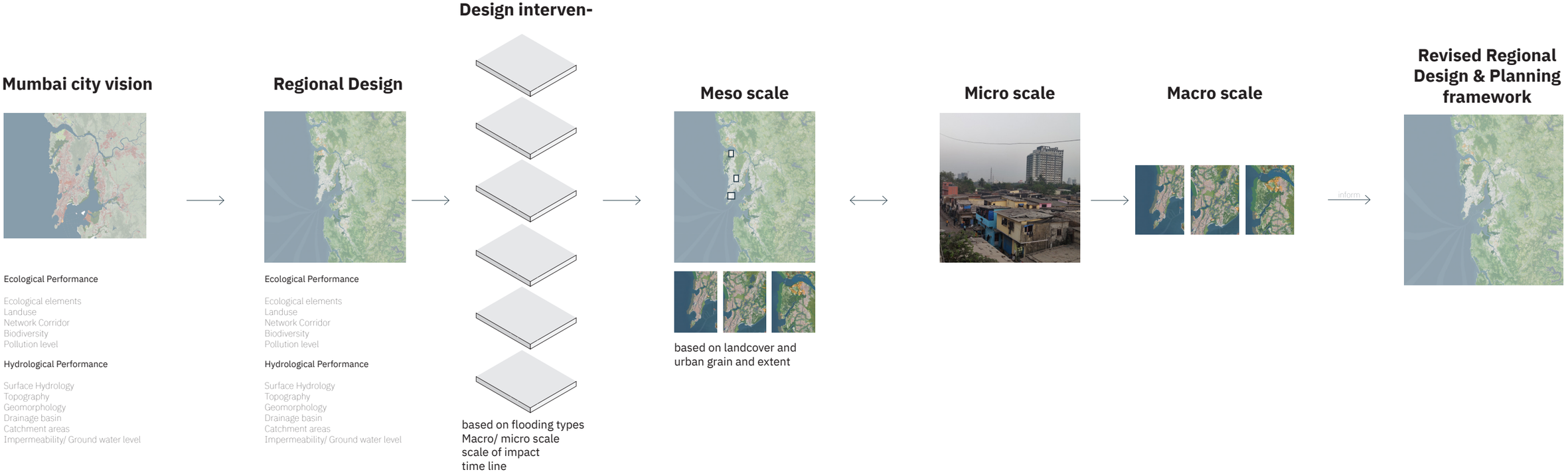
It provides a basis to undertake the relevant layers in response to flooding for the natural system. Ecological performance includes an understanding of the land cover, the elements of the ecology defined as ecological infrastructure in the project, the spatial extent and the ecological processes involved.Hydraulic performance undertakes the study of the layers related to the hydrological processes in the city that includes the topographic elevation, the catchment basin, watershed basin and the overlap of water elements that are already covered in the ecological performance forming the natural water system.

Three cases

Three areas where there are varying gradients of natural and urban system with differentiations and commonalities but with a need to be resilient in future and exemplify the different cases in which these strategies can be applied to create an adaptive city. The cases will be explained in the consequent chapters along with the operationalisation of the theories, concepts and the methods. The three cases include the Island city, Bandra-Kurla Complex and the Salt Pan Area which would be explored in meso,micro and macro scale to project the ecological infrastructure in these locations.

Planning framework

Based on the regional design responding to the socio-economic construct of the city responding to the ecological vulnerability, a comprehensive understanding of the implementation and planning of the design is necessary. This would require looking at actors, governance structure, planning process, horizontal and vertical collaboration mechanisms.



Understanding the socio-economic system

Challenges & opportunities

The existing socio-economic system layers could be represented from the land cover, transport infrastructure (in this case railways and roads), commercial and industrial areas, slum areas (bustling microeconomy in themselves) and existing and future urban growth as planned which could prove to be potentials as both challenges and opportunities to be considered for adaptation in the future. As Taneha describes Urbanisation is a synthetic ecology of different flows, materials and processes, extensive and intensive, combining waste and water, fuel and food, mobility and power. (Taneha, 2015) This human inhabitation needs to be adapted to the changing conditions that awaits its future, by using the strengths and transforming its shortcomings in the process. The coupling of different flows and calibration of different processes of production bears the potential for transforming linear, monofunctional structures into circular, polyfunctional infrastructures. Thus if hard industrial structures including their effluents and emissions, can be understood as part of urban infrastructure, then the design of softer, leaner ecological can reform, protect and drive contemporary spatial morphologies and generate new regional economies. While reintroducing the connection between socio-economic system and ecological system through ecological infrastructure, it is essential to understand the spatial morphology of the current socio-economic system to find ways to adapt it using the ecological elements and create synergies amongst them to form a new socio-ecological system that can deal with the impending climatic changes.

The transformation requires an integration of these natural and human processes which form an ecosystem together and needs to function in harmony. Slums in Mumbai, is a big challenge that needs to be accounted for to make this transformation an opportunity to gauge that as well. The presence of banks, commercial centres and large business groups also needs to be used as a potential for change, since right from slum dwellers to big business groups ,all have the right to the city. The socio-economic construct needs to reform along with a preparedness for the urban growth that is projected.

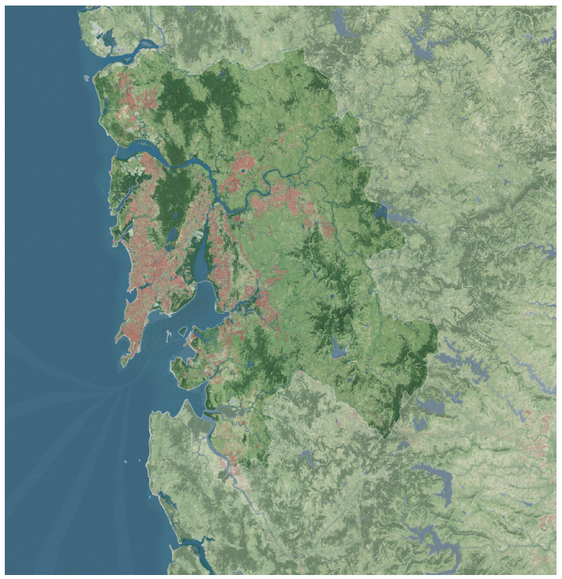


FIG. 1.133 Land cover. source: author .

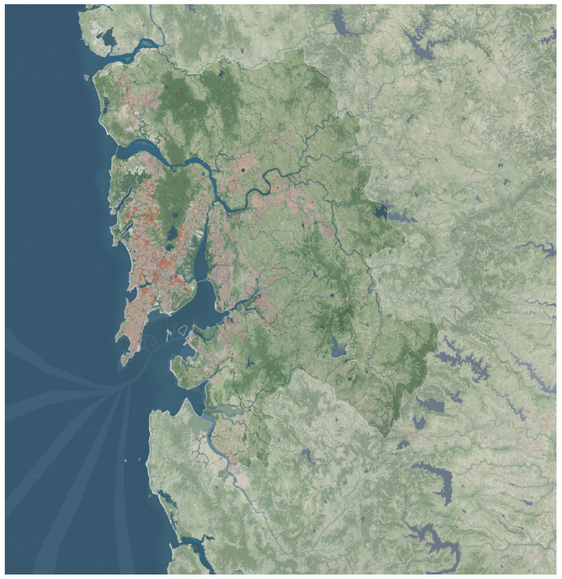


FIG. 1.134 Slums in Mumbai.source: author .

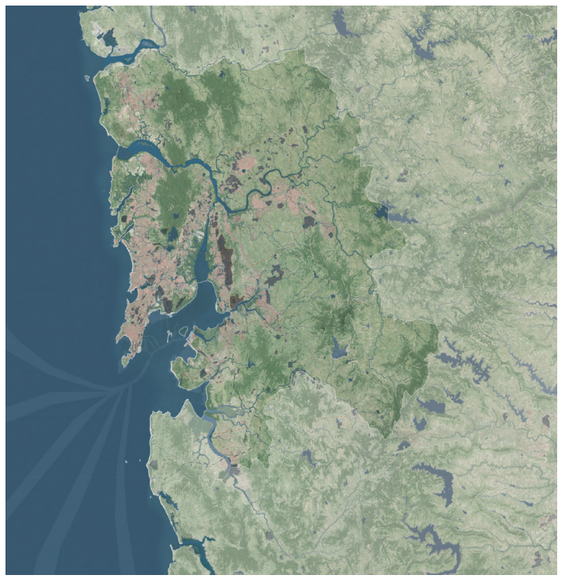


FIG. 1.135 Slum in Mumbai source: author .

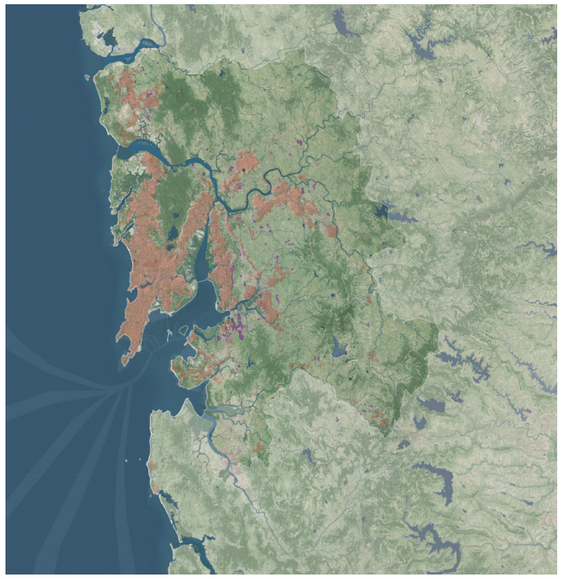


FIG. 1.137 Existing Urban morpholgy.source: author .



FIG. 1.136 Railway and Metro infrastructure.source: author .

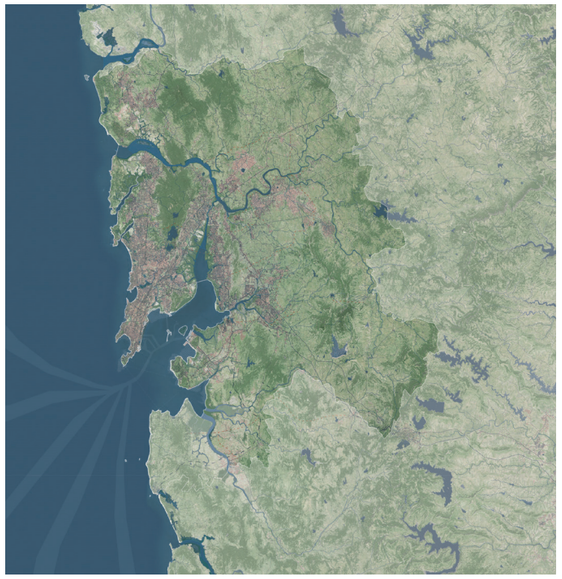
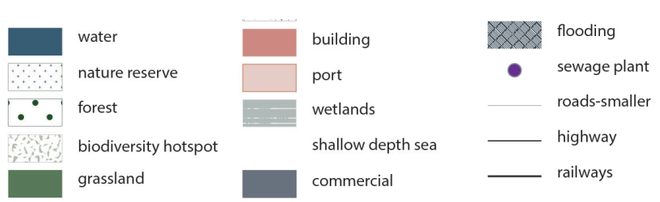


FIG. 1.138 Road infrastructure.source: author .



Identification of ecological Infrastructure

For the scope of the project , the author has considered wetlands, grasslands, agriculture area , forests, protected areas, salt pans and the water ecology formed by Sea,rovers, creeks , lakes and smaller water bodies. The strategic design of both man-made and ecological infrastructure would be embedded in a synthetic landscape of living, biophysical, and sociopolitical systems and would operate as urban infrastructures that would shape the future of urban economies and cultures.
The analysis started with exploring both Spatial Patterns and Processes of ecological Infrastructure.

Patterns: This includes observing the spatial patterns of the green ecological structure and understanding the morphology of both the current green and the potential green network. It involves looking at the extent and limits of the existing ecological elements along with the change in the same over the past few decades.

Processes: Understanding the interactions and exchanges that occur amongst ecology and society which are also called as ecosystem services but rather represent the interactions that take place between the two systems. Thus the author steps away from the classification of services as that interprets the ecology as an entity existing to serve humans but rather views it as processes where the two systems benefit each other. The analysis involved comprehending the critical layers which form the part of the ecological system which could function as an element that could provide flood prevention. It involved a topological understanding of urban landscape to articulate the design in a systemic way- landscape functional performance of visual perception as an intelligible whole where the functional performance would be gauged through Ecological performance and hydraulic performance of the territory.(Taneha, 2015)

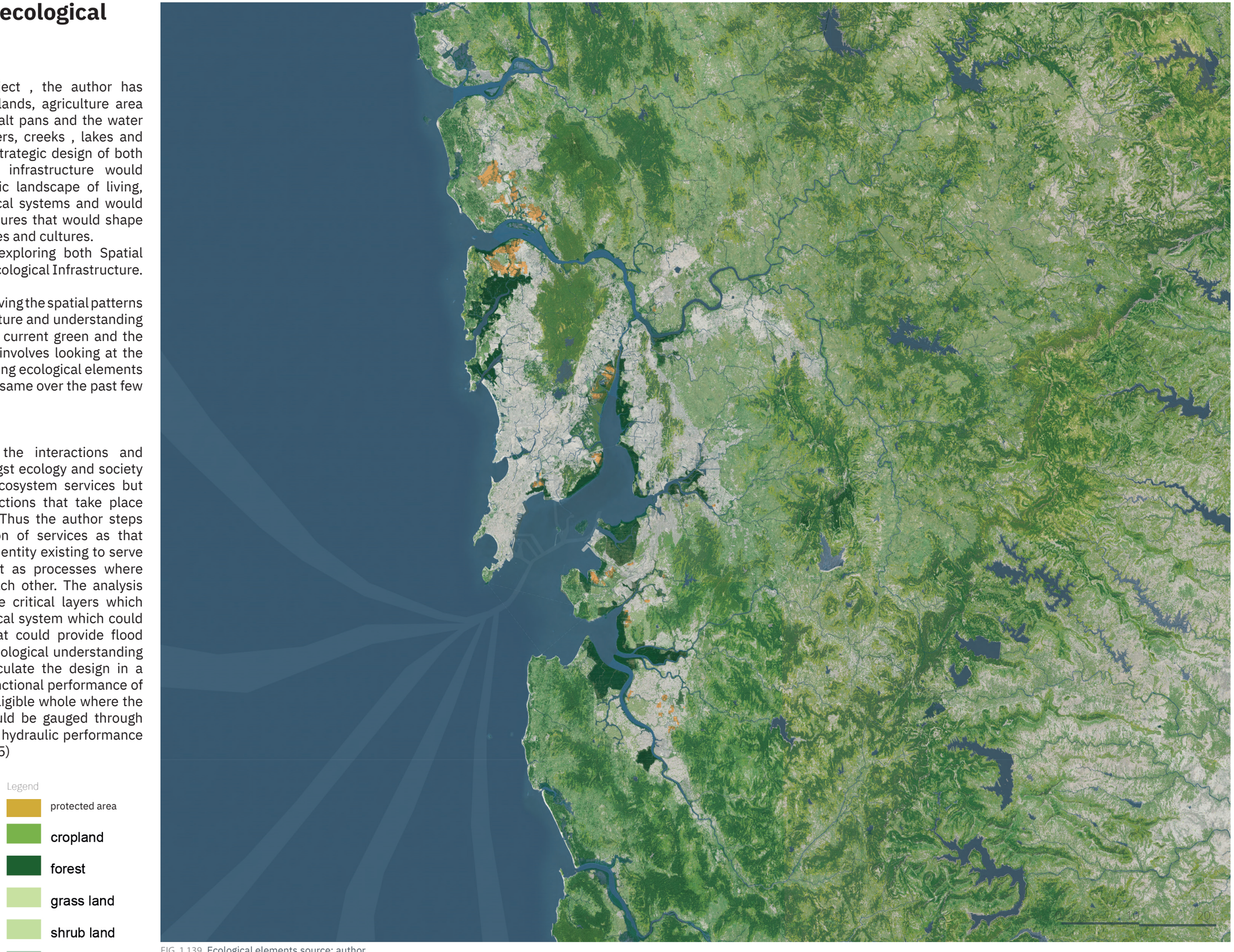


FIG. 1.139 Ecological elements.source: author .

Ecological Performance

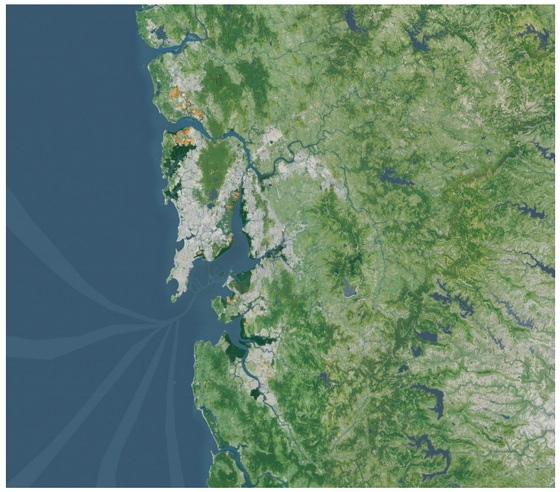


FIG. 1.140 Ecological elements.source: author .

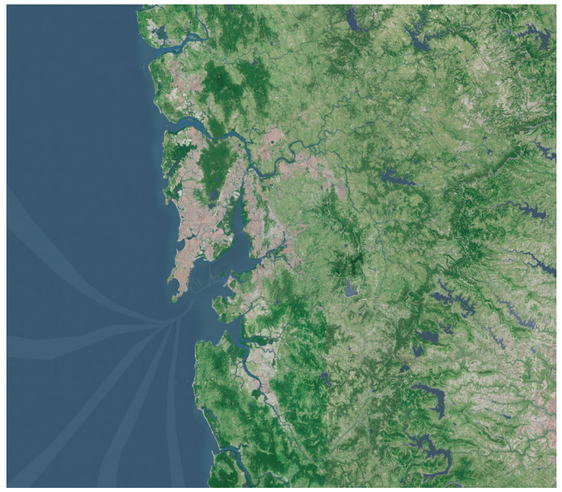
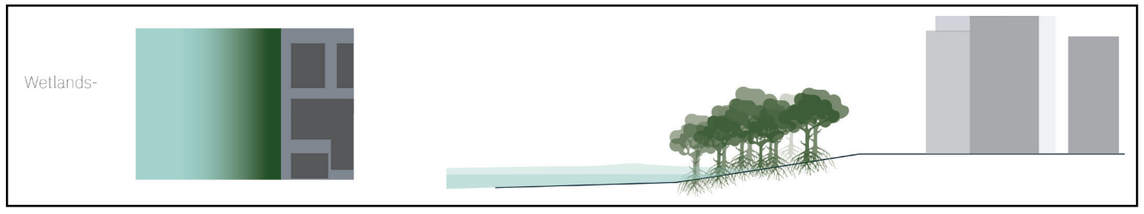


FIG. 1.141 Networked landscape .source: author .

This encompasses a comprehensive exploration and assessment of different layers of ecology that would contribute in providing resilience to the system.
It primarily involves the analysis of the ecological elements to comprehend the mechanism that could provide flood resilience. It also involves understanding the potentiality of the green network to both society and ecology as well as considering the biodiversity of the region in view of the design. The ecological performance would be gauged through the ecological elements mechanism for flood protection and extent but also looking at the network landscape, to observe the fragmentation of the landscape. GIS tools with spatial modelling techniques can measure the current and existing connectivity , but for the scope of the project it would not be empirically measured but rather integrated in a qualitative manner. The functional performance needs to be understood in terms of the **type of flooding it responds to, the extent of area the propagation of the element requires and the potential benefits** it can offers apart from flood management.

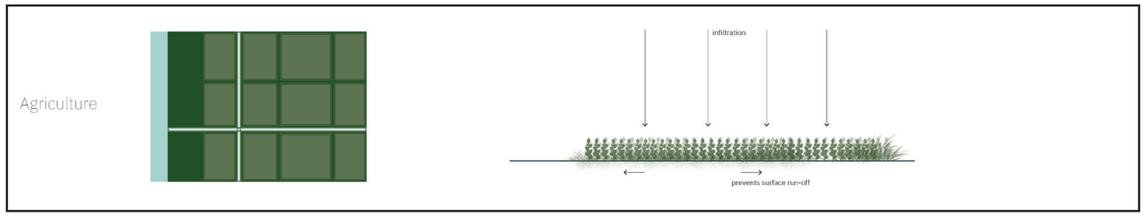
Flood Defense Mechanism



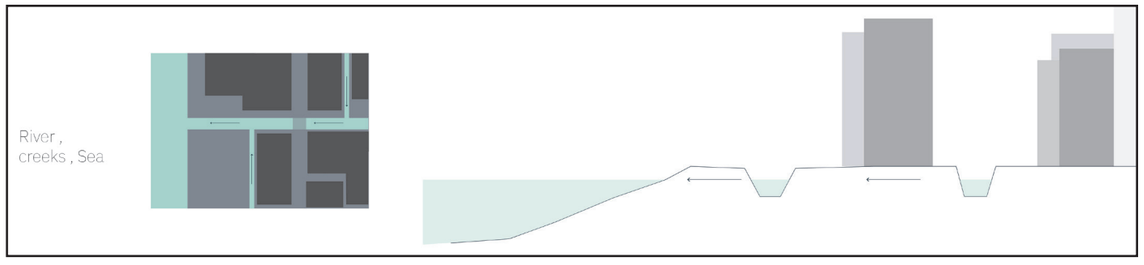
Mangroves are known to be the Natural Coastal flood defense mechanism which is a biodiversity rich ecological element. Mangroves can tackle tidal flooding by breaking the flow and energy of tidal waves which attempts to pass through them. Both the aerial roots and the dense complex branches of mangroves can diminish the height of the waves and protect the urban area from damage and losses. They also help in reducing the erosion and enhance both coastal and riverine sedimentation. Mangroves can also tackle sea level rise due to peaty soil formation and upward soil movement due to its roots. (Spalding et al, 2015)



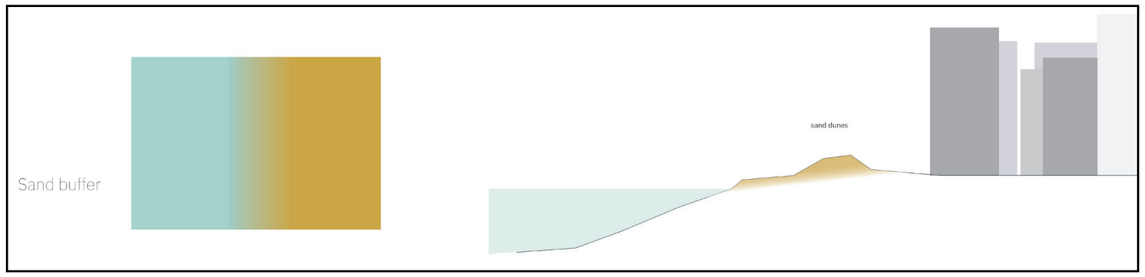
This involves a network of green spaces -grasslands , shrublands, row of trees with a connectivity within themselves. This contributes to achieving and maintaining healthy water ecosystems and offer multiple benefits to the water sector by providing regulation of water flows, water retention for further use, groundwater percolation, and water provisioning, species protection, biodiversity enhancement, climate change mitigation and adaptation. It helps in prevention and mitigation of floods. (EEA, 2017)



Farmlands also provide an opportunity for the rainwater to percolate and recharge the groundwater, the variation in percolation would be based on the soil typology. In these areas, different soil types along with precipitation incurred on the piece of farmland can determine the type of farming that could be practiced. The use and management of floods can help in improving the productivity of the agricultural land by relatively low-investment and low-skill interventions.



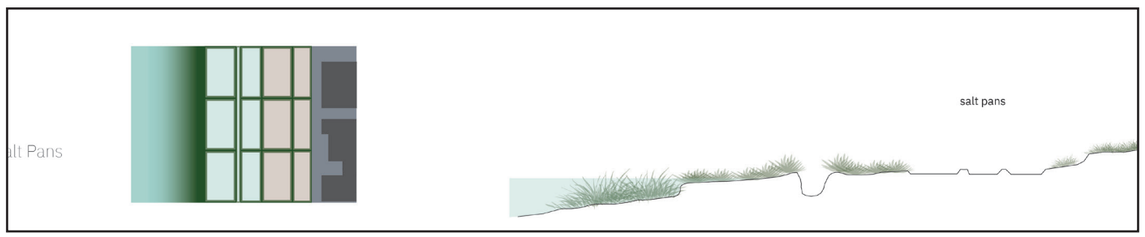
These are an essential ecological element which acts both as a larger scale storage at the same time drainage element when compared to porous green spaces. But the width and depth of these features need to be spatially gauged inorder to respond to the potential flooding in the area. Mumbai was once an archipelago of 7 islands, which means it had much more water than it has now. The challenge is to integrate this water network in the current urban context without one dominating the other. Mumbai has three main rivers, sits at the mouth of the Arabian Sea and has multiple creeks and water bodies which forms the current water system.



Sand dunes as a natural barrier for coastal defense as it breaks down the force of both wind and waves, thereby protecting against coastal storms as well as beach erosions. They absorb the impact of storm surge and high waves, preventing and delaying flooding of inland areas and damages to the inland urban structures as well. These natural sea walls are favored over the cement constructed coastal walls which have a high time and cost investment and could have a dire hydrodynamical effect on the shoreline as it disperses back the wave energy to the ocean and that would have a detrimental effect somewhere else at the coast. (Norbord, 2013)



Forests have a sponge-like effect on rainfall that tends to soak up abundant rainfall and stores it before releasing it in regular amounts over an extended period of time. Considerable quantities of rainfall (upto 35 per cent) are commonly intercepted by the canopies of tropical forests and evaporated back into the atmosphere. The water infiltrates into the porous soil, enriches it and is consumed by the trees themselves. (FAO & FICOR, 2005) Both the natural forest canopies and the porous soil have a storage capacity of rainwater and riverine flood waters. (Calder & Aylward, 2006)



Saltpans act as a natural barrier to coastal flooding. They form shallow depressions where water enters and its force and intensity gets disrupted along with acting as storage vessels thereby protecting the urban areas from any damage. It also hosts a large species of insects and birds that thrive on them and is a source of livelihood as well.



FIG. 1.142 Salt pans in Mira Bhayander.source: author

Ecological Performance

Biodiversity -Networked Landscape

Mumbai, also called a concrete jungle that succumbed to the rapid urbanisation happening everywhere has not yet compromised its ecological asset completely. As mentioned earlier, it is a part of the western ghats ,being one of the 32 Biodiversity hotspots in the world, also with a National Reserve park and mangrove ecology ,it inhabits a wide range of species of flora and fauna. Many researchers have begun to photographically journal them and efforts to identify this diversity has also been made together with the World Wildlife Fund for Nature ,India. The essential aspect that the project would extract from the understanding of biodiversity is the significance of **integration of fragmented landscapes into an interconnected network of green blue network** which forms as a means for different species to flow as well. The term ecological infrastructure could be extended in terms of the understanding of this element for flow of other species as well to integrate various biophysical processes together. This spatial structural integration of the landscape ecology could be through patches, corridors and matrix. (Marenzi & Hardinger, 2006)The landscape spatial structure has a close relation to the biodiversity conservation ,making connectivity amongst ecological elements essential.

Mumbai houses a large variety of species of birds, mammals, reptiles and aquatic animals but these are deteriorating over time, the approach of ecological infrastructure could conserve the existing species at the same time nurture newer ones.



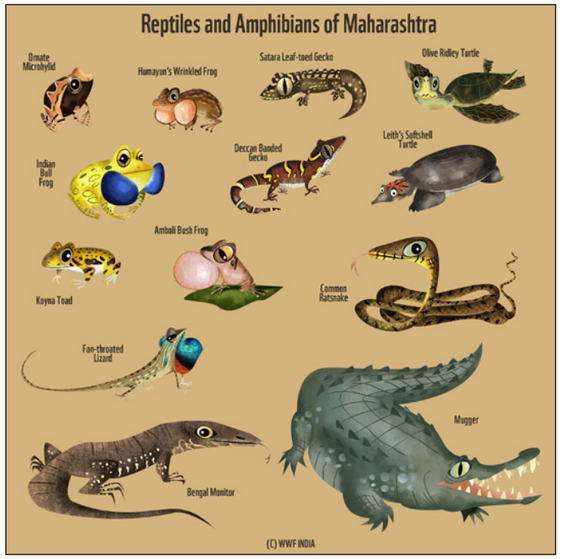


FIG. 1.143 Biodiversity.source:WWF,India .

FIG. 1.144 Biodiversity.source:WWF,India .



FIG. 1.146 Biodiversity.source:WWF,India .



FIG. 1.145 Biodiversity. dfdsourcesourcesource:google .

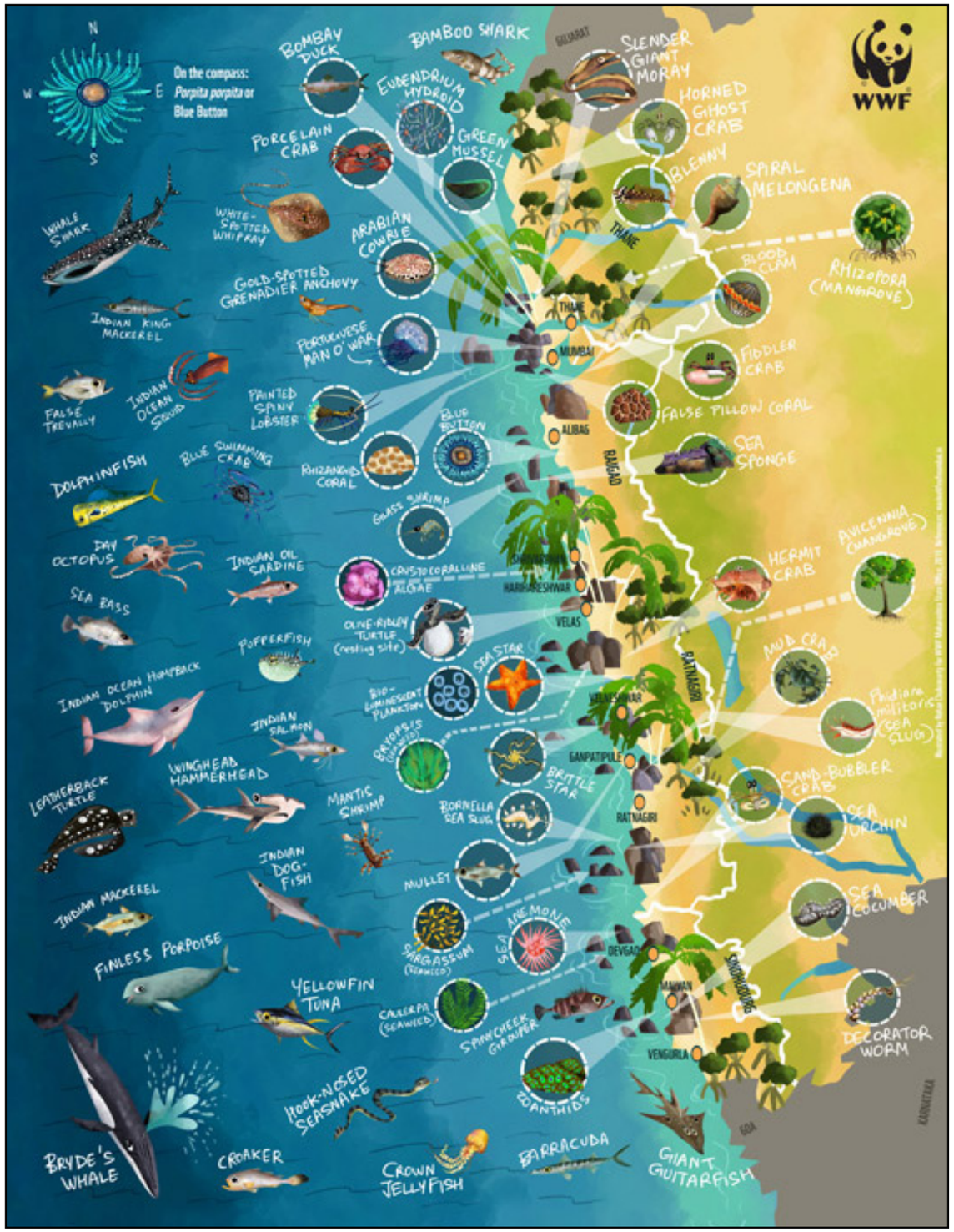


FIG. 1.147 Biodiversity.source:WWF,India .

Hydraulic Performance

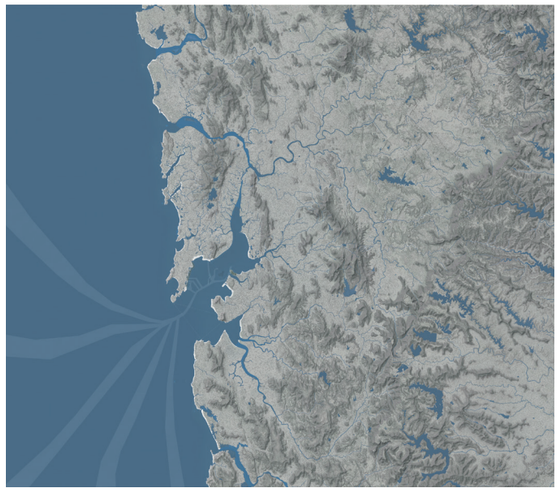


FIG. 1.148 Topography.source:author .

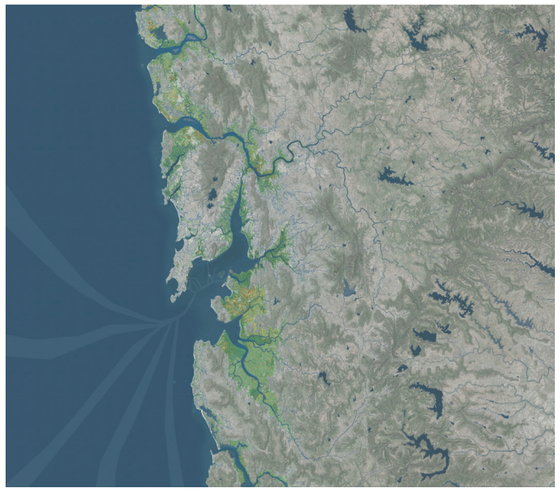


FIG. 1.149 Elevation below sea level.source:author .

It primarily involves the analysis of the surface water, the hydroshed basin, the elevation of the territory and the catchment basins to understand the water dynamics in the event of flooding and to design the ecological system in view of this to provide capacity for effective water management. The functional performance of the topography that would guide the flow of water along with areas that would be more sensitive to coastal and pluvial flooding and sea level rise as they lie below the sea level. The catchment area can define the flooding areas in the city with each basin specifying the hydrological processes and this would guide in an understanding to design the ecological infrastructure that responds to both ecological performance and hydraulic performance.

Mumbai experience three types of flooding - Pluvial flooding , Fluvial and Coastal flooding . Flooding has become a perennial event for the city and requires different strategies based on different location and degree of threat in the area to play out in space and different times of the year and near future .
The delineation of time exposes a complex stratification of temporal processes that can be sequenced and synchronized to form new, and more complex ecologies. Time carries power to not only shape patterns of growth and processes of movement, but it can redefine conventions of site and property by opening new scales and systems of intervention leaving room for emergence, growth, propagation, movement, indeterminacy, uncertainty



FIG. 1.150 Catchment area .source:author

and risk.

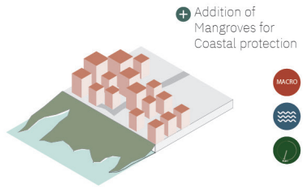


FIG. 1.151 Mangroves in Airoli .source: author

Exploration of Design Interventions

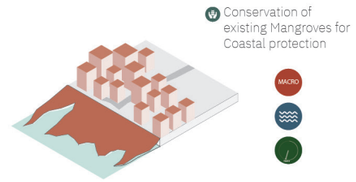
Wetlands

W



Addition of large strips of Mangrove natural buffers

Type of flooding : Coastal
Scale of spatial intervention : Macro
Timeline consideration : Long-term

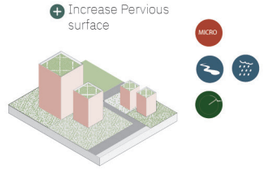


Preservation of existing large strips of Mangrove natural buffers

Type of flooding : Coastal
Scale of spatial intervention : Macro
Timeline consideration : Short-term

Grass/ Trees/
Shrubs
Green cover

G



Increasing impervious surfave-footpaths/pavement

Type of flooding : Pluvial & Fluvial
Scale of spatial intervention : Micro
Timeline consideration : Short-term

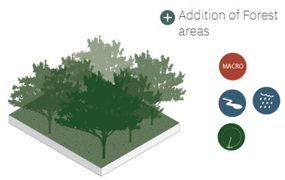


Addition of green pathways

Type of flooding : Pluvial
Scale of spatial intervention : Micro
Timeline consideration : Short-term

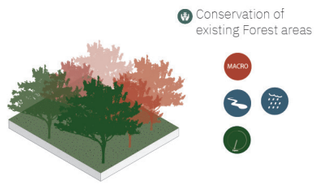
Forest

F



Addition of large areas of Forest - Afforestation

Type of flooding : Pluvial & Fluvial
Scale of spatial intervention : Macro
Timeline consideration : Long-term



Preservation of existing forest areas from destruction to urban development

Type of flooding : Pluvial & Fluvial
Scale of spatial intervention : Macro
Timeline consideration : Short-term

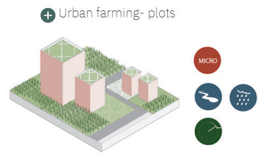
Agriculture/
cropland

A



Urban farming practices on roofs

Type of flooding : Pluvial & Fluvial
Scale of spatial intervention : Micro
Timeline consideration : Long-term

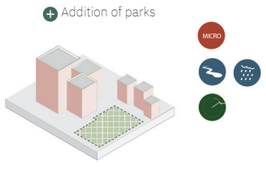


Urban farming practice on plots of lands

Type of flooding : Pluvial & Fluvial
Scale of spatial intervention : Micro
Timeline consideration : Short-term

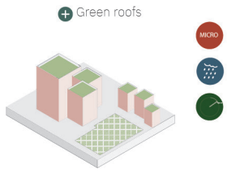
Grass/ Trees/
Shrubs
Green cover

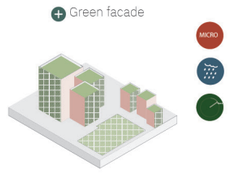
G



Addition of open green spaces as parks & public spaces

Type of flooding : Pluvial & Fluvial
Scale of spatial intervention : Micro
Timeline consideration : Short-term



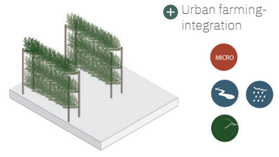


Retrofitting buildings with green roofs and facades

Type of flooding : Pluvial & Fluvial
Scale of spatial intervention : Micro
Timeline consideration : Short-term

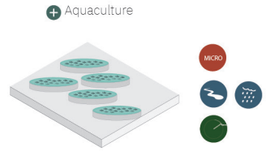
Agriculture/
cropland

A



Integration of urban farming practices in public spaces- incorporation of hrdroponics as well

Type of flooding : Pluvial & Fluvial
Scale of spatial intervention : Micro
Timeline consideration : Short-term



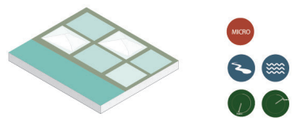
Urban Aquaculture- aquatic farming of organisms

Type of flooding : Pluvial & Fluvial
Scale of spatial intervention : Micro
Timeline consideration : Short-term

Urban farming- roofs

Salt pans

S



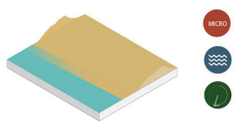
Saltpans preservation and addition as buffer

Type of flooding : Coastal
Scale of spatial intervention : Macro
Timeline consideration : Short-term

Sand dunes

Sand dunes

D



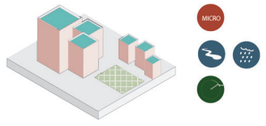
Introduction of sand dunes as flood defense

Type of flooding : Coastal
Scale of spatial intervention : Macro
Timeline consideration : Long-term

Water collection- roofs & tanks

Water network

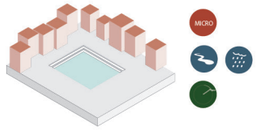
B



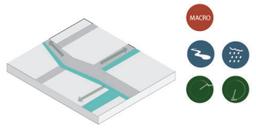
Water collection at roof tops and tanks at the plot

Type of flooding : Pluvial & Fluvial
Scale of spatial intervention : Micro
Timeline consideration : Short-term

Water squares



Water network



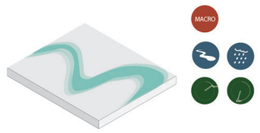
Water network and water squares at public space

Type of flooding : Pluvial & Fluvial
Scale of spatial intervention : Micro /Macro
Timeline consideration : Short-term / Long-term

Widening of creeks , canals and rivers

Water network

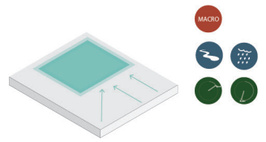
B



Widening of creeks, canals and rivers

Type of flooding : Pluvial & Fluvial
Scale of spatial intervention : Macro
Timeline consideration : Long-term/ Short-term

Retention ponds and reservoirs



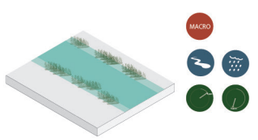
Retention ponds and reservoirs

Type of flooding : Pluvial & Fluvial
Scale of spatial intervention : Macro
Timeline consideration : Long-term/ Short-term

Remediation

Water network

B



Phytoremediation- crucial aspect of water management

Type of flooding : Pluvial & Fluvial
Scale of spatial intervention : Macro
Timeline consideration : Short -term/ Long-term

9.

Vision in Making

Strategic principles over the terriory

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

-Thogmorton(1995)

FIG. 1.152 In Mumbai. source: Safwan Patrawala

Regional Vision in Development

Mumbai needs to align its spatial reality to the projected climatic reality of the future, where the projected climatic changes set new conditions of existence to be prepared for.
Thus through the formulation of a comprehensive methodology of ecological and socio economic analysis , the region could develop strategies in place which respond to the future flooding in the urban environment. This involves a proposal for both built and ecological systems based on an understanding of the processes in play .
The forthcoming section deals with the three regional strategies- Ecological corridor, Capillaries and Coastal Protection and comprehends its translation in space. The strategies extrapolate the existing built and natural systems to propose an urban plan oriented towards a different form of infrastructure which has a capacity to adapt to future flooding. This adaptive capacity embodies within itself the power to store, drain or absorb water. These three strategies can be extended in the whole city and extrapolated to the region as well(shown later on pg.188). It forms a framework for further defining urban planning and design at a smaller scale as it forms a guide for setting goals and objectives ,making decisions and coordinating and evaluating work based on its reduction of the complex issue into a simplistic concept comprehendible and easily communicative to all. Sustenance of Mumbai city would depend on embedding these strategies with its urban spatial reality and to avoid displacement of one of the most dense cities in the world.

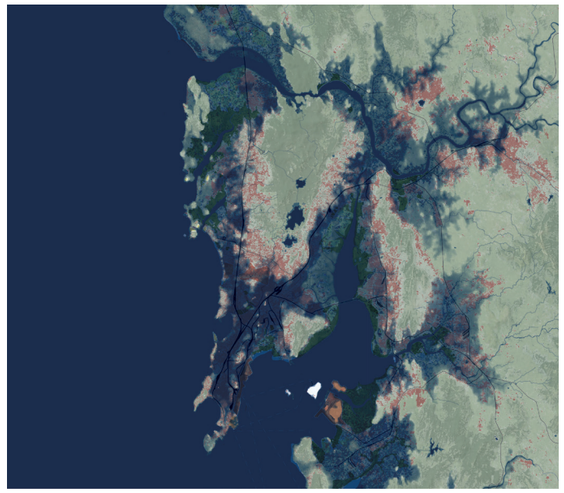


FIG. 1.153 Future flooding in Mumbai .source:author .

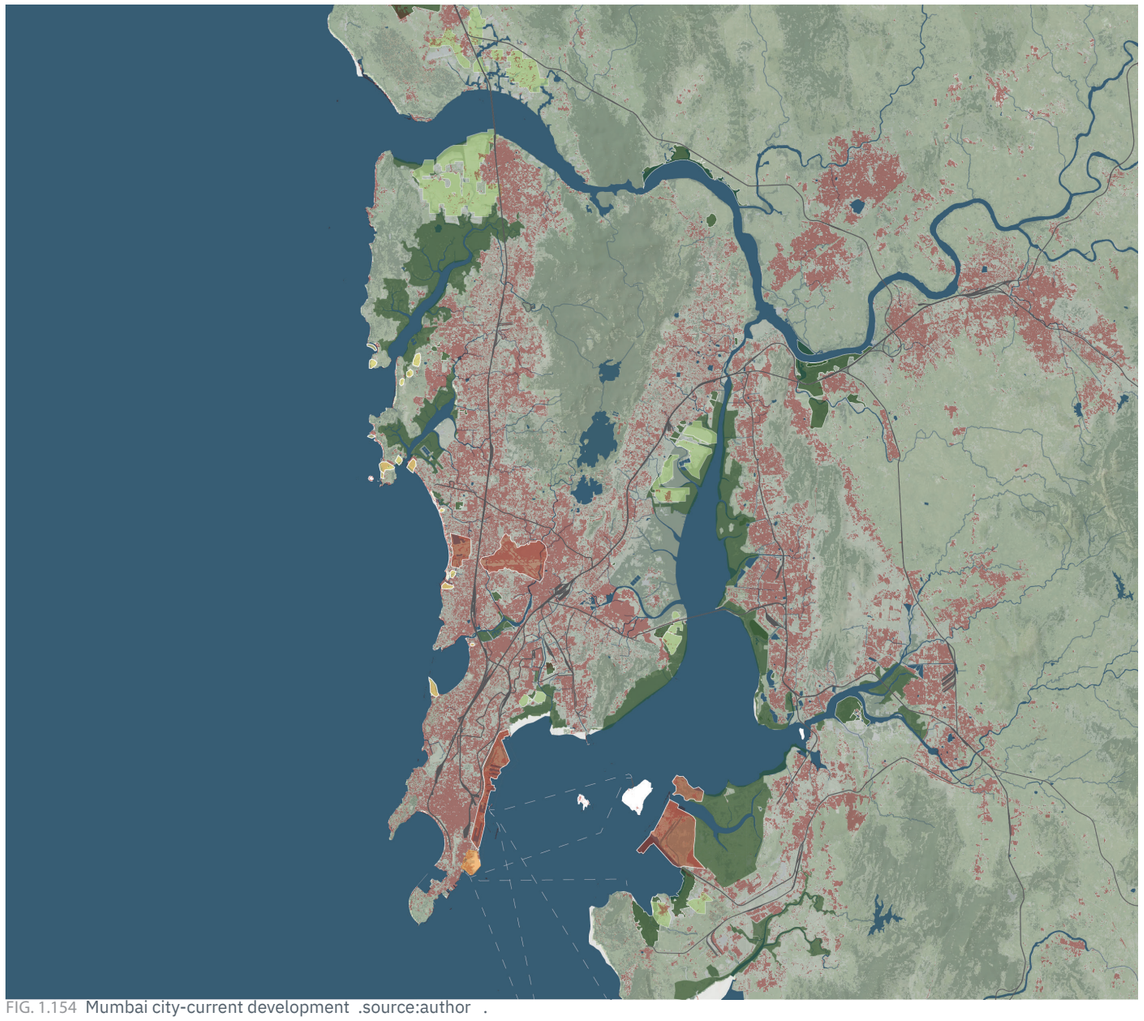


FIG. 1.154 Mumbai city-current development .source:author .

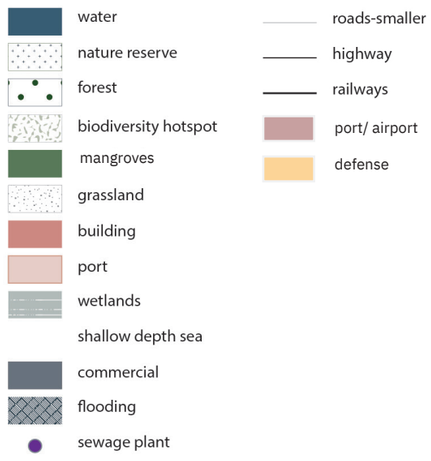
Flooding - adaptive capacity

Absorptive capacity

Storage capacity

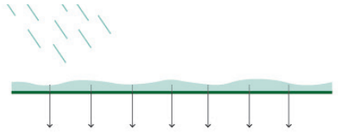
\+

Drainage capacity

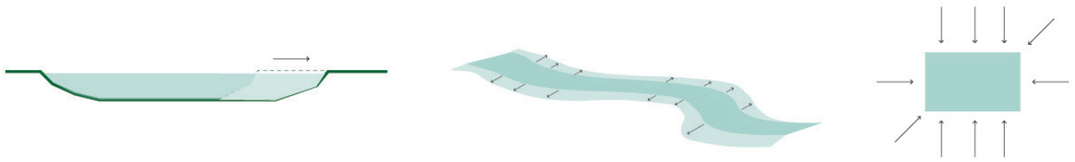


ECOLOGICAL CORRDIOR

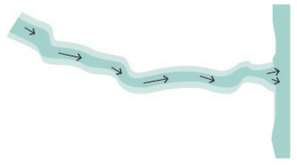
The Ecological Corridor manifests as zones representing spatial configuration which are formed by the extrapolation of the current natural system. They form a networked landscape to increase the adaptive capacity of the city responding primarily to fluvial and pluvial flooding, but also to coastal flooding. These corridors have the capacity to either store, absorb or drain within them distributed based on the ecological element. The corridor would at least have one or a combination of multiple principles or values as described. The ecological corridor could have high porosity, larger storage capacity or higher drainage capacity or all the three. Ecological corridors help in delineating the ecological buffers and the urban fringes of the built and natural environment. If urban is seen as a gradient of ecology and urbanity, then the corridor would have a higher gradient of ecology and very less presence of urbanity. It would also support biodiversity and improve liveability in the City.



1 - Increased percolation or recharging ground water Absorptive capacity



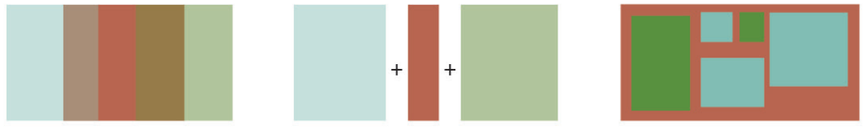
2 - Increased storm water capacity- storage Storage capacity



3 -Increased drainage Drainage capacity



4 - Buffering capacity-Delineate ecological buffers & urban fringes



5 - High integration of ecology with existing built area

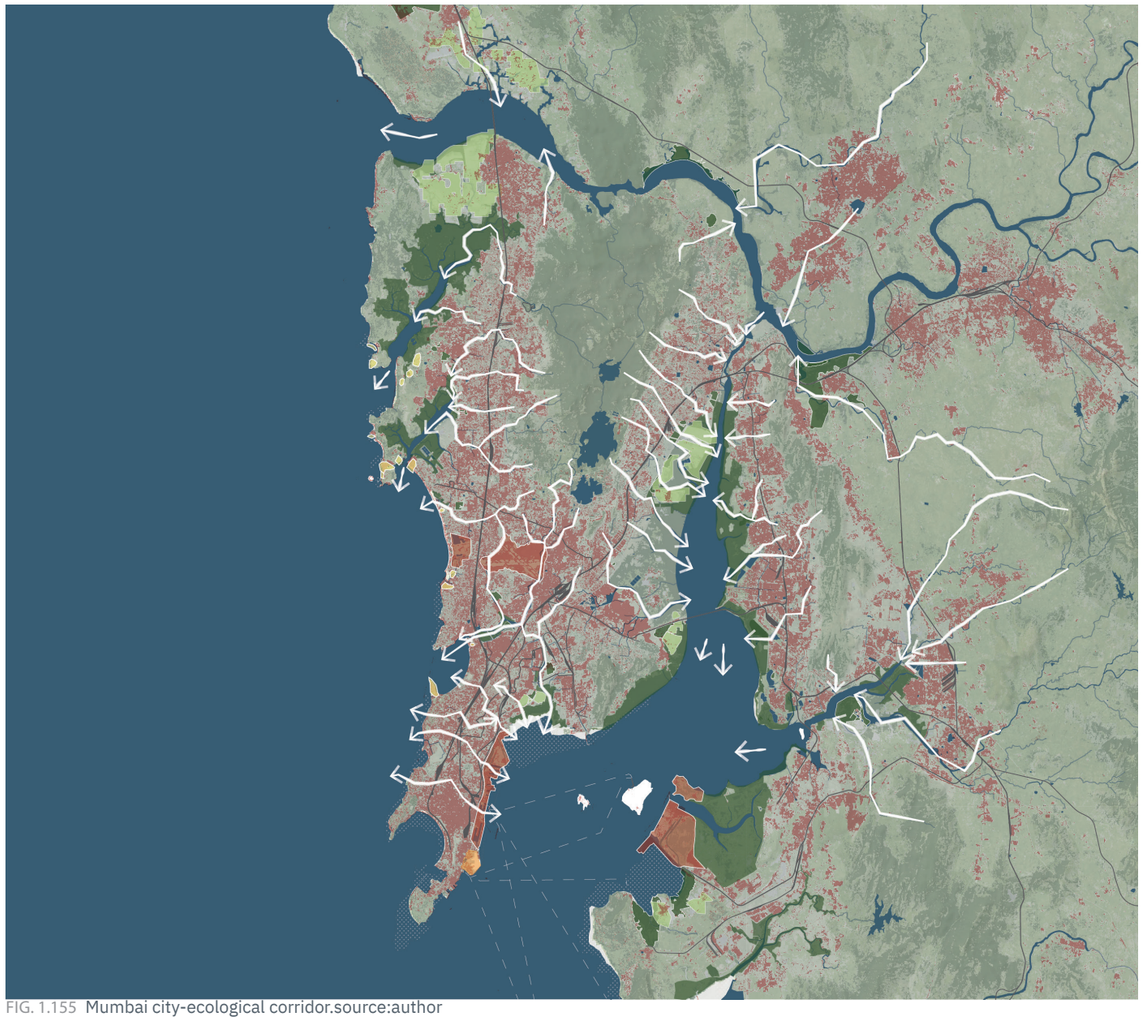


FIG. 1.155 Mumbai city-ecological corridor.source:author



6 - Support biodiversity



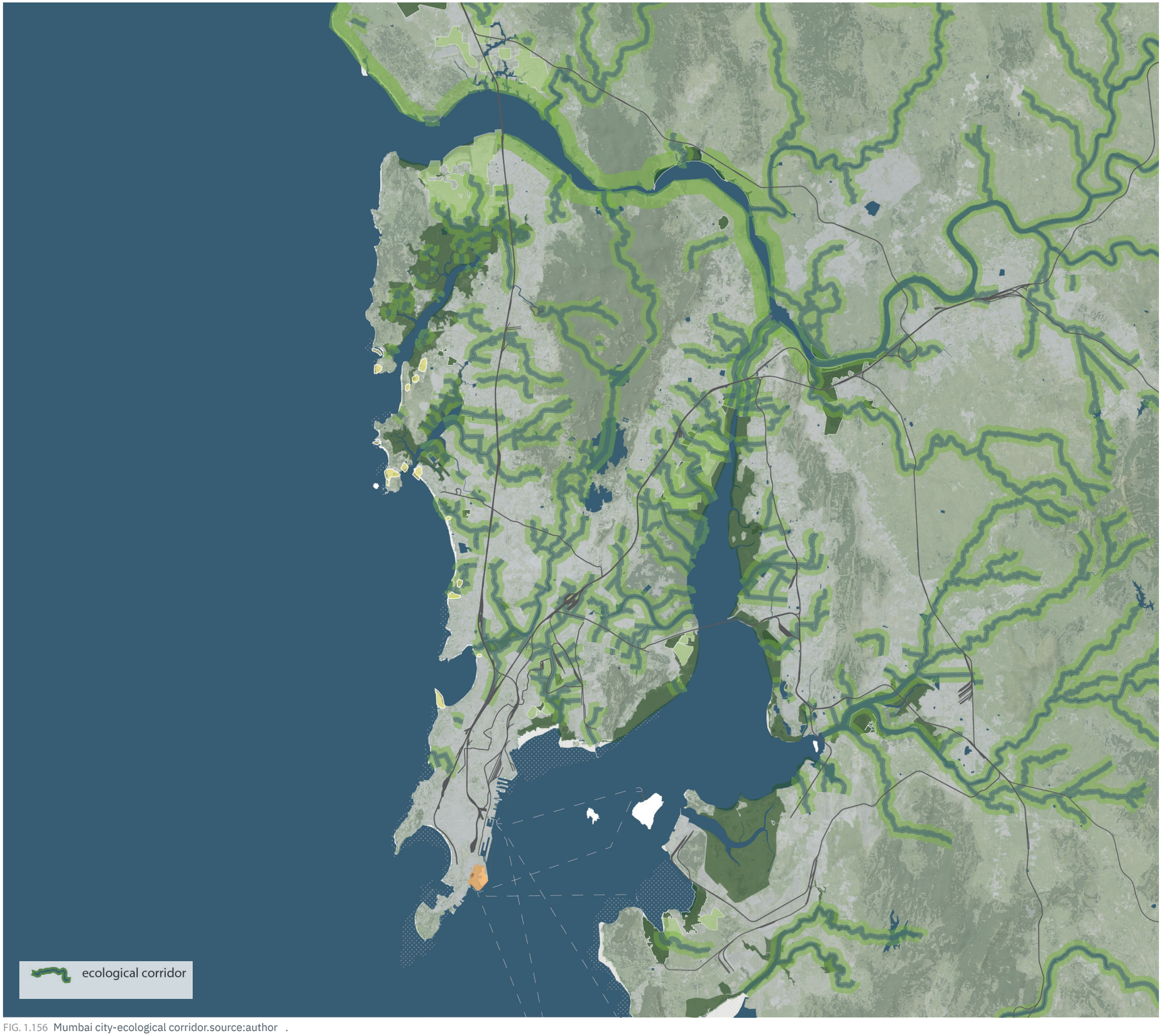
7 - Improve liveability



Analogy to human carrying capacity as blood vessels, these corridors form the main veins

ECOLOGICAL CORRDIOR

These corridors would further need more iterations and needs to be translated as definitive delineation of urbanity and ecology defining the spatial configuration of these zones. It emphasises the specificity of the presence of an extensive green-blue network which has an inherent ability to adapt to the climatic effects and would also contribute in mitigating the climate change impacts.
This vision portrays the intention of creating large programmes of natural elements which can tackle flooding- this would include the Mithi river extensions- widening ,deepening, fringed by mangroves, increasing the capacity of all the rivers and creeks in Mumbai along with increasing the green spaces alongside them , incorporating phytoremediation. This strategy helps to select the design interventions necessary which can together form corridor programs that are prioritised based on the flooding that it deals with and the short term and long term planning necessary for the same. The timeline for this vision would involve superimposing the corridors with the existing flood areas and future flood areas to develop a timeline for its development.



Ecological Corridor
Flooding - Pluvial, Fluvial and Coastal

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

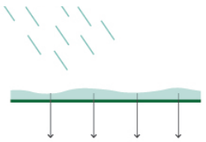
FIG. 1.156 Mumbai city-ecological corridor.source:author .

CAPILLARIES

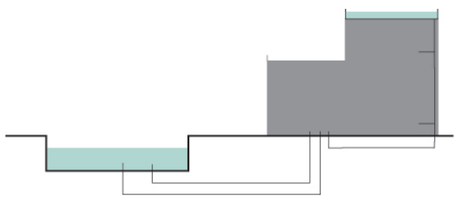
The urban environment needs to adapt to the impending climatic changes. The corridor strategies lead to the creation of main storage , drainage or absorptive areas but the rest of the area adjoining it also needs to function as a part of this system. Just like human blood carrying vessels have a system of main veins and capillaries which holds, absorbs and directs to the main veins, similarly capillaries function.



1 - Introduce/ increase storage capacity



2 - Increase percolation



3 - Capacity to use flood water



4 - Capacity to drain / direct to ecological corridors



5 - Improve liveability

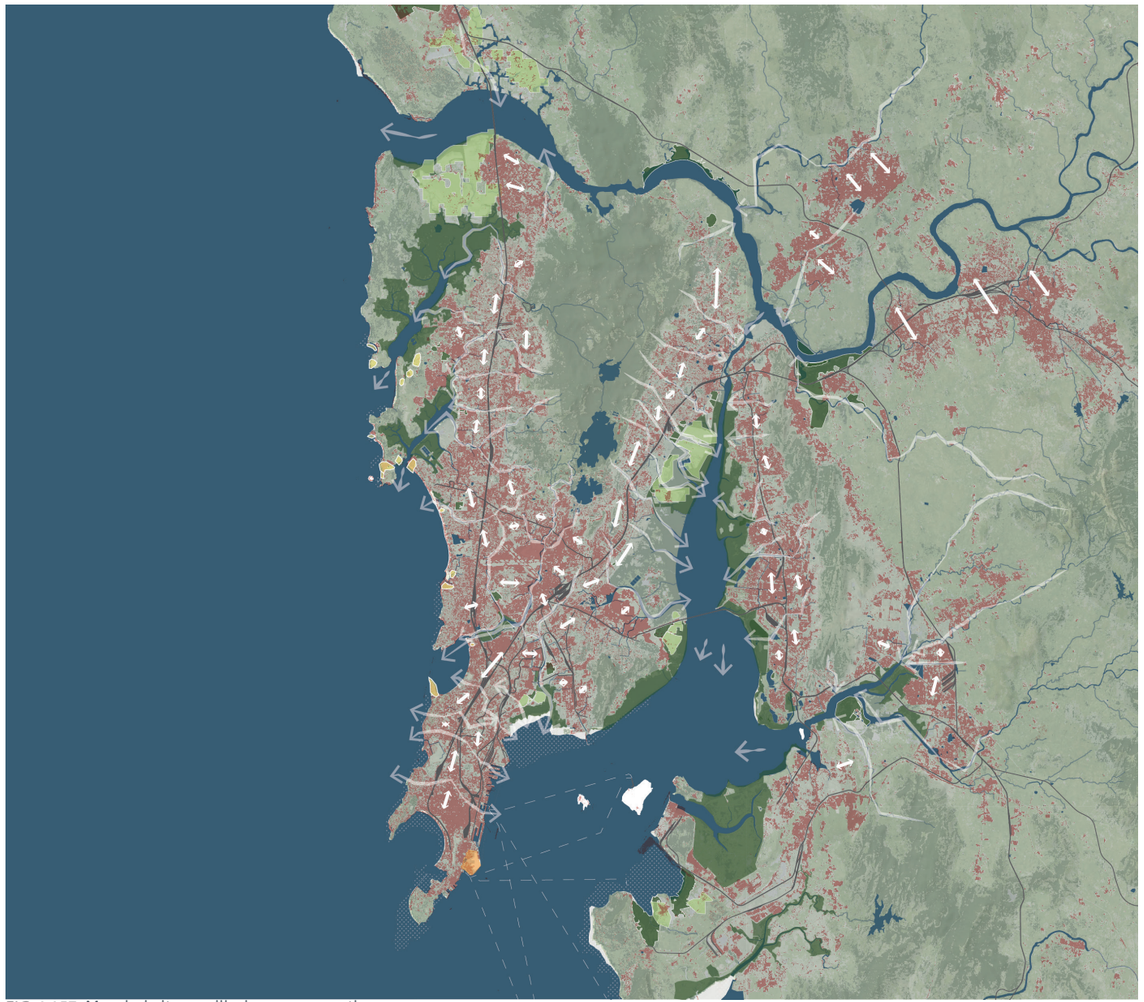
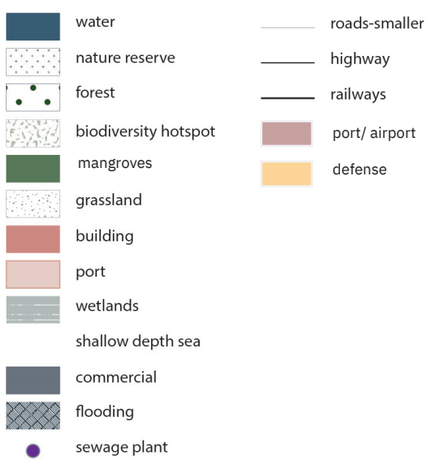


FIG. 1.157 Mumbai city-capillaries.source:author





Analogy to human carrying capacity as blood vessels, these capillaries form the branches that directs to the main vein

CAPILLARIES

The transformation to urban capillaries of the built environment would be incremental. The priority would be based on the urgency of flooding in the city and would need efficient and systematic planning. The capillaries could be seen similar to the concept of ‘sponge city’ but with an added feature of drainage. The water stored in these urban capillaries can be used for consumption, this makes it a cyclical process and also responds to the water challenge that lies ahead of us. The design interventions for the capillaries needs to be planned in response to the socio-economic and ecological context. The built structures could be imagined to have green roofs, green facades, water squares, urban farming, permeable paving and an array of interventions that could work in each setting.

The vision exemplifies a future built environment which would be more green than grey, it would be in harmony with the ecological system and resilient to flooding in the process. Policies changes would be necessary to ensure new urban development would have to adhere to function as urban capillaries and this could be measured in terms of neighborhoods having a specific index that needs to be maintained based on the projection of flooding in each area. This index could also be developed in the existing area for the incremental transformation, this concept would be explained in later chapters.

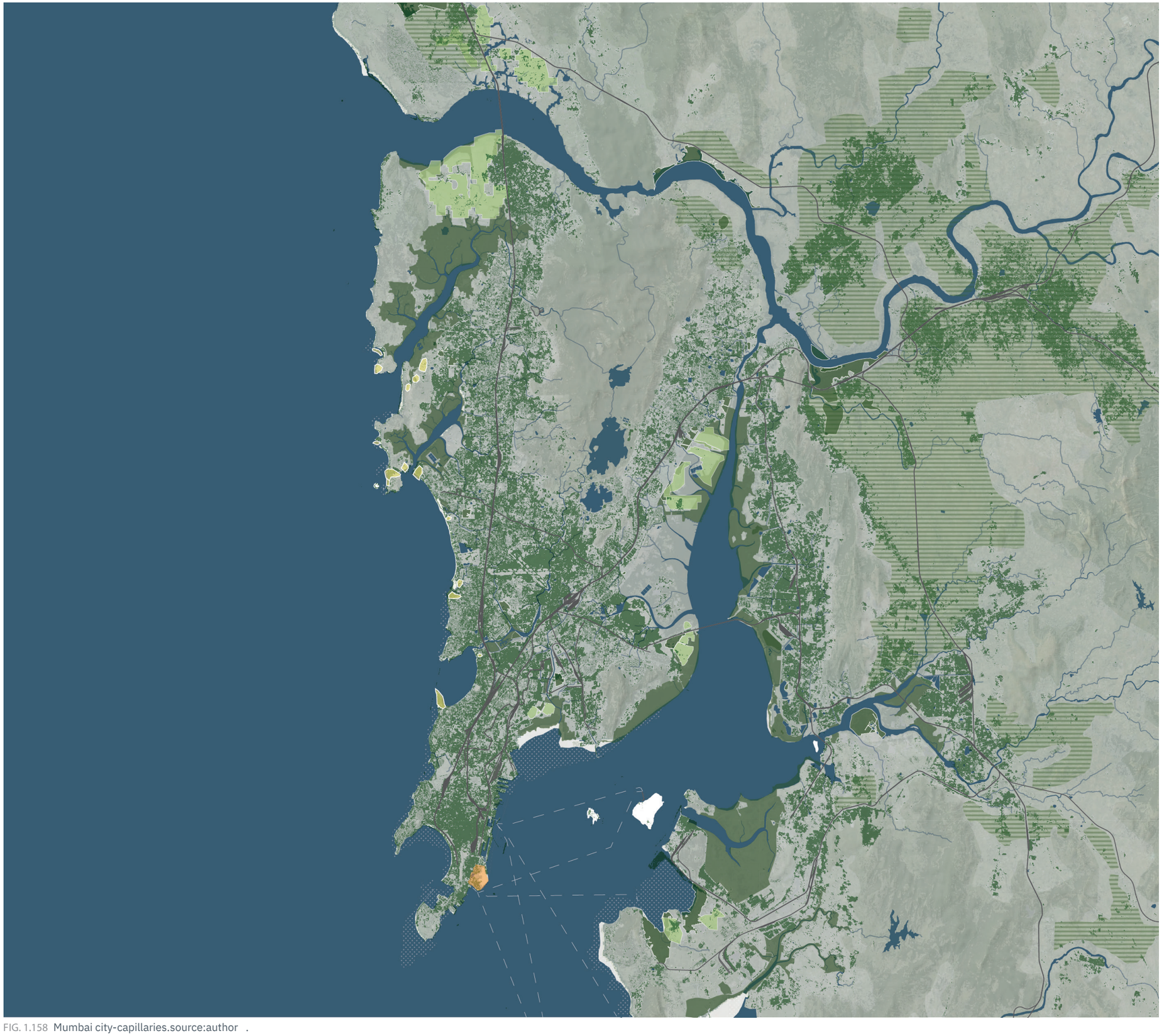
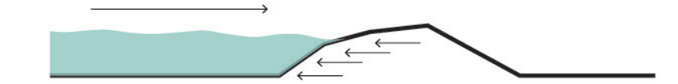


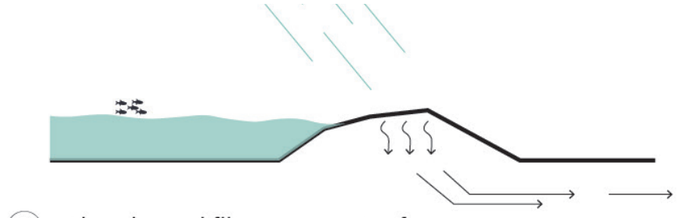
FIG. 1.158 Mumbai city-capillaries.source:author .

COASTAL PROTECTION

Mumbai boasts a coastline of more than 167km. This exposes the population to the chances of coastal flooding even more and poses a threat of damage to the socio-economic system even higher. But this coastline could be seen in light of a defense line that could be embedded with natural defense mechanisms like sand dunes or mangroves which would naturally absorb the energy of the lashing waves and strong winds ,thereby protecting the city from the wrath of coastal flooding. These natural solutions opens up wider possibilities of added benefits, firstly it would nurture and support the biodiversity of the sea and land, as well as it presents an opportunity to make these natural defense barriers a part of public space. It can further help in re-establishing the connection of people with the waterfront. Through accessibility to these sand dune beaches and mangrove forests ,people can connect with the coast that they are a part of and right now have their backs to.



1 - Barrier to flood water



2 - Absorbs and filters sea water for use



3 - Support biodiversity

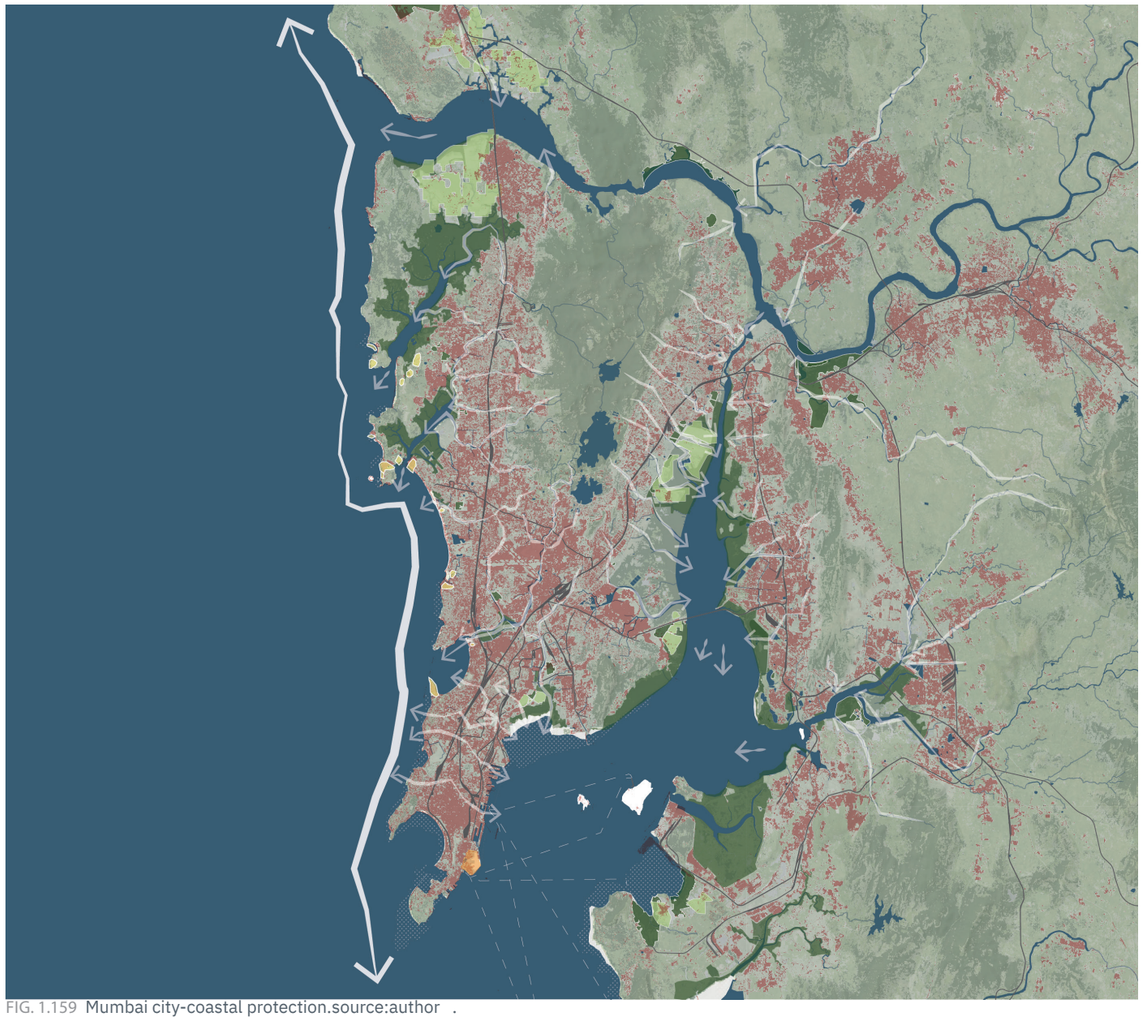
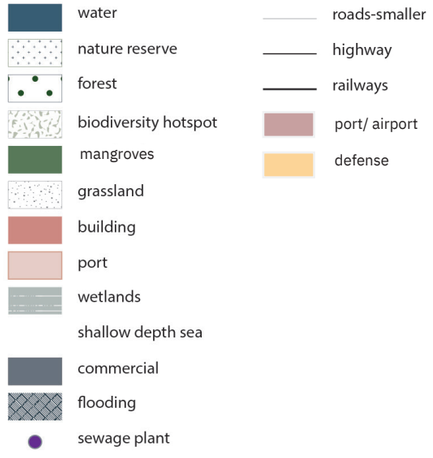
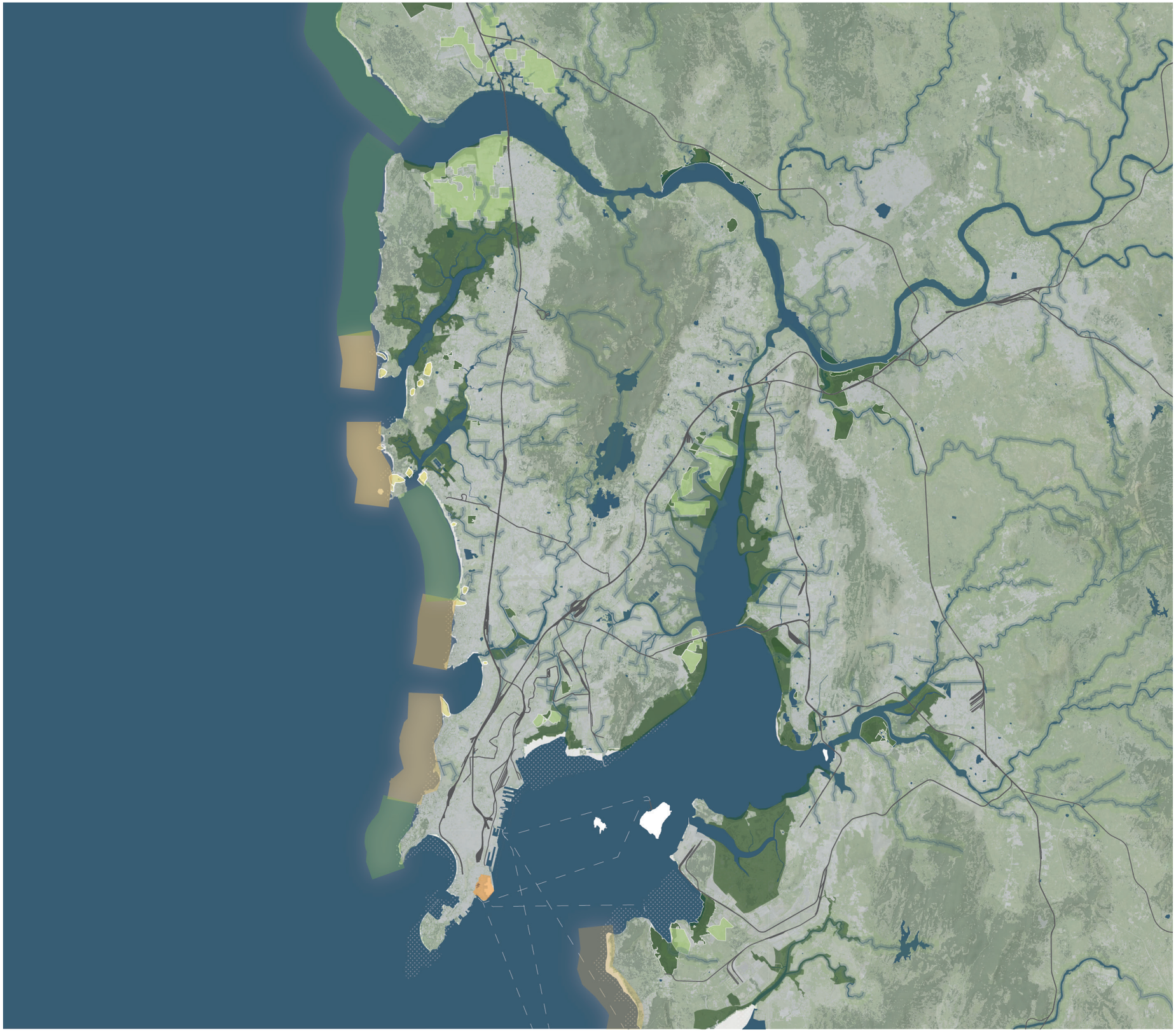


FIG. 1.159 Mumbai city-coastal protection.source:author .



COASTAL PROTECTION

Coastal protection would require an alternating intervention of sand dunes and mangroves or saltpans which acts as a buffer or barrier to the coastal floods. These design interventions would need to respond to the socio economic system that sits next to them and tackle the challenge of flooding and the needs for the community together. For instance areas with fishing communities would need a participation engagement process where the mangroves or sand dunes that benefit them needs to be designed. The ecological infrastructure needs to be inclusive, connecting and resilient. They can help re-establish the lost connection between the city and the Sea which is only limited to the marine drive or speeding Worli Sea Link currently.



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

FIG. 1.160 Mumbai city-coastal protection.source:author

VISION

The vision of Mumbai city with the three strategies aims to bring people together and engage them in a unified conversation about the future of the City. This is a proposition of a paradigm shift when the focus of the built changes from an inward looking development to a development oriented towards ecology to unify the socio-ecological system together. The three strategies cover the entire city and could be developed further on larger scales. The design implementation would require a policy framework, planning process and capacity building in place which could support the implementation by engaging the relevant actors in the process.



FIG. 1.161 Mumbai city-vision-3 strategies.source:author

REGIONAL VISION

The strategies of the Mumbai city vision can be extrapolated to the Mumbai Metropolitan Region by extending the ecological corridor, adapting the urban environment to urban capillaries and introducing coastal protection at the coast. The simplicity of this strategy could help develop guidelines for planning and development in future in these areas and restructure the existing spatial configuration to prepare for the new conditions of existence.
Urbanisation is a synthetic ecology of different flows, processes, interactions of material and living beings. The coupling of different flows and calibration of different processes of production bears the potential for transforming linear monofunctional structures into circular polyfunctional infrastructures. Thus if hard industrial structures can be regarded as a part of urban infrastructure, then the design of softer, ecological systems as part of the same can reform, protect and drive contemporary spatial morphologies and generate new regional economies. (Taneha, 2015)

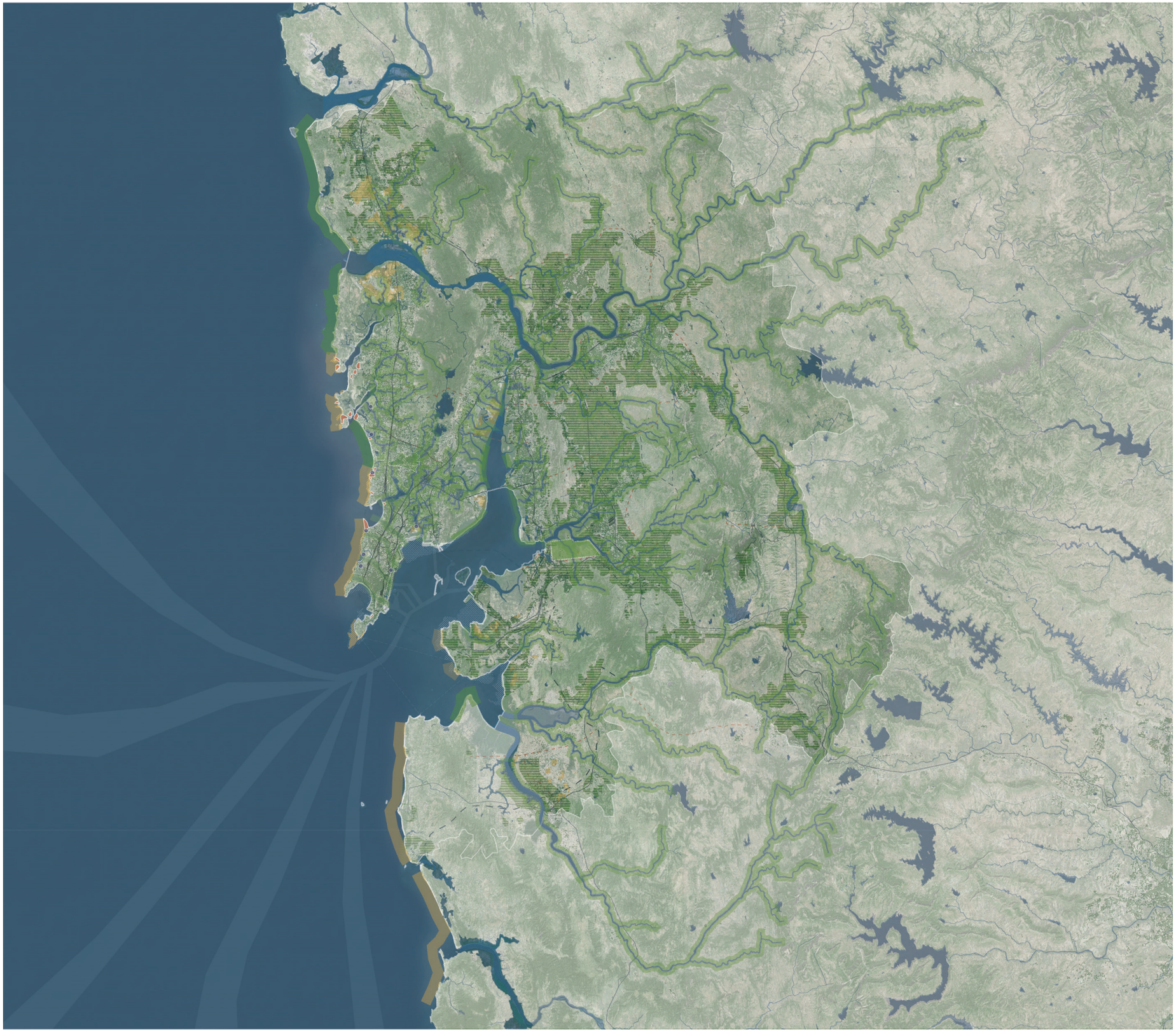


FIG. 1.162 Mumbai Regional-vision-3 strategies.source:author

REGIONAL VISION

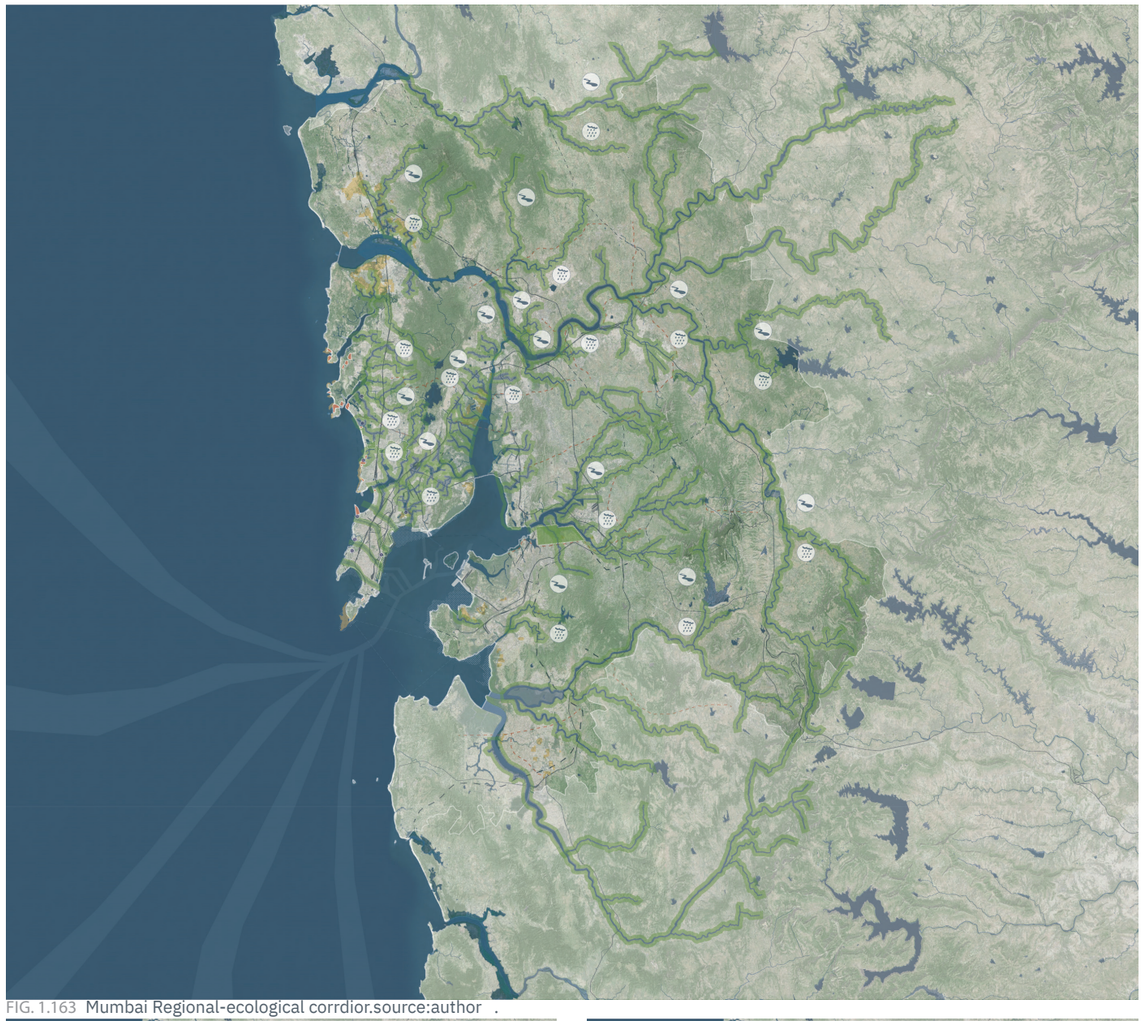


FIG. 1.163 Mumbai Regional-ecological corrdior.source:author .

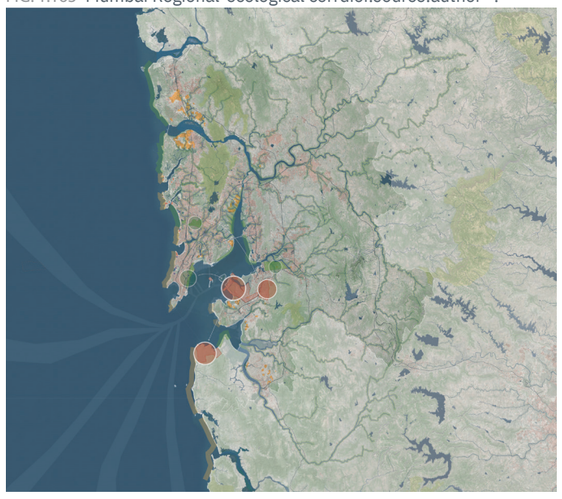


FIG. 1.164 Mumbai Regional-strategic transformation. source:author



FIG. 1.165 Mumbai Regional-strategic transformation. source:author

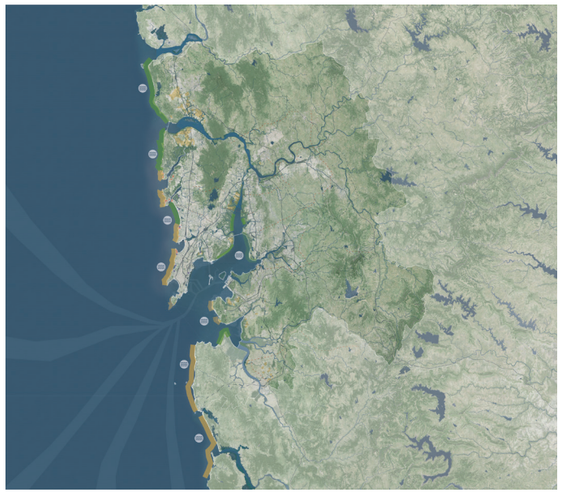


FIG. 1.166 Mumbai Regional-response to coastal floods.source:author

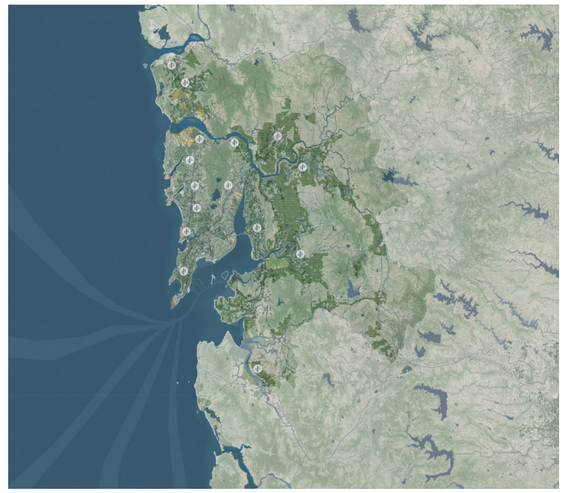


FIG. 1.167 Mumbai Regional-capillaries. source:author

The Ecological Corridor and Urban Capillaries tackles as explained earlier, the fluvial and pluvial flooding ,and the Coastal Protection deals with the coastal flooding. There are strategic transformations that could open possibilities for further restructuring of the built fabric. The strategic displacement of the current airport which sits in the middle of the city right now exacerbates the microclimate of the city by contributing to noise and air pollution. If it shifts to a new location which does not affect ecology and society adversely, then this frees up approximately 750 hectares of land which can trigger the capillary transformation of the built environment. Also the plans of redevelopment of old Mumbai port needs to be done in conjunction with the strategy for a resilient Mumbai by orienting its development towards ecological infrastructure which assess future flooding situations.

10.

INTRODUCTION TO THE THREE CASES

Design Principle and interventions



FIGURE 10.1 Mumbai Regional-capillaries source:author

The Three Cases

Meso- Micro - Macro Scale analysis

Selection was based on the **extent of urbanisation and the built grain in conjunction with the extent of the natural system coexisting** within the area. These locations have certain commonalities but the variation of the built and natural gives an overview of the transferability of the spatial strategies in these contrasting cases.
The density, typologies of the built fabric, ecological areas- rivers, sea, creeks, open green spaces are present in differing extent and intensity in these locations along with a mix of population which is homogeneously heterogeneous throughout Mumbai.

- The Island City
- Airport-Bandra Kurla Complex
- Saltpan Area

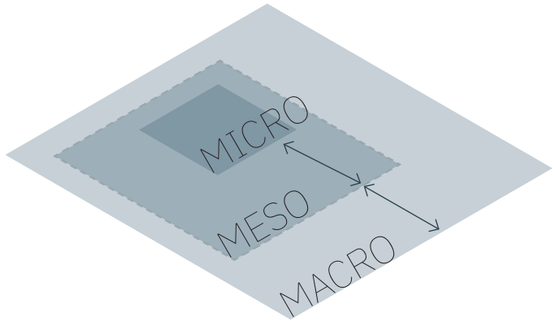




FIG. 1.169 The 3 Meso scale areas . source : author .

Salr pan & Creek Area



Airport- BKC Area



Island City



11.

AIRPORT-BKC AREA

Design Principle and interventions





FIG. 1.170 Mumbai Regional Graphics (Source: author)

Introduction

The forthcoming section deals with the comprehension and translation of the three regional strategies- Ecological corridor, Capillaries and Coastal Protection in space of the selected area of Airport-BKC(Bandra Kurla Complex). The selected site exploration involves responding to the specificity of the built and ecological system to project a design and planning framework for the given location.
The Airport-BKC area has a history of reclaimation of river, mangroves and wetlands which has now resulted in flooding of the neighboring areas. The development of this area would involve bringing back the ecology within the dense urban environement. The Mithi river is a critical river in Mumbai which

Built environment + Natural environment

[Structure + Function] ecological elements

flood protection

other benefits

accordian to historian Jagdish Gandhi has been there for about 60 million years. It is one of the world's oldest surviving river systems. (Gupta, 2015) The Urbanisation in the past four decades have gradually taken up the space of the river through reclamation, concrete embankments, diversions,



FIG. 1.171 Location of the selected Meso case.source:zoom earth



FIG. 1.172 Satellite image of Airport -BKC area.source:google

and encroachments. 'Mumbai was once a city within a river system',(Gupta, 2015)that connection with river and ecology needs to be revived.



FIG. 1.173 Mumbai BKC from Mithi river .source:author



FIG. 1.174 Mumbai -ecological elements .source:google .

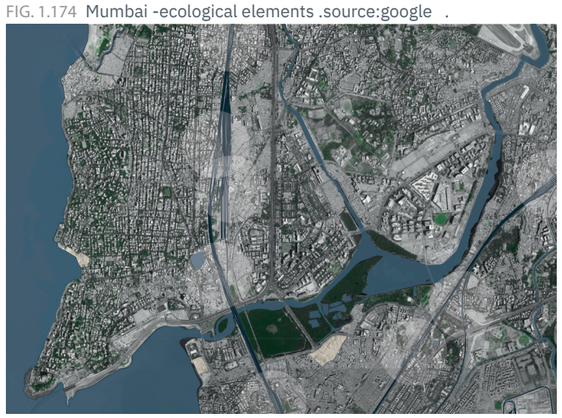


FIG. 1.175 Mumbai Infrastructure & station buffer.source:google .



FIG. 1.176 Flooding in Airport - BKC area.source:google .

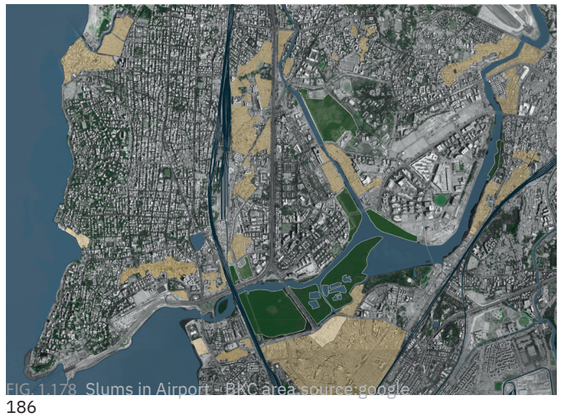


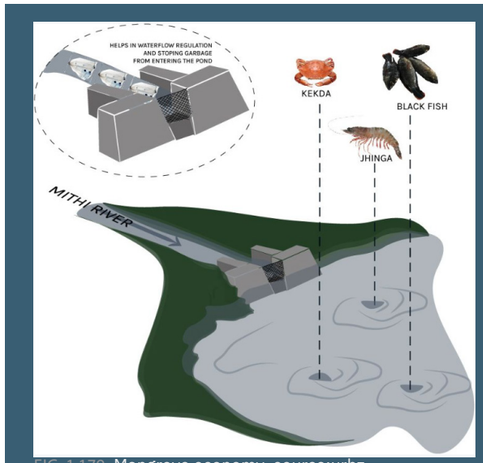
FIG. 1.178 Slums in Airport - BKC area.source:google .

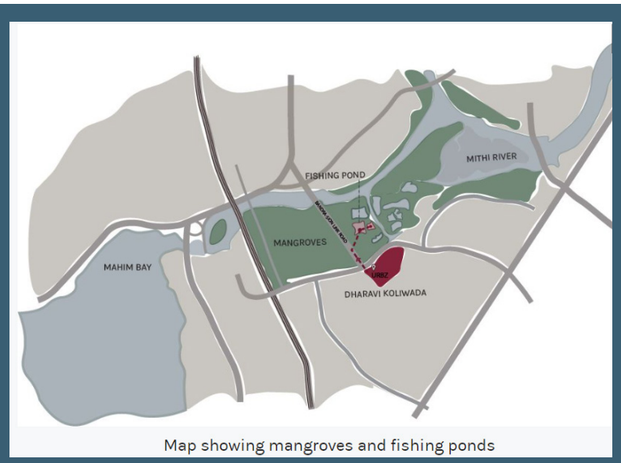


FIG. 1.177 Airport - BKC Area with ecological elements. source: Googleearth

The selected site study involves observing different built and ecological layers with a detailed analysis of the socio-economic system along with the ecological system to find potentialities of the dynamics and synergies in the systems possible.

This area includes one of the vital rivers of this region -Mithi River . The area also has the airport which has been strategically relocated to free up the space in the central dense area of the city. There is also an existing mangrove ecology which has been reduced to its current extent due to its conflict of space with urban growth. This area faces constant flooding every year and needs to adapt through the three strategies proposed in the vision.





Map showing mangroves and fishing ponds

FIG. 1.179 Mangrove economy .source:urbz

BEST PRACTICES AND POTENTIALS

‘ The mangroves of Mumbai are a metaphor for Dharavi - both have managed to survive and thrive in areas where others cannot, are tolerant of difficult conditions, are extremely productive, have far-reaching influence and provide the foundations for larger ecosystems. Both of them are important in the functioning of larger systems and are often taken for granted. Considering the ecological, cultural and historical importance of mangroves to Dharavi and the rest of Mumbai, more needs to be done to foster public understanding of mangroves, as well as provide an economic incentive to maintain them.’(Joanne et. al, 2020)

The current approach for Mangroves is of conservation which does not interest the political-economic actors ,and always needs constant attention of the policymakers to reinforce policies to protect this natural habitat. However the lack of ‘public gaze’ and interaction becomes a major drawback of conservation policies which sometimes leads to violation of restrictions and modification of the same in favour of real estate lobbies. Inorder to protect and nurture Mangrove forests in the city,policies should be made more interactive rather than prohibitive. Mangrove has a vast amount of value chain benefits that could be tapped into and be consciously integrated within the economic system.(Joanne et. al, 2020)

Existing Mangrove economy
There exists a human-nature relationship between the Dharavi Koliwada- an indigenous fishing village

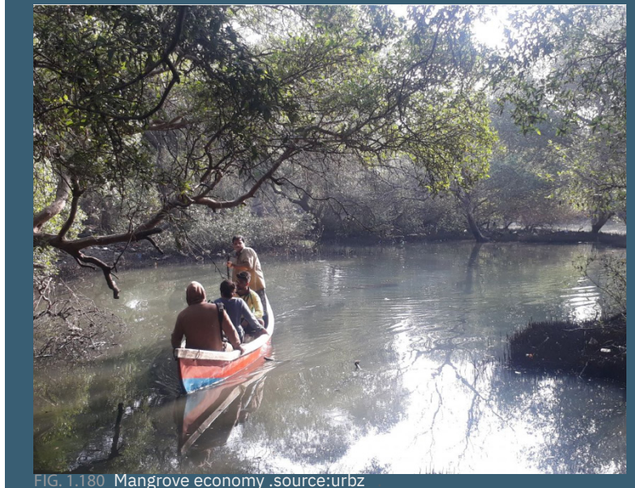


FIG. 1.180 Mangrove economy .source:urbz

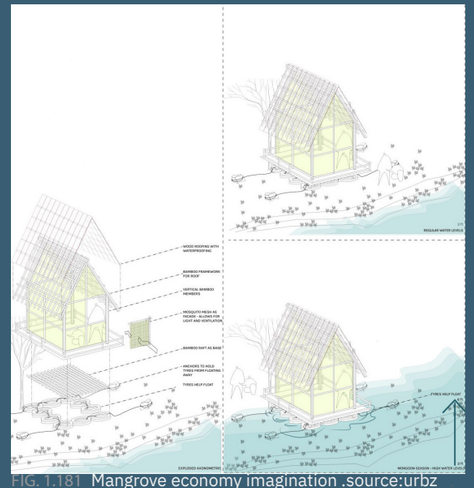


FIG. 1.181 Mangrove economy imagination .source:urbz

and the mangroves of the Mithi River. Mangroves are integrated as a part of the local economy, as fishermen in this community have created ponds within these mangroves and have devised mechanisms to keep the water in pond clean enough to breed fishes in them.Such integration efforts needs to be supported and pushed forward by the local authorities.They have a micro -economy based on the fishes they catch in these ponds during high tides. The community is actively involved in the mangrove economy since the Men of the community catch fishes in these ponds during Monsoon and the women sell these fishes in the local markets. However the past decades have witnessed urban development that have degraded the health, quality and quantity of mangroves and made the lives difficult for these fisherfolks dependant on mangroves.(Joanne et. al, 2020)

The richness of Mangroves not only rests in the biodiversity it hosts but also in the multiple uses and integration into the economy that it offers. Mangroves, as the author suggests, would be a part of ecological infrastructure with multiple benefits both to Dharavi and Mumbai City.
There are currently 30 fishing ponds in the Mangrove area adjacent to Dharavi, possibilities of boardwalks and the expedition of the State project of Mahim State Park could create a natural recreational area within the city for people and tourists to experience the beauty of nature. There were old fishing cabins at certain points owned by the fishermen, washed by the floods later, The creation of a recreational space could invite into an immersive journey of watchtowers and boardwalks into these forests.
Mangroves are fast growing and act as a source of wood, leaves, fruits and roots. The wood could be a good affordable building material as it is rot resistant and also salt water resistant, therefore it can withstand floods. It could be used as a building construction for slum upgradation.It could also be used by the fishermen to create tools for fishing. The natural dye that can be obtained by the bark of some mangroves could also be used for dyeing fabrics and leather in Dharavi’s leather industry. (Joanne. et al, 2020)
The Mangroves also have the capacity to filter out heavy metals and pollutants without damaging their own growth, therefore they could also be used to improve water quality.
Mangroves are a natural flood defense system but it also presents an opportunity to be integrated into the local urban economies. An interactive and integrative approach in planning Mumbai’s mangroves and economy could pave a new way for the perception and interaction of an ecological system where a ‘host of primary, secondary and tertiary human activities can thrive with nature instead of against it.’ (Joanne. et al, 2020)

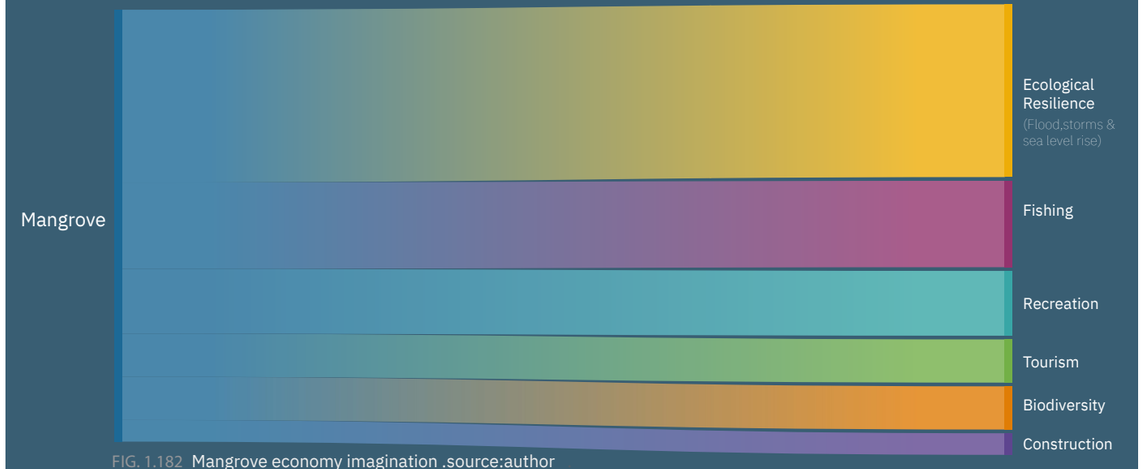


FIG. 1.182 Mangrove economy imagination .source:author

Meso scale- Ecological Corridor

The Mithi river along with the mangrove ecology presents an opportunity to create the ecological corridor which would absorb, store and drain the flood water. It is essential to translate the principles of absorption, storage and drainage capacity to these delineated spaces through varied design intervention responding to the cause of flooding and the existing and potential spatial system.

Opportunities for developing urban forests at vacant/ unused plots combined with other functions such as cemetery or pushing forward the urban farming initiative by organisations like Urban leaves is essential for providing resilience in the neighborhood.

Certain areas also include incorporation of mangroves and restructuring of the built environment. The airport relocations frees up a large amount of space close to 7 sq km that enables the built environment to restructure in phases .

The Mithi river widening project gives encroached spaces of the river's floodplain back to ecology through removal of paved surfaces, addition of mangroves, urban forests , urban farms or addition of water bodies or parks along the river bank. The reclaimed area of Bandra Kurla Complex gets regenerated to include ecology which it neglected earlier in its annexation of the river.

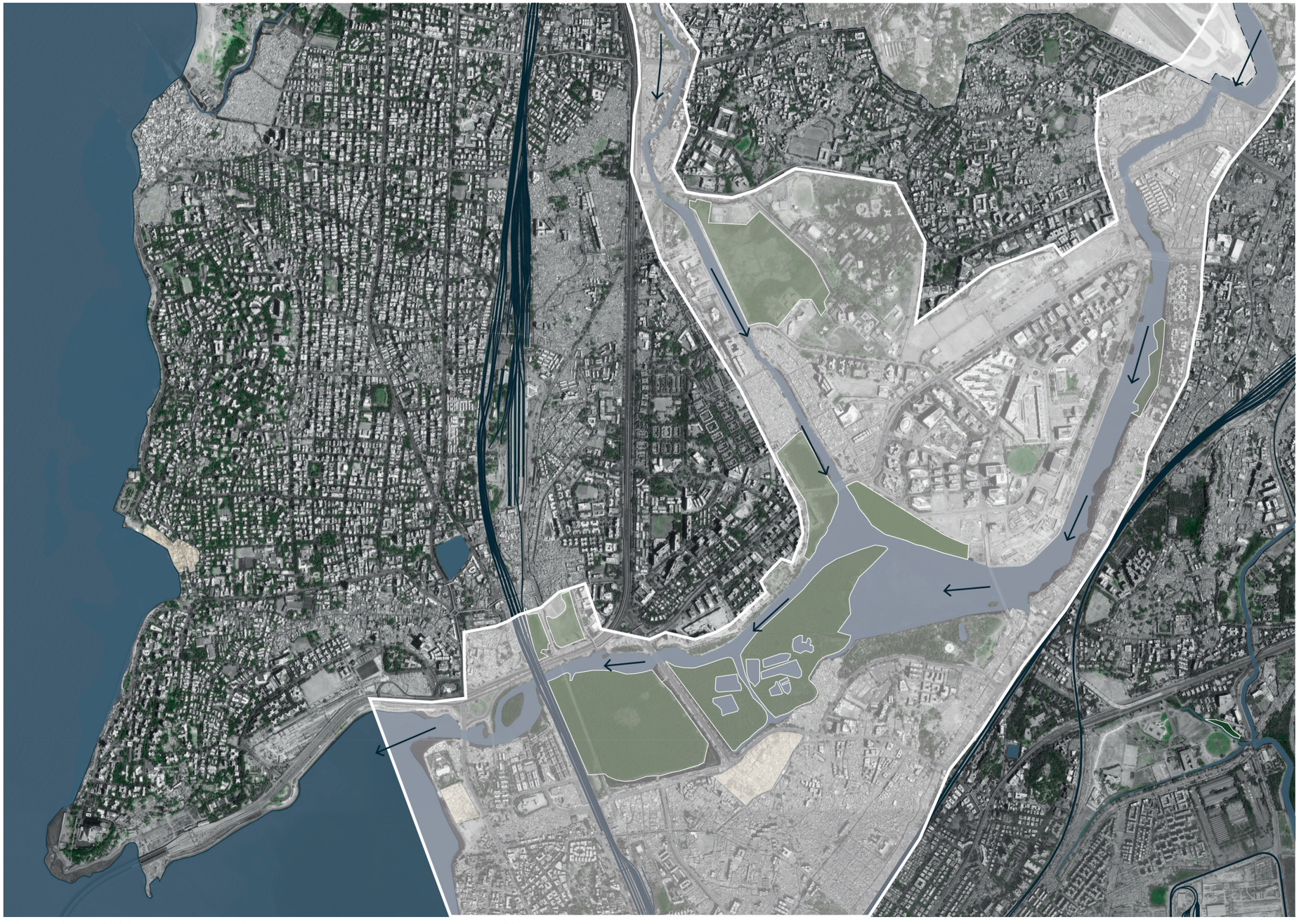
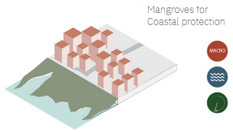


FIG. 1.183 Airport BKC Area with Ecological Corridor .source:author;based on Google earth;GIS data;

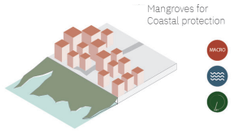
Ecological Corridor

Design Interventions

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



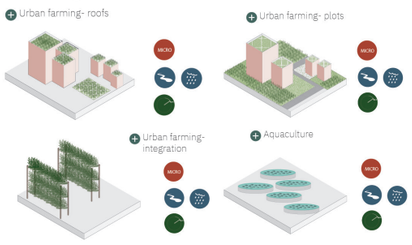
2 **Mangrove State Park -** Develpment of a Mangove forest recreational park with mangroves and other species which would protect from floods and serve as a recreational park for locals & tourists



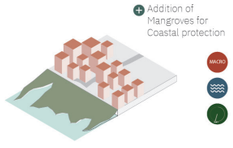
3 8 11 **Urban forest-** Introduction and intensification of forest areas in the city to provide a dense rich habitat to support biodiversity, increase rainfall percolation



4 7 **Urban Farming -** Combination of Urban farming in the built areas- integration of aqua culture or crop farming within the built structure through redevelopment/ reftrofitting



5 6 9 14 **Mangrove Habitat -** Preservation and intensification of Mangroves on the fringes of the banks of the river to provide natural flood barrier



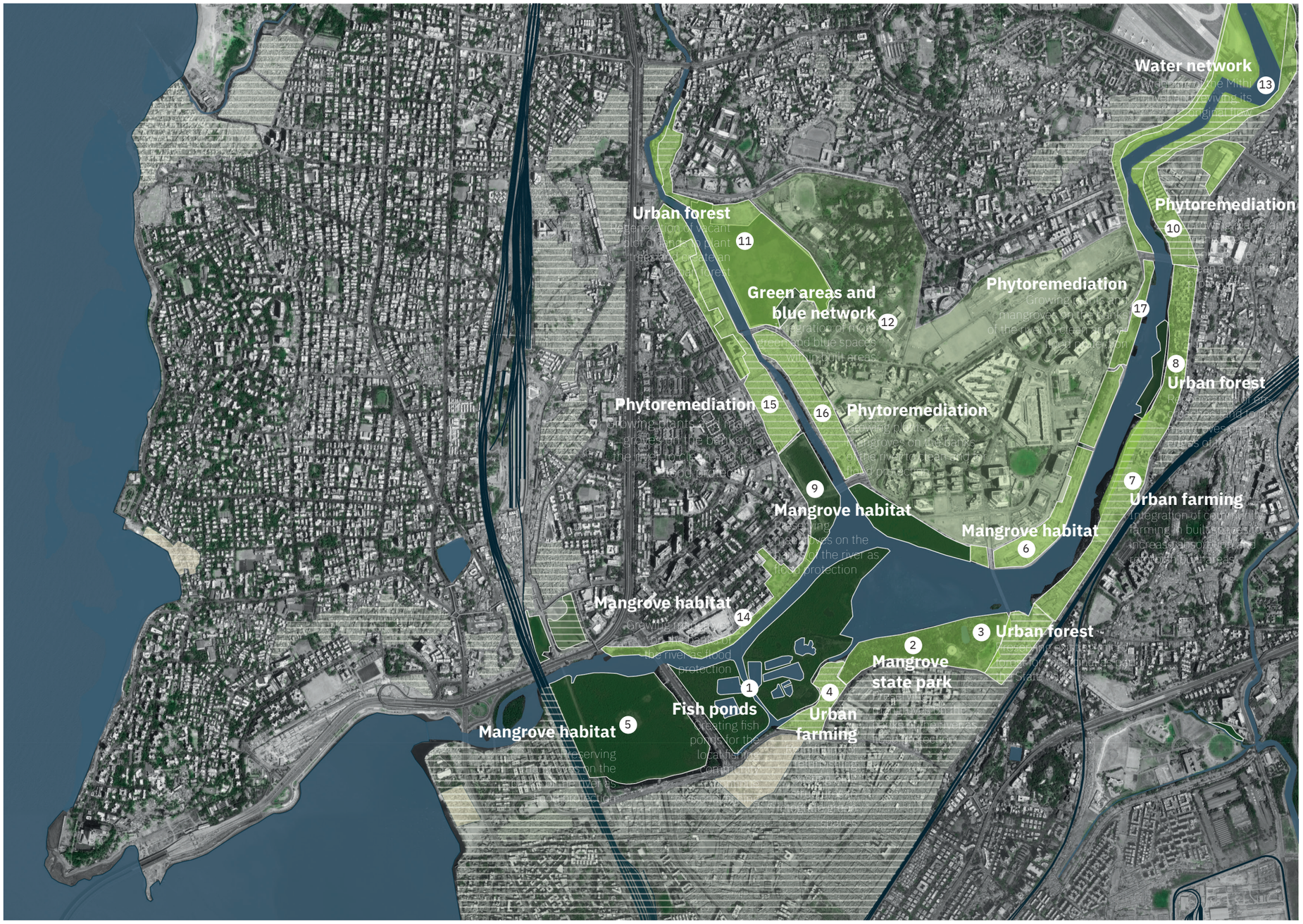


FIG. 1.184 Airport BKC Area with design interventions.source:author;based on Google earth;GIS data;

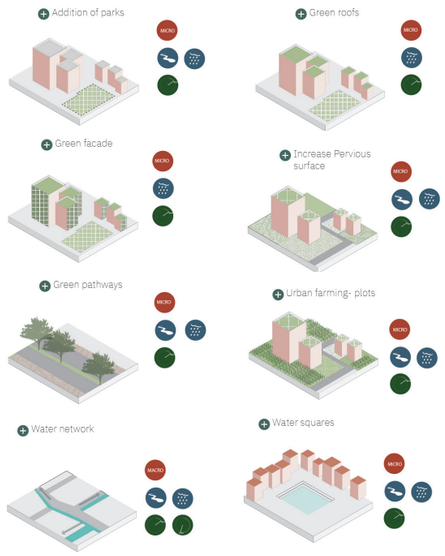
Ecological Corridor

Design Interventions

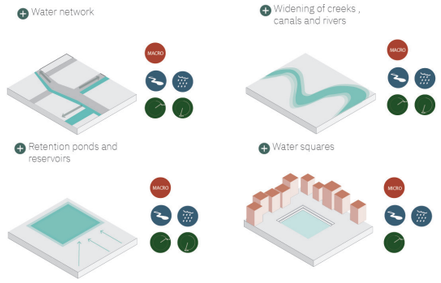
10 15 16 17 **Phytoremediation**- Preserving and regenerating to convert green areas/ vacant / unused plots into urban forest. Also this involves growing plants specifically for purifying the water and improving the water quality.



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.



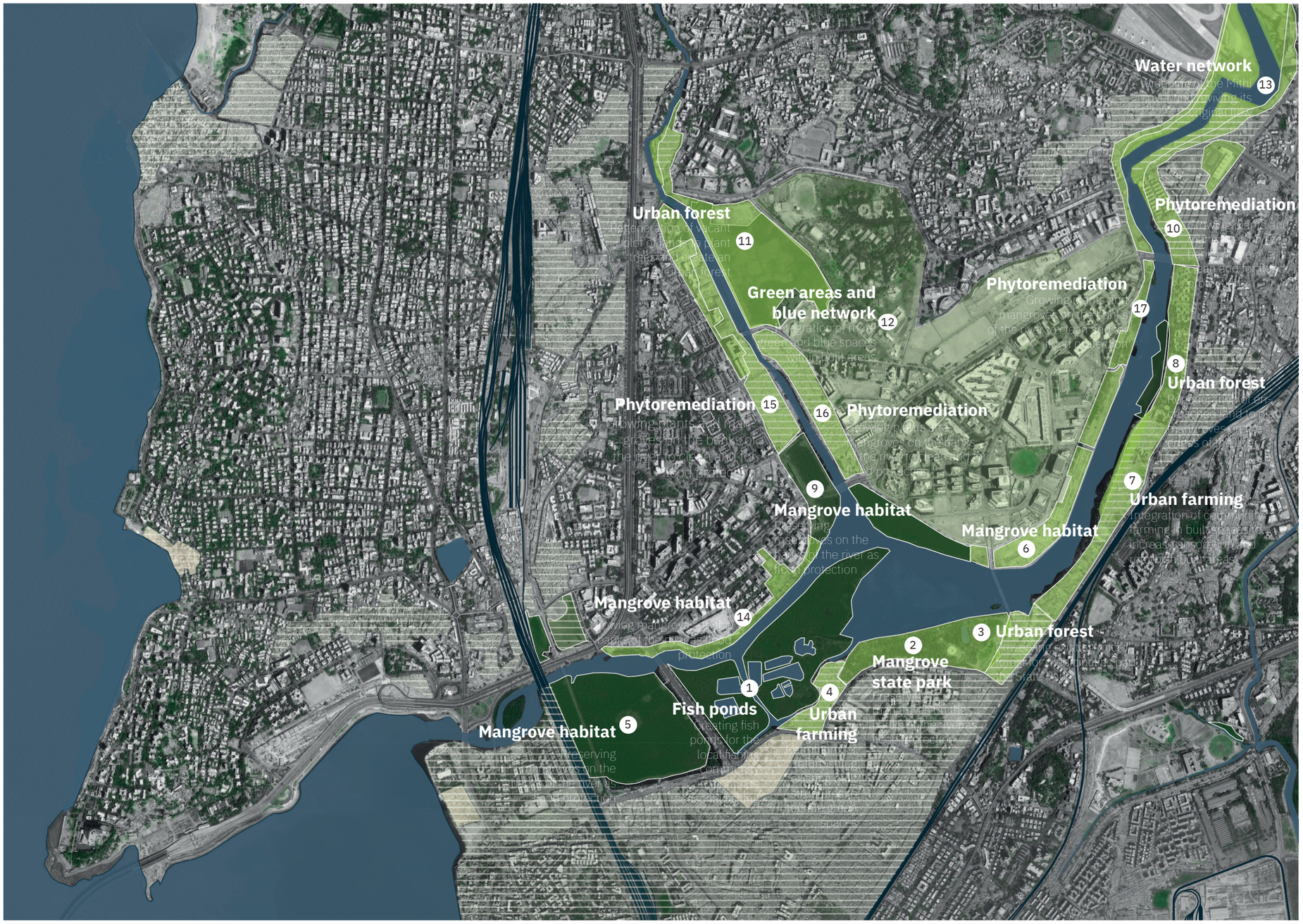


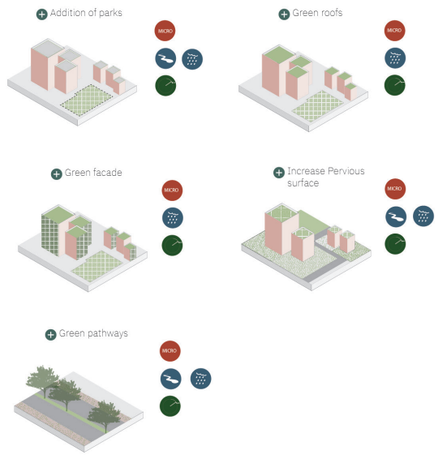
FIG. 1.185 Airport BKC Area with design interventions.source:author;based on Google earth;GIS data;

Capillaries

Design Interventions

This strategy requires an incremental phasing into a green blue network which has a capacity to adapt to existing and future flooding. The transformation would require changes in policies and regulations in order to gradually transform the current built environment to employ ecological interventions. The new built areas would require to integrate the green blue network from the beginning of the construction and this would require formulation of policies and other planning instruments to subsidise and promote the inclusion of ecological elements.

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 capcity on roofs and facades of buildings. It requires collection of water ain large spaces like creation of lakes, raingardens or water squares.

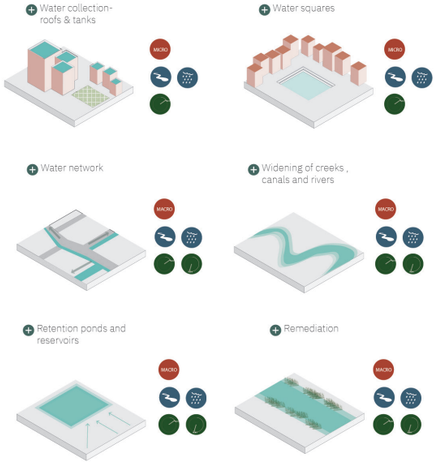


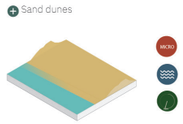


FIG. 1.186 Airport BKC Area with Capillaries .source:author;based on Google earth;GIS data;

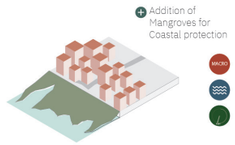
Coastal protection

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



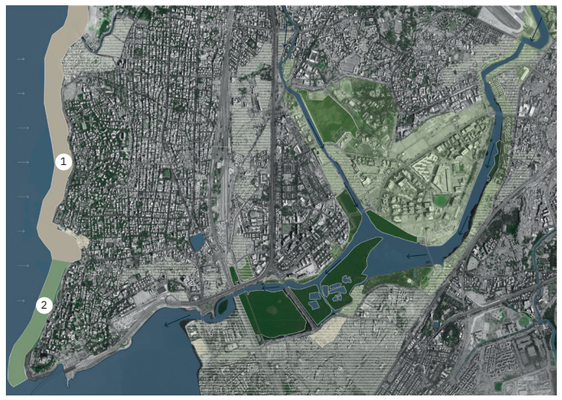




FIG. 1.187 Airport BKC Area with Coastal protection .source:author;based on Google earth;GIS data;

The 3 strategies

Together with the Ecological Corridor, Capillaries and Coastal Protection, the 3 strategies can provide resilience to this area until 2100 from all three types of flooding .
A combination of different interventions ranging from green roofs/ facades to water squares to mangroves or sand dunes can be introduced in specific locations based on the spatial extent , time scale of impact of intervention and planning and the type of flooding it tackles along with the built environment existing and potentialities for transformation of the same.



FIG. 1.188 Airport BKC Area-Vision strategies .source:author

Microscale

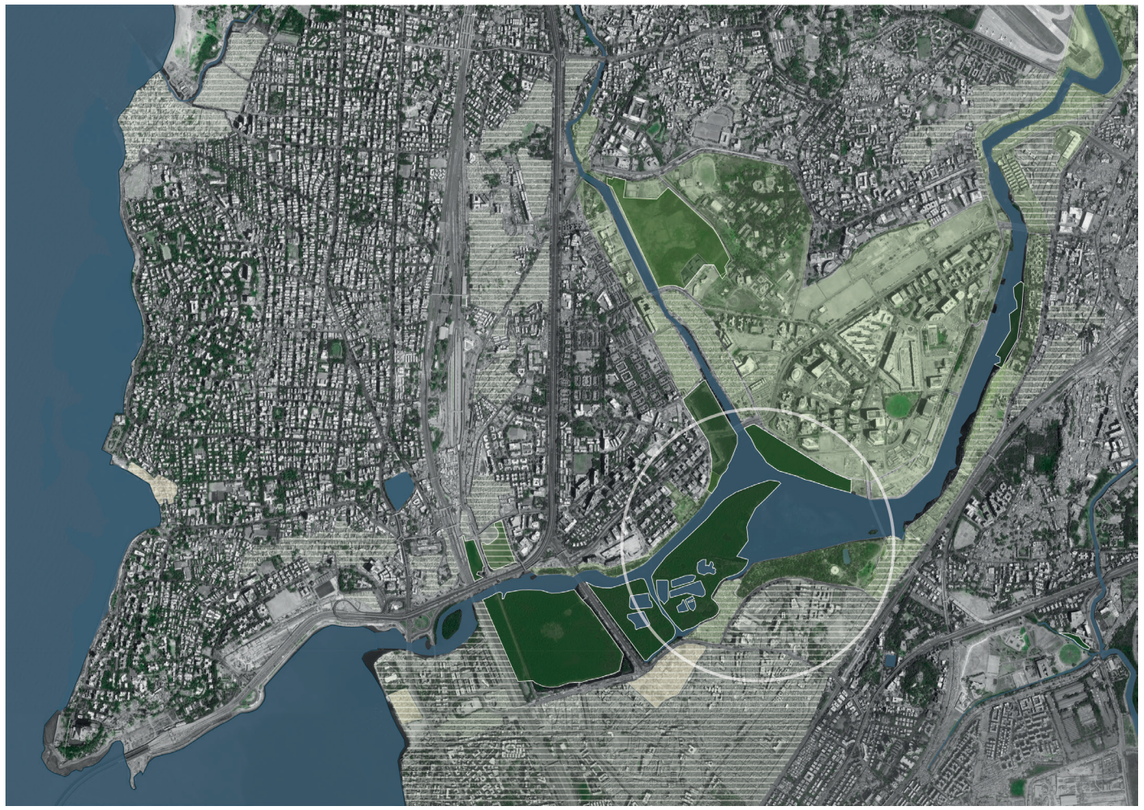


FIG. 1.189 Airport BKC Area-Microscale selection .source:author

The area marked in circle is chosen to further design in detail and exemplify the interventions in the actual space to visualise the spaces created by the same along with possible synergies possible that would help in planning the interventions. This scale would help in portraying the plausible flows that are generated due to the regenerated urban spaces conceived for this location.

Strategies on the Microscale



FIG. 1.190 Airport BKC Area-Microscale .source:author

The area taken up for further zoom-in has various features and interventions introduced to gauge flooding. Firstly it is marked in the figures on the page right, how the division of ecological corridors and capillaries are designed along with the kind of ecological elements that are introduced in the same.

The capillaries primarily introduces the concept of addition of blue / green roofs/ facades or maximisation of green areas within once plot or built structures. This requires support from the state to be pushed and implemented by different landowners.

The ecological corridor includes more space for the Mithi river. It includes protection of the Mangrove and Forest State Park which needs to be designed in conjunction with leading researchers and planners to create a rich vibrant mangrove ecosystem.

An essential aspect in this system is phytoremediation to improve the quality of the water, the sewage system is being worked upon by the state and work is already ongoing to completely disconnect the storm water drainage from sewage lines. Along with this River clean up projects with introduction of reed beds for purification and 'clean-up projects' by various institutions both state and Research Institutions are already taking place to clean and improve the quality of water and enrich the river ecosystem.

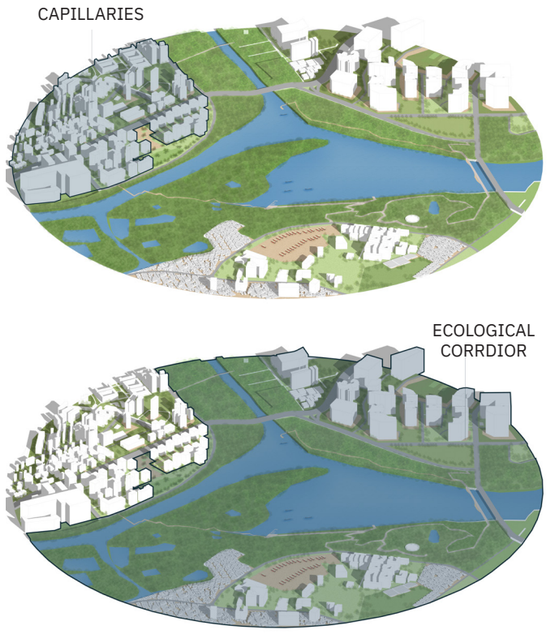


FIG. 1.191 Airport BKC Area-Corridor & capillaries .source:author

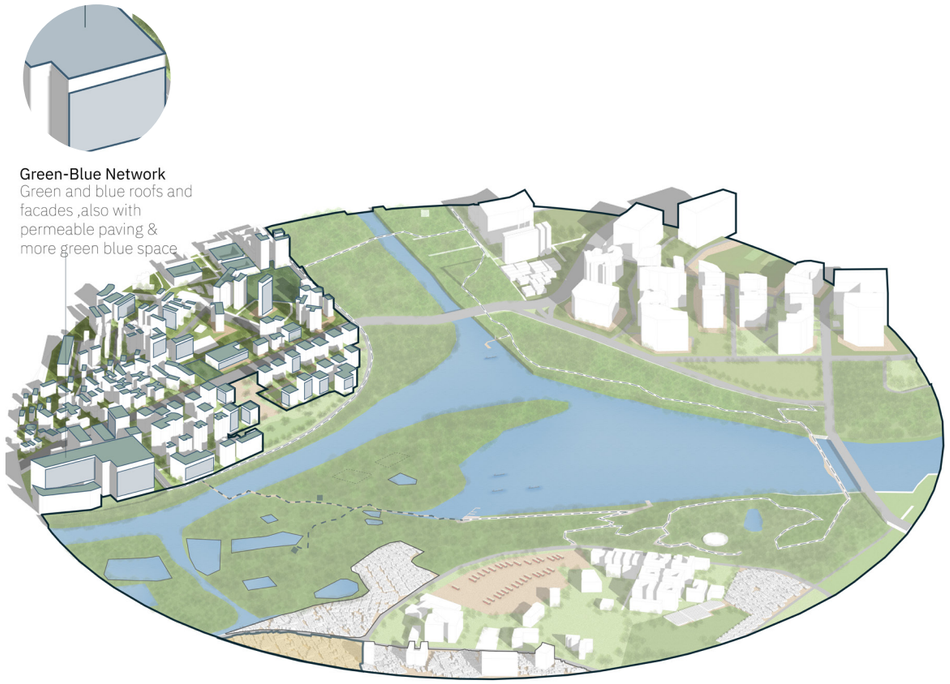


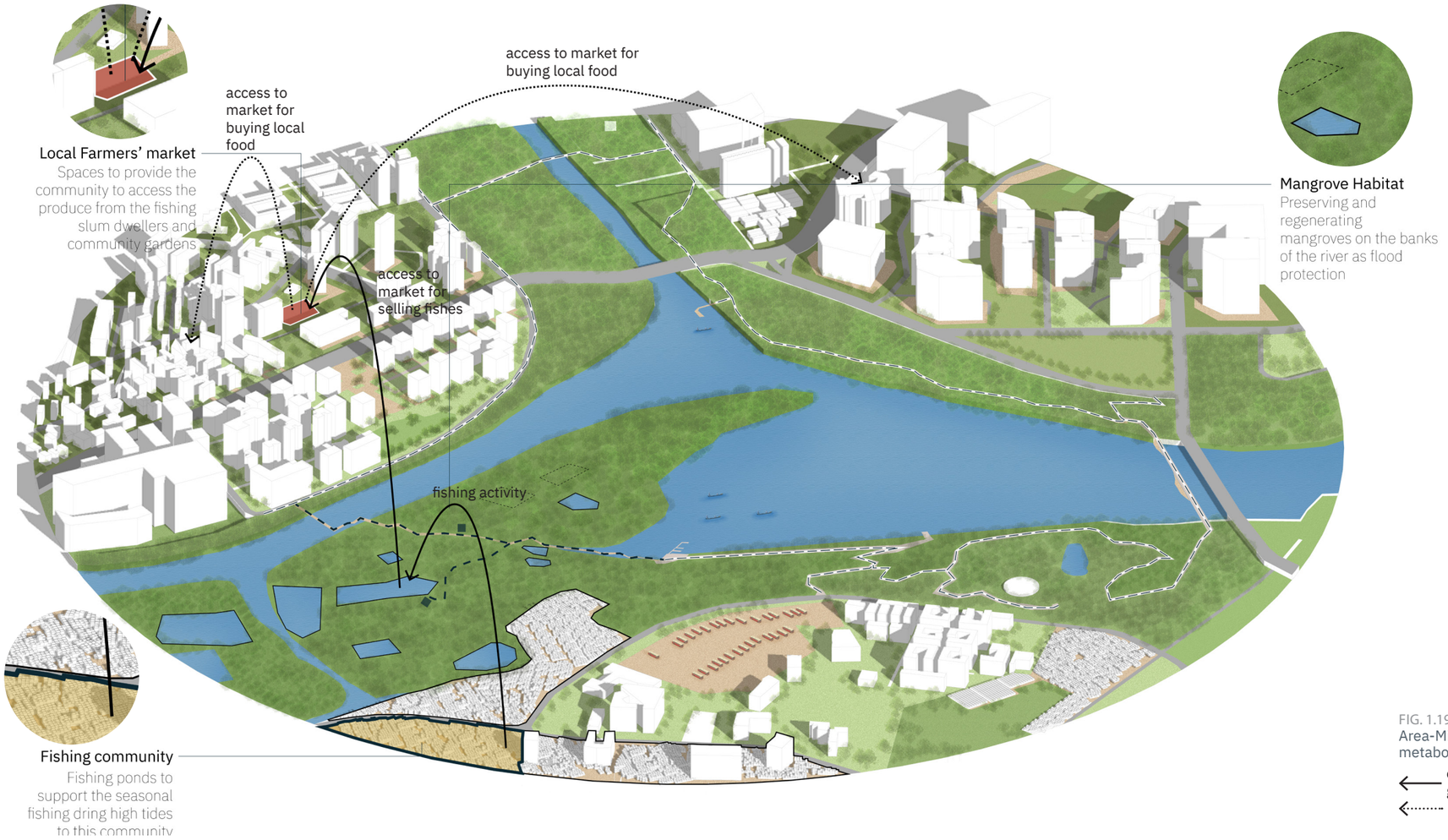
FIG. 1.192 Airport BKC Area-Capillaries .source:author

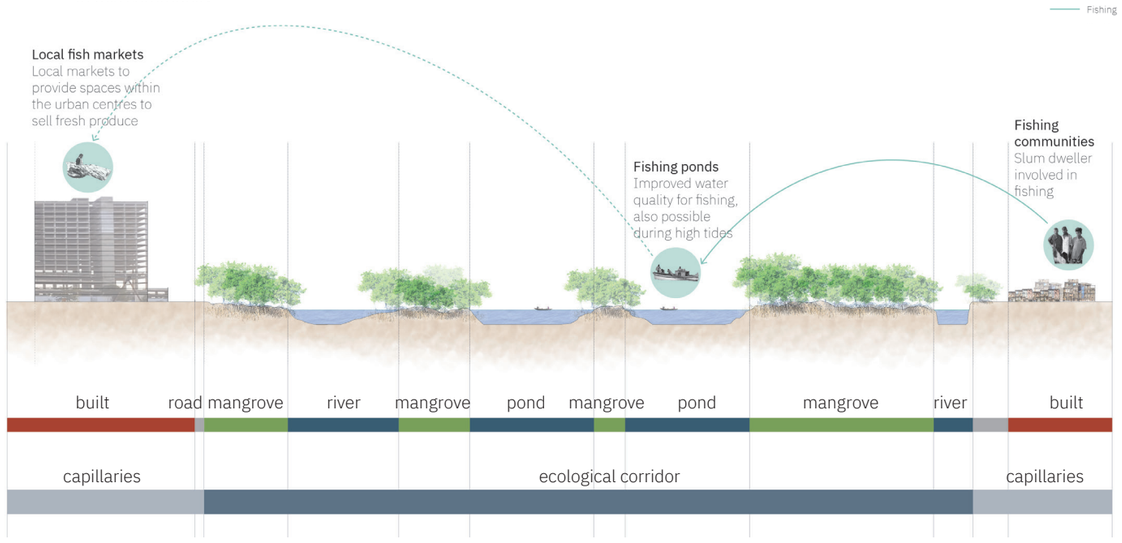


FIG. 1.193 Airport BKC Area-Ecological corrdior .source:author

Urban Metabolism

Fishing





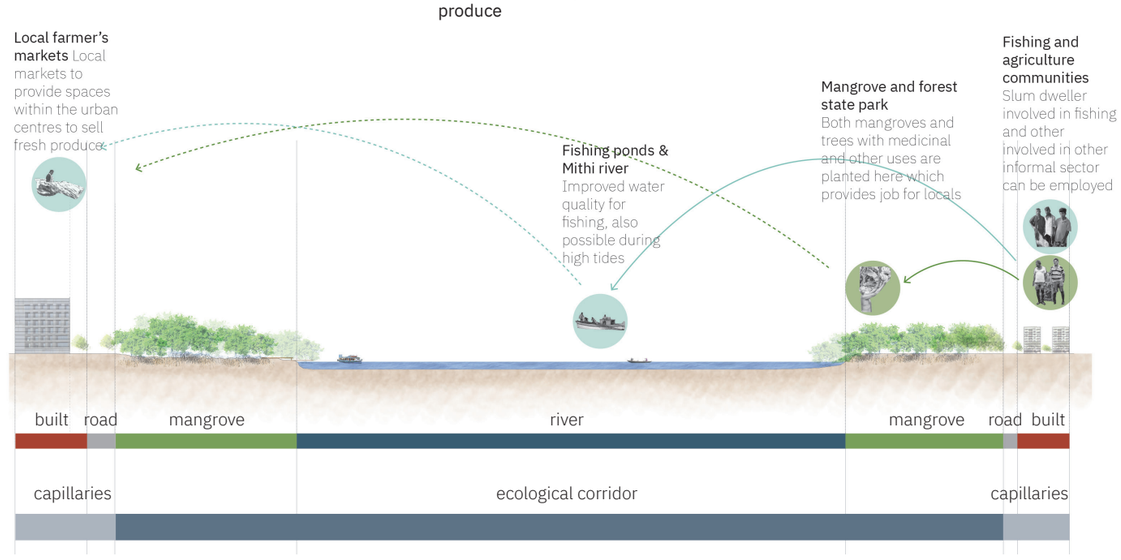


FIG. 1.194 Airport BKC Area-Microscale urban metabolics ,source:author

← employment generation

⇠ access to service / produce

The promotion of Mangroves in this area is essential and can stir up synergies in the social-economic system. The slum community involved in fishing who have already created a few ponds can create more fishing ponds in the mangroves ,the extent and quality of mangroves would improve the biodiversity of marine life and would also clean water. Currently the fishing communities have started fishing in these ponds already as it also helps them continue fishing during high tides and cleans certain levels of impurities from the water through their vernacular techniques to clean water through mangroves.
The fishing produce from these ponds can be further sold at local fish/ farmer's markets within the city and create a profitable market dynamic for both state and local people.

Also the creation of Mangrove State Park offers an opportunity to grow Urban forests and mangroves together also to provide medicinal plants which is already a micro-scale business for few people. Further intensification of the forest and areas allocated for urban farming can add to fresh produce for the city which can in turn be sold at the local farmer's market.

Urban Metabolism

Toursim

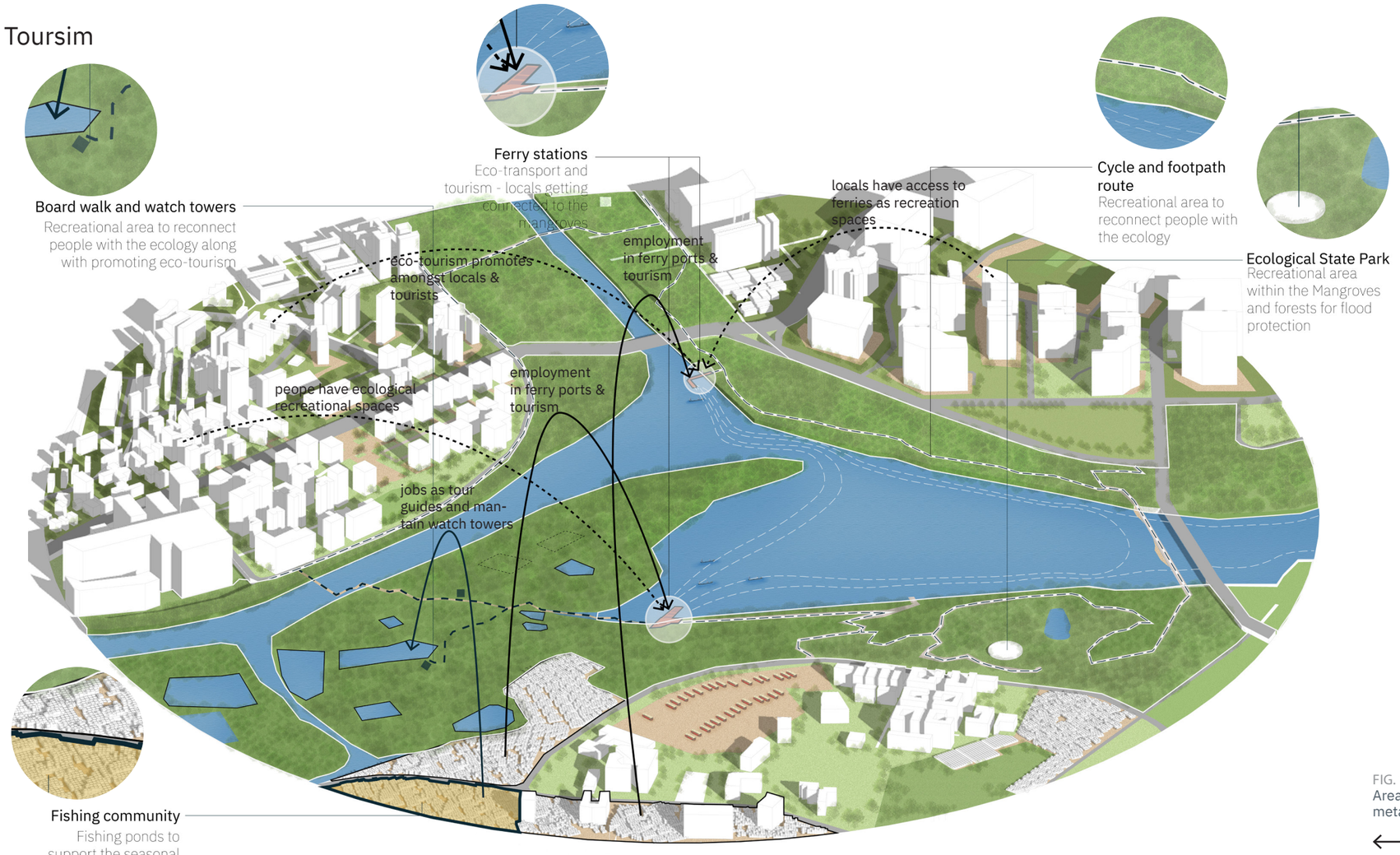
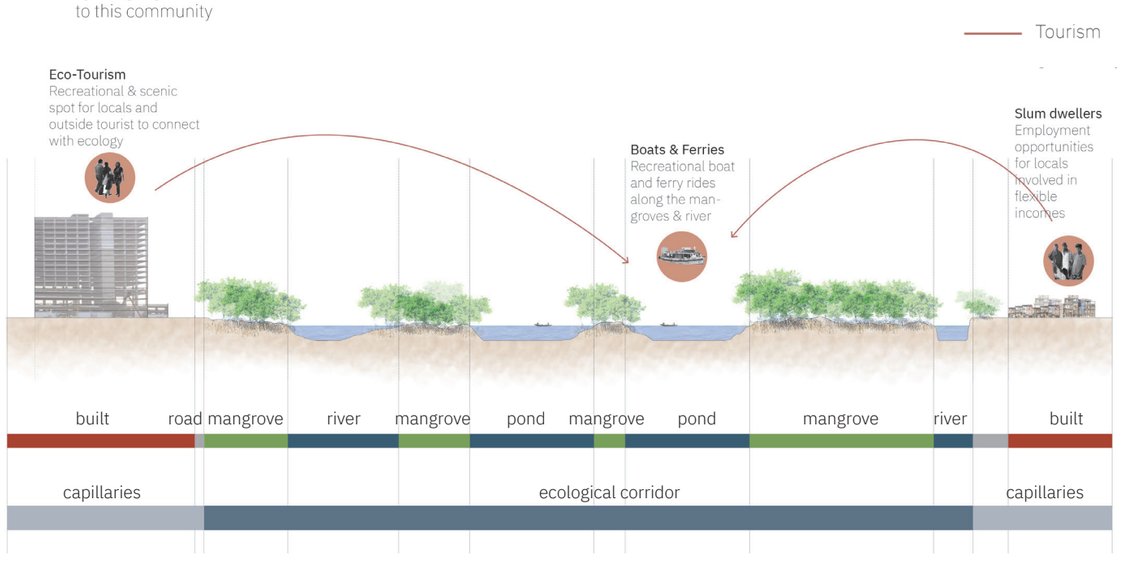
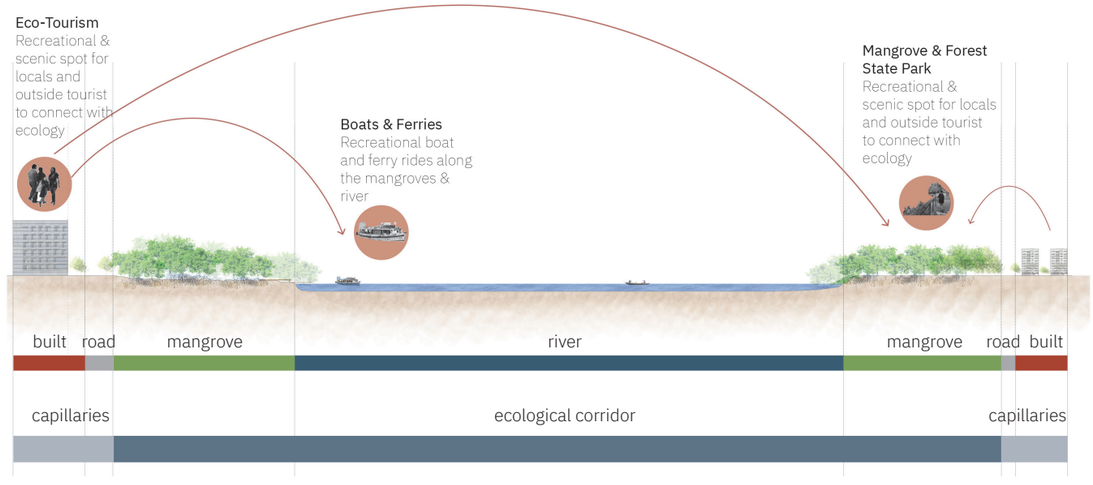


FIG. 1.195 Airport BKC Area-Microscale urban metabolics .source:author

- employment generation
- access to service / produce
- tourism

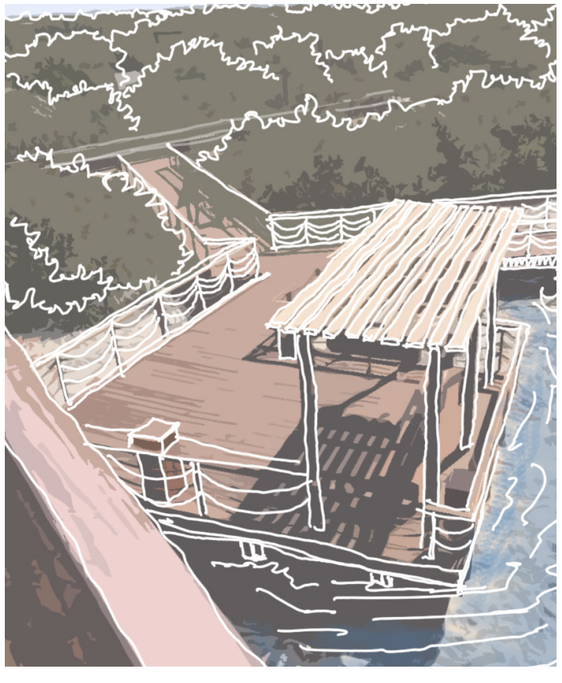
The promotion of Mangroves in this area also provides an impetus for the state to promote local and national/ international tourism. These mangroves along with the river can be designed for people to experience this rich ecosystem through board-walks, ferries/ boats and watch towers. An introduction of walking and bike paths for people to connect with the ecology within their city limits is essential . This would provide a recreational space for the local but at the same time also introduce employment opportunities for the people where the informal income population has a chance to be absorbed in. This would further add to a green image of the city but essentially provide resilience to the city profiting all- the people, large companies and the State.











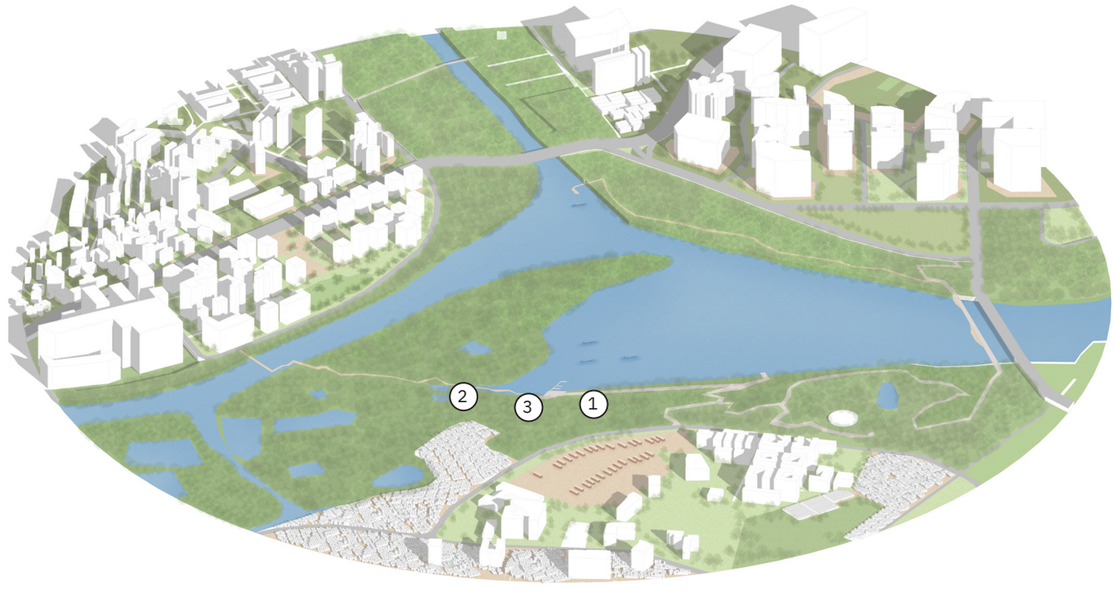


FIG. 1.196 Airport BKC Area-View points(Right) .source:author

FIG. 1.197 Airport BKC Area-View on the boardwalks in the mangroves (left).source:author

FIG. 1.198 Airport BKC Area-View within the mangrove trail (right) .source:author

FIG. 1.199 Airport BKC Area-View from the watch tower(right) .source:author

Urban Metabolism

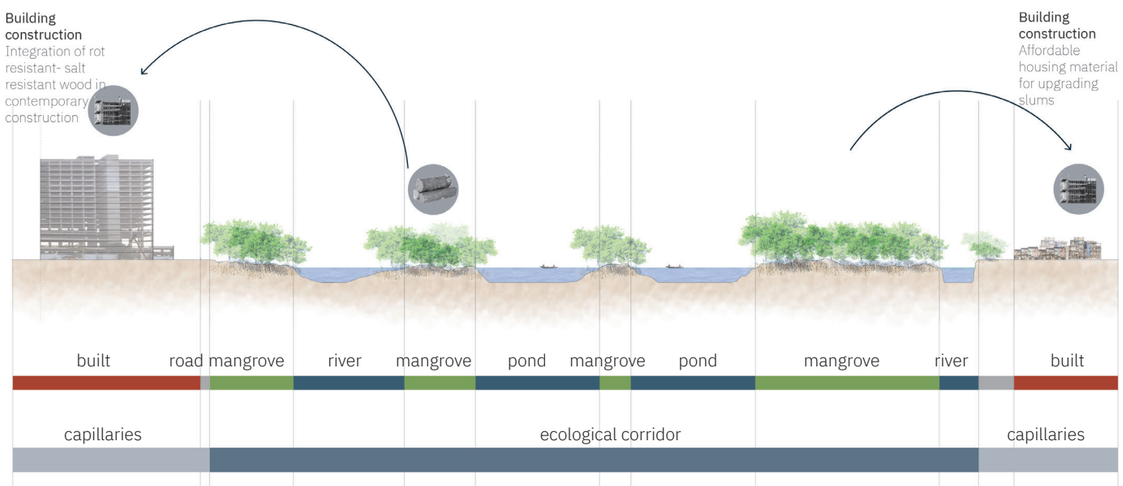
Construction

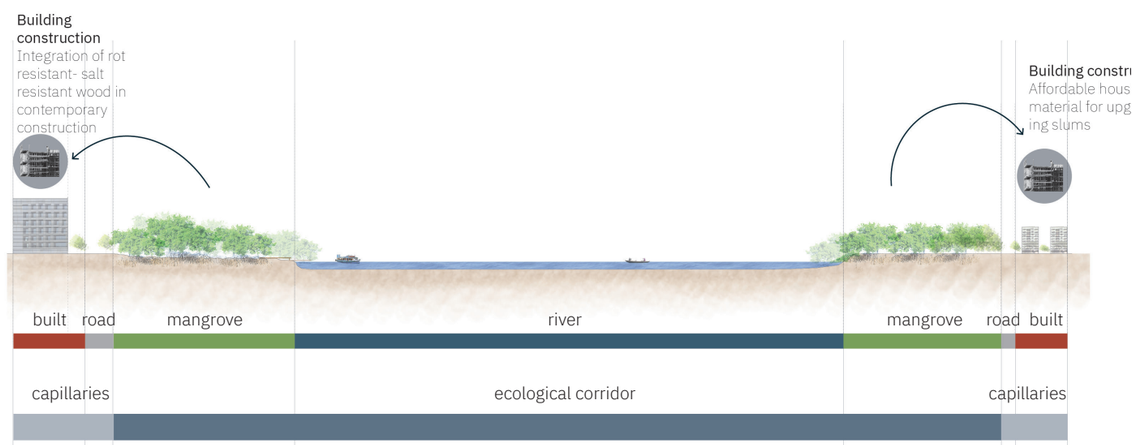


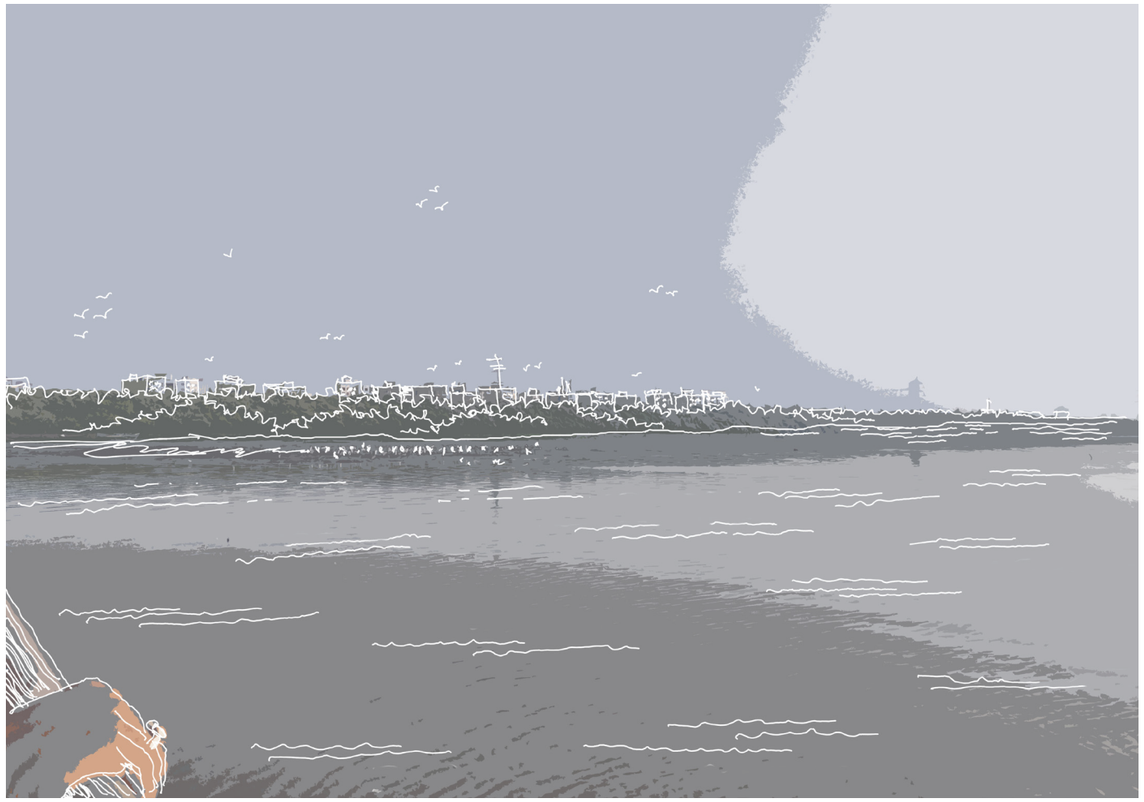
The promotion of Mangroves in this area also provides an opportunity to be used in the construction industry since the wood from these fast-growing trees is rot resistance and can withstand salt water. This can form an essential material for building affordable housing for the slum communities to upgrade eventually with their economic growth.
Also the use of wood in the contemporary building construction has been re-introduced as a new architectural style and feature being promoted by leading contemporary architects.

FIG. 1.200 Airport BKC Area-Microscale urban metabolics ,source:author

<..... access to service / produce







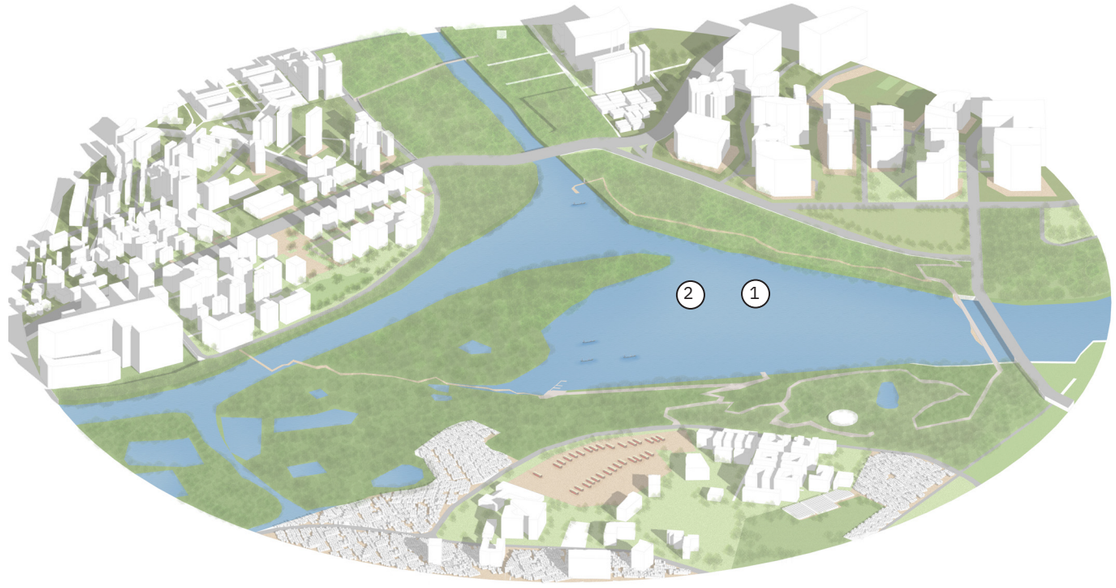


An imagery of the view from the ferry which would be an experience for the locals and tourists engaging with both water and mangroves along with the built environment..

FIG. 1.201 Airport BKC Area-View from ferry (left) .source:author

FIG. 1.202 Airport BKC Area-View of the built environment(left) .source:author

FIG. 1.203 Airport BKC Area-location of viewpoints(right) .source:author



Macroscale

Synergies due to the strategies

The strategies in the territory create a vibrant synergistic dynamic in the urban development where the relocation of the airport provides an opportunity for large scale re-structuration of the built environment.
It opens up the possibility for intensification of density at transport nodes where the FSI was regulated at a low amount of 1-2 because of proximity to the airport. Thus a more ecological integrated built environment with efficient use of transport is possible. In this approach of planning , the natural open space area for public would increase from the alarming amount of 1.24sq m per person closer towards the average area of green space per person of at least 9sq.m as recommended by the World Health Organisation.
Land use planning also plays a critical role in reducing emissions and reducing carbon emissions due to transport. It is essential to plan the area in such a way that the neighborhoods are self sufficient and limits the promotion of long distance travel for daily activities.
While developing the coastal protection strategy on a larger scale, fishing communities, recreation, heritage and other built structure and society along with flora and fauna needs to be taken into account inorder to create a mangrove or sand dune protection alternatively as necessary.
The delineation of the ecological corridor along the Mithi River becomes essential as it defines the urban extent and provides space for the river and the floodplain, which would need large scale interventions that could provide the storage, absorptive or drainage capacity required for this area to adapt to flooding. It also includes the reclamation areas along this river which are still a part of the hydrological process and floods each year , therefore needs to be adapted and planned in a way that it could adapt to the current and future flooding conditions.

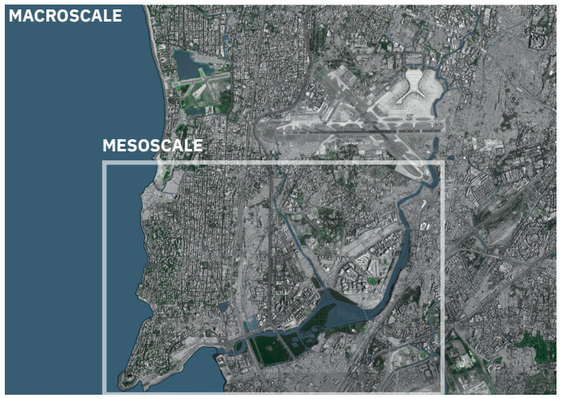


FIG. 1.204 Airport BKC Area-Macroscale urban metabolics

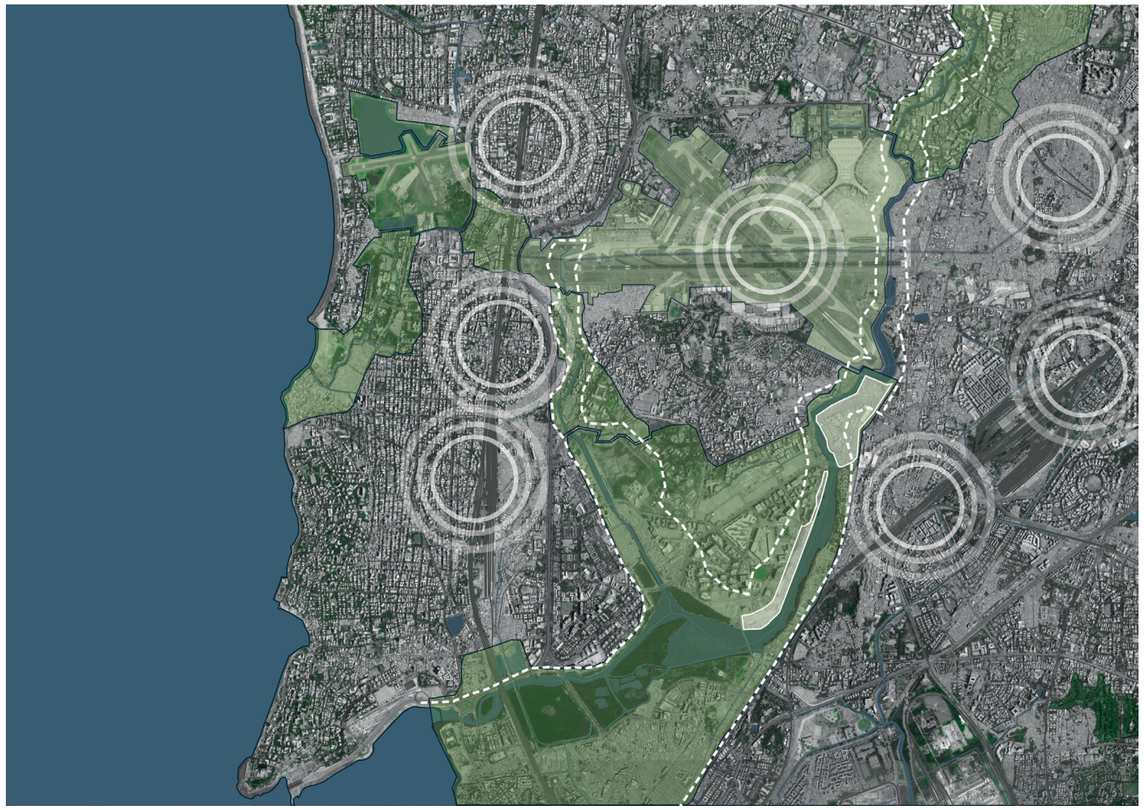


FIG. 1.205 Airport BKC Area-Densification at Transport hubs .source:author

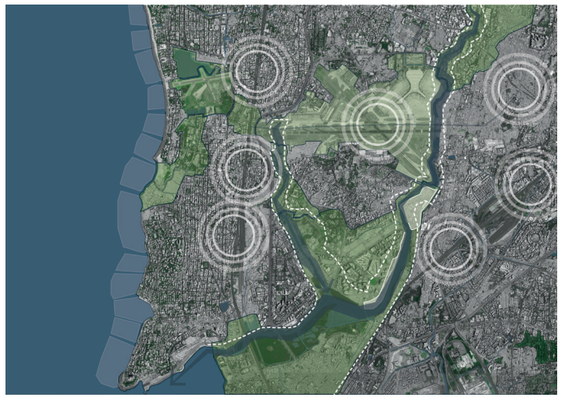


FIG. 1.206 Airport BKC Area -River ecological corridor .source:author

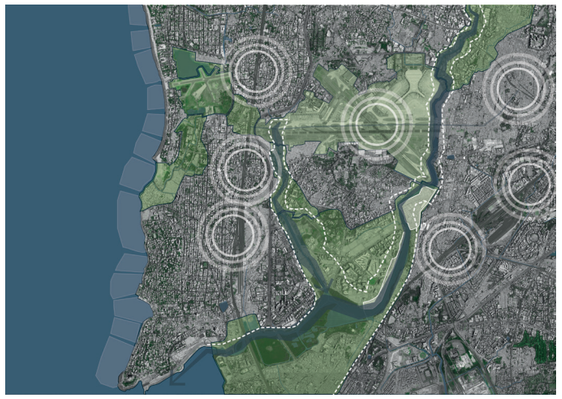


FIG. 1.207 Airport BKC Areas-Coastal protection .source:author

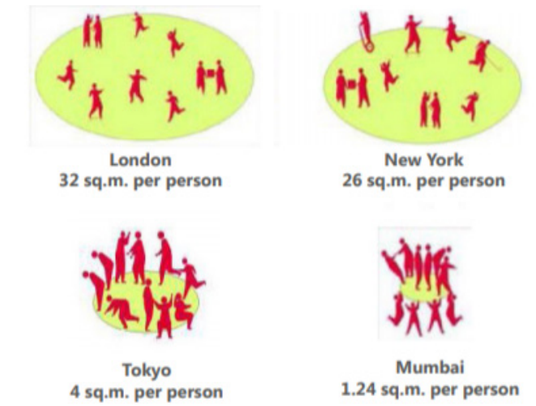


FIG. 1.209 Open space per person in cities CitiesCities

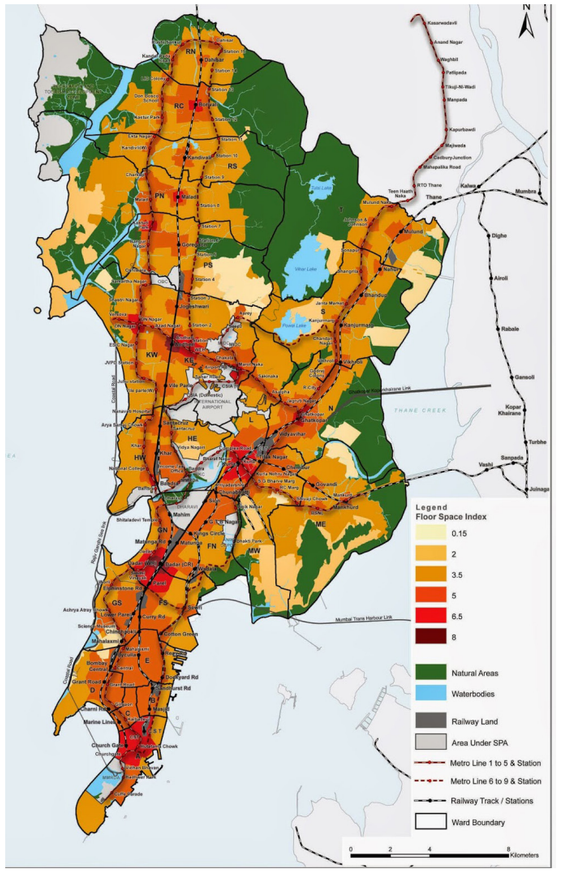


FIG. 1.208 Exisitng FSI .source:MCGM

12.

SALT PAN AREA

Design Principle and interventions



FIG. 1.210 Drone view of Mumbai. source: Safwan Patrawalaource:S

Introduction

The forthcoming section deals with the comprehension and translation of the three regional strategies- Ecological corridor, Capillaries and Coastal Protection in space of the selected area of Salt Pan & Creeks. The selected site exploration involves responding to the specificity of the built and ecological system to project a design and planning framework for the given location.
The Bhayander area with saltpans is largely ecological and has a low dense urban fabric. Recently ,the State politicians attempted to resolve the housing problem in Mumbai by opening up these salt pan areas (approximately 1,781 acres of land) for development in the name of social housing.

Built environment + Natural environment

[Structure + Function] ecological elements

flood protection

other benefits

But this poses a serious threat to the ecological vulnerability of this area. The Saltpans act as natural barriers to flooding in this area, and acquisition of this land to turn into a housing solution would create a new problem of flooding. Thus development of this ecologically sensitive land presents a two-fold



FIG. 1.211 Saltpan & Creek Area .source:author



FIG. 1.212 Saltpan & Creek Area .source:author

challenge of urban development with preservation of social and ecological wellbeing in this area as a large part of this population is also dependent on salt farming and fishing.This area currently comes under the jurisdiction of Mumbai Metropolitan Region Development Authority which acknowledges the significance of Saltpans and mangroves in this area.



FIG. 1.213 Saltpan & Creek Area .source:author



FIG. 1.214 Saltpan & Creek Area-agriculture & saltpans .source:author

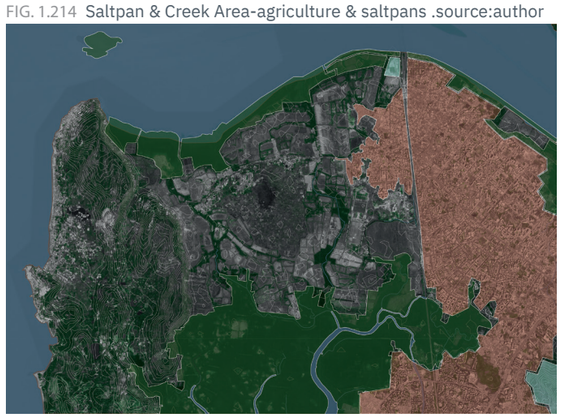


FIG. 1.215 Saltpan & Creek Area -built & ecology.source:author



FIG. 1.216 Saltpan & Creek Area-railway infrastructure .source:author





FIG. 1.217 Saltpan & Creek Area -ecological elements .source:author

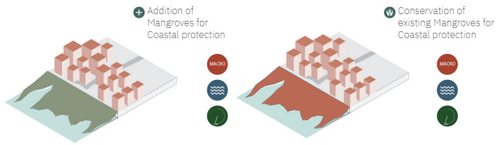
The design exploration would involve taking into account different built and ecological layers with a detailed analysis of the socio-economic system and to find potentialities of the dynamics and synergies in the systems possible.
This area includes salt pans which employs a large population of neighborhoods around. There is also an existing mangrove ecology which has been reduced to the extent that it is now due to urban growth. The area faces constant flooding every year and adapts through the buffer provided by the mangroves and salt pans. The political lobbying of development has opened up this area for development and the question is how should the future of urban development in this area look like. What kind of urban growth in harmony with the ecological system is possible. This would initiate the operationalisation of the strategies in this area which would mainly involve coastal protection and capillaries. Planning the spatial morphology of the built and the ecological elements in this area is necessary to maintain the spatial qualities of this area and to maintain an equilibrium between the buil and the natural systems.

Coastal protection

Design interventions

The Salt pans along with the mangrove ecology presents an opportunity to create the coastal protection which would absorb, store and drain the flood water. It is essential to translate the principles of adaptive capacity to these delineated spaces through varied design intervention responding to the cause of flooding and the existing and potential spatial structure.
The strategy primarily involves preserving the existing salt pans, mangrove forests and agricultural areas and simultaneously designating space for more.

(1) **Mangroves** - Preserving and regenerating to convert green areas/ vacant / unused plots or replacing certain spaces to mangroves for flood protection.



(4) (5) **Salt pan areas** - Preserving and regenerating to convert salt pan areas for productivity and for flood protection.



(2) (3) **Agriculture** - Intensifying the farmland with more water intensive crops & creating a buffer for the inhabitants in the area





FIG. 1.219 Saltpan & Creek Area -Coastal protection zone .source:author



FIG. 1.218 Saltpan & Creek Area-Design interventions .source:author

Urban growth: Spatial pattern

The rich ecology rarely present anywhere else in the city needs to be preserved and intensified and a careful spatial pattern of the built structures need to be promoted which responds to the spatial morphology of this rich diverse natural environment and also benefits from the same. This requires defining the edges of the urban extent which would involve urban growth and densification along with the intensification and preservation of the ecological elements. This would create a vibrant urban environment that people would enjoy aligned with the natural environment that would contribute to the liveability and also would generate livelihoods for the community. The urban growth would include social housing as well, where migrant workers could find possibility for liveable housing opportunities along with more stable jobs by employment in primary activities like farming and fishery apart from potential secondary and tertiary activities.

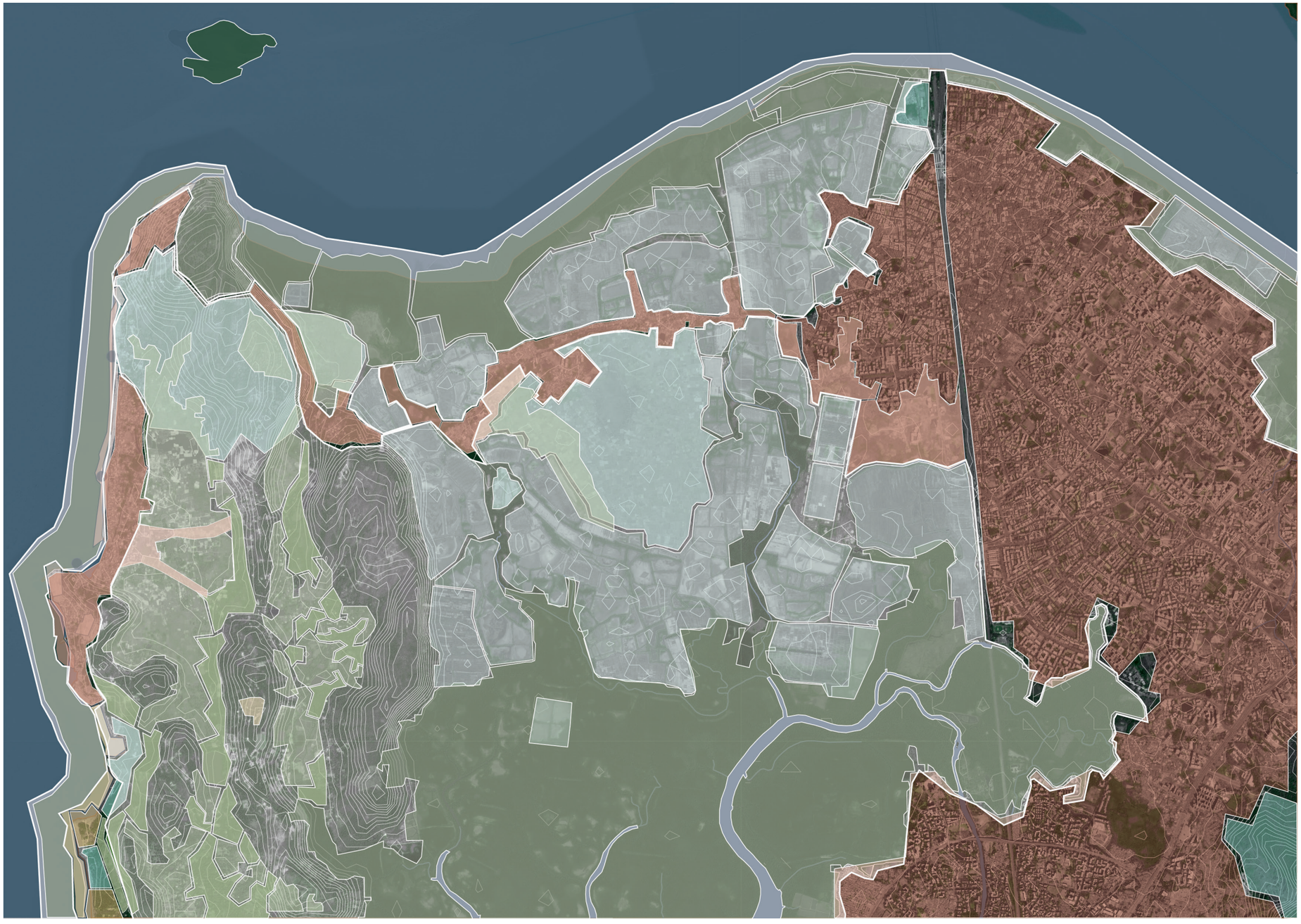


FIG. 1.220 Saltpan & Creek Area -Spatial morphology.source:author

Microscale

Coastal protection

An abstraction of the future of this area at a micro-scale would help in envisioning the possible spatial pattern that could be promoted in this area. This microsalce exploration would exemplify the potential flows and interaction that would be generated as a result of the design interventions. It would show how ecological infrastructure could reform, strengthen and steer current spatial morphologies and new local and regional economies. In this case, it is crucial to maintain the equilibrium between built and nature and it needs to be interspersed within each other to symbiotically benefit each other. This spatial pattern projected would operationalise flows ,processes and nexus between Sea,salt farms, mangroves, agriculture land and built areas along with its functions. The Coastal protection strategy would be covering most of this area as this location is highly susceptible to coastal flooding in the future. The coastal protection includes salt buffers, mangroves and agricultural farms with water intensive farming along with sand dunes being introduced at parts of the coast. The Coastal protection of this area with these strategies would stir different benefits.

The mangroves on the North of this area and around the creek needs to be preserved and intensified close to it along the northern coast which would

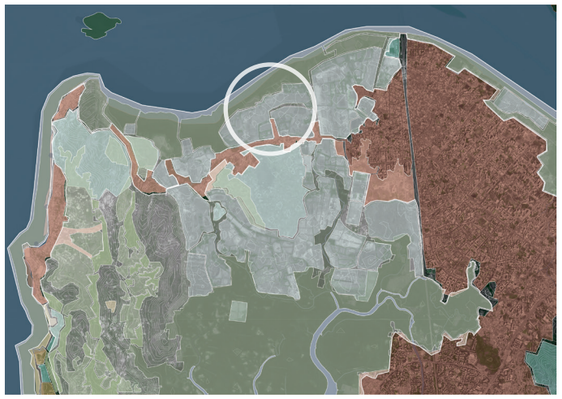


FIG. 1.221 Saltpan & Creek Area-microscale .source:author

be a barrier to waves and winds and also enrich marine life. The mangroves would also help in protection from sea level rise and would generate flows that would integrate the ecology with the socio-economic system. The saltpan farms function as large storage dishes for flood water which gets stored and absorbed in these pans. The farming area also has a capacity to adapt to flooding as it stores and consumes the water for specific types of farming.

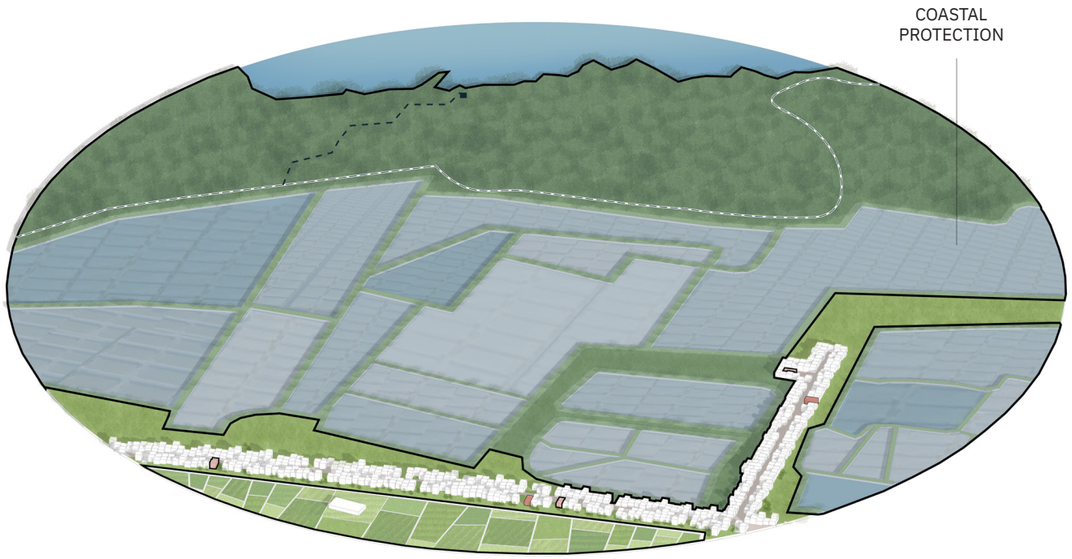


FIG. 1.222 Saltpan & Creek Area- coastal protection .source:author

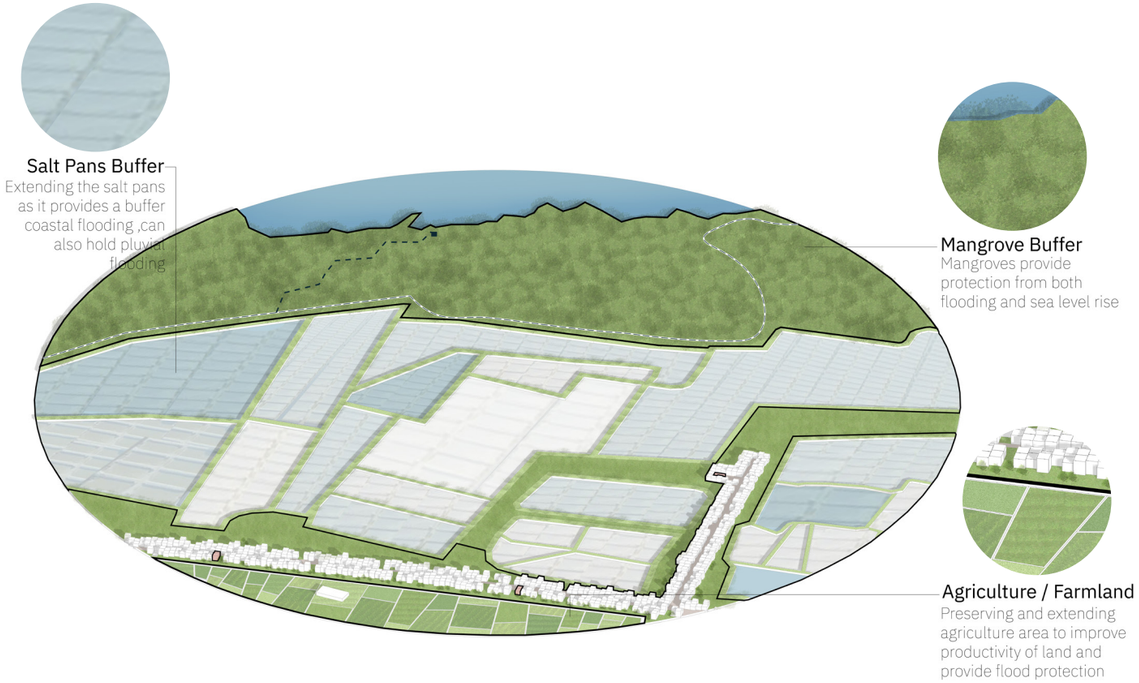


FIG. 1.223 Saltpan & Creek Area-ecological elements .source:author

Urban Metabolism

Fishing,farming & Tourism

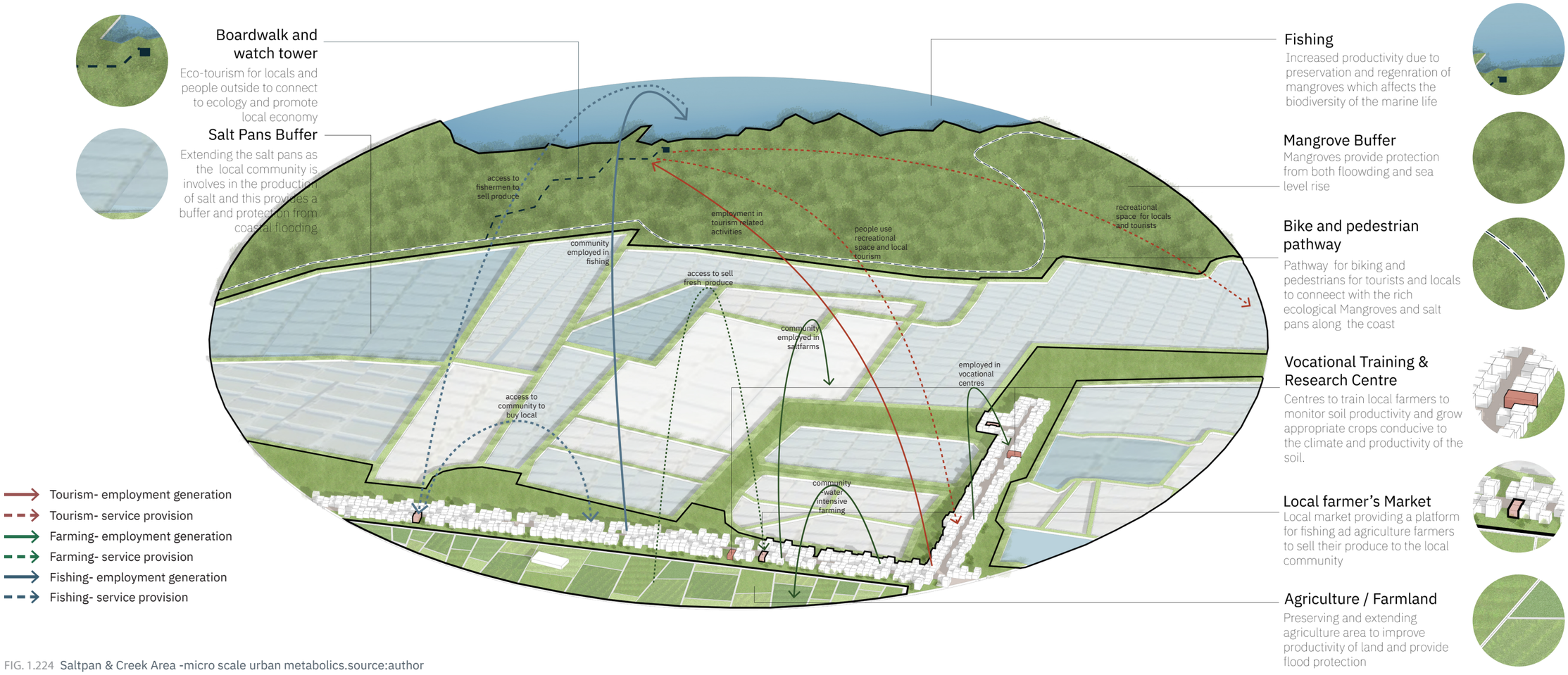


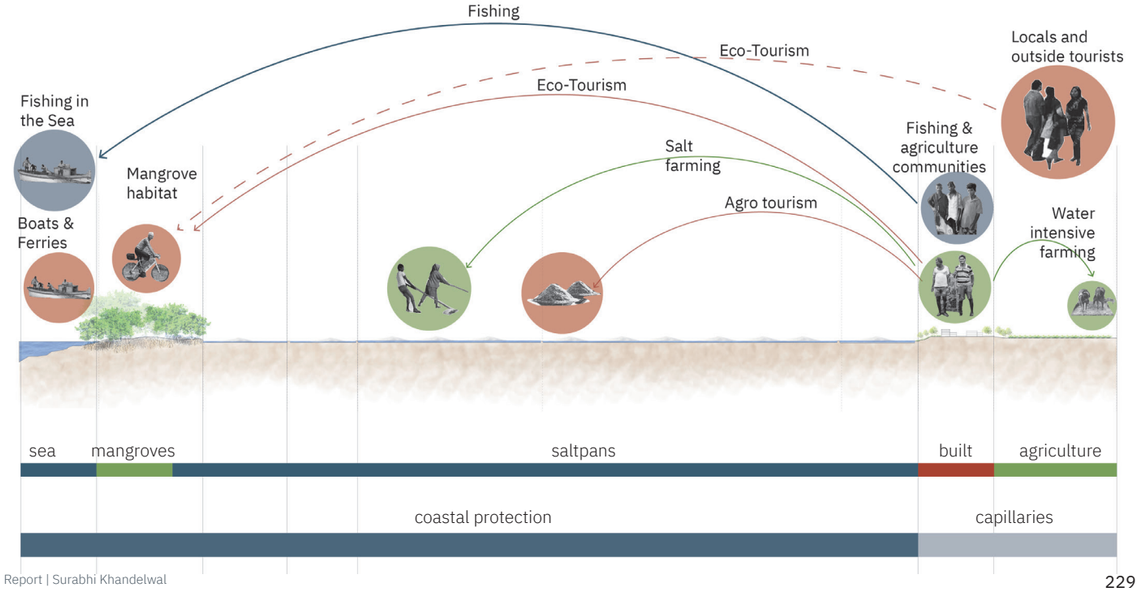
FIG. 1.224 Saltpan & Creek Area -micro scale urban metabolics.source:author

The salt farming currently an existing employment sector on further intensification would provide more employment absorption of the people in the community. Mangroves on the other hand could be integrated in the socio-economic system. Training people to practice fishpond farming and creating small scale tourist hubs for stay and visit mangroves could stimulate ecological tourism which is not yet part of the economic sector in this area yet. Improved ecology of the mangroves can further profit the fishing industry and creation of farmer's markets in more places can create a vibrant market dynamics in these areas.

The salt pans and mangroves together provide an opportunity to be combined and promoted for eco-tourism which can stimulate new market dynamics in this area. As mentioned before, the Mangrove habitat can be further developed to create small scale tourist hotspots along with boardwalks, watch towers in certain areas. It would involve boating and further adding more ferry points for recreation. Bike and pedestrian routes in this part could help the inhabitants of the city to connect with ecology that they are a part of.

An integrative approach is essential for promotion of ecology so that people understand their significance and further promote their intensification and extension in the built environment.

Promotion of water intensive farming would also diversify the source of income generation in these neighborhoods. This would also involve promotion of research institutes being set up in these areas which monitor the productivity of soil and climate



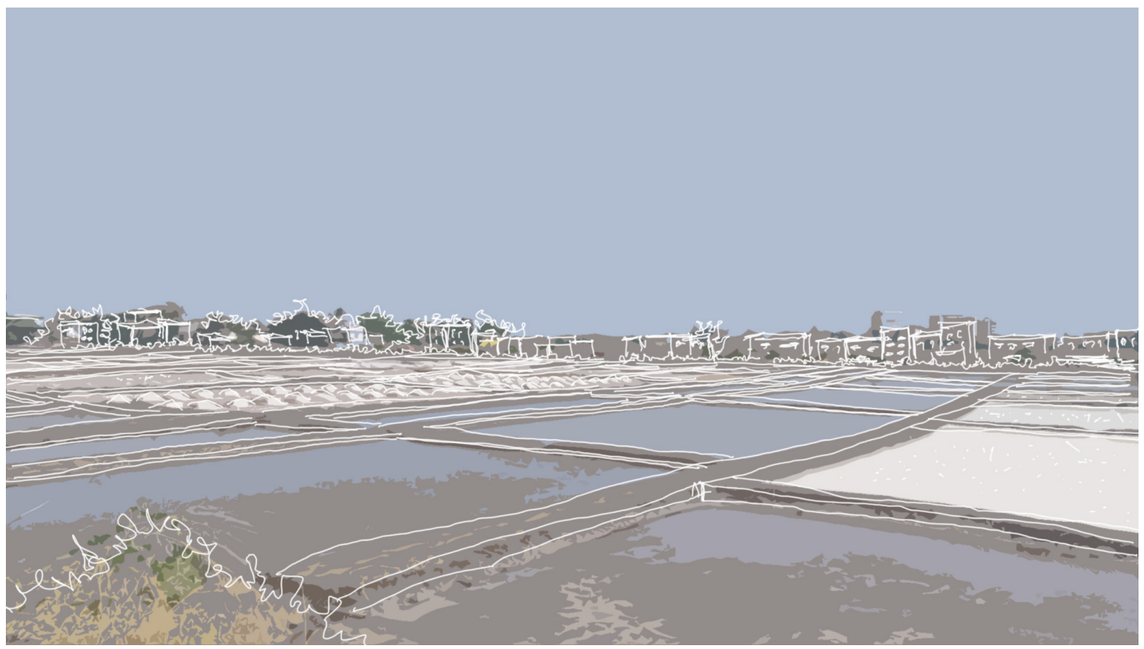


FIG. 1.225 Saltpan & Creek Area -Spatial qualities.source:author

and the kinds crops that are possible.It needs to be combined with a vocational training institute which teaches the farmers the kind of farming possible each planting season. These vocational training institutes could upskill the people in these communities especially migrants who would come here as a part of social housing to equip themselves to generate livelihood and thrive in these areas especially in the agriculture,fishing and tourism sector.

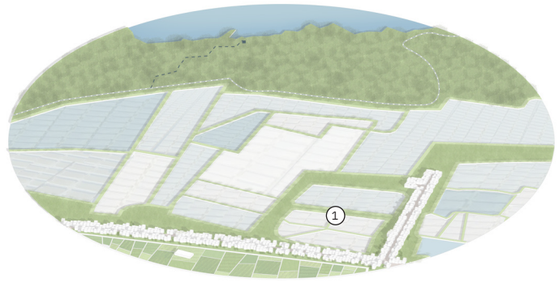


FIG. 1.226 Saltpan & Creek Area-location of view point .source:author

Macroscale

Synergies due to the strategies

The strategies in the territory create a vibrant synergistic dynamic in the urban development where an urban growth with harmony with nature is possible and benefit from each other without being in competition for space. The spatial and functional inter-relationships can be seen at a micro and meso scale which can further be translated to a macroscale in this area.
Promotion of the farming, tourism and fishery sector together with supporting and complimentary secondary and tertiary activities could strengthen this community ecologically,economically and socially. A comprehensive housing solution with creation of jobs is a holistic solution for social housing rather than displacing people away from the work hubs. The challenge is integration of housing and job opportunities which would address the needs of the most vulnerable population of the city.
This macro scale area comes under two development authorities which proposed development plans which received little consensus from the



FIG. 1.227 Saltpan & Creek Area-macro scale .source:author

local population. Both MCGM and Mira-Bhayander have administrative jurisdiction over these areas but need a consolidated plan that needs to develop for this area. It would require a collaborative planning process with the two municipalities along with community participation which can guide the

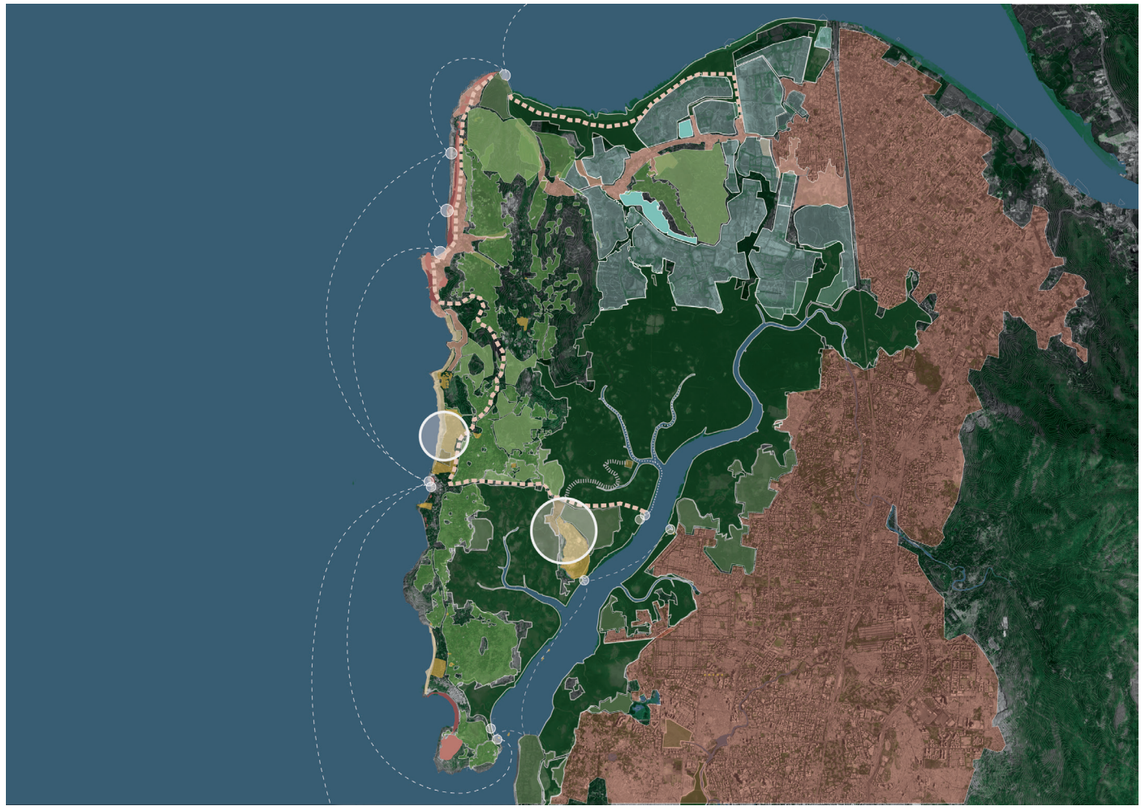


FIG. 1.228 Saltpan & Creek Area-recreational and micro- tourist hubs .source:author



FIG. 1.229 Saltpan & Creek Area- Eco-/agro- tourism routes .source:author

institutions to evolve a Development plan for this macro region.
The macro region presents an opportunity to promote ecological tourism as a forerunner in Mumbai, with an interactive and immersive travel route along the agriculture lands, salt farms, mangroves and ferries. Tourist hotspots marked in yellow could become a promoter for the same by connection with bicycle and hiking routes which would connect people with the rich ecology of Mumbai. Further promotion of ferries can create a possibility for expanding the water transport and making these areas more accessible through water infrastructure than through cars and buses.
The coastal protection on the west coast would also include a series of both mangroves and sand dunes as a defense which is designed based on the needs of the community. Sand dunes can be created as interactive beach landscapes which becomes a recreation spot for both tourists and locals and also provides spaces for drying fishes for the

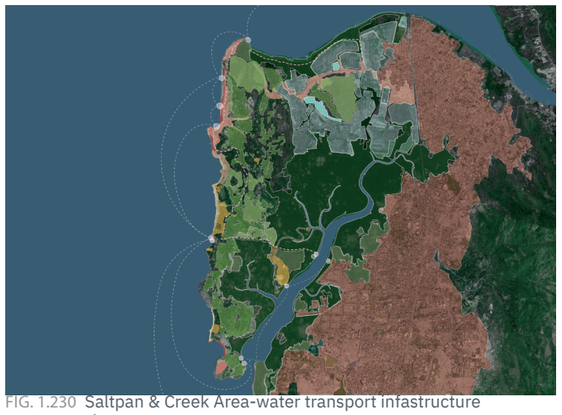


FIG. 1.230 Saltpan & Creek Area-water transport infastructure .source:author

community. Whereas mangroves would also create ecological recreation spaces along with tidal ponds which would help in fishing during high tides.

13.

ISLAND CITY

Design Principle and interventions

FIG. 1.231 Saltpan & Crew Area, source: author

Introduction

The selected area of the Island city has a high urban built up area and has low amount of ecological elements within the area, same is true for the rest of the Island city area. This selected location also includes a part of the old port area and large parts of this area is currently facing perennial pluvial flooding issues. The storm water drainage department is working on these sites but it is a short term fix for a problem which is systemic in its cause. The initial analysis in this area exhibits potential redevelopment of the old port area which has been relocated in its entirety. The building typologies need adaptation to equip itself with the capacity to tackle flooding and other spatial transformations are necessary to stimulate an urban environment which is adaptive and can withstand future climate change impacts.

Built environment + Natural environment

[Structure + Function] ecological elements

flood protection

other benefits

The approach of orienting the urban development towards ecological infrastructure requires identification of the existing ecological elements in this location and at the same time explore potentialities for intervening and introducing these green-blue network.



FIG. 1.232 Geographic selection of Island City .source:zoom earth



FIG. 1.233 Island City .source:zoom earth



FIG. 1.234 A glimpse of the Island City .source:author



FIG. 1.235 A glimpse of the Island City .source:author



FIG. 1.239 Island City -transport infrastr. source:zoom earth

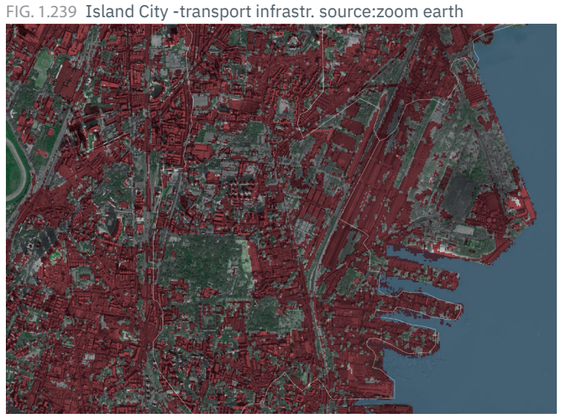


FIG. 1.237 Island City and built area .source:zoom earth



FIG. 1.238 Island City-flooding .source:zoom earth



FIG. 1.240 Island City-slums .source:zoom earth



FIG. 1.236 Island City with existing ecological infrastructure .source:zoom earth

This specific site has an old port area which would be subjected to urban regeneration to create an adaptive neighborhood. This part of the island city is highly susceptible to both pluvial and fluvial flooding as it also includes areas at lower elevation. There is an existing zoo and some public spaces which could present an opportunity for transformation inorder to translate the three strategies in this area. This area is flanked by the sea on the east but just like the whole Island city ,it does not have any natural streams or water system within its terrain. Ecological corridors , urban capillaries and Coastal protection strategies are attempted to be translated at multiple scales in this example to reveal possible flows and synergies that could create a spatial reality for a climate resilient urban environment.

Translation of the strategy of Ecological Corridor in this location includes densifying and intensifying forest and trees in zoos and parks.It also explores the possibility of integration of urban farming and inclusion of rain gardens and water squares in public spaces.Creation of a green-blue network is essential to ensure drainage, absorption and storage of water.

BEST PRACTICES AND POTENTIALS

Mumbai has many citizen led initiatives where communities are already involved in urban farming practices. The have developed various sustainable techniques to grow local food and have developed platforms to reach out to people to build this community bigger and to provide access to people to consume locally produced food.



FIG. 1.241 Snippets from the webpage of ‘urban leaves’ - civic initiative . source: urbanleaves



FIG. 1.242 Snippet from local farming in Mumbai. source: youtube

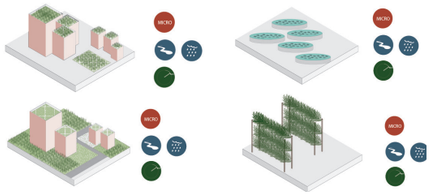


FIG. 1.243 Island City .source: author

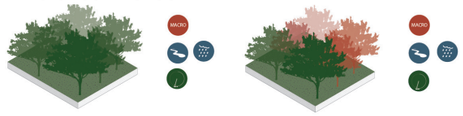
Ecological Corridor

Design interventions

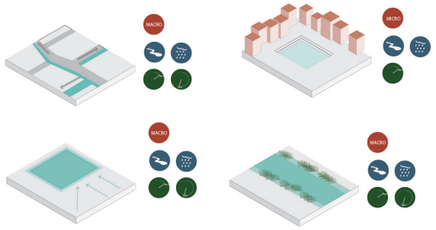
1 2 9 Urban Farming - Combination of Urban farming in the built areas- integration of aqua culture or crop farming within the built structure through redevelopment/ reftrofitting



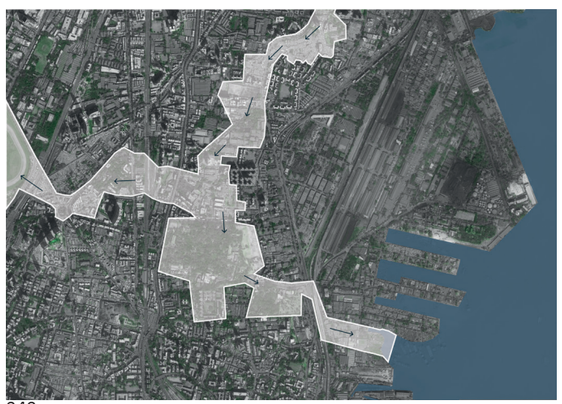
4 6 7 **Urban Forest** - Preserving and regenerating to convert green areas/ vacant / unused plots into urban forest



3 5 8 **Water Network** -Networks for water storage or connection of water to the Sea. Introducing rain gardens, water square, channel system or water storage in large roofs and part of the plots



3 5 8 Green Network -Networks through regenration and addition of green pathways, parks, permeable gorunds, and incorporating large green areas on roofs of public buildings and facades



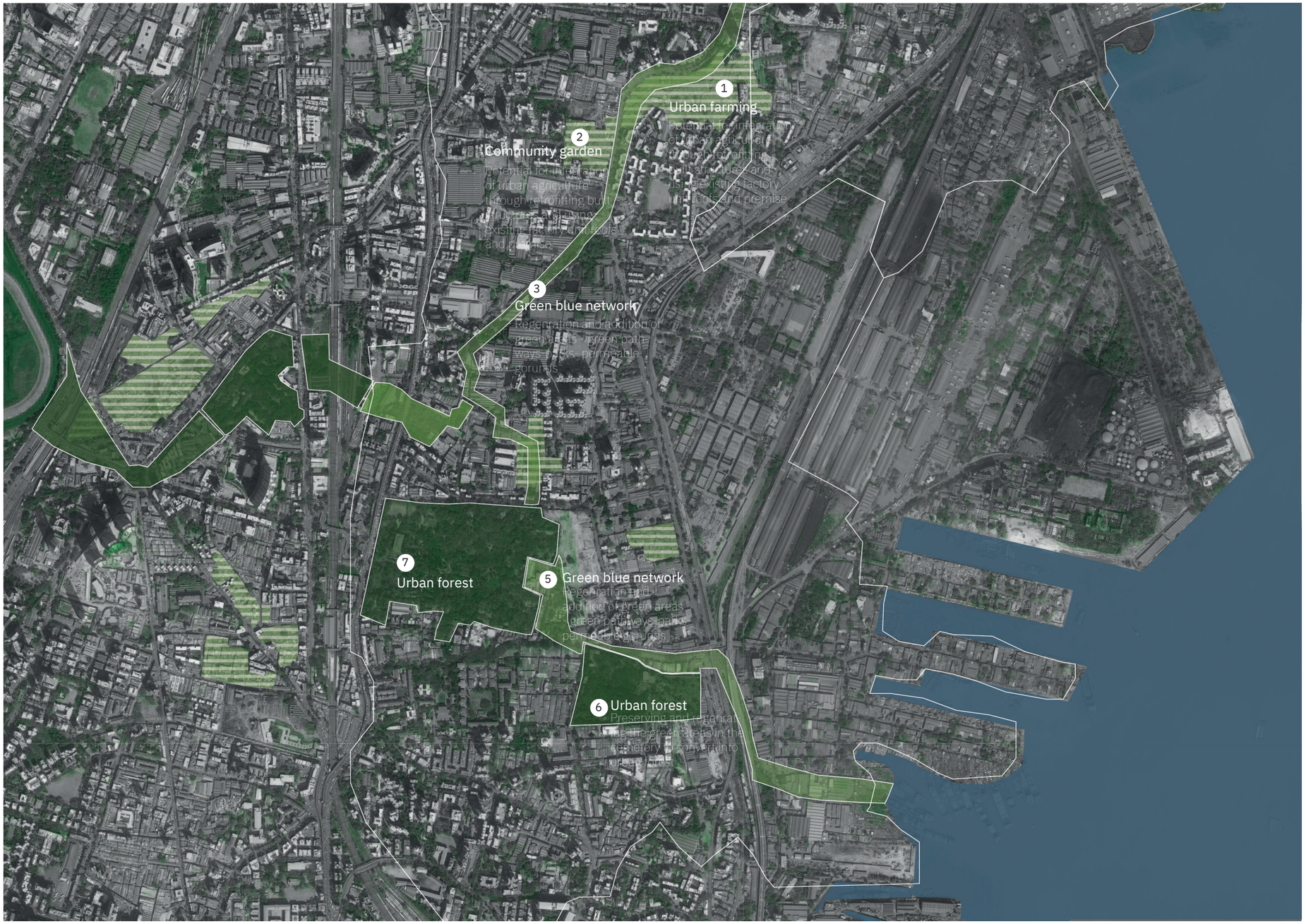


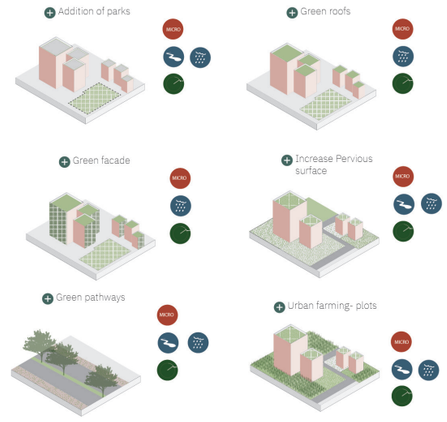
FIG. 1.244 Island City- design interventions- ecological corridor .source:zoom earth;NDVI

Capillaries

Design interventions

Delineation of urban capillaries would be entailed after the definition of Ecological Corridors. This would necessitate the transformation of the existing urban fabric into a more adaptive system with a green blue network embedded in this system. The interventions can be of varying scales and degree of engagement of people, from a rainwater storage tank, to green facades, community gardens, permeable paving to addition of parks in the neighborhood. The transformation to capillaries would be incremental over the years and would require policies and other regulatory and fiscal instruments to expedite this imagination into spatial reality.

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



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

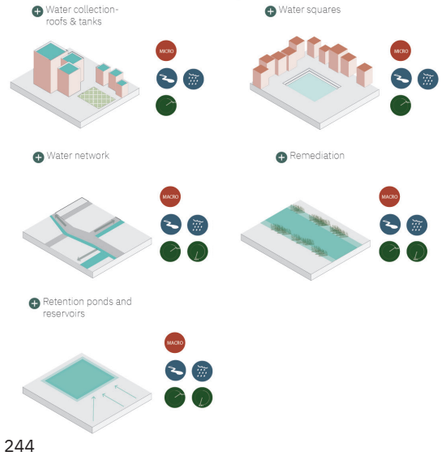




FIG. 1.245 Island City - capillaries .source:zoom earth;NDVI

Coastal protection

Design Interventions

In this location the coastal protection strategy would be the introduction of mangroves on the coastline. This needs to be in response to the old port development which would introduce possibilities of ferry points as a promotion of water infrastructure as transport in the future. Here the mangroves would act as a critical coastal flood defense as this area is highly susceptible to coastal flooding in the next decade. Thus the coastal protection in this area is highly urgent and its planning needs to be put in action as soon as possible. The mangrove extent and width needs to be appropriately assessed and the Island city needs to turn into an adaptive Island City which could work in the future like a sponge city or a stream city where mangroves act as a flood defense on the coast and the green blue network could further absorb the excess water and store it and eventually drain or consume this water.

1 **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

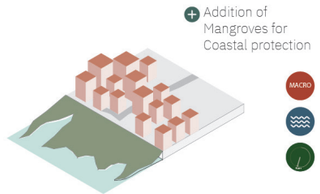




FIG. 1.247 Island City-Mangroves .source:zoom earth;NDVI



FIG. 1.246 Island City-Coastal protection- design interventions .source:zoom earth;NDVI

Water sensitive neighborhood :Relocated port area

The Old Mumbai Port owned by the Mumbai Port Trust-MbPT (earlier called Bombay Port Trust,BPT-spans a length of 10km and is one of the best waterfronts in the heart of the city.(HCP,2019)
The complete shift of all port activities from this area to the Jawaharlal Nehru Port(JNPT) would open up a large area for urban transformation. This area would require planning from scratch and this presents an opportunity to orient this new urban environment towards ecological Infrastructure. It is essential to model the flooding in future and the sea level rise that is an impending climate change impact that this waterfront would experience.
Based on the layer approach, first based on the ecological and hydraulic performance of this area, a network of ecological structures are created in line with the three strategies. It would involve large scale ecological intervention which would form the ecological corridor extending to the sea, coastline being protected by a large expanse of Mangroves and parks and building typologies which could store and recycle water. It could offer possibilities of creating building typologies which could withstand floodable spaces. Certain areas could be turned



FIG. 1.248 Old port area .source:zoom earth

into experimental labs where talented architects from the city could experiment with constructing buildings that are flood resistant ,in turn being flood resilient. After the ecological infrastructure ,then a street network along with building plots and functions are planned. Urban planning and design innovations like Hafencity,Hamburg or Ijburg in Amsterdam could be examples to consider multi level public spaces which are flood proof and could

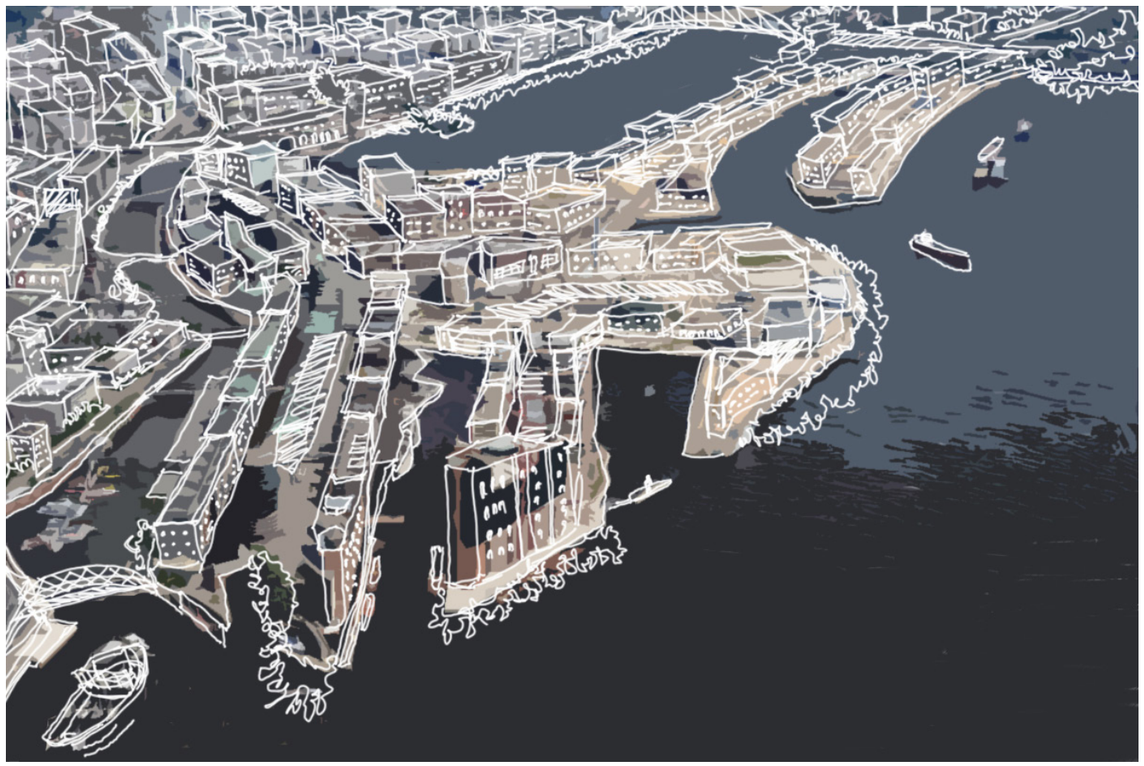


FIG. 1.249 View from the water sensitive neighborhood.source:author

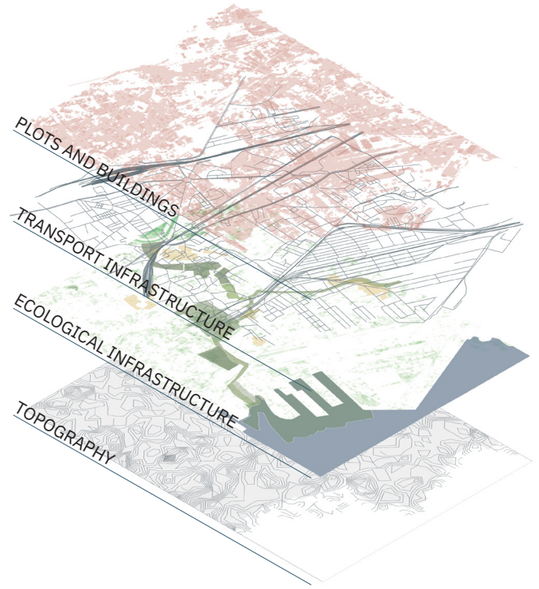


FIG. 1.250 Layer approach with ecological infrastructure as a base layer .source:zoom earth

alternate levels based on the flooding season. This neighborhood in the selected site location could be created as a part of this scheme and turned into a water sensitive neighborhood which follows these principles to create an adaptive capacity against flooding.

The 3 Stratgies : corrdior ,capillaries and coastal protection

Together with Ecological corridor, capillaries and coastal protection, the 3 strategies can provide resilience to this area until 2100 from all three types of flooding .
A combination of different interventions ranging from green roofs/ facades to water squares to mangroves or sand dunes can be introduced in specific locations based on the extent , time scale of impact of intervention and planning and the type of flooding it tackles along with the built environment existing and potentialities for transformation of the same.

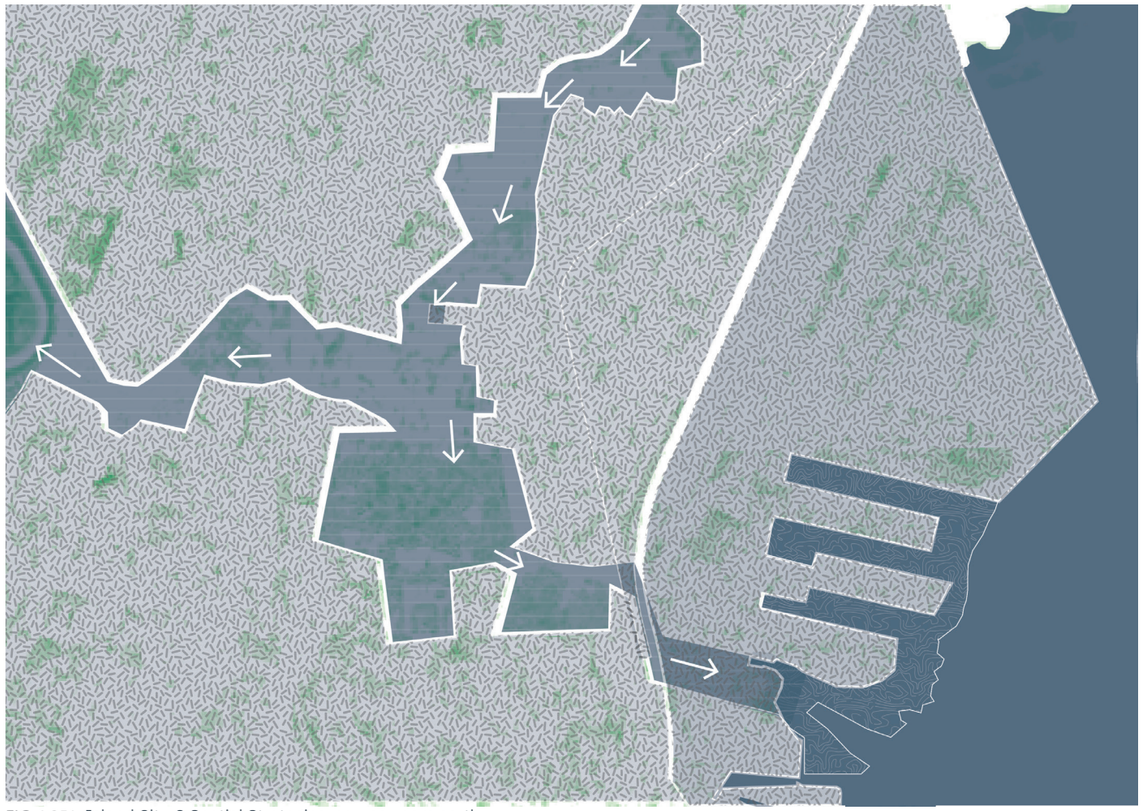


FIG. 1.251 Island City-3 Spatial Strategies .source:zoom earth

Micro scale

The area marked in circle is chosen to further design in detail and exemplify the interventions in the actual space to visualise the spaces created by the same along with possible synergies that would help in planning the interventions. This micro scale area includes a diverse arrangement of built typologies and public space configuration which would exemplify the integration of these strategies in actual space and place.The two strategies -Ecological Corridor and Capillaries are demonstrated in actual workability of actions and interventions in these areas. First demarcation of ecological corridors as mentioned earlier is necessary to interweave ecological elements like Urban forests, urban agriculture and water squares along with a pathway flanked with trees. The remaining area being the Capillaries would require urban regeneration or transformation. It would require incremental transformation into an adaptive neighborhood. This would require a blue -green network embedded in the whole neighborhood. The planning implementation of this transformation would be explained in a later chapter but the design of these spaces would involve green roofs or facades, permeable paving, removal of paver blocks and creation of green spaces wherever possible. It also includes retrofitting old factory roofs into urban farms or houses with roof gardens and promoting urban agriculture more and more in these areas. It also includes introducing water reservoirs in apartments buildings with podiums and highrise building blocks. Instead of multiple swimming pools, these complexes could design a water reservoir which could function as a recreational nano lake where water could be used for multiple purposes.

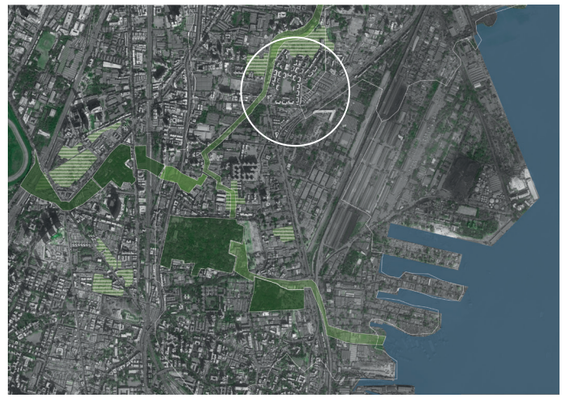
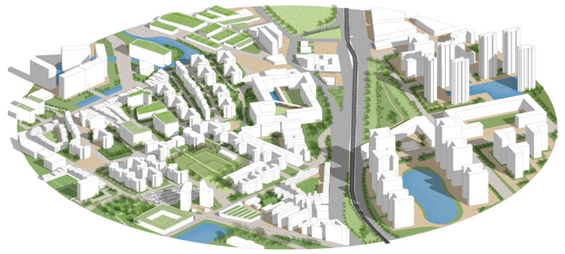


FIG. 1.252 Island City- micro scale .source:author





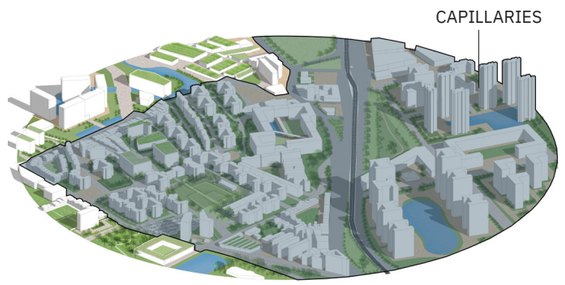
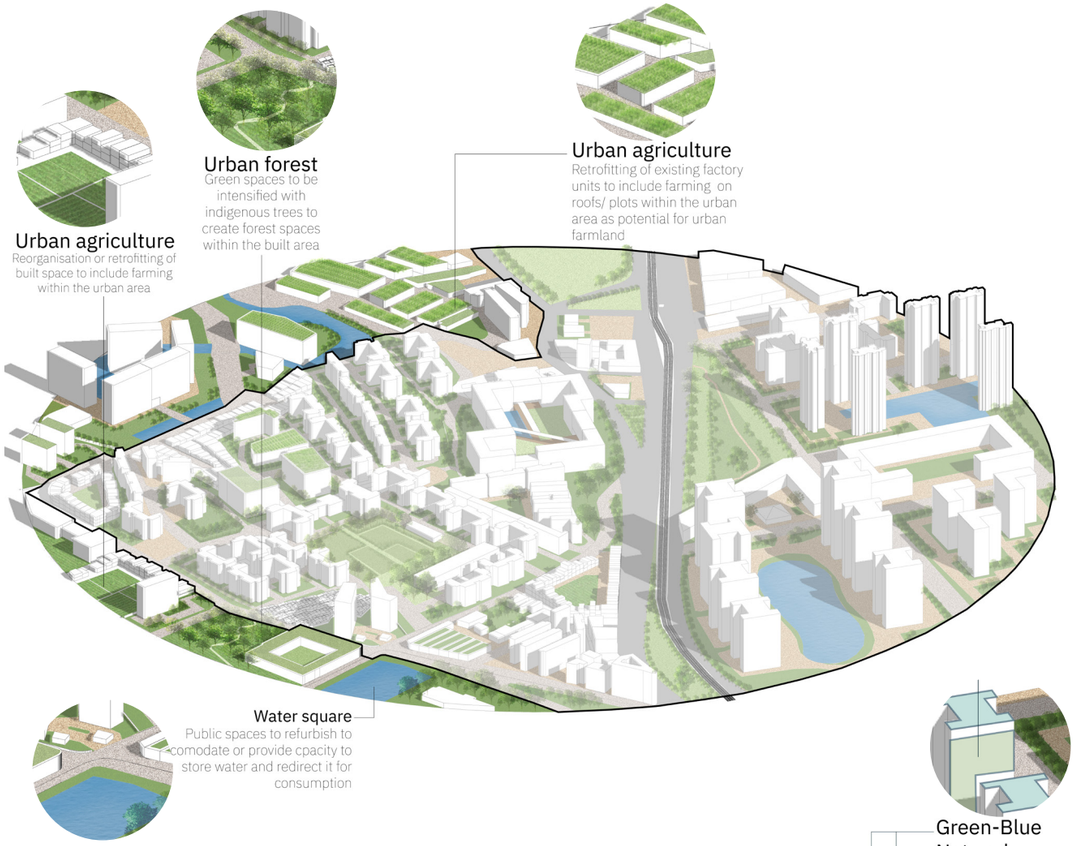
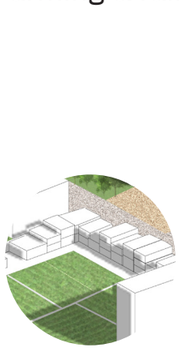


FIG. 1.253 Abstraction of the microscale .source:author
FIG. 1.254 Ecological corridor .source: author
FIG. 1.255 Capillaries .source: author

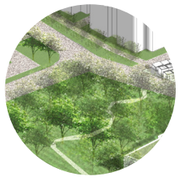


Urban Metabolism

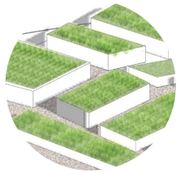
Farming & rainwater harvesting



Urban agriculture
Reorganisation or retrofitting of built space to include farming within the urban area



Urban forest
Green spaces to be intensified with indigenous trees to create forest spaces within the built area



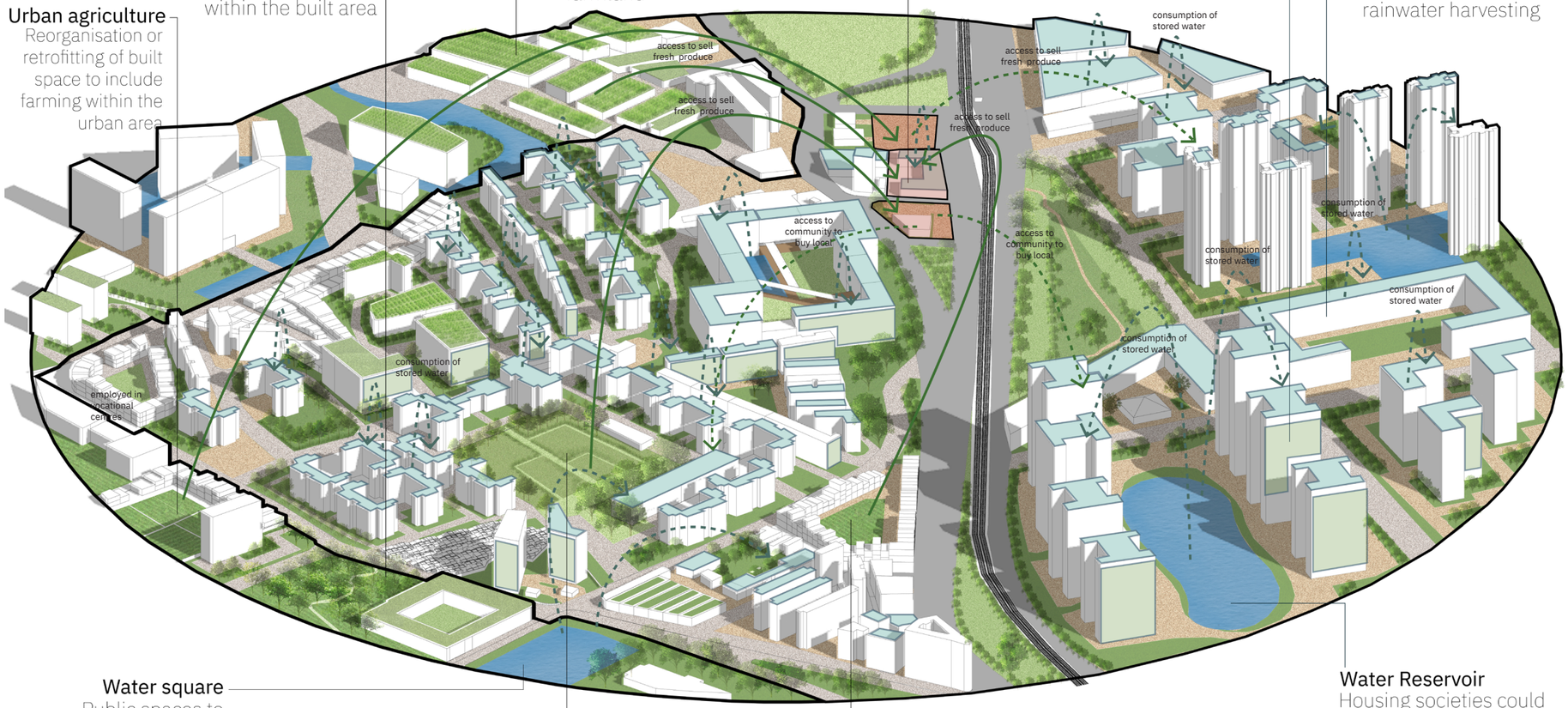
Urban agriculture
Retrofitting of existing factory units to include farming on roofs/ plots within the urban area as potential for urban farmland



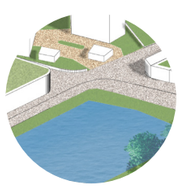
Farmer's Market
Local farmer's market space for the community to get together and sell their produce.



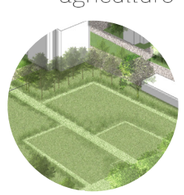
Green-Blue Network
Roof and facades as a potential for green roofs/ facades or rainwater harvesting



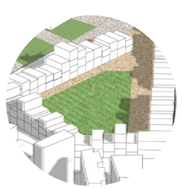
Water square
Public spaces to refurbish to accomodate or provide cpacity to store water and redirect it for consumption



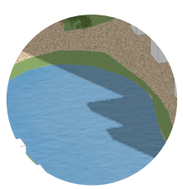
Community garden
Open/ public spaces could provide an opportunity for incorporating urban agriculture



Urban agriculture
Reorganisation or retrofitting of built space to include farming within the urban area



Water Reservoir
Housing societies could have spaces for collecting excessive rainwater which also serves as recreational space



Urban transformation of this area through the strategies of ecological corridor and capillaries would mobilise urban metabolics creating a socio-economic and ecological system interaction.The urban agriculture and community gardens and roof farms could provide possibility for fresh produce in the neighborhood. This provision of spaces for the local farmer's market would stimulate a new flow of products. Urban agriculture would further be promoted and city farmers would get access to market spaces where they can sell their fresh produce and on the other hand the residents of the neighborhood would get access to buy fresh organic food. Blue green networks would also stimulate a cyclical process of consumption, where water from the rain could be stored and reused by houses for various purposes. The green roofs/ facades could also present an opportunity to absorb water. This way the rainwater which on a concrete impervious surface would have accumulated and eventually led to flooding in the area ,is now stored, absorbed or drained through a water network in this area. Public spaces with large open spaces could be converted into water squares (De Urbanisten,Rotterdam) or large water reservoirs or rain gardens and urban forests which would involve large areas which collect , absorb or drain water. This would create ecologically sensitive recreational spaces and improve the liveability of the urban environments. It would also affect drastically on the heat island effect of the city as more green-blue spaces would reduce the overall land surface temperature. A lot of these interventions can create a circular chain of water.This could resolve two challenges at once, apart from tackling flooding, it would also tackle the challenge of water scarcity which is foreseen by experts in near future and is experienced by certain parts of the province already.

FIG. 1.256 Island City-urban metabolics .source:author

employment generation
access to market
Rainwater harvesting

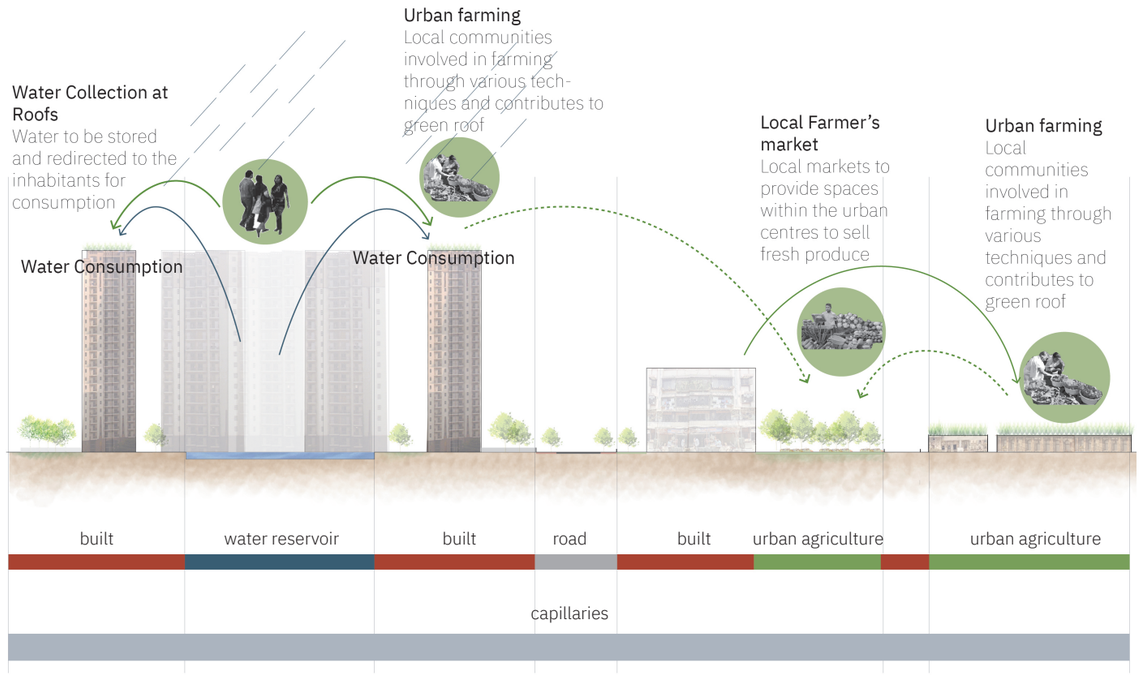


FIG. 1.257 Island City-section-urban metabolics .source:author

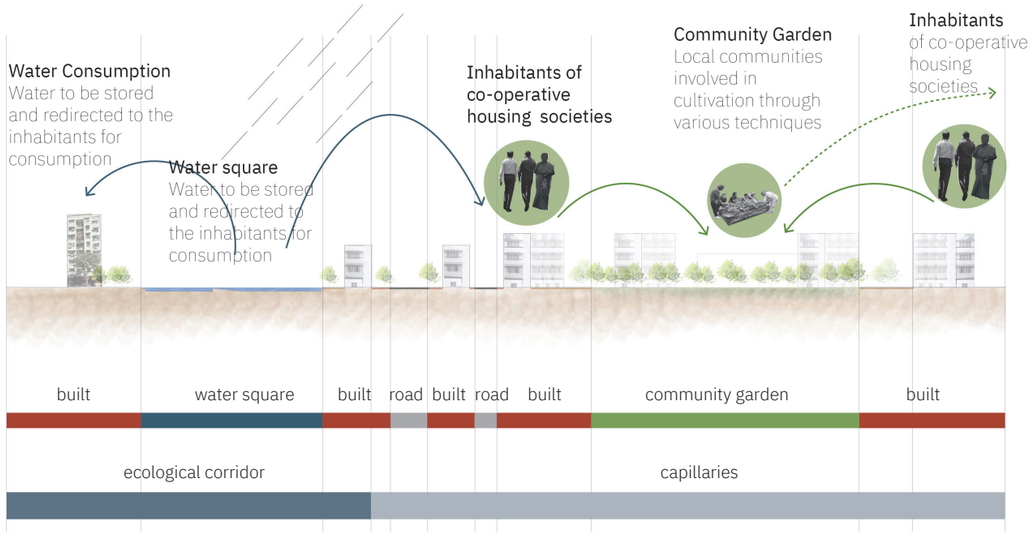


FIG. 1.258 Island City-section- urban metabolics .source:author

Macroscale

Synergies due to the strategies

The whole island city would require delineation of ecological corridors along with the remaining area to be phased incrementally into capillaries with increased adaptive capacity. The coastline of this area would either be mangroves or sand dunes. Recreational beach areas would involve transforming it into sand dune beaches which would add a multifunctional layer to this urban landscape. The Old Port Area would create a large water sensitive neighborhood block which is newly constructed and is oriented towards ecological infrastructure. The future in this area also presents an opportunity for promoting water infrastructure for transport and that could eventually lead to decreasing the number of roads in this area in future and giving it up for a water network of canals.

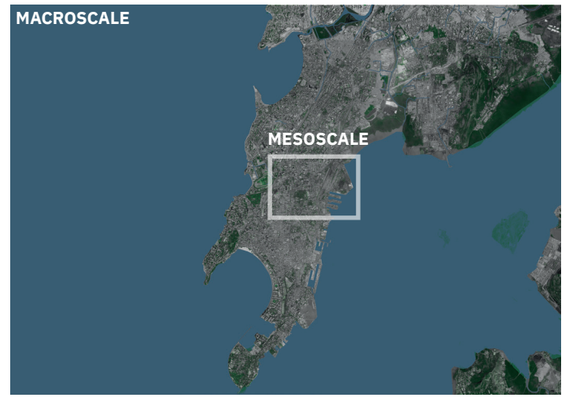


FIG. 1.259 Island City-macroscale .source:zoom earth



FIG. 1.260 Macroscale-ecological corridor .source:zoom earth

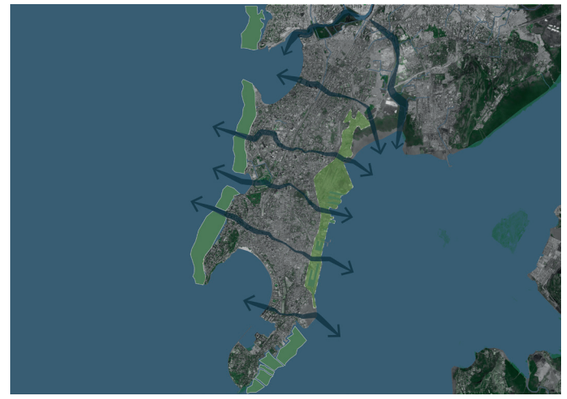


FIG. 1.261 Macroscale-coastal protection .source:zoom earth



FIG. 1.262 Macroscale- transport infrastructure .source:zoom earth

14.

Planning framework

Actors, institution, processes and instruments

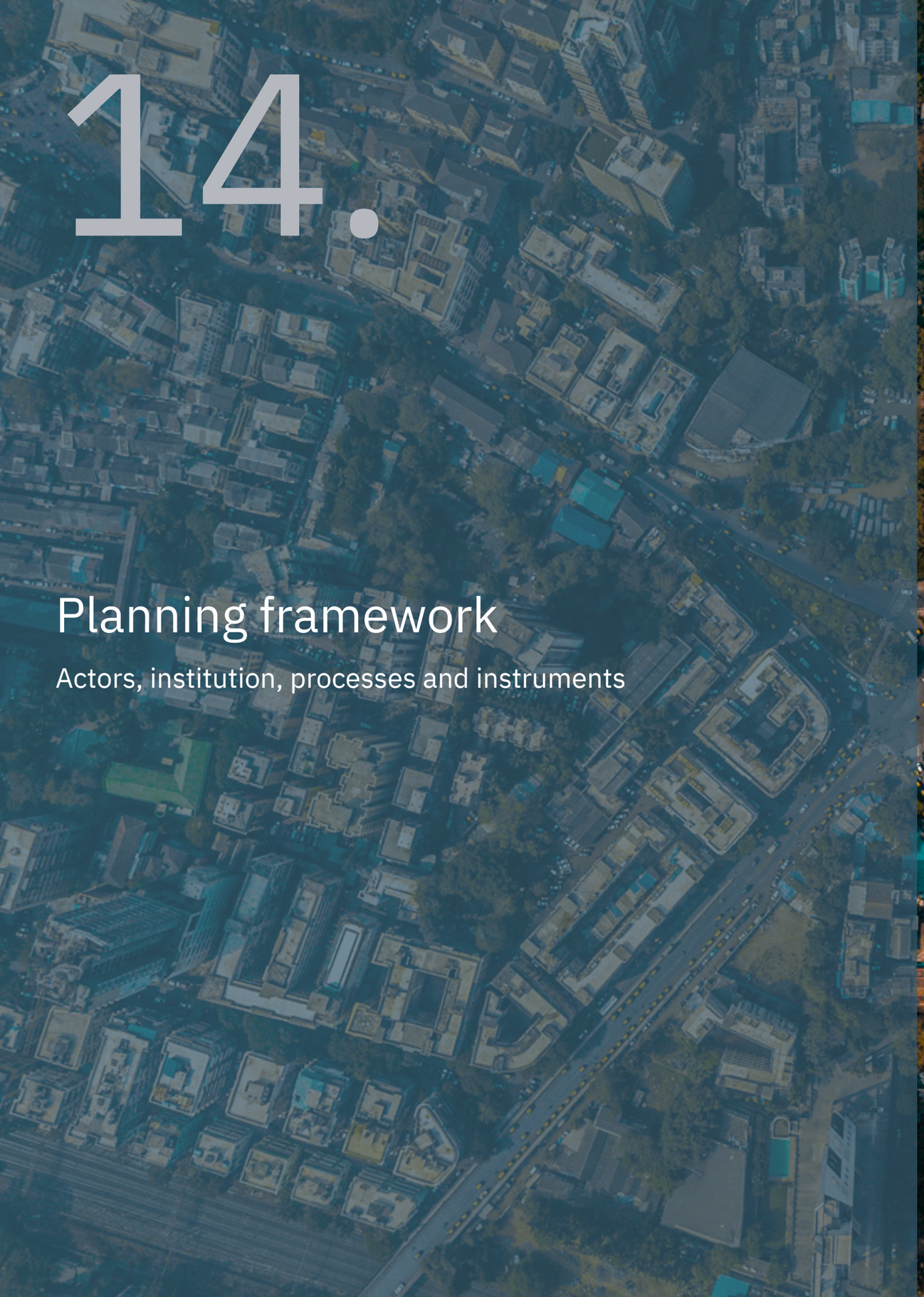




FIG. 1.2.3 Island City .source:zoom earth:NDVI

Introduction

Design and planning dialectic is not dichotomous or chronologically separated. Both planning and design influence and evolve each other in the whole process. The realisation of the strategic regional design at multiple scales would require a comprehensive plan formulation to understand and break down the complexity of the situation and effectively implement these strategies in the city. Planning involves multiple actors -public, private and civic sector in different steps of the process. This requires formulation of timeline for various steps/stages with engagement points and purpose for processes. This coordination and negotiation with stakeholders requires careful consideration of planning instruments at hand that need to be implemented to achieve an inclusive effective outcome at each stage of the process. This chapter would give an overview of the aspects of planning necessary to be understood and taken into account to realise spatial strategies for adaptation in the city of Mumbai, India. The author suggests a collaborative planning framework with effective implementation of planning instruments to promote ecological infrastructure in the city and adapt the city to tackle flooding in future.

STAKEHOLDERS

GOVERNANCE STRUCTURE & PROCESSES

PLANNING INSTRUMENTS

TIMELINE

An excerpt from Collaborative Planning,Patsy Healey (2006) :

'Spatial planning touches us through many dimensions, whether we move through local environments in our daily routines, or select where to live, send the kids to school or look for work. As we look out to the world, and to the environments through which we move, we view them from the point of view of our life strategies. What opportunities are there, what constraints and oppressions, what resources can we reach and how are we frustrated? Managing our existence involves complexity and activities at a multiple time scale- daily and weekly routines, yearly patterns, career and personal development trajectories and generational time. As we think about what we need and what to do, we discover layers of 'stakes' in places- places to live, places to work, to go for holidays, places which symbolise aspects of our identity and culture, places we fear. '



FIG. 1.264 Mangroves near Borivali,Mumbai .source:author

Stakeholders

Any spatial plan or action in the city has an effect at varying degrees to multiple actors. Thus planning process should involve organisations or individuals who have a stake in or could possibly influence the project. In order to effectively plan and implement the adaptation strategies in Mumbai, a careful assessment of various actors involved would be necessary along with an understanding of the mutual benefits to strategically design engaging mechanisms. There are multiple classification tools, but the author would incorporate the approach developed by Murray-Webster and Simon in 2008 which develops 8 typologies of stakeholders. (Murray-Webster and Simon, 2008) Based on the fieldwork and secondary research, actors are assessed based on the extent of power, interest and support for the objective to mobilise the plan and design in action. This helps to design the planning process to target the key stakeholders and design engagement activities and instruments to achieve the aim of the project.

A framework for ‘communication, coordination, collaboration and cooperation’ is important to facilitate the implementation of the projects which can be divided into five broad steps of stakeholder engagement, these include -Identify stakeholders, stakeholder analysis- power, interest and support, planning engagement to achieve the objective, engage, review progress and re-engage to make further progress.

In order to develop and implement the strategy for adaptation, the planning authorities of the city along with the State and National authorities would be important stakeholders to be taken into account. Public sector actors would also incorporate global organisations like the United Nations, World Bank along with the Environmental and finance Ministry at the national level. It also requires the support of private sectors like financial institutions, private corporations, banks, small, medium and big businesses. Research Institutes, think tanks, universities or academic institutions would help in developing the necessary knowledge, skills and expertise for the approach. In the civic sector, environmentalists, relevant NGOs, cooperative housing societies, slum dwellers, fishermen, and overall support of the citizens would generate the necessary momentum needed to tackle this challenge.

The classification model has a division of two blocks for each of the three categories which

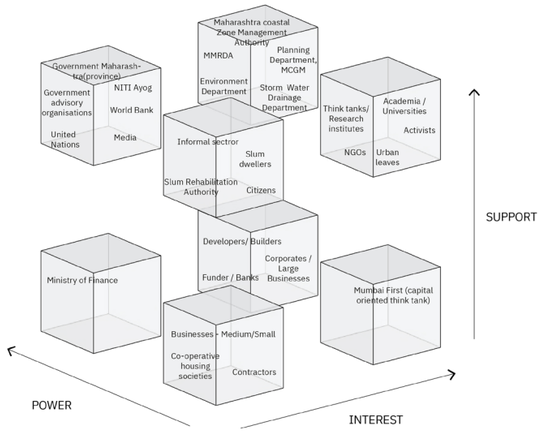


FIG. 1.265 Stakeholder cube analysis.source:author

include actors with active or passive interest, influential or insignificant actors and actors who would be backers or blockers when it comes to the support/ attitude to the objective. This process of classification distinguished the key stakeholders which firstly constitutes people with a higher power, higher interest and higher support. But it also includes organisations/ individuals who are influential but could be active/ passive-blockers and actors with active interest and positive support but are not in high power as they could be the voice



FIG. 1.266 Benefits of stakeholders.source:author

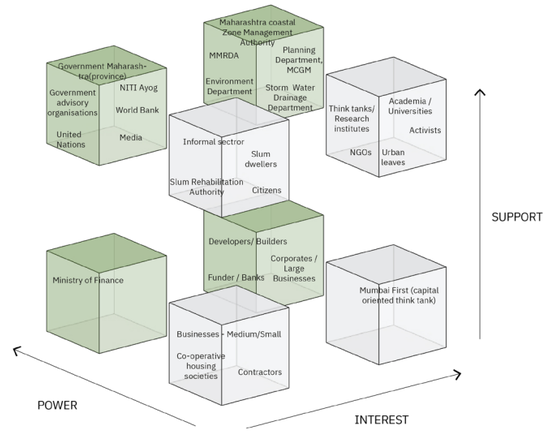


FIG. 1.267 Stakeholders with high power.source:author

for the objective. This would help to define critical strategies that would persuade significant actors to increase the mobilisation capacity of the project and play an instrumental role in aligning the necessary resources for the same. It is important to note in this classification that the reality of this classification would be different at different points of the project, also it would be challenging to classify actors per category in two types as there are gradients of power, interest and support of actors. However,

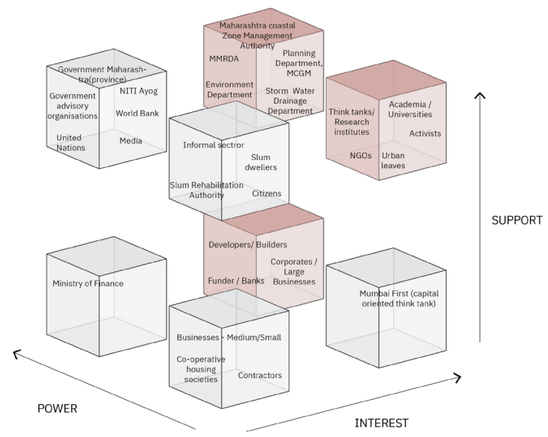


FIG. 1.268 Key Stakeholders.source:author

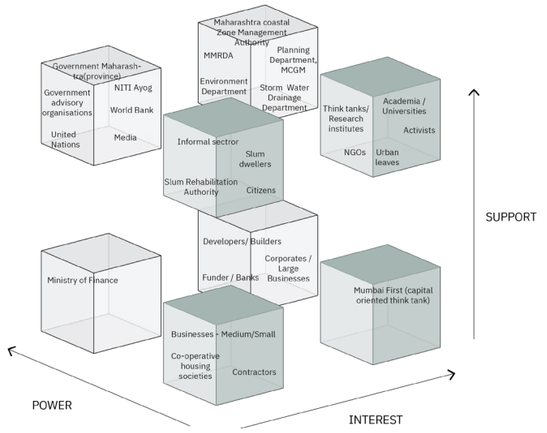


FIG. 1.269 Stakeholders to be empowered. source: author ssos

this classification would make this complex task of engagement into a more systematic and effective process.

‘Adaptation requires a fundamental shift in how cities make their decision.’(Bapna, 2020)People living in poverty and marginalised groups should be a part of the decision-making process since they are the ones who get affected the most in the event of flooding. They must be engaged in decisions to develop the design and plans to adapt their direct area of influence. These actors need to be empowered with the necessary information and tools to adapt to the changing climate. (Bapna, 2020)Including these communities would channelise the social capital in an inclusive way, also the traditional knowledge of such communities to deal with flooding like in the case of fishermen in Dharavi could provide techniques that could be upscaled and institutionally implemented for effective outcomes. Through this inclusive approach to resilience, the Municipal authorities would not only safeguard lives but the benefits would transcend to other challenges that the city deals with.

Apart from each actor having different interest, power and support for the project, there are certain overarching benefits provided by the Public, Private and Civic sector actors separately The next section identifies benefits to and by each sector exclusively that could inform strategies to persuade these actors.

Stakeholders

Stakeholder and benefits

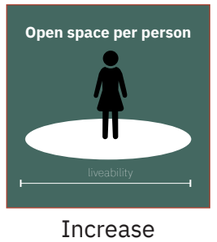
‘The State’

Desired : **promoters - support - collaborate**

Why? ***Acceptance & sustainability***

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

This represents the Public sector stakeholders which in this case would primarily be Planning authorities. The major benefit of this actor is to ensure effective implementation of the spatial plans and strategies through policies, regulations and other planning instruments. The authority ensures acceptance of the strategies in the political system and holds accountability for people to know who to contact incase of violations or queries.



Increase recreational spaces



Opportunity for slum upgradation



Improve image of Mumbai city



Income generation



Expenditure/ investment at risk



Flood protection



Improve biodiversity

The State would benefit in multiple ways by the implementation of this adaptation strategy. Firstly it would be a frontrunner in immediate scalable actions for adaptations to climate change thereby contributing to the sustainability goal of Climate Action. Also in terms of goals linked to UN sustainable development, this would benefit by the creation of jobs related to this nature-based solution, it would combine economic growth with the solution to changing climate instead of getting adversely affected by the changing climate and losing money to climate damage control. The promotion of ecological elements in this process would improve the biodiversity, most importantly the quality of marine life in the Arabian Sea. Job opportunities, growth in income, availability of affordable housing solutions, the opportunity for slum up-gradation would contribute to reducing the inequalities in the society. A resilient city would improve the image of the city, and provide it with a new identity. This approach would increase the open spaces in the city per person and improve liveability for the inhabitants of the city. Adaptation would safeguard the vast infrastructure investment in other amenities by the city.

‘The Big Business’

Desired : **support - collaborate - involve**

Why? ***Economic efficiency***

- cost saving
- broader benefits

Social cohesion & equity

- fostering corporate social responsibility

This represents the private sector stakeholders of the society but framed in the narrative of the private companies with resources that could be channelised immediately into ecological infrastructure development for adaptation. Generally, these actors are highly focussed on the socio-economic system but present an opportunity to be involved and collaborated with the public sector for economic efficiency and social cohesion to combine economy with ecology for a resilient future of the city.



Economic investment at risk



Economic benefits



Economic benefits



Social responsibility



Economic benefits

Mumbai being developed as a global city would require investments to be distributed such that this economic future is sustained. This could be achieved through investment in adaptation through an ecological infrastructure which would firstly require 3-5 times lesser investment as compared to hard physical infrastructure solutions and make the city resilient to future. With the world acknowledging the impacts of anthropogenic activities on climate, the current economic system more reliant in investment in exacerbating the conditions needs to shift to a system which understands the future conditions and prepares and grows in this process of adaptation. With new financial models that are being aligned with these efforts (e.g. ‘Pay for performance’) these ecological infrastructures could present the future of market investments. With state-of-the-art technology being developed to monitor and quantify the mitigation and adaptation by these ecological elements, it would be beneficial in the long term, not only existentially but also financially. Further benefits would be explained in detail in the ‘Fiscal Instrument’ section. With an unequal distribution of costs and benefits, it also becomes a social responsibility of the privileged few to share these benefits amongst all.

Stakeholders

Benefits for the stakeholders



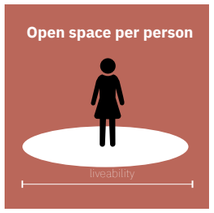
This represents the Civic sector of society with organisations and individuals who are part of the city. For the generation of active momentum for this strategy, these actors should be informed, consulted, and empowered in the process to generate capacity and develop knowledge along with social cohesion and equity. The inclusion of this sector would build trust and confidence of the people in the efforts and also contribute to knowledge and raising awareness for a crisis which demands immediate action.



Flood protection



Opportunity for economic growth



Improve liveability

Expenditure/ investment at risk

Flood protection

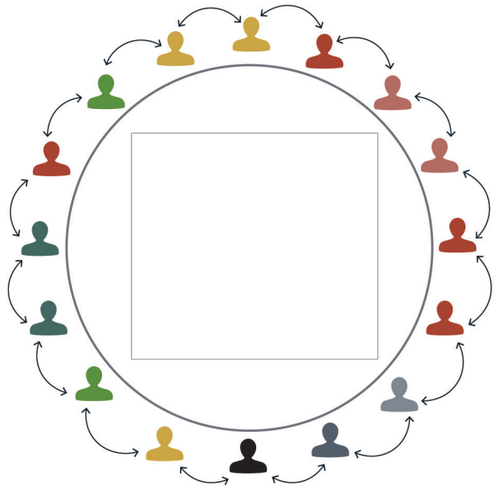
Improve biodiversity

The adaptation to flooding would primarily solve the immediate annual problem of the people of the city as their everyday life is disturbed in the monsoon season due to flooding. The implementation of this strategy would safeguard the life and livelihood of people from the threat of future flooding but also present other benefits due to the inclusion of ecological infrastructure in this approach.
This solution provides food, jobs/ livelihood; sustains cultural traditions; and offer health and recreational benefits. (Cook,2020) It creates a more liveable environment in one of the densest cities in the world and provides a habitat for biodiversity as well. Changes in climate would affect every sector in varying degrees, it would risk the current investment in these sectors and its sustenance could only be ensured with adaptation to the future. This approach understands the social structure of the city and responds to uplift and improve the living conditions of the slum dwellers of Mumbai as well. It provides them with opportunities to improve their living conditions through job creation and economic growth.

Stakeholders

Engagement/ Participation processes

Spatial planning system needs to be developed to a collaborative approach which addresses the concerns of the multiple stakes in relation to a spatial transformation and should reflect the society's capacity for collaboration across diverse interests. 'The planning processes need to work in ways which inter-relate technical and experiential knowledge and reasoning, which can cope with a rich array of values, penetrating all aspects of the activity, and which involve active collaboration between experts and officials in governance agencies and all those with a claim for attention arising from the experience of co-existence in shared places. '(Healey, 2006)
The planning system needs to create arenas with relational webs which constitute of formal organisations and informal relationships through which collective actions with respect to a set of concerns is accomplished. (Healey, 2006)
The system of engagement of these multiple stakeholders needs to be systematically organised and planned to enable effective outcomes at each moment of the process. Each engagement or participation process needs clear agenda-setting that defines the purpose -whether it is information dissemination, consultation or active participation. Regional, national and local governments, development agencies and NGOs, scientists and companies are increasingly eager to reap the benefits of actively engaging in decision-making processes diverse perspectives and those who will be affected by policies. (Elliott et al, 2005) The participation toolkit manual describes methods to engage different participants which are based on the key 5 aspects of the session. Firstly the objectives where the reason for involvement and expected outcomes are defined. The second involves the nature and scope of the issue at hand with regard to the knowledge, complexity, maturity and controversy. Thirdly, defining the participants for the event, but that would be taken into account with the budget, time and scale of the project.
When implementing the three strategies, firstly the planning authorities would require collaboration with technical experts in ecology, hydrology, climate data modelling and spatial planner who could define the draft proposal of the strategic zones. This would be an iterative process with the inclusion of other experts and community participation. The planning process of each corridor and capillary would require community participation along with prospective financial investors who would benefit this process. Different phases of the process would generate different participation configuration using multiple instruments like workshops, meetings, surveys, deliberate polling, expert panels, focus groups, scenario building exercises and expositions or popup labs. These phases occur at different timeframes to accomplish varying tasks like designing the plan, planning the design, creating consensus, capacity building, resource allocation, implementation and assessment which leads to the development of a timeline to efficiently plan the process.



Timeline



FIG. 1.270 Steps in planning .source:author

Time is an unseen territory of design and vital zone of intervention where different processes
and projections converge, coincide, and collide. (Bacchin, 2015)
It is important to understand and plan the processes of planning as well. Broadly the process of adapting Mumbai to tackle flooding could be categorised into 5 steps which would be iterative and simultaneous.
1. Assessment
2. Design/Plan
3. Capacity Building
4, Execution
5. Evaluation & feedback

The first step would involve a comprehensive assessment of the risk, vulnerabilities, impacts, technical knowledge and exploration of flooding scenarios in compliance with the possible emissions in the future. It would include assessment of the hydrological and ecological performance of the ecological elements in the city with the inclusion of all possible impact layers. For the purpose of this project, only critical layers were taken into account but the actual project implementation would encompass a detailed assessment of all the parameters to indicate performance. It would entail the assessment of possible collaborators as well at different points of the process. The second step includes the design of the ecological corridor, capillaries and coastal protection while addressing the concerns of the multiple stakes. It would include collaborative planning with the community where the details of the engagement processes can be further defined in the process alongside experts. The third step is a horizontal and vertical collaboration where different mechanisms, tools for participation along with identification of participants to be involved would be developed. This should happen immediately, right from the commencement of the project. Vertical collaboration would also be orchestrated to produce successful outcomes. The fourth step is of implementation which involves phase by phase design and execution alongside planning instruments that would support the same. The fifth step is the 'Assessment' which needs to occur periodically at crucial moments and act as a feedback loop to review any changes necessary for the smooth functioning of the project. It is essential for planning to understand 'adaptation pathways' as climate change involves a certain extent of uncertainty and planning should include this level of flexibility to choose a different adaptation pathway if the realities and results vary at different points of time. Therefore planning framework should itself be adaptable to changing spatial realities and processes.

Dynamic Adaptive Policy Pathways: supporting decision making under uncertainty using Adaptation Tipping Points and Adaptation Pathways in policy analysis

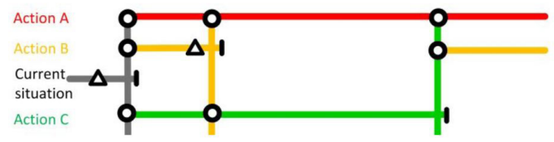


FIG. 1.272 Adaptive pathways. source : author

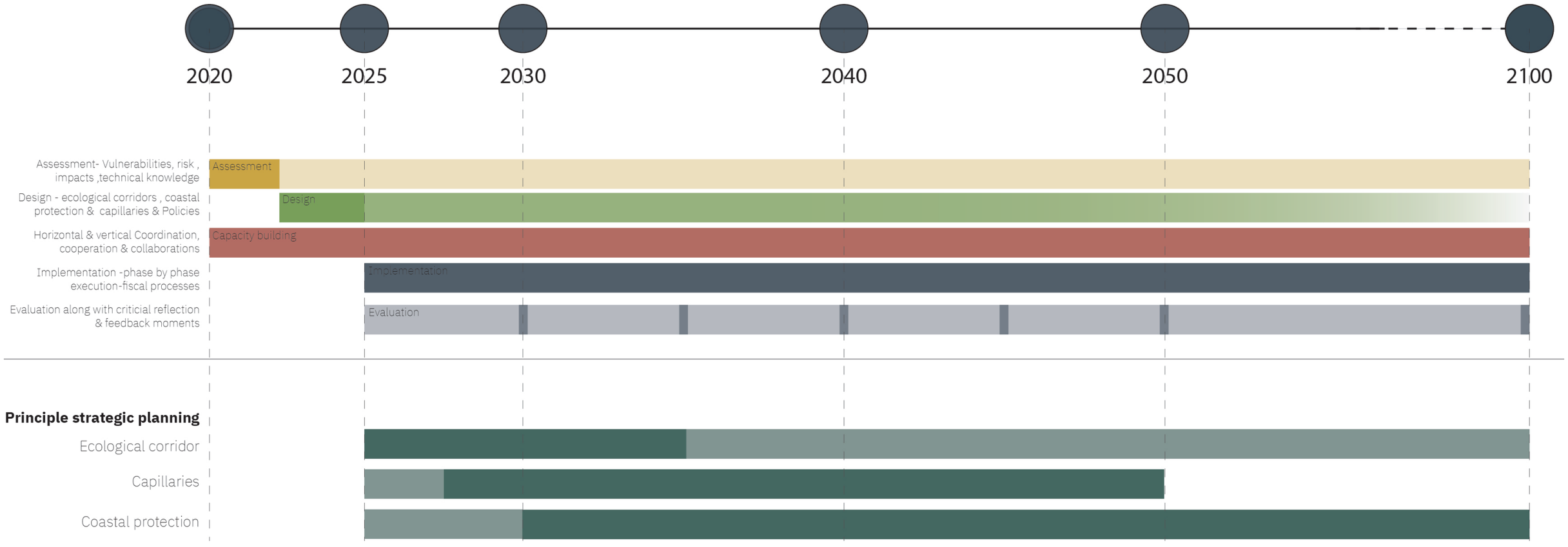


FIG. 1.271 Timeline of the Spatial stategies planning . source : author

Timeline

Phasing of Ecological Corridors

The timescale of the strategies would require prioritising first the Ecological Corridors, Capillaries and then the Coastal Protection based on the short term and long term response to future flooding. Furthermore, the Ecological Corridors would require a hierarchy of planning phase based on the urgency and priority of each one of them. The first phase would involve the critical corridors which would have a larger area of impact and lie in the most vulnerable areas of climatic risks,e.g. the Mithi River Ecological corridor. This corridor would have a wider scale of impact as it runs like a central spine through the dense urban environment of Mumbai. There would be a gradient of prioritisation for each of the Corridor. The island City would have the central corridor being planned which could lead to the incremental planning of the other corridors as the success of the first phase would mobilise popular support and more financial resources to speed up the further process. Each corridor in itself would further be planned into sub-phases of development based on the ancillary arrangements for its implementation like land ownership, community participation, political negotiations, financial arrangements, impact assessment and other necessary tools. The current fluvial and pluvial flooding spots are the critical determinants for prioritising these Ecological Corridors along with the current physical infrastructure that is supporting the adaptation to flooding. Therefore after Mithi River ecological corridors, the other three rivers- Dahisar and Oshiwara and Poisar need to be taken up chronologically based on priority and then the other corridors based on the climate impact assessment. Following a comprehensive timeline, the Corridor strategy can be laid out completely in the region by 2100 to achieve adaptation to flooding.

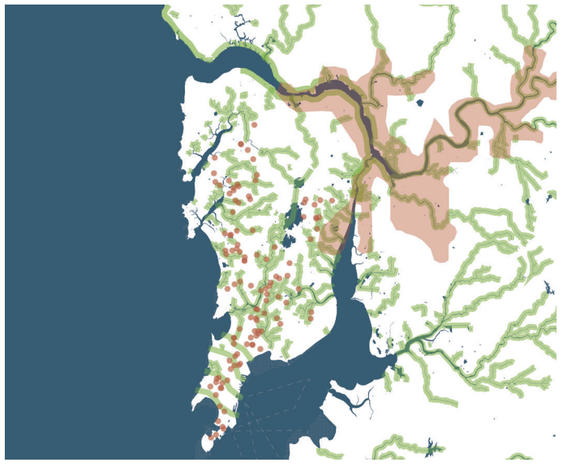


FIG. 1.274 Criticial flooding points .source:author

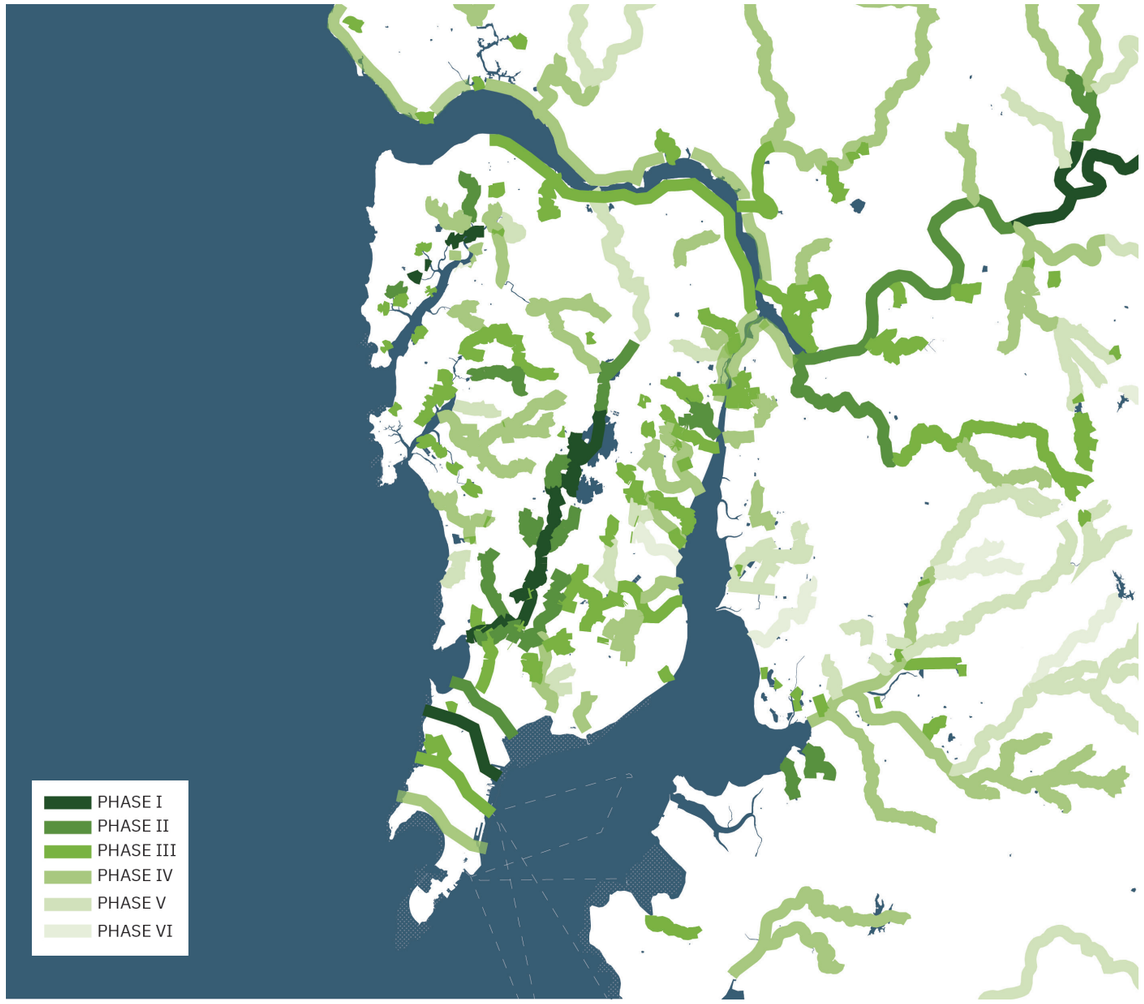


FIG. 1.273 Timeline for Ecological Corridor .source:author

Phasing of Coastal Protection

Planning for Coastal protection could begin at an early stage but it could get an extended time period for mobilising resources as the implementation actions for this strategy is not immediate since it is a response to coastal floods which is not an urgent climatic risk. This strategy would also develop phase by phase based on the risk assessment and a response to the most critical areas on the coastlines along with the most marginalised population.

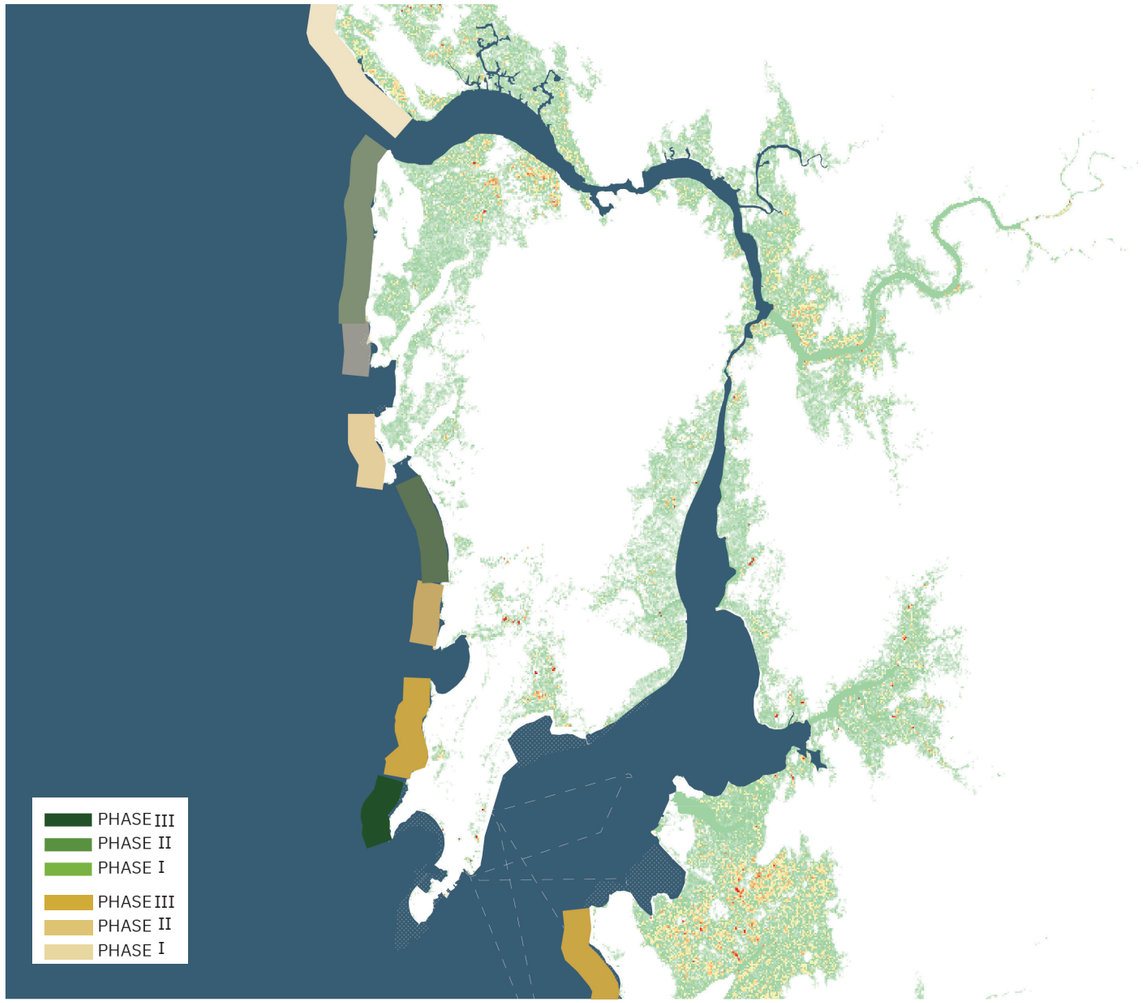


FIG. 1.275 Timeline for Coastal Protection .source:author

Timeline

Phasing of Urban Capillaries

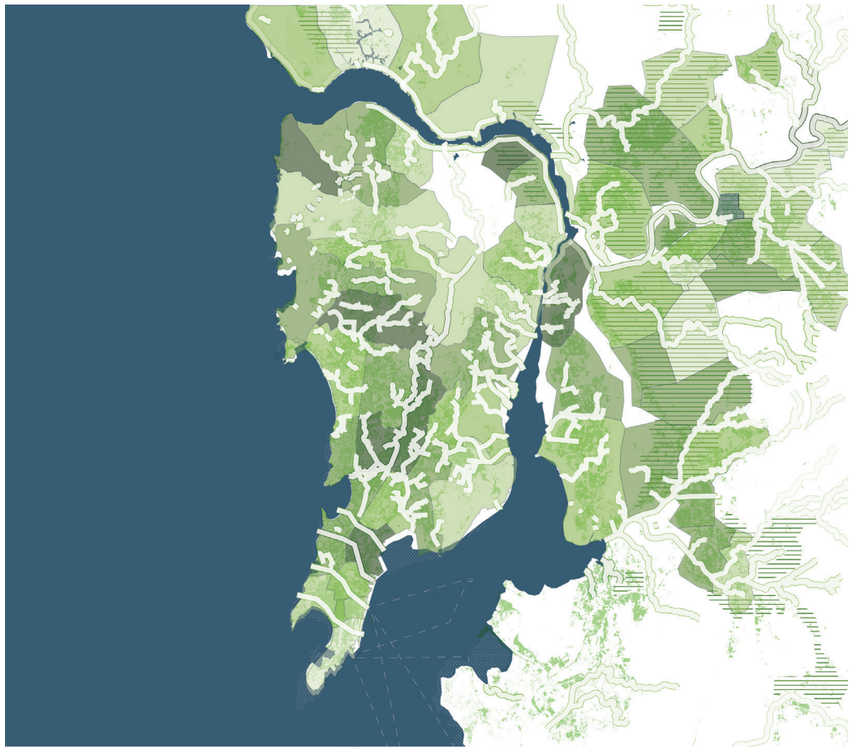


FIG. 1.276 Timeline for Capillaries based if wards were the area unit .source:author

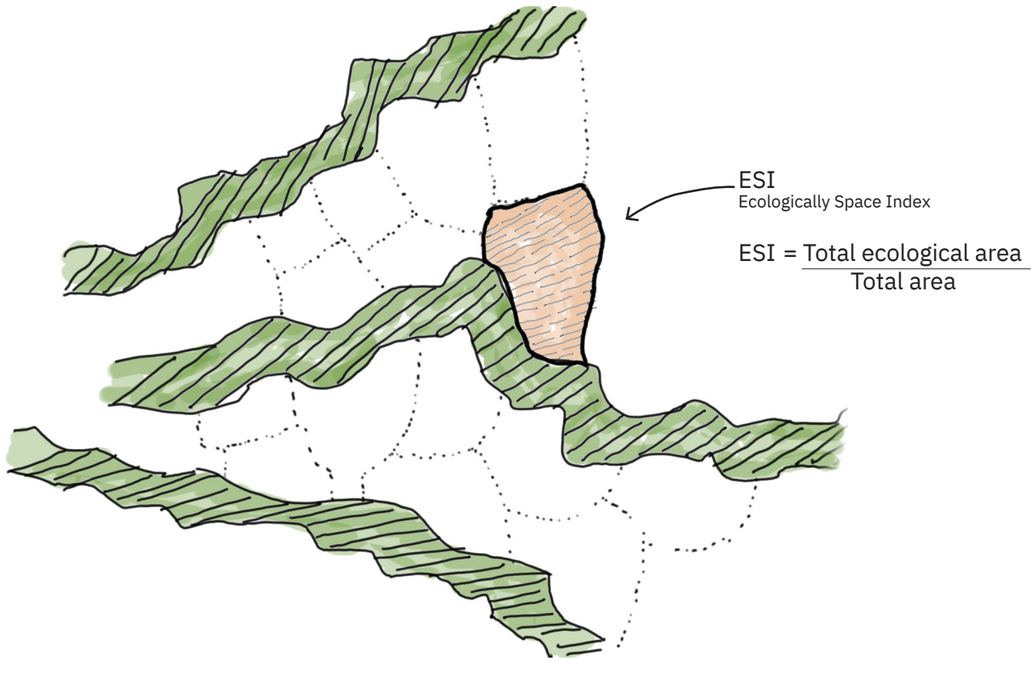


FIG. 1.277 Concept of Ecological Space Index .source:author

The capillaries need policies and dissemination of strategic planning instruments that need to be formulated and implemented at different time intervals to incrementally capacitate the neighbourhoods to flood resilience. In the case of Capillaries, an introduction of the concept of ESI- Ecological Space Index could provide a shift in urban planning to orient itself towards ecological infrastructure. This concept works similar to the principle of FSI, Floor Space Index where the permissible built area is defined for a specific plot or a given area. The intention was to limit the building height and footprint of the area to allow open space and improve liveability. However, only defining the built area lead to concretised open spaces or permissible structures with certain functions which do not provide any added benefit to the liveability and ecological aspect of the urban environment. In order to maximise benefits developers searched for loopholes in the policy and exploited ground floor space as podiums or commercial area in some cases to get an increased FSI, but in this process, the idea for compact and 'liveable' urban areas got lost. Therefore the addition of ESI could present an opportunity to ensure the aim of creating green open spaces to facilitate liveable healthy urban environments. Ecological Space index could be defined as the ratio of total ecological area upon the total area of the block. Here the blocks could be defined as wards or small neighbourhood blocks based on a further assessment of the workable area to determine performance and planning. If we consider the wards as the unit to define ESI. Each of the wards would have a mandatory ecological space necessary to adapt itself to the future, thereby determining the ESI. The Municipality of Mumbai together with the wards would allocate ESI to each of these wards and the wards would prepare a timeline target plan to transform its area completely until 2050 to achieve its target ESI. Each ward would then along with its community develop this timeline through spatial actions over the course. Community participation could help in identifying possible spatial interventions to incorporate the necessary ecological area and adapt the area to withstand future risks. In some cases, local and indigenous communities like the fisherman of Dharavi would have ample understanding of Nature's value for people.(Cook, 2020) It would help in developing the policies and provisions necessary to enable these transformations. Municipality of Mumbai could also provide incentives for the wards to achieve their targets within the timeline. This concept could help in translating the Capillaries strategy effectively in the City and develop the adaptive capacity the urban environment needs.

Fiscal Instruments

Economics of Climate Adaptation strategy

Policymakers need to understand the value of ecological infrastructure. The investment in ecological infrastructure not only generates ecological benefits but also provides the opportunity for an increased value chain. For instance, mangroves provide a natural flood defence which proves to be two to five times cheaper than the creation of large concrete walls. The average cost of Mangrove restoration is about 0.01$ per square foot, which is far less than the cost of the built infrastructure. Also, that would have a significant impact on carbon footprint to create concrete blocks, transport and its construction. Mangroves at the same time also reap other benefits like fisheries and tourism. Research by the Global Commission on Adaptation found out that the net benefit of protecting mangroves globally is 1trillion $ by 2030.(Cook, 2020) The significance of the nature-based solution in adaptation is the 'way to go' in the future.

A recent study by a Research Institute in India reported that if the projections of IPCC come to fruition,climate-related factors could cause India's GDP to decline by up to 9%. The Agriculture patterns would be severely affected, along with a large displacement of over 7million people due to submersion of parts of Mumbai and Chennai. ( ) Therefore India having the world's highest social cost of carbon needs to muster all its resources to protect itself from such an irreversible loss. The Municipality of Mumbai which is the richest civic body in the country needs to set an example to



channelise ample resources in the integration of ecological infrastructure in its urban development. Currently, it is spending billions of Indian national rupees(INR) in infrastructure projects without the inclusion of adaptation in its planning. The lack of adaptation integration in the planning of Mumbai would lead to billions of INR into threat and post-flooding, would damage these infrastructures and would add to the damage relief costs.

Climate risk also poses a severe threat to the assets and supply chain of companies which would cause a huge financial setback. The global city dream would literally be washed out if most of the parts of the city get submerged in water based on the IPCC projection if the temperature rises by 2 degrees. A sense of urgency is imperative and the business community needs to lead the way to a climate-resilient city as it has the power of capital to fulfil this mission. (Mumenthaler, 2020) A risk assessment is of utmost importance for the companies to be aware of the total climatic risk that it is exposed to. It needs to be equipped with tools to carry out a loss assessment and a cost/benefit analysis to steer its attention to the potentialities of ecological infrastructure investment which could safeguard both the company's and the city's future. 'Investment in nature can be one of the most effective adaptation measures in the fight against climate change.' (Scotti, 2020) This points out to the responsibility of the decision makers to incentivise and steer the economic system shift towards the ecological system for multi-layered profits by reorienting policies, subsidies and public investment. They can also incentivise private investors to finance adaptation projects and explore funding opportunities and implement multiple financial models as highlighted by the report by Goldman Sachs which mentions financing urban adaptation would likely require an 'all of the above approach'.(Goldman Sachs Group Inc, 2019)



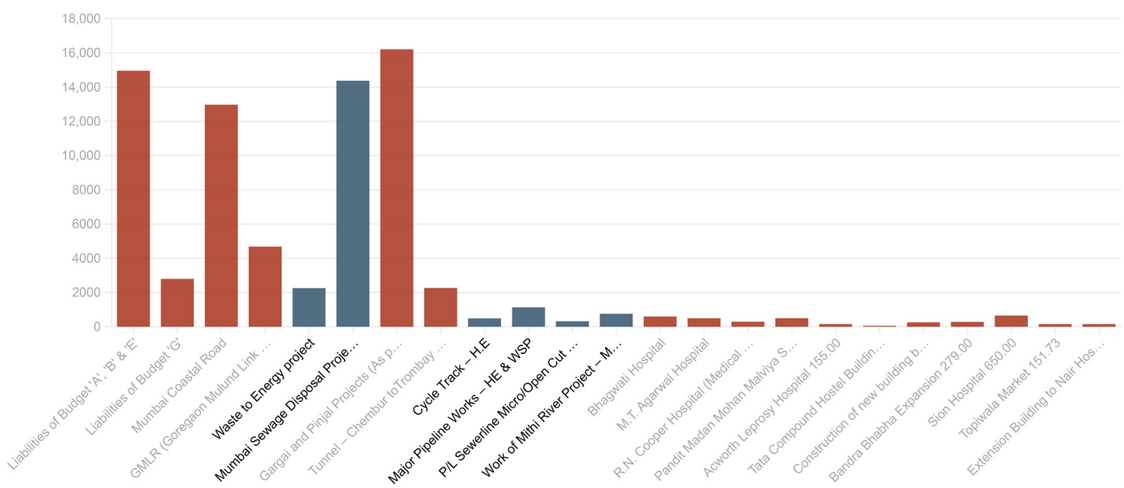


FIG. 1.278 Graph shows the infrastructure investment by the Municipality which is at risk if adaptation is not incorporated in planning .source:author based on the Budget 2019-20 MCGM

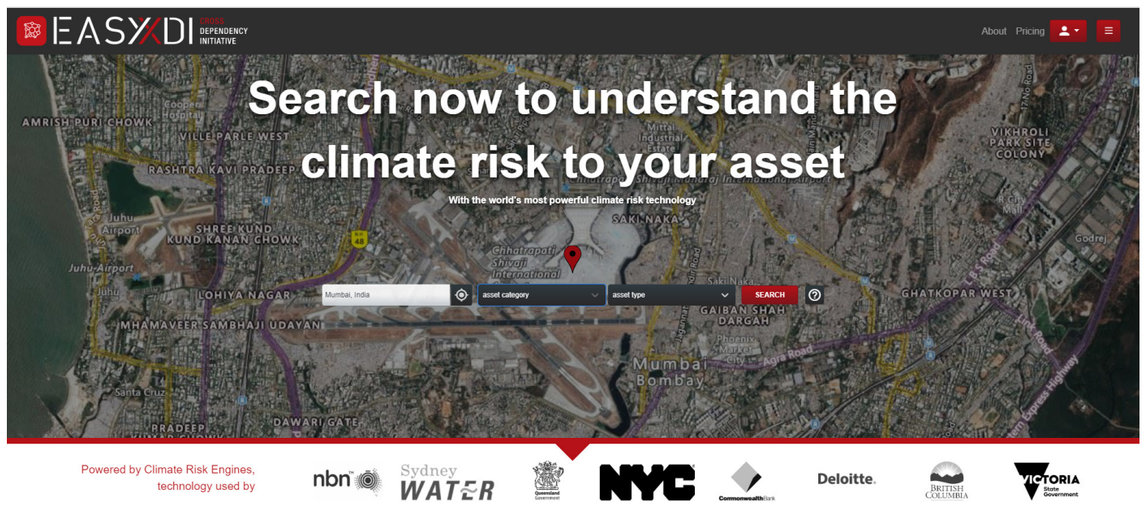
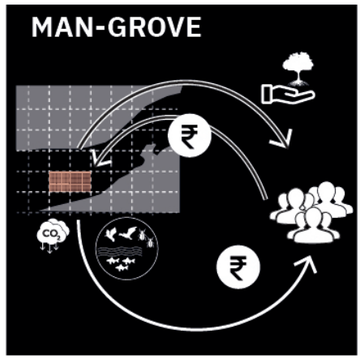
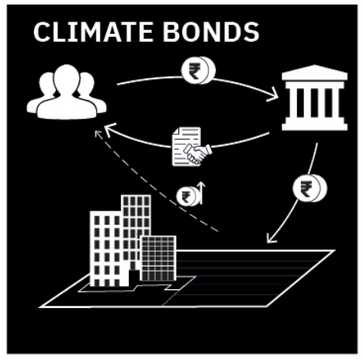


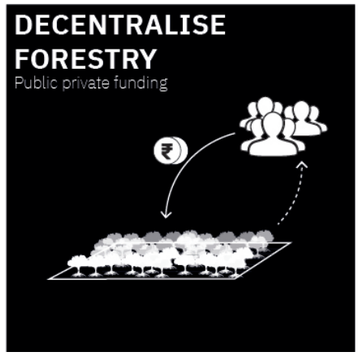
FIG. 1.279 Example of a website showing company or house location in conjunction withecological vulnerability. source: easxdi .source:easyxdi

Fiscal Instruments

Significance of Mainstreaming Climate Adaptation



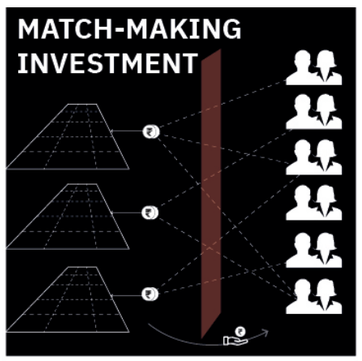




MAN-GROVE: Man-grove would be a financial model where the bond between people and mangroves is strengthened. In this model, the area of the mangrove is divided into grids of 50mx50m or even smaller grids and is open up for people to buy these plots of mangroves. Man-grove would be a portal with satellite imagery technology which could monitor the growth of biomass in forests which could further help in quantifying the carbon capture and biodiversity support provision. Based on these quantities , people are paid for the performance and this generates a regular income for people.

CLIMATE BONDS: This enables the planning authorities to generate capital investment for ecological infrastructure projects where climate bonds are given to investors which could reap profits also based on the performance of the ecological element.

DECENTRALISED FORESTRY: This helps in large-scale reforestation and coastal protection strategy transformation since the search and contracting costs gets saved. It also would increase the private sector investment in ecological infrastructure and adapt the city to gauge future floods.







MATCHMAKING INVESTMENT: This model includes a platform which presents the investors with an opportunity to find all the current ecological infrastructure projects in Mumbai. It would include a consolidated data regarding the project which includes the location and specification of actors involved, the status of the project, financial investment requirement, financial leverages, expected social and environmental impact, risk assessment, financial analysis and policies that are supporting the project.

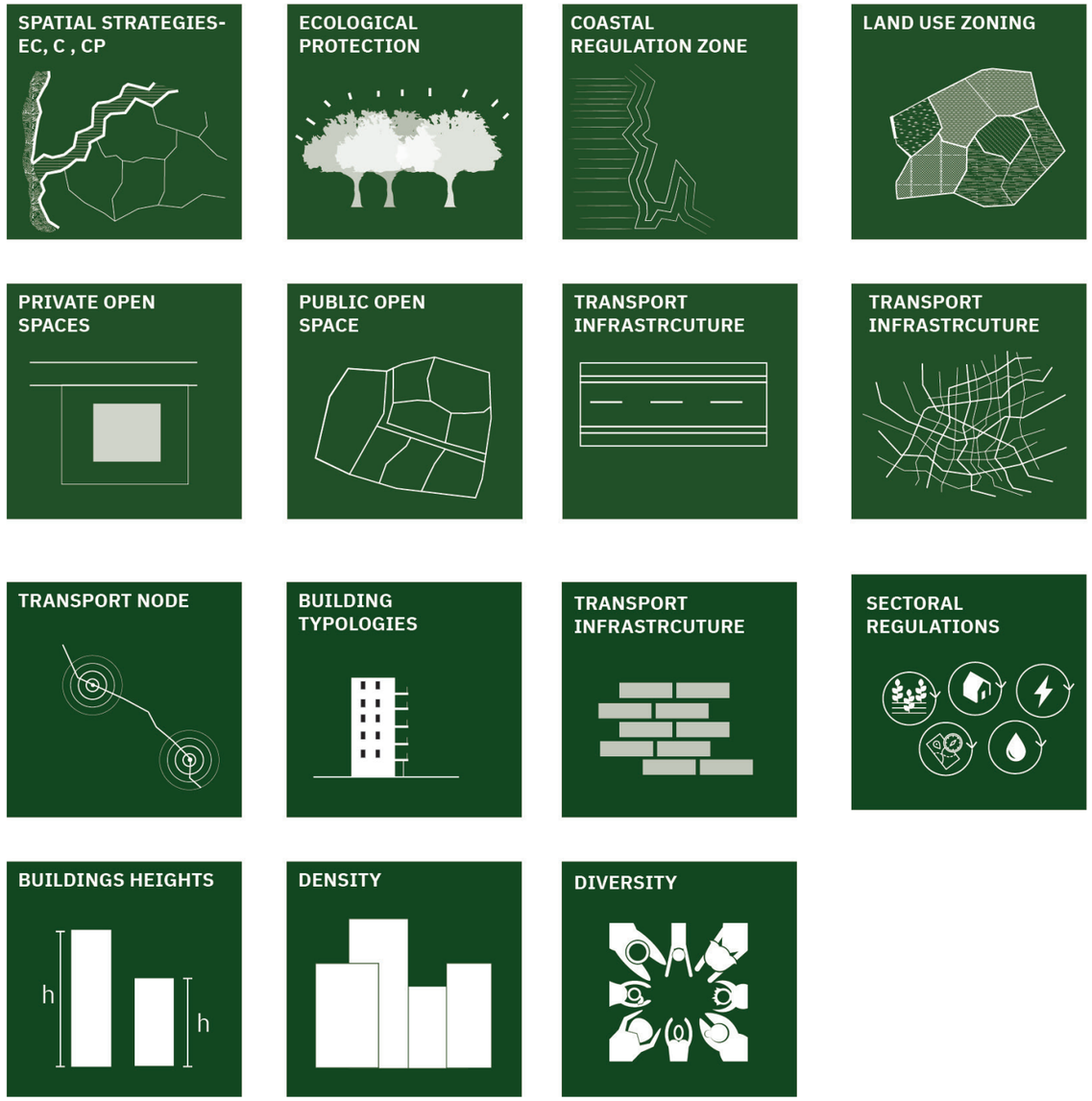
TAX BENEFITS: This is a financial instrument that helps to incentivise more climate-related investments where private sectors benefit from this in saving a substantial amount of their taxes in the form of text return. Thereby making a win-win situation for both authorities in the form of capital investment and private companies.

ECOSYSTEM SERVICE- PAY FOR PERFORMANCE: Ecosystem service is an ecological narrative increasingly being integrated into planning as it helps to create an understanding of the valuation of the ecological elements to humans and attract the attention of the economic and political actors into nature-based climate-related actions. This concept could be integrated into economic assessment of the ecology as the pay for performance could be based on the valuation of each category of service provided by the ecology. This requires state-of-the-art technologies to be integrated in these infrastructure projects to evaluate the performance of these elements to generate income for the people.

Regulating Instruments

Regulatory instruments are used to denote a broad variety of regulations where the ‘public authority sets binding requirements which in case of non-compliance are followed by sanctions and influences actor’s behaviour.’ (Bouwma et al., 2015) These instruments have a varying degree of compliance, in certain cases, they contain strict prohibitions and assessments while in the other cases they contain more flexible and relaxed regulations. (Bouwma et al., 2015)
There are multiple forms of regulatory instruments which could be categorised as - compulsory regulations, bans, limits, monitoring & auditing, codes & standards and other mandatory requirements. This section would deal with the aspects of the built environment in each of these categories which needs to be considered during the planning process.

Compulsory regulation



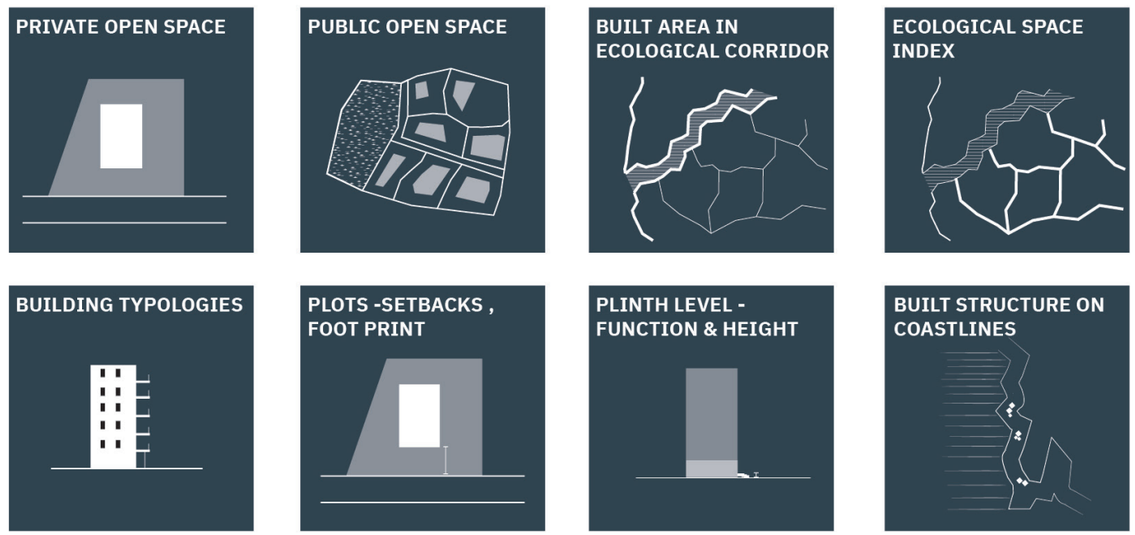
Firstly the demarcation of the three spatial strategies would require careful consideration of immediate compulsory regulations needed to support these. It would necessitate the conservation of green blue spaces in the city and also carefully drafting regulations for the Coastal zones to avoid encroachment and ecological vulnerability. Land Use zoning is also an important aspect to form regulations which could enable more mixed and self sufficient neighborhoods to avoid long distance travel and promote biking and walking. In terms of transport infrastructure, various aspects like street sections, road network and connectivity, bike lanes and neighborhoods densification at transport nodes. Regulations would also be necessary to ensure porosity in both private and public open spaces. ESI would help in guiding more regulations to enable the translation to capillaries.

Bans



These are based on ‘command and control’ principle (Bouwma et al., 2015) to forbid certain behaviour and make it legally consequential. Inorder to ensure climate change mitigation is followed, industries having emissions with toxic amount of pollutants needs to be prohibited, they need to have a comprehensive environmental assessment including the health and well being of people in and around these industries. The effluents discharged from these industries also need to be checked to ensure that it does not pollute the water streams and does not leach into the soil and groundwater too. Encroachment of ecology needs to be banned and detrimental for people or organisations.It needs to be made punishable by law to ensure such violations cannot happen. Also encroachment of pavements needs to be avoided to firstly have a clear pedestrian route, also it could cause threat to these encroachers in times of flooding.

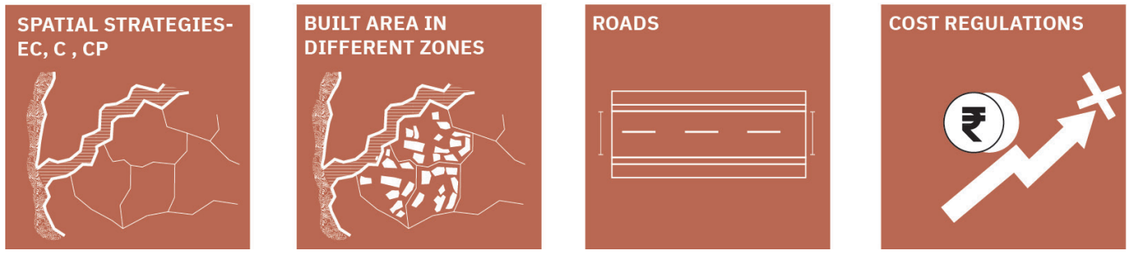
Codes and Standards



Regulating Instruments

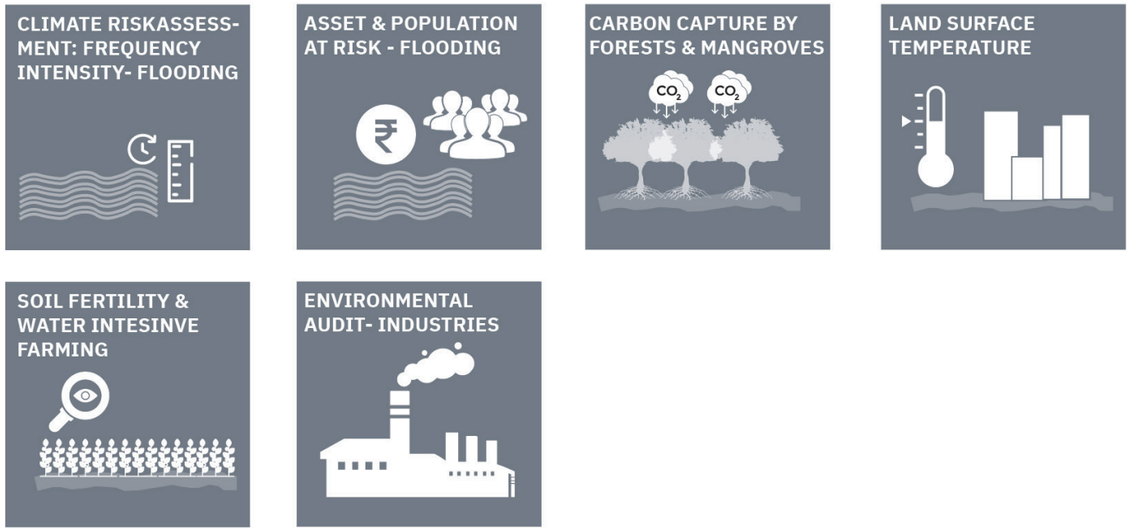
Development control Regulations needs to be updated inorder to implement these spatial strategies where building codes and standards are updated. Firstly the incorporation of ESI would ensure Urban capillary transformation in the built environment. It would need new building typologies to incorporate ecological spaces- green blue network elements embedded within it. Private and open spaces paving that could be regulated for eg- allowing only 45% of the plot to be impervious, and wherever possible the pavement needs to be porous. There needs to be certain building standards for structure on the coastline as they are highly vulnerable and needs to respond to it. The plinth level function and also height in certain cases needs to be standardised in high risk zones for floods.

Limits



This would define the limits of the different spatial strategies and ensure built zone demarcation specifically in the corridor zone or the coastal protection zone. This would also define the permissible limit of the car streets and would help in cost regulations if the prices tend to increase due to ecological transformation and improved liveable areas ,ensuring people from all income classes can enjoy a liveable urban environment.

Monitoring & Auditing



The authorities need to collaborate with research institutes to promote flood risk modelling of the city to identify the threats and intensity of the threat in detail to plan actions accordingly. The assets and population at risk needs to be carefully mapped and tabulated. Satellite imagery analysis needs to be financed and supported to ensure quantification of carbon capture. Land surface temperature along with soil fertility and water intensive farming practice needs to be monitored regularly. Regular monitoring of environmental impact by carbon emissions of industries and vehicles needs to be carried out as well to draw adaptation and mitigation actions.Two main types of environmental impact decision-making support instruments—Strategic Environmental Assessment (SEA) and Environmental Impact Assessment (EIA) should be used in the city and extended to the whole country.

Other Mandatory Requirements



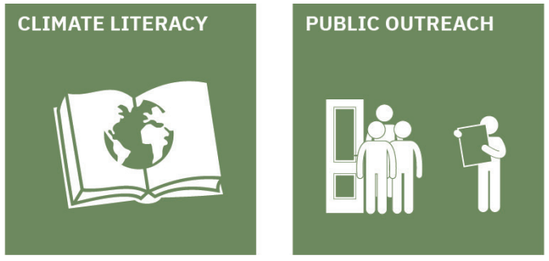
Regulations needs to be drawn regarding emissions check and ensure the carbon emission of the city goes down and contributes in the National and international goal of keeping the temperature below 2 degrees. New housing and buildings needs to have a higher energy label to ensure that less energy is needed to cool these buildings.Rainwater harvesting needs to be carefully considered for mandating it across the city along with certain streets to limit vehicular entry and giving way to pedestrian and bikes only.

The regulation instruments would be applied at varying scales , from the building scale to plot or neighborhood to ward or to the city scale. Careful considerations are needed to plan the policies framing these regulations and the appropriate time and space of their impact and implementation.

Informative Instruments

The acceptance , consensus and resource mobilisation for an issue requires instruments that would provide the correct information and educate people regarding the necessary aspects of the issue at hand. For climate change, we need more and more tools to spread accredited information to people to muster all the resources- human, financial and knowledge possible to tackle this herculean challenge.

Education



Climate Change literacy is a crucial necessity of the current times to educate people of the impacts of our existing actions, practices and systems to the climate and consequently to the planet. It's important to develop climate change literacy individually, institutionally, and societally to make people understand the significance of immediate actions, who needs to be involved and what transformations are necessary and urgent.(Julie Johnston, 2019) It involves understanding the different spatio-temporal challenges entailing climate change and how we could deal with these challenges for the sake of our existence. An important aspect of information spreading is outreach, where the vast sea of research and assessments that is out there needs to be taken to people. The communication and outreach to people is an important aspect for making people climate literates. This could happen over workshops, surveys ,seminars and other platforms to disseminate the information necessary for people to know and understand regarding their actions and practices.

Information Campaigns



Informative instruments need to communicate the climate risk to citizens, businesses and especially the most vulnerable population.Possible local adaptation and mitigation actions needs to be shared with people to generate acceptance to policies and plans that would help in tackling the future floods.

Performance Labelling



The authorities need to constantly monitor the risk of flooding and the performance of the adaptation actions that are implemented to revisit the transformation and revise the planning if necessary. As a result of the scope and limitation of the graduation project, certain parameters of ecological & hydrological performance were selected, but during the actual implementation of the strategies ,all possible parameters that would contribute to the performance needs to be taken into account.

Advisory Services & Capacity Building



A switch to an economy that works with ecology needs to train the people individually,sectorally and institutionally to understand how this would work. Research institutes and vocational training institutes need to be setup to develop this knowledge and share it amongst people to upskill them and keep them upbeat with the transition.Adaptation workshops for businesses are also needed to understand the actions,both spatially and systemically.

Environmental Monitoring & Reporting



A transparent system for flood risk assessment needs to be generated which needs to be made accessible to people, where public participation generates a dialogue for change where it is necessary and urgent. It would bring out the voices of all people in the active transformation of the city to adapt to flood. A transparent environment impact assessment needs to be carried out and made public before the clearance of all development projects. This process could be time-taking but would ensure avoidance of any negative impacts to the society and ecology.

Access to Information/ Justice Rights



Informative Instruments

This information regarding the climate crisis and adaptation actions needs to be accessible in multiple forms and translations to ensure all people from the society could understand and take part in the planning. It needs to be accessible to all the citizens, rich or poor. Also many countries have given legal rights to ecology, it could be a food for thought.This would generate discussion which could support the conservation of the existing ecology in the city and prevent compensation or trade-offs with ecology.

Labelling /Branding



Mumbai can mobilise all its resources to transform itself into a resilient city where branding of the city as a ‘resilient’ Mumbai could present an opportunity to promote itself as a eco-tourism hotspot, which would contribute to economic growth as well. It could become one of the leading cities in the world for Coastal Flood management and embedding the spatial strategies of ecological infrastructure into its urban planning to build a resilient future.



FIG. 1.280 Aerial view of Mumbai from an airplane .source:author

Example of spreading information

The people in Mumbai need to understand the gravity of the current situation.Multiple communication techniques could be incorporated to reach out to the people and provide them with the necessary information. The example shows a preview of the future to the citizens to communicate the urgency of action transformation and the incorporation of adaptation strategies in the city.

LOCAL • FAST

Mumbai Mirror

MUMBAI, TUESDAY, JULY 28, 2015 www.mumbaimirror.com 80 pages*

FORECAST TEMPERATURE COLABA MAX 30 | MIN 26 | SANTA CRUZ MAX 31 MIN 25 | RAIN SUNRISE 0616 HRS | SUNSET 1914 HRS | SENSEX 27561 | NIFTY 8361 | GOLD 26053 | SILVER 33705 | DOLLAR 64.2



MUMBAI TO BE SUBMERGED IF NO ACTIONS ARE TAKEN!

Adaptation is the key to a resilient MUMBAI

Surabhi Khandelwal, 2020

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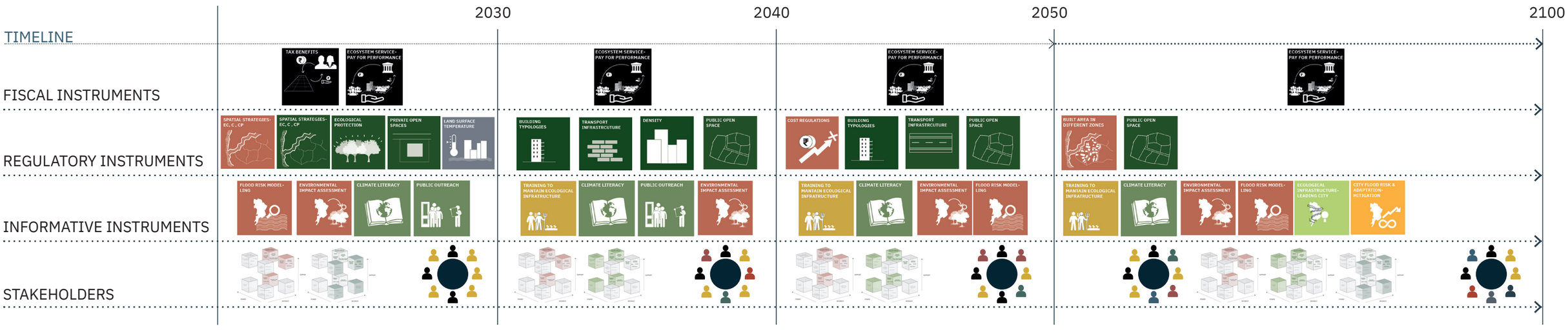
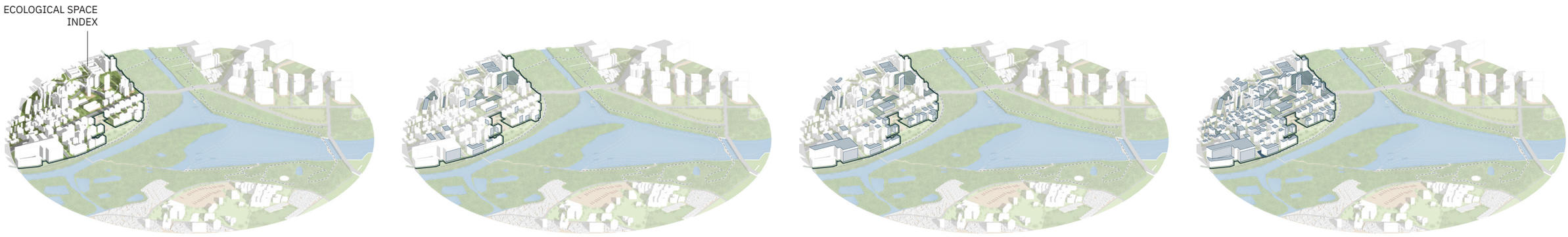
FIG. 1.281 Example of an informative communication tool .source:author

Planning - Urban Capillaries

Phasing of the Tranformation



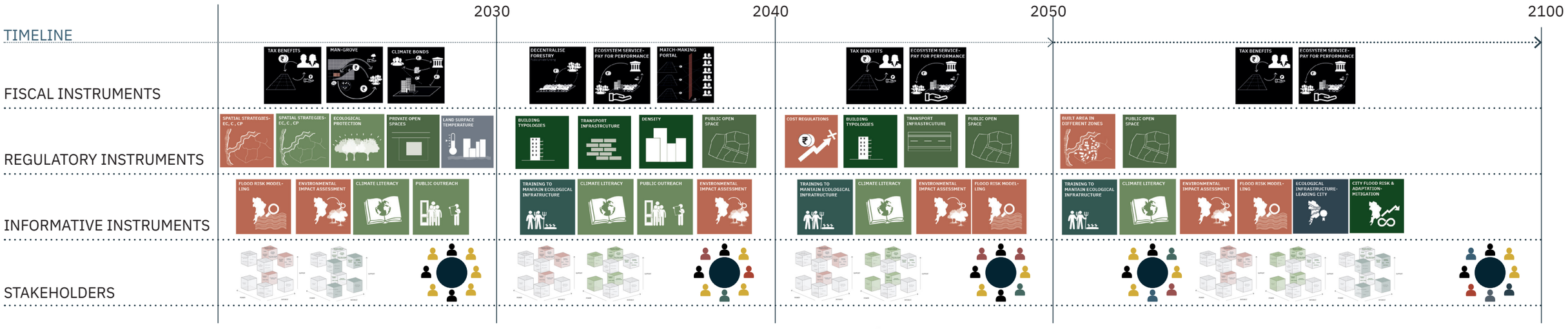


Gradual transformation with community participation to match upto the ecological space index on the target decided by each ward / administrative unit for ESI

Report | Surabhi Khandelwal

Planning Ecological Corridor

Phasing of the Tranformation





Governance Structure

Planning approach & process

The current approach in flood resilience needs a shift. It presently is a cycle of disaster management action and reaction but there is an urgent need to shift this approach and add an adaptation cycle to this process of tackling flood resilience.
This stems from changing the notion of climate crisis to an understanding of new conditions of existence. Where we begin to understand the anthropogenic actions causing this change in climate and systemically begin to alter these practices and actions.Thus the approach of resilience to flooding would involve the introduction of 'Adaptation' in the process where the urban environment orients itself to the new climatic reality. Adaptation would provide a capacity to the city to tackle future floods,where water gets absorbed, stored or drained in the new spatial environment that it would not be a flood anymore but rather would be an opportunity for the city to recharge its water stores in different forms. The City should be adapted to thrive in the new climatic conditions. Although the factor of uncertainty would also necessitate disaster management as a connected approach where the critical aspect is to be prepared for what is known.This panarchy model of resilience needs to be adopted for providing resilience in Mumbai City.

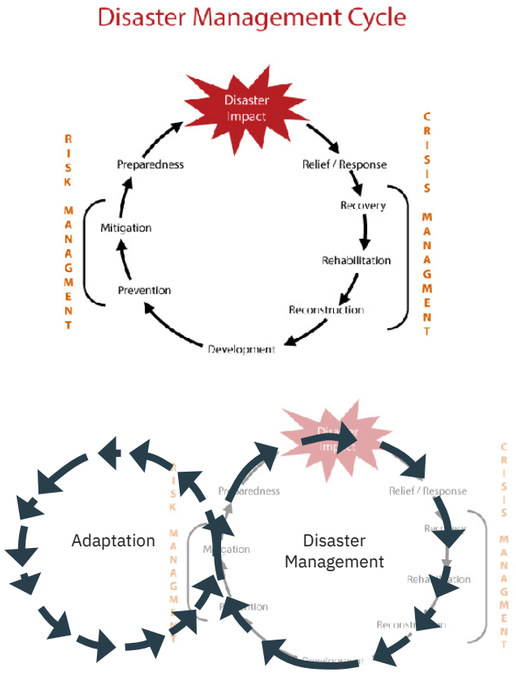


FIG. 1.282 Flooding planning process. source: author based on Gudenrson & Holling, 2002)

Figure1.1. Integrative approach

Adaptation - integrative approach

The city's approach for flood resilience needs to be restructured. Instead of Storm water department and Disaster Management department planning and working for adaptation towards flooding independently, there is an urgent need for collaboration across sectors in this concern to stir up action for future and guarantee a safe resilient Mumbai. Climate change impact of flooding would not only affect the stormwater drains or need rescue operations , but the threat of floods would impact a multiplicity of sectors in the city. Agriculture sector would have to adapt itself to the changing monsoon patterns, businesses would get affected due to disruption in the supply chain. The tourism industry would be affected due to the submergence of certain locations in water and disruption in travel.The floods would likely damage infrastructure and cause disruption in transportation. Energy sector would also be affected by the adverse effects of flooding. In conclusion, each and every sector would be affected by this event to varying degrees. The issue of flooding would be everyone's business let alone the Storm water department or Disaster Management Department. Therefore an integrative approach is the need of the hour. Adaptation as a strategy needs to be integrated in the policy and action agenda for all sectors. These sectors need to assess along with the flood modelling,how ,where and what will be the impact of flooding in their function and explore possible solutions to tackle this challenge. Collaboration and cooperation is a key aspect of Adaptation.Future adaptation planning requires building up mechanisms to enable these horizontal coordinations and collaborations.

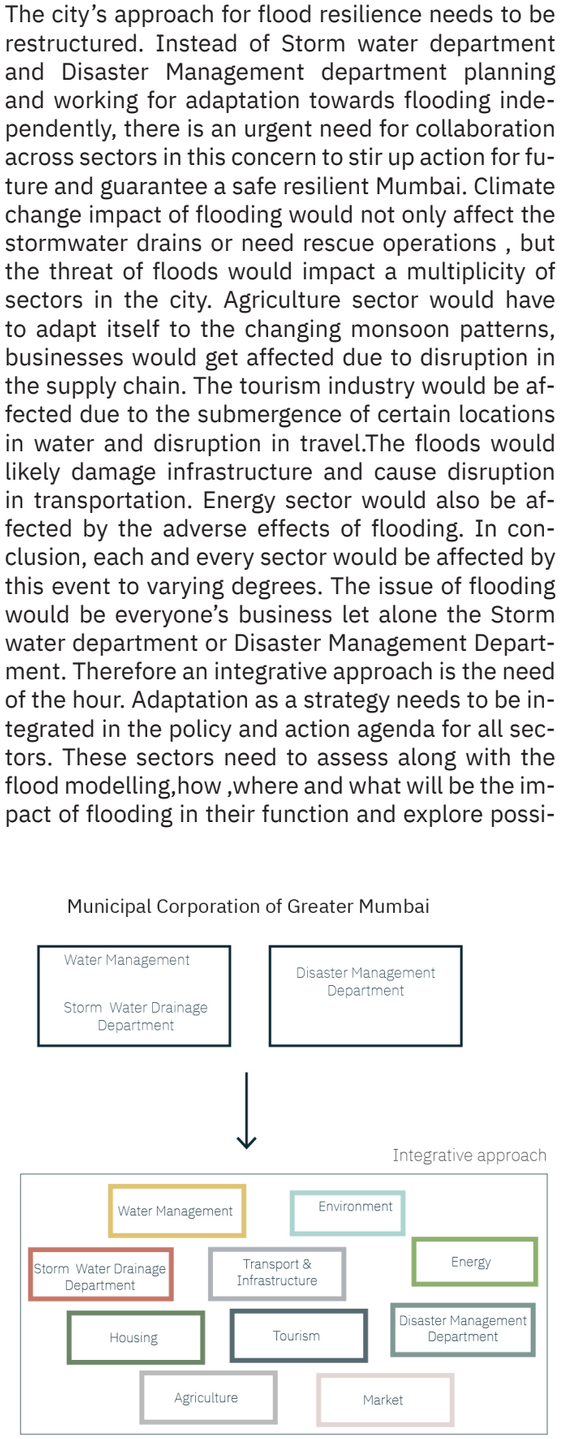


FIG. 1.283 Integrate adaptation. source: author.

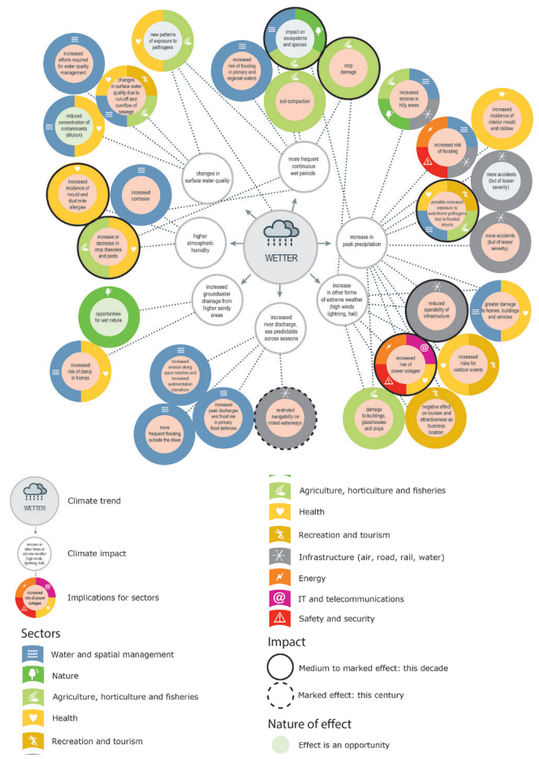
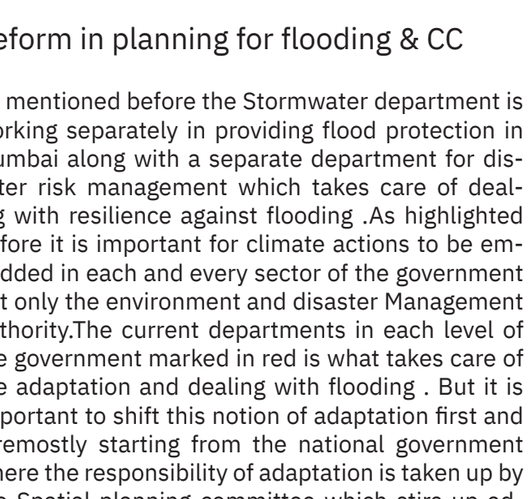


FIG. 1.284 Sectoral linkage to flooding. source: ruimtelijkeadaptatie.nl,NASadaptive

Governance Structure

Reform in planning for flooding & CC

As mentioned before the Stormwater department is working separately in providing flood protection in Mumbai along with a separate department for disaster risk management which takes care of dealing with resilience against flooding .As highlighted before it is important for climate actions to be embedded in each and every sector of the government not only the environment and disaster Management authority.The current departments in each level of the government marked in red is what takes care of the adaptation and dealing with flooding . But it is important to shift this notion of adaptation first and foremostly starting from the national government where the responsibility of adaptation is taken up by the Spatial planning committee which stirs up adaptation in all sectors. The relevant spatial planning authority at all levels needs to be incharge of the spatial adaptation for the impacts of Climate change like flooding etc.



National Government :Government of India

Ministry of Environment , Forest & Climate Change → NITI Ayog

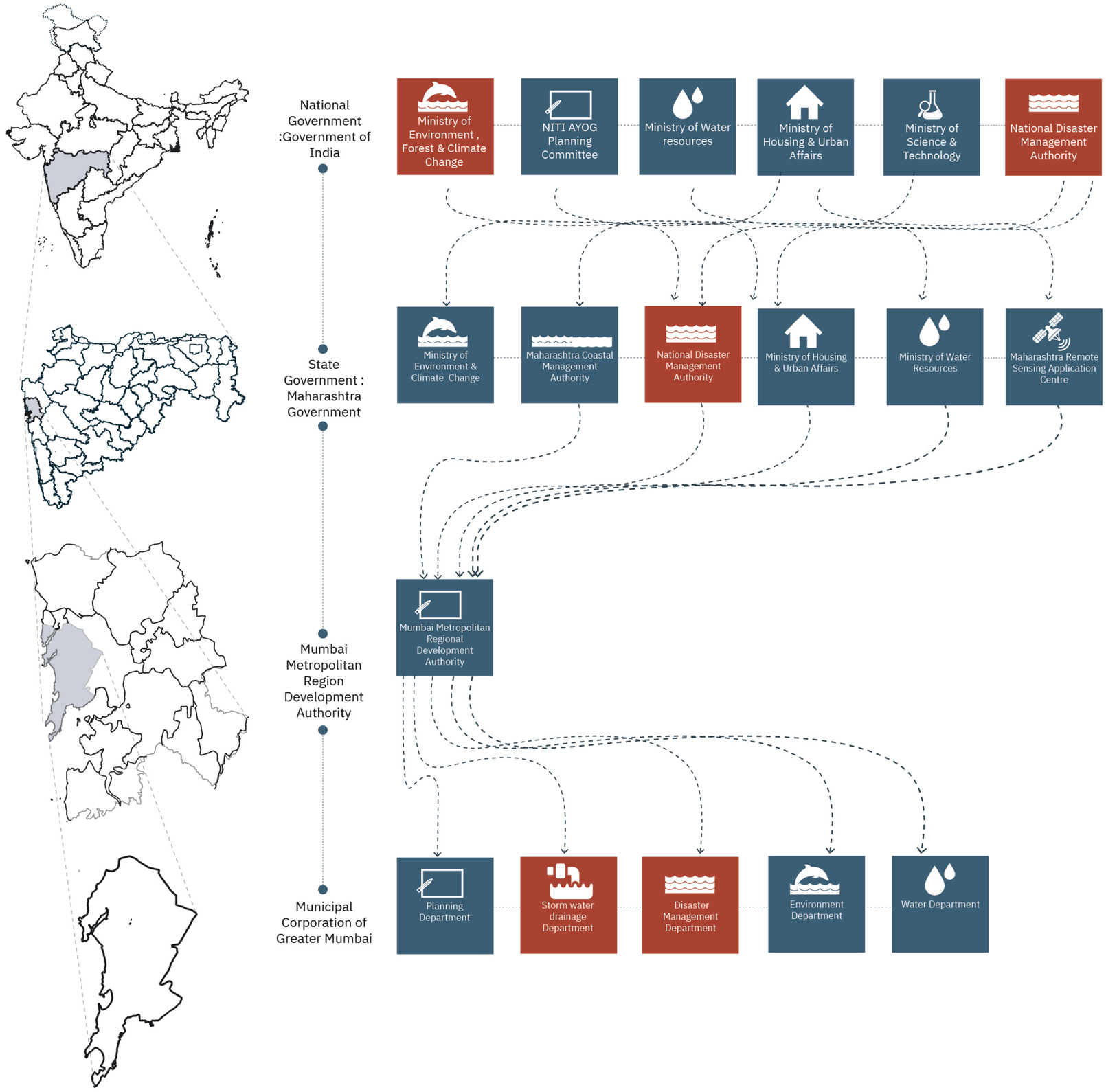


FIG. 1.285 Governance structure. source: author.

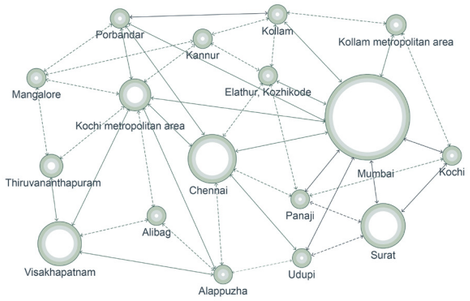
Governance Structure

National-Global- Collaboration



FIG. 1.286 Collaboration across coastal cities in India. source: author.

Both present and future demands collaboration, sharing of knowledge and experiences. It is essential for different coastal cities in India to network together and share their expertise, knowledge and experiences. Mumbai can become the initiator of this collaboration, where the lessons from the spatial strategies for adaptation are shared and assessed to be able to transfer this strategy in other geographic contexts. Furthermore a network of Asian and Global coastal cities could be envisioned where



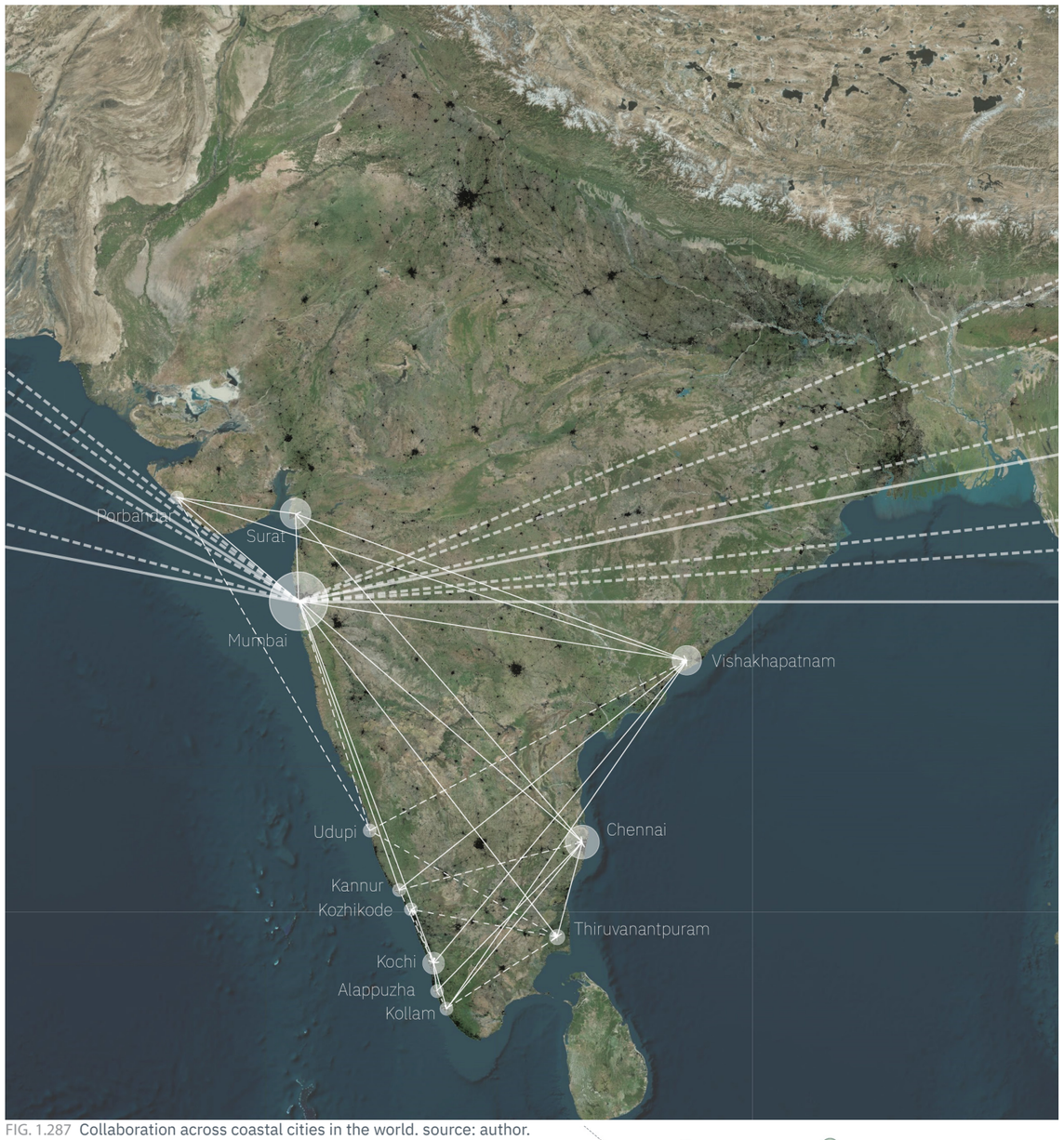
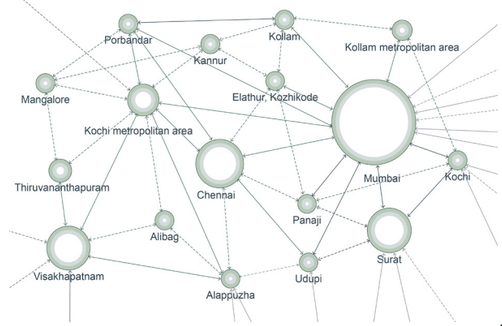


FIG. 1.287 Collaboration across coastal cities in the world. source: author.

organisations of United Nations,like Global Adaptation Commission becomes the mediating platform where such network actions of Coastal Cities could be organised to share knowledge, expertise, and build capacity along with growing the network to act urgently.



15.

Conclusion of the Synthesis

Summary & Discussion

’ When the climate is changing, why aren’t we’ .
This simple sentence is as powerful as its meaning and impact within it. The project has attempted to put forward the necessity of Adaptation and has proposed regional design strategies which provide spatial guidelines for development with ecology to make Mumbai flood-proof. It attempts to change the notion of crisis linked with flooding in Mumbai to an opportunity to merge the socio-economic system into ecology which would generate and introduce new flows to the urban metabolism.

The spatial strategies proposed for Mumbai could be further transferred and applied in different geographic locations but adapted based on the suitability to the specificities of the given context. This confluence of economy and ecology is the new paradigm shift necessary which could mobilise transformations which are urgent and necessary to tackle climate change, at the same time would respond and provide solutions for other urban challenges. Green solutions is the new paradigm necessary and as we fight this pandemic and reflect on the current systems in place,more and more leaders, policy makers, businesses are recognising the effectiveness and need for ecological solutions. But it is important to distinguish between greenwashing and effective sustainable solutions and for that purpose ,policy makers and planners need to develop an assessment criteria to ensure that the solutions are sustainable. As a starting point the SDG goals as suggested in IPCC report in the field of energy for policymakers could be used as a tool to assess the solutions and its viability.

Planning framework surrounding the issue of Climate change and flooding in Mumbai required remodelling . The approach of ‘adaptation’ is the one-way solution for Mumbai to sustain itself in the long term, let alone Mumbai, adaptation is continuously being recognised as the only way to go for the current world into the future. Collaboration is also a key aspect of planning when dealing with climate change. This global emergency requires us to gather as many resources as possible since the magnitude of its impact would be unimaginable. Therefore collaborating across cities, regions and nations would help in exploring strategies that could make our world climate change resilient.



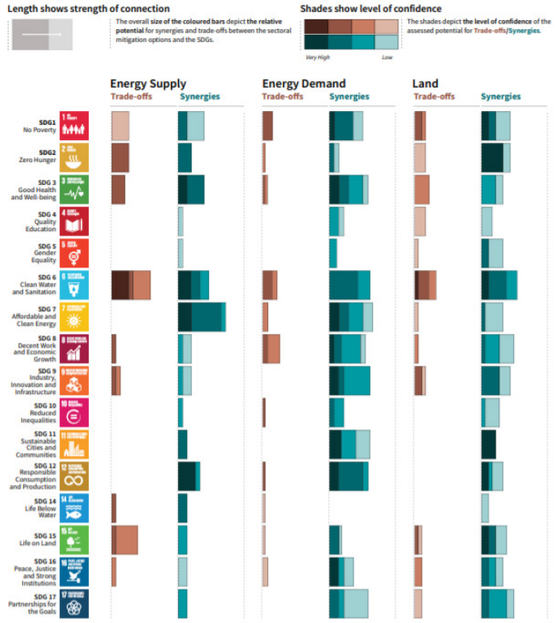


FIG. 1.288 Tool for Assessment where SDG are the indicators to test the synergies and trade-off in actions..source:IPCC.

The concept of Ecological Space Index(ESI) also could become a starting point for further research on development as a comprehensive planning tool to steer urban development towards ecology. The current form of urban development needs a shift and powerful tools like this could structure the market and inform the agency for stakeholders to make decisions with ecology rather than against it.

The Challenge in this process would be the current economic sector which is deeply rooted in its existing practices and is too comfortable and profitable to change. But the role of education would come instrumental to enable this shift. Currently, most people are climate illiterates, people are too comfortable to believe that the political leaders and necessary organisations are setting targets and taking actions to achieve it. But the reality is far from this. The changes necessary would need each and every individual, organisation and the whole society to educate themselves and be a climate literate citizen. The awareness would mobilise the need and demand for transformations which earlier would have seemed unthinkable.
The silver lining in this Pandemic is the ray of hope that it offers to mankind that when necessary , the society can make global structural changes within hours for the safety of humans.
When we talk about adaptation , it is also important to remember that Mitigation is a complementary aspect to it. The global emissions have already reached a point where climatic changes have been mobilised and we need to make sure that the situation does not go beyond repair. Therefore simultaneous mitigation actions and reforms need to be stirred up to ensure that emissions do not surpass the maximum threshold between 1.5 and 2 degrees.
When considering these mitigation adaptation actions, Mumbai could imagine a future where transport infrastructure switches to cleaner and greener transport. It could be a city where people walk , bike or use boats to travel within the city. With car streets not being used, it could transform certain streets into water networks to adapt to climate changes , at the same time would present a new opportunity of canals as travel routes for people.
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

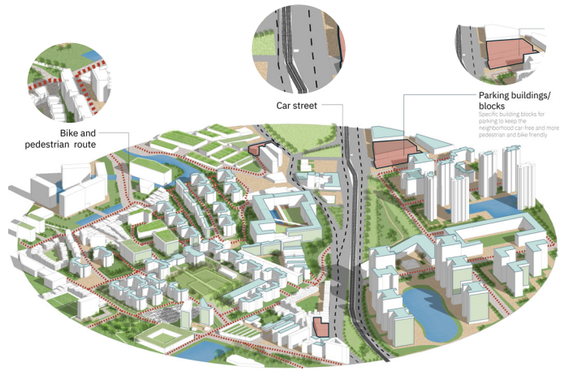


FIG. 1.289 Future of transport infrastructure in Mumbai. source: author. source:NL,

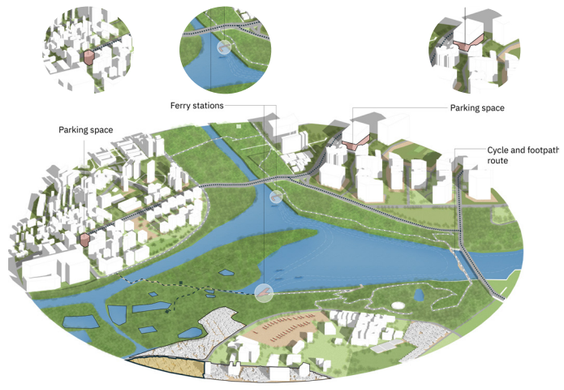


FIG. 1.290 Future of transport infrastructure in Mumbai. source: author. source:NL,

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.

Reflection Chapter

The project and its relation with studio and Urbanism track

The project deals with adapting our urban environments to new conditions of existence as a consequence of climate change. It explores the extent to which regional design and planning framework provides resilience against flooding in Mumbai Metropolitan Region. This project is a part of Planning Complex Cities studio of the Urbanism track due to the focus and expertise of the studio in comprehending Regional constructs and understand the complex forces involved in urbanisation. It helped to explore the spatial distribution of the ecological structure and identify the potentialities of strengthening those in the region. The emphasis of scalar inter-relations by the studio reflects in the project as it helped in understanding how different ecological processes play out at different spatial-temporal scales interacting with a varying built grain and extent. Most importantly the combination of spatial design and territorial governance has been very critical in defining the process and developing possible strategies for the project. The process has constantly led me to question the role of an Urbanist and partly answering it through this non-linear process of design and planning.
The Urbanism track with the scientific approach of theory and method is very well structured to venture out in the discourse of antithesis, synthesis and thesis. All five studios seem to enable us to begin our journey in the discourse with a different starting point of science, design or Engineering and guiding us through their respective methodologies in the graduation project in a systemic and systematic way.

A description of societal relevance

Climate change is one of the biggest crisis that the world is dealing with right now (apart from the other crisis we all are in, as I write my reflection). It is important to change this notion of crisis to an understanding of 'new conditions of existence'. With rapid urbanisation in developing countries like India, due to the multiplicity of problems that the state and society already face, climate change seems to be less of an urgent issue at hand. But the problem with such an approach is the repercussions the society would have to face later when it would be too late. It is necessary to integrate this understanding in the current planning approach to adapt our urban environments to deal with the changing conditions of existence and simultaneously tackle the problems at hand.
With time, society, once a part of ecology has become a co-existing separate system. The current form of development is oriented towards physical human-made infrastructure co-existing with ecology next to it. The aim of the project is to identify the ecological infrastructure within the ecological relational geography in the Mumbai Metropolitan Region in order to provide resilience to the socio-ecological system of the region against flooding.

A reflection on the advantages and limitations of the chosen methodology

The process, as mentioned earlier has not been linear due to the constant crossing of paths with limitations and adaptation needed to go forward. The project has made me realise the need for resilience in oneself and the process which constantly needs to adapt to the challenges ahead. With an understanding at the regional scale of the systems, it became essential to work on smaller scales and keep going back and forth to understand the cascading effect the design at any scale has on the others.
Accessing data as well as lack of expertise in fields like hydrology, ecology, meteorology has been a limitation to my project but at the same time has made me realise the aim of the course itself. Results would be data-driven in the real world but the course involves understanding the methodological framework and understanding the role of an Urbanist as facilitating a process of bringing all the disciplines together and visualising the spaces and planning framework that needs to be developed to achieve the results.
Also, the project had to limit itself to mostly ecological aspects and focus less on but exploring the societal benefits and ways of inclusion. This choice of incomprehensive inclusion of social aspect in the project was taken due to the limitation of access of social data of Mumbai, India and also the location of the project different from the location where the project is worked at as gathering the social data would have required months of fieldwork.

A discussion on possible problems that occurred during data collection and how one tried to overcome or compensate these problems

Based on my starting point of a Regional Design and analysis, right before my Design proposal, I went to Mumbai for further fact-finding and data collection. Also, the site visit involved getting an impression of the space and the institutional system. Upon my visit, I realised the urgent need for a renewed planning framework needed in the Spatial planning system. Right from the need to integrate a participatory planning process as the current planning excludes that and deals with years of litigation, being highly ineffective and exclusive. Also the need for comprehensive integration of Ecological assessment with the necessary parameters in order to avoid the creation of another problem(s) to solve one problem. Climate change will exacerbate the situation of flooding in Mumbai, but this problem has become an annual phenomenon not only because of its Geographic location but as a result of negative externalities due to inefficient planning. This impression was heightened by the lack of awareness of the seriousness of climate change amongst both people and the planning bodies. Efforts by certain researchers and organisations are not able to bring the desired momentum due to the missing understanding amongst the majority. This motivated me to work on a new approach for the planning framework to deal with Climate resilience but at the same time lead to doubting the need for a Regional Design to solve the problem. Both from discussion with my mentors and a talk from Paola Vigano helped me resolve the doubt and motivated me to move further with my research question of both the necessity of Design and Planning framework as the Design is important for people to see the abstract idea in visuals that are more persuasive and can become an important tool for planning itself.

A reflection on ethical issues and dilemmas encountered in doing the research and in potential applications of the results in practice

Due to the limitation of social data and the choice to focus on the ecological aspect in the project, raised an ethical dilemma of not tackling one of the biggest challenges in Mumbai, 55 percent of the population In Mumbai live in slums. But this provoked me to look for possible future scenarios, how spatial planning can give room for this section of the society who are the most vulnerable and could present itself as an opportunity for improving their living conditions. At the same time understanding that the project would not be capable of solving all the issues but it is important to have a sensitivity and awareness of all the aspects that are affected during spatial planning and design. It is critical that as an urbanist, we understand our responsibility, firstly that we deal with multidisciplinary professions. And most importantly we need to be sensitive professionals, as our role involves understanding the processes and systems and their impact on space which is utilized by the society and shared on this planet with ecology.

A reflection on the role of an Urbanist.

Urbanists are spatial designers and planners who could facilitate spatial transformations necessary for different socio-economic- ecological processes. Urbanists have multiple roles. Firstly they are visionaries who could present visions of the future imagineries.They can visualise the transformations necessary to enable any change in the system and use the power of visualisations of concept to communicate ideas and initiate discussions on abstract idea by transforming into something more concrete to have a discussion with multiple actors and ensuring that everyone is at the same page and could engage themselves in the discussion.
They also act as coordinators, mediators and negotiators who have a comprehensive overview of the processes and could enable changes in space. The scalar understanding of Urbanists also helps in critically reviewing actions at multiple scales and to assess the cascading effect it has on each scale.
A critical task of an Urbanist is to comprehend complex tasks and simplify it to engage the urban actors for an inclusive, efficient and effective solution through engagement of multiple stakeholders.

16.

Appendix

Bibliography

3 Steps to Scaling Up Nature-Based Solutions for Climate Adaptation. (2020, May 21). World Resources Institute. https://www.wri.org/blog/2020/05/3-steps-scaling-nature-based-solutions-climate-adaptation

(7) Estimating the uninsured losses due to extreme weather events and implications for informal sector vulnerability: A case study of Mumbai, India | Request PDF. (n.d.). ResearchGate. Retrieved 10 June 2020, from https://www.researchgate.net/publication/283537429_Estimating_the_uninsured_losses_due_to_extreme_weather_events_and_implications_for_informal_sector_vulnerability_a_case_study_of_Mumbai_India

7 key highlights of BMC Budget 2020-21. (n.d.). Mumbai Live. Retrieved 6 May 2020, from https://www.mumbailive.com/en/civic/10-highlights-of-bmc-budget-2020-44947

(8) (PDF) Mumbai: Where is the Water? (n.d.). ResearchGate. Retrieved 23 January 2020, from https://www.researchgate.net/publication/308750382_Mumbai_Where_is_the_Water/figures

(10) (PDF) Incorporation and application of resilience in the context of water-sensitive urban design: Linking European and Australian perspectives. (n.d.). ResearchGate. Retrieved 20 March 2020, from https://www.researchgate.net/publication/264718284_Incorporation_and_application_of_resilience_in_the_context_of_water-sensitive_urban_design_linking_European_and_Australian_perspectives

20 Shocking Photos That Show How Urgently We Need to Take Care of the Planet. (n.d.). PEOPLE.Com. Retrieved 28 June 2020, from https://people.com/lifestyle/climate-change-horrifying-photos/

20-year plan for MMR may open floodgates to disasters. (2019, August 16). Hindustan Times. https://www.hindustantimes.com/mumbai-news/20-year-plan-for-mmr-may-open-floodgates-to-disasters/story-2A4ujIoiCQf2pkQXSqjMsO.html

26 July, 2005: Flooded streets, crazy traffic and near darkness in Mumbai. (n.d.). Retrieved 5 July 2020, from https://www.dnaindia.com/mumbai/report-26-july-2005-flooded-streets-crazy-traffic-and-near-darkness-in-mumbai-1865653

77b140737ee0f2a432972cb0aedd5f9f.jpg (564×376). (n.d.). Retrieved 29 June 2020, from https://i.pinimg.com/564x/77/b1/40/77b140737ee0f2a432972cb0aedd5f9f.jpg

808893-bmc1.jpg (970×545). (n.d.). Retrieved 16 May 2020, from https://english.cdn.zeenews.com/sites/default/files/2019/08/04/808893-bmc1.jpg

889382Mumbai DCPR 2034.pdf. (n.d.).

1995391d1587275060t-climate-change-impact-india-world-groundwatermapofindia900x821.png (802×745). (n.d.). Retrieved 5 June 2020, from https://www.team-bhp.com/forum/attachments/shifting-gears/1995391d1587275060t-climate-change-impact-india-world-groundwater-mapofindia900x821.png

3661667E-A945-483E-96E3-2976A4030BFD.jpg (3569×2376). (n.d.). Retrieved 16 May 2020, from https://media.voltron.voanews.com/Drupal/01live-166/styles/sourced/s3/2019-04/3661667E-A945-483E-96E3-2976A4030BFD.jpg?itok=0LFUNtDC

39721444.pdf. (n.d.). Retrieved 30 June 2020, from https://www.oecd.org/env/cc/39721444.pdf

A+BE | Architecture And The Built Environment. (2019). A+BE | Architecture and the Built Environment, No 7 (2019): Welgelegen | Analyse van Hollandse buitenplaatsen in hun landschappen (1630-1730). https://doi.org/10.7480/ABE.2019.7

A Brief History of Land Reclamation in Mumbai, India. (n.d.). Retrieved 29 January 2020, from https://theculturetrip.com/asia/india/articles/a-brief-history-of-land-reclamation-in-mumbai-india/

A passenger bus moves through a water-logged road during rains in Mumbai. (n.d.). The World from PRX. Retrieved 5 July 2020, from https://www.pri.org/file/rtx3dt9ejpg

A tale of two cities: Flooding in Houston and Mumbai – time to learn? (n.d.). Retrieved 28 January 2020, from https://www.ids.ac.uk/opinions/a-tale-of-two-cities-flooding-in-houston-and-mumbai-time-to-learn/

About The World. (n.d.). The World from PRX. Retrieved 5 July 2020, from https://www.pri.org/about

Abraham, R. (2019, January 13). India is more urban than politicians know. ThePrint. https://theprint.in/opinion/india-is-more-urban-than-politicians-know/177223/

Activists Raise Concern Over BMC's Miyawaki Method For Plantation. (n.d.). Mumbai Live. Retrieved 12 June 2020, from https://www.mumbailive.com/en/environment/activists-raise-concern-over-bmc's-miyawaki-method-for-plantation-aditya-thackeray-save-aarey-zoru-bathena-yash-marwah-44617

Adnitt, C., Great Britain, Environment Agency, & DEFRA/Environment Agency Flood and Coastal Erosion Risk Management R & D Programme (Great Britain). (2007). Saltmarsh management manual. Environment Agency.

Adriaenssens, V., Dige, G., Eichler, L., Ferreira, A., Kolaszewska, D., Rademaekers, K., Vermeulen, J., & European Environment Agency. (2017). Green infrastructure and flood management: Promoting cost-efficient flood risk reduction via green infrastructure solutions. http://dx.publications.europa.eu/10.2800/324289

[ANALYSIS] Monsoon mayhem: Why does Mumbai get flooded year after year? (n.d.). Retrieved 24 January 2020, from https://www.timesnownews.com/india/article/monsoon-mayhem-why-does-mumbai-get-flooded-year-after-year/450105

Analytics), M. K. (Institute for E. (n.d.). Show Your Stripes. Retrieved 2 June 2020, from https://showyourstripes.info/

Anniversary Of Mumbai's 26/7 Floods: Throwback To A Nightmare | The Weather Channel. (n.d.). Retrieved 5 July 2020, from https://weather.com/en-IN/india/monsoon/news/2018-07-26-mumbai-floods

Anonymous. (2016a, September 28). Maritime spatial planning [Text]. Maritime Affairs - European Commission. https://ec.europa.eu/maritimeaffairs/policy/maritime_spatial_planning_en

Anonymous. (2016b, November 23). EU Adaptation Strategy [Text]. Climate Action - European Commission. https://ec.europa.eu/clima/policies/adaptation/what_en

April 10, & Denchak, 2019 Melissa. (n.d.). Flooding and Climate Change: Everything You Need to Know. NRDC. Retrieved 9 June 2020, from https://www.nrdc.org/stories/flooding-and-climate-change-everything-you-need-know

As Mumbai Turns Into A 'Water Park', Who Should Be Held Responsible? (2019, July 4). Youth Ki Awaaz. https://www.youthkiawaaz.com/2019/07/mumbai-flooding-due-to-rain-are-only-authorities-responsible/

As the Monsoon and Climate Shift, India Faces Worsening Floods. (n.d.). Yale E360. Retrieved 16 May 2020, from https://e360.yale.edu/features/as-the-monsoon-and-climate-shift-india-faces-worsening-floods

As waters rise, coastal megacities like Mumbai face catastrophe | Science News. (n.d.). Retrieved 11 March 2020, from https://www.sciencenews.org/article/waters-rise-coastal-megacities-mumbai-face-catastrophe

Aug 18, C. L. | T. |, 2018, & Ist, 06:06. (n.d.). Mumbai, suburbs finally get new CRZ rules | Mumbai News—Times of India. The Times of India. Retrieved 2 March 2020, from https://timesofindia.indiatimes.com/city/mumbai/mumbai-suburbs-finally-get-new-crz-rules/articleshow/65446772.cms

Author, G. (2018, August 21). Reasons for Floods in Mumbai Year after Year and How to Mitigate. Green Clean Guide. https://greencleanguide.com/reasons-for-floods-in-mumbai-year-after-year-and-how-to-mitigate/

Bendix, A. (n.d.). Drone photos of Mumbai reveal the places where extreme poverty meets extreme wealth. 16.

Better urban planning needed to dodge disasters—Sri Lanka. (n.d.). ReliefWeb. Retrieved 5 July 2020, from https://reliefweb.int/report/sri-lanka/better-urban-planning-needed-dodge-disasters

Bhagat, R. B., Guha, M., & Chattopadhyay, A. (2006). Mumbai after 26/7 Deluge: Issues and Concerns in Urban Planning. Population and Environment, 27(4), 337–349. https://doi.org/10.1007/s11111-006-0028-z

Biodiversity Hotspots of the World. (2018, April 10). Jagranjosh.Com. https://www.jagranjosh.com/general-knowledge/biodiversity-hotspots-of-the-world-1523356211-1

Biological-hotspots-labels-title.pdf. (n.d.). Retrieved 27 January 2020, from https://atlas-for-the-end-of-the-world.com/images/World_Maps/biological-hotspots-labels-title.pdf

BMC is the new planning authority for Gorai-Manori. (n.d.). Mumbai Live. Retrieved 30 April 2020, from https://www.mumbailive.com/en/civic/mmrda-will-not-be-responsible-for-gorai-uttan-and-other-6-villages-9295

BMC unveils budget for 2020-21 with total outlay of over Rs 33,441 crore; allocation for coastal road project increased by 25%. (n.d.). Firstpost. Retrieved 6 May 2020, from https://www.firstpost.com/india/bmc-unveils-budget-for-2020-21-with-total-outlay-of-over-rs-33441-crore-allocation-for-coastal-road-project-increased-by-25-8001421.html

Bourne, L. (2015, April 4). For Stakeholders, 2×2 Is Not Enough! Mosaicproject's Blog. https://mosaicprojects.wordpress.com/2015/04/04/for-stakeholders-2x2-is-not-enough/

Broken Nature and Circulatory Lives | urbz. (n.d.). Retrieved 16 May 2020, from https://www.urbz.net/articles/broken-nature-and-circulatory-lives

Brouwer, H., Kormelinck, A. G., & van Vugt, S. (n.d.). Tools for Analysing Power in Multi-stakeholder Processes—A menu -. 48.

Buczkowski, A. (2016, October 14). Top 11 maps that ultimately explain climate change and its impact. Geoawesomeness. https://geoawesomeness.com/top-11-maps-ultimately-explain-climate-change-impact/

Burdett, R., Rode, P., Shankar, P., Vahidy, S., Gomes, A., Lee, M., Moss, F., Heeckt, C., & Freedman, S. (n.d.). ORGANISED BY LSE CITIES AT THE LONDON SCHOOL OF ECONOMICS AND POLITICAL SCIENCE AND DEUTSCHE BANK'S ALFRED HERRHAUSEN SOCIETY IN PARTNERSHIP WITH THE NATIONAL INSTITUTE OF URBAN AFFAIRS. 56.

Can the pandemic sound the alarm on climate change? (n.d.). Greenpeace International. Retrieved 2 June 2020, from https://www.greenpeace.org/international/story/29970/pandemic-alarm-climate-change-covid-19-coronavirus-environment

Cardoso, R., & Meijers, E. (n.d.). AUTHORS' VERSION – FORTHCOMING BOOK CHAPTER. 22.

CCSM4_rcp85_global_temperature_change_spiral.gif (800×861). (n.d.). Retrieved 2 June 2020, from https://prd-wret.s3.us-west-2.amazonaws.com/assets/palladium/production/s3fs-public/thumbnails/image/CCSM4_rcp85_global_temperature_change_spiral.gif

Census of India Website: Office of the Registrar General & Census Commissioner, India. (n.d.). Retrieved 10 June 2020, from https://censusindia.gov.in/2011census/population_enumeration.html

Climate Change: 11 facts you need to know. (n.d.). Retrieved 28 June 2020, from https://www.conservation.org/stories/11-climate-change-facts-you-need-to-know

Climate change impact on India & the world. (n.d.). Team-BHP.Com. Retrieved 5 June 2020, from https://www.team-bhp.com/forum/shifting-gears/221546-climate-change-impact-india-world.html

Climate Change: Perspectives from India. (n.d.). 72.

Climate spirals | Climate Lab Book. (n.d.). Retrieved 2 June 2020, from http://www.climate-lab-book.ac.uk/spirals/

Closer look at Dharavi—Mumbai/Dharavi. (n.d.). Retrieved 18 May 2020, from https://sites.google.com/a/kubickova.net/mumbai-dharavi/closer-look-at-dharavi

Coastal areas—Climate-ADAPT. (n.d.). Retrieved 7 May 2020, from https://climate-adapt.eea.europa.eu//eu-adaptation-policy/sector-policies/coastal-areas

Coastal Regulation Zone Norms Are Supposed to Protect the Environment, But Here Are 5 Ways in Which They Fail. (2015). Economic and Political Weekly, 7–8.

Dabre, R. (2019, May 20). Bridge of discontent: Gorai prefers peace to development. The Hindu. https://www.thehindu.com/news/cities/mumbai/bridge-of-discontent-gorai-prefers-peace-to-development/article27180434.ece

Das, P. K. (2015, October 19). Claiming Participation in Urban Planning and Design as a Right. The Nature of Cities. https://www.thenatureofcities.com/2015/10/19/claiming-participation-in-urban-planning-and-design-as-a-right/

Das, S. (2015, July 21). In Pictures: #MumbaiRains Affect Local Train Services, Massive Waterlogging Disrupts Movement. https://www.scoopwhoop.com/news/mumbai-rain-monsoon-local-trains-affected/

DCRs for Mumbai Metropolitan Region, 1999.pdf. (n.d.).

DelhiAugust 2, I. T. W. D. N., August 2, 2016UPDATED:, & Ist, 2016 14:34. (n.d.). #IWearHandloom to promote Indian textile tradition: Know all about India's first textile mill. India Today. Retrieved 5 July 2020, from https://www.indiatoday.in/education-today/gk-current-affairs/story/indias-first-textile-mill-332483-2016-08-02

DelhiJuly 6, I. T. W. D. N., July 6, 2019UPDATED:, & Ist, 2019 11:44. (n.d.). Heavy rains, waterlogging in Mumbai, high tide likely. India Today. Retrieved 1 May 2020, from https://www.indiatoday.in/india/story/mumbai-rains-waterlogging-high-tide-1563306-2019-07-06

Deshpande, A. (2019, August 8). 'Plan for MMR has no mention of flood control measures'. The Hindu. https://www.thehindu.com/news/cities/mumbai/plan-for-mmr-has-no-mention-of-flood-control-measures/article28873847.ece

Development of a Flood Early Warning System and an Adaptive Flood Risk Management plan for Sukhothai district / Yom River Basin. (n.d.). Deltares. Retrieved 7 May 2020, from https://www.deltares.nl/en/projects/development-of-a-flood-early-warning-system-and-an-adaptive-flood-risk-management-plan-for-sukhothai-district-yom-river-basin

Dhupkar, A. D., Mar 29, M. M. | U., 2018, & Ist, 18:38. (n.d.). Paver blocks at Mahim park raise eyebrows. Mumbai Mirror. Retrieved 2 May 2020, from https://mumbaimirror.indiatimes.com/mumbai/civic/paver-blocks-at-mahim-park-raise-eyebrows/articleshow/63524164.cms

Do you really understand the influential warming stripes? (2019, December 3). Voilà. https://chezvoila.com/blog/warmingstripes/

Doc_eng_16_ MUMBAI CITY REPORT.pdf. (n.d.).

Eastern waterfront revamp: New plan leaves just 74 hectares open space for Mumbai. (2019, February 4). Hindustan Times. https://www.hindustantimes.com/mumbai-news/eastern-waterfront-revamp-new-plan-leaves-just-74-hectares-open-space-for-mumbai/story-ZWGC0qEJMeB5m5XrX3M0VP.html

Eckstein, D., Hutfils, M.-L., Winges, M., & Germanwatch. (2018). Global Climate Risk Index 2019 Who Suffers Most From Extreme Weather Events? Weather-related Loss Events in 2017 and 1998 to 2017.

EIA report_env impact assessment_coastal road.pdf. (n.d.).

ENGLISH SPEECH-budget.pdf. (n.d.).

Entry_presentation~watershed.pdf. (n.d.). Retrieved 4 March 2020, from https://www.preventionweb.net/files/globalplatform/entry_presentation~watershed.pdf

Bibliography

Environment, U. N. (2020, March 3). How climate change is making record-breaking floods the new normal. UN Environment. http://www.unenvironment.org/news-and-stories/story/how-climate-change-making-record-breaking-floods-new-normal
Factfinding committee_chitale fllod 2005.pdf. (n.d.).
Factitious-city.pdf. (n.d.).
Fears of flooding as Mumbai plans to open salt pans for social housing. (n.d.). Retrieved 29 January 2020, from https://www.preventionweb.net/go/58257
Fears of flooding as Mumbai plans to open salt pans for social housing. (2018, May 11). Reuters. https://www.reuters.com/article/us-india-landrights-environment-idUSKBN1IC0XT
Final-Report-LBFT_28Aug2014 (1)Land Based Fiscal Tools and Practices for.pdf. (n.d.).
Flood Preparedness Guidelines 2019.pdf. (n.d.).
Flood-risk zones not mapped even after '2005 deluge: Supreme Court panel | Mumbai News—Times of India. (n.d.). Retrieved 14 January 2020, from https://timesofindia.indiatimes.com/city/mumbai/flood-risk-zones-not-mapped-even-after-2005-deluge-supreme-court-panel/articleshow/71074275.cms
Floods. (2016, August 17). World Meteorological Organization. https://public.wmo.int/en/our-mandate/water/floods
Floods | World Problems & Global Issues | The Encyclopedia of World Problems. (n.d.). Retrieved 9 June 2020, from http://encyclopedia.uia.org/en/problem/132954
Freitas, F., Denton, M., DeRitis, C., & Malone, S. (n.d.). The Risk Management Impact of Climate Change & ESG. 29.
Frey, M., & Gasbarro, F. (2020). Adaptation and Mitigation Synergies and Trade-Offs. In W. Leal Filho, A. M. Azul, L. Brandli, P. G. Özuyar, & T. Wall (Eds.), Climate Action (pp. 1–9). Springer International Publishing. https://doi.org/10.1007/978-3-319-95885-9_17
Front pages 1_coastal road.pdf. (n.d.).
Galeria de Grandes cidades enfrentam maiores risco de inundação segundo relatório do Goldman Sachs—2. (n.d.). ArchDaily Brasil. Retrieved 5 July 2020, from https://www.archdaily.com.br/br/931293/grandes-cidades-enfrentam-maiores-risco-de-inundacao-segundo-relatorio-do-goldman-sachs/5e04a6c23312fd2093000093-major-cities-face-high-risk-of-flooding-according-to-a-goldman-sachs-report-photo
Garnett, P. (2020). Artificial Intelligence and Global Changes. In W. Leal Filho, A. M. Azul, L. Brandli, P. G. Özuyar, & T. Wall (Eds.), Climate Action (pp. 32–42). Springer International Publishing. https://doi.org/10.1007/978-3-319-95885-9_105
Global Maps. (2020, June 2). [Text.Article]. NASA Earth Observatory. https://earthobservatory.nasa.gov/global-maps
Governance, Power and Participation. (n.d.). Retrieved 6 May 2020, from https://www.ids.ac.uk/research/governance-power-and-participation/
Grover, A., & Singh, R. (2015). Analysis of Urban Heat Island (UHI) in Relation to Normalized Difference Vegetation Index (NDVI): A Comparative Study of Delhi and Mumbai. Environments, 2(4), 125–138. https://doi.org/10.3390/environments2020125
Grover, A., & Singh, R. (2016). Monitoring Spatial Patterns of Land Surface Temperature and Urban Heat Island for Sustainable Megacity: A Case Study of Mumbai, India, Using Landsat TM Data. Environment and Urbanization ASIA, 7(1), 38–54. https://doi.org/10.1177/0975425315619722
Grulla Vieja Negra Fotos e Imágenes de stock—Alamy. (n.d.). Retrieved 5 July 2020, from https://www.alamy.es/imagenes/grulla-vieja-negra.html
Gunderson, L. H., & Holling, C. S. (2002). Panarchy: Understanding transformations in human and natural systems. Island Press.
Haphazard land reclamation fuelled Mumbai's maximum dreams. (n.d.). Retrieved 27 January 2020, from https://www.downtoearth.org.in/news/haphazard-land-reclamation-fuelled-mumbais-maximum--dreams-40745
Heavy Rain and High Tide Combine to Flood Mumbai – 300 mm of Rain in 24 Hours – FloodList. (n.d.). Retrieved 5 July 2020, from http://floodlist.com/asia/heavy-rain-high-tide-floods-mumbai-june-2015
Heavy rains paralyse Mumbai—The Hindu BusinessLine. (n.d.). Retrieved 5 July 2020, from https://www.thehindubusinessline.com/economy/policy/Heavy-rains-paralyse-Mumbai/article20329057.ece
Here's Why Mumbai Floods Year After Year. (n.d.). The Wire. Retrieved 24 January 2020, from https://thewire.in/urban/mumbai-heavy-rains-floods-reasons
Home. (n.d.). Retrieved 30 April 2020, from http://www.mumbaidp24seven.in/
Home—Climate-ADAPT. (n.d.). Retrieved 7 May 2020, from https://climate-adapt.eea.europa.eu/#t-database
How the airport ate up Mithi river | Mumbai News—Times of India. (n.d.). The Times of India. Retrieved 17 May 2020, from https://timesofindia.indiatimes.com/city/mumbai/How-the-airport-ate-up-Mithi-river/articleshow/1193563.cms
Hundreds stuck in India's financial capital Mumbai as heavy rain disrupts Mumbai rail service. (2019, August 5). Reuters. https://www.reuters.com/article/us-southasia-floods-india-idUSKCN1UV0IL
Hussein, I., de Fátima Alves, M., & Morgado, F. (2020). Artisanal Fishing and Climate Change: The Case of Pemba, Mozambique. In W. Leal Filho, A. M. Azul, L. Brandli, P. G. Özuyar, & T. Wall (Eds.), Climate Action (pp. 42–51). Springer International Publishing. https://doi.org/10.1007/978-3-319-95885-9_121
I-1-90367577-this-simple-graphic-is-a-brilliant-visualization-of-climate-change-2.jpg (6000×6000). (n.d.). Retrieved 2 June 2020, from https://images.fastcompany.net/image/upload/wp-cms/uploads/2019/06/i-1-90367577-this-simple-graphic-is-a-brilliant-visualization-of-climate-change-2.jpg
Image: 26 July, 2005: Flooded streets, crazy traffic and near darkness in ... (n.d.-a). Retrieved 16 May 2020, from https://www.google.com/imgres?imgurl=https%3A%2F%2Fcdn.dnaindia.com%2Fsites%2Fdefault%2Ffiles%2Fstyles%2Ffull%2Fpublic%2F1865656.jpg&imgrefurl=https%3A%2F%2Fwww.dnaindia.com%2Fmumbai%2Freport-26-july-2005-flooded-streets-crazy-traffic-and-near-darkness-in-mumbai-1865653&tbnid=o1HHdzUvV78HtM&vet=12ahUKEwiox-X_s7jpAhUJgKQKHeUMA1wQMygMegUIARCRAg..i&docid=b5X8vAnkV2DMrM&w=1280&h=720&q=2005%20floods%20in%20mumbai%20images&ved=2ahUKEwiox-X_s7jpAhUJgKQKHeUMA1wQMygMegUIARCRAg#h=720&imgdii=NX3eTN3NhUKyvM:&vet=12ahUKEwiox-X_s7jpAhUJgKQKHeUMA1wQMygMegUIARCRAg..i&w=1280
Image: Robot finds sewage line in flood drain | Mumbai News - Times of India. (n.d.-b). Retrieved 27 January 2020, from https://www.google.com/imgres?imgurl=https%3A%2F%2Fstatic.toiimg.com%2Fphoto%2Fmsid-67633069%2F67633069.jpg&imgrefurl=https%3A%2F%2Ftimesofindia.indiatimes.com%2Fcity%2Fmumbai%2Frobot-finds-sewage-line-in-flood-drain%2Farticleshow%2F67630559.cms&docid=Xxw1zr-1J8WIn-M&tbnid=0TYwR1q4nFMmmM%3A&vet=10ahUKEwjTjZmB4qTnAhU0xcQBHd6eB84QMwhxKBEwEQ..i&w=635&h=668&bih=722&biw=1536&q=storm%20water%20drains%20mumbai%20&ved=0ahUKEwjTjZmB4qTnAhU0xcQBHd6eB84QMwhxKBEwEQ&iact=mrc&uact=8
Image: Storm Drain Cleaning | Vactor Combination Sewer Cleaner | Storm ... (n.d.-c). Retrieved 27 January 2020, from https://www.google.com/imgres?imgurl=http%3A%2F%2Fjtv-cipp.com%2Fimages%2F6b-jtv-storm-sewer01.png&imgrefurl=http%3A%2F%2Fjtv-cipp.com%2F-storm-drain-cleaning-florida.html&docid=Hm2yIWFctE54XM&tbnid=1BqWHoBSSV2KCM%3A&vet=1&w=1128&h=695&itg=1&bih=722&biw=1536&ved=2ahUKEwjRvf2P4qTnAhVFIVAKHcVmA6YQxiAoAHoECAEQFw&iact=c&ictx=1
Impact Map. (n.d.). Climate Impact Lab. Retrieved 2 June 2020, from http://www.impactlab.org/map/
In a crisis, it isn't resilience but the helplessness of Mumbaikars that lets them carry on. (n.d.). Firstpost. Retrieved 22 January 2020, from https://www.firstpost.com/living/in-a-crisis-it-isnt-resilience-but-the-helplessness-of-mumbaikars-that-helps-them-carry-on-2802054.html
Inamdar, A. (2018, October 4). A Picture is Worth a Thousand Words. Fundamatics. http://www.fundamatics.net/testing-times/
Increasing Flood Risks Create Major Challenges for World's Coastal Cities. (n.d.). Retrieved 23 January 2020, from https://blogs.worldbank.org/climatechange/increasing-flood-risks-create-major-challenges-worlds-coastal-cities
Indbur1.pdf. (n.d.). Retrieved 23 January 2020, from http://moef.gov.in/wp-content/uploads/2017/08/indbur1.pdf
India – Heavy Rain and Floods Cause Major Disruption in Mumbai – FloodList. (n.d.). Retrieved 17 June 2020, from http://floodlist.com/asia/india-floods-mumbai-september-2019
India Floods – Mumbai and the Mithi River 9 Years On – FloodList. (n.d.). Retrieved 17 June 2020, from http://floodlist.com/asia/mumbai-floods-mithi-river
India: Maharashtra's story of developing its state climate change policy. (n.d.). Retrieved 29 June 2020, from https://www.preventionweb.net/go/61934
India-Taking-on-Climate-Change.pdf. (n.d.). Retrieved 29 January 2020, from http://moef.gov.in/wp-content/uploads/2017/08/India-Taking-on-Climate-Change.pdf
Indorewala, H. (n.d.). Does Mumbai really need 11 lakh more houses? [Text]. Scroll.In; https://scroll.in. Retrieved 30 April 2020, from http://scroll.in/article/802830/does-mumbai-really-need-11-lakh-more-houses
Indorewala, H., & Wagh, S. (n.d.). RESOURCES, LIVELIHOODS AND SPATIAL CONTROL: 37.
Integrated Impact Assessment of Mithi River. (n.d.). 257.
International Union for Conservation of Nature and Natural Resources. (1960). Nature, 188(4752), 716–717. https://doi.org/10.1038/188716b0
Is the IPCC Wrong about Sea Level Rise? (n.d.). Retrieved 11 March 2020, from https://www.forbes.com/sites/uhenergy/2018/06/15/is-the-ipcc-wrong-about-sea-level-rise/#5f6aa8233ba0
Jadav, D. (2014, June 30). Major Water Logging (Flood Prone) Areas Locations in Mumbai. Mumbai77 - Mumbai City and Travel Guide. https://www.mumbai77.com/city/3667/travel/water-logging-locations/
Jain, P. (n.d.). Rail infrastructure in colonial Mumbai. 15.
Johnston, J. D. (2020). Climate Change Literacy to Combat Climate Change and Its Impacts. In W. Leal Filho, A. M. Azul, L. Brandli, P. G. Özuyar, & T. Wall (Eds.), Climate Action (pp. 200–212). Springer International Publishing. https://doi.org/10.1007/978-3-319-95885-9_31
Kadave, P. T., Kale, A. D., & Narwade, S. (2016). Mumbai Floods, Reasons and Solutions. 6(3), 5.
Klautau de Araújo, T. L. (2020). Brazilian Amazônia and Climate Change: Barriers and Pathways for Forthcoming Sustainability. In W. Leal Filho, A. M. Azul, L. Brandli, P. G. Özuyar, & T. Wall (Eds.), Climate Action (pp. 65–77). Springer International Publishing. https://doi.org/10.1007/978-3-319-95885-9_25
Kumar, H. (2019, July 2). 32 Dead as Worst Flooding in a Decade Hits Booming Mumbai. The New York Times. https://www.nytimes.com/2019/07/02/world/asia/32-dead-as-worst-flooding-in-a-decade-hits-booming-mumbai.html
Land Reclamation in Mumbai. (n.d.). Scribd. Retrieved 29 January 2020, from https://www.scribd.com/doc/45133629/Land-Reclamation-in-Mumbai
Leal Filho, W., Azul, A. M., Brandli, L., Özuyar, P. G., & Wall, T. (Eds.). (2020a). Abrupt Climate Susceptibilities. In Climate Action (pp. 1–1). Springer International Publishing. https://doi.org/10.1007/978-3-319-95885-9_300001
Leal Filho, W., Azul, A. M., Brandli, L., Özuyar, P. G., & Wall, T. (Eds.). (2020b). Abrupt Climate Vulnerabilities. In Climate Action (pp. 1–1). Springer International Publishing. https://doi.org/10.1007/978-3-319-95885-9_300002
Leal Filho, W., Azul, A. M., Brandli, L., Özuyar, P. G., & Wall, T. (Eds.). (2020c). Adaptation and Mitigation Inter-relationships. In Climate Action (pp. 1–1). Springer International Publishing. https://doi.org/10.1007/978-3-319-95885-9_300003
Leal Filho, W., Azul, A. M., Brandli, L., Özuyar, P. G., & Wall, T. (Eds.). (2020d). Adjusting. In Climate Action (pp. 10–10). Springer International Publishing. https://doi.org/10.1007/978-3-319-95885-9_300004
Leal Filho, W., Azul, A. M., Brandli, L., Özuyar, P. G., & Wall, T. (Eds.). (2020e). Binding Emission Reduction Targets. In Climate Action (pp. 53–53). Springer International Publishing. https://doi.org/10.1007/978-3-319-95885-9_300005
Leal Filho, W., Azul, A. M., Brandli, L., Özuyar, P. G., & Wall, T. (Eds.). (2020f). Building Resilience and Preparedness for Climate Impacts. In Climate Action (pp. 86–86). Springer International Publishing. https://doi.org/10.1007/978-3-319-95885-9_300006
Leal Filho, W., Azul, A. M., Brandli, L., Özuyar, P. G., & Wall, T. (Eds.). (2020g). Carbon Literacy. In Climate Action (pp. 87–87). Springer International Publishing. https://doi.org/10.1007/978-3-319-95885-9_300007
Leal Filho, W., Azul, A. M., Brandli, L., Özuyar, P. G., & Wall, T. (Eds.). (2020h). Cities. In Climate Action (pp. 87–87). Springer International Publishing. https://doi.org/10.1007/978-3-319-95885-9_300008
Leal Filho, W., Azul, A. M., Brandli, L., Özuyar, P. G., & Wall, T. (Eds.). (2020i). City Form. In Climate Action (pp. 87–87). Springer International Publishing. https://doi.org/10.1007/978-3-319-95885-9_300009
Leal Filho, W., Azul, A. M., Brandli, L., Özuyar, P. G., & Wall, T. (Eds.). (2020j). City Functions. In Climate Action (pp. 87–87). Springer International Publishing. https://doi.org/10.1007/978-3-319-95885-9_300085
Leal Filho, W., Azul, A. M., Brandli, L., Özuyar, P. G., & Wall, T. (Eds.). (2020k). City Planning. In Climate Action (pp. 87–87). Springer International Publishing. https://doi.org/10.1007/978-3-319-95885-9_300010
Leal Filho, W., Azul, A. M., Brandli, L., Özuyar, P. G., & Wall, T. (Eds.). (2020l). Climate Action. Springer International Publishing. https://doi.org/10.1007/978-3-319-95885-9
Live rainfall data on Mumbaiites phones. (2018, April 21). Urban Update. http://urbanupdate.in/live-rainfall-data-on-mumbaiites-phones/
LK_A_Particpatory_Methods.pdf. (n.d.).
London School of Economics and Political Science, Cities Programme, Urban Age Project, Alfred Herrhausen Gesellschaft für Internationalen Dialog, & Urban Age India Conference (Eds.). (2007). Urban india: Understanding the maximum city. Cities Programme, the London School of Economics and Political Science ; Alfred Herrhausen Society.
Mahul-report-draft-2-small.pdf. (n.d.). Retrieved 4 March 2020, from https://csainquiry.files.wordpress.com/2018/04/mahul-report-draft-2-small.pdf
Major Cities Face High Risk of Flooding According to a Goldman Sachs Report. (2019, December 31). ArchDaily. https://www.archdaily.com/930963/major-cities-face-high-risk-of-flooding-according-to-a-goldman-sachs-report
Makar, GadgilMakar, Gadgil, May 29, M. M. | U., 2016, & Ist, 02:48. (n.d.). Mumbai Port Trust to take back its land from tenants. Mumbai Mirror. Retrieved 17 April 2020, from https://mumbaimirror.indiatimes.com/mumbai/cover-story/Mumbai-Port-Trust-to-take-back-its-land-from-tenants/articleshow/52485512.cms
Makar, GadgilMakar, Oct 24, G. / U., 2016, & Ist, 04:48. (n.d.). State for freeing up salt pans, but MMRDA thinks otherwise. Mumbai Mirror. Retrieved 17 June 2020, from https://mumbaimirror.indiatimes.com/mumbai/other/State-for-freeing-up-salt-pans-but-MMRDA-thinks-other-

wise/articleshow/55021634.cms
McFarlane, C., Silver, J., & Truelove, Y. (2017). Cities within cities: Intra-urban comparison of infrastructure in Mumbai, Delhi and Cape Town. Urban Geography, 38(9), 1393–1417. https://doi.org/10.1080/02723638.2016.1243386
Mehrotra, S., Bardhan, R., & Ramamritham, K. (2018). Urban Informal Housing and Surface Urban Heat Island Intensity: Exploring Spatial Association in the City of Mumbai. Environment and Urbanization ASIA, 9(2), 158–177. https://doi.org/10.1177/0975425318783548
Mehta, S. (2019, May 30). Coastal Regulation Zone: How rules for building along coast have evolved. Marine Life of Mumbai. https://www.marinelifeofmumbai.in/coastal-regulation-zone-how-rules-for-building-along-coast-have-evolved/
Milind Deora resigns as Congress Mumbai president, says looking for national-level role | India News. (n.d.). Retrieved 29 January 2020, from https://www.timesnownews.com/india/article/milind-deora-resigns-as-mumbai-congress-president-says-looking-for-national-level-role/450065
Mithi is a river, not real estate. (n.d.). Retrieved 29 June 2020, from https://www.downtoearth.org.in/interviews/africa/mithi-is-a-river-not-real-estate--19
Mogelgaard, K., Dinshaw, A., Ginoya, N., Gutiérrez, M., Preethan, P., & Waslander, J. (n.d.). FROM PLANNING TO ACTION: MAINSTREAMING CLIMATE CHANGE ADAPTATION INTO DEVELOPMENT. 24.
Morgado, F., & Vieira, L. R. (2020). Biodiversity and Biogeography of Zooplankton: Implications of Climate Change. In W. Leal Filho, A. M. Azul, L. Brandli, P. G. Özuyar, & T. Wall (Eds.), Climate Action (pp. 53–65). Springer International Publishing. https://doi.org/10.1007/978-3-319-95885-9_119
Mumbai braces for more rain, flood creates havoc in several states. (2019, August 4). Zee News. https://zeenews.india.com/mumbai/mumbai-braces-for-more-rain-red-alert-in-7-maharashtra-districts-2224761.html
Mumbai chaos after heaviest rain in decade. (2019, July 2). BBC News. https://www.bbc.com/news/world-asia-india-48835828
Mumbai eastern waterfront revamp: Speak up before it is too late. (2019, February 6). Hindustan Times. https://www.hindustantimes.com/mumbai-news/mumbai-eastern-waterfront-revamp-speak-up-before-it-is-too-late/story-Y4YTaOPqPIYbmpjHvNseII.html
Mumbai: Five extremely heavy rain days in Monsoon 2019 alone, eight in past decade | Mumbai News - Times of India. (n.d.-a). The Times of India. Retrieved 29 June 2020, from https://timesofindia.indiatimes.com/city/mumbai/5-extremely-heavy-rain-days-in-monsoon-2019-alone-8-in-past-decade/articleshow/71354313.cms
Mumbai Floods Kill 5 | Voice of America—English. (n.d.). Retrieved 16 May 2020, from https://www.voanews.com/east-asia/mumbai-floods-kill-5
Mumbai: For buildings in CRZ areas, wait for extra FSI just got longer | Mumbai News - Times of India. (n.d.-b). The Times of India. Retrieved 14 January 2020, from https://timesofindia.indiatimes.com/city/mumbai/mumbai-for-buildings-in-crz-areas-wait-for-extra-fsi-just-got-longer/articleshow/68196007.cms
Mumbai: India's Global City. (n.d.). 40.
Mumbai_ India's Global City.pdf. (n.d.).
Mumbai mapped by a city designer. (2014, September 4). Mid-Day. https://www.mid-day.com/articles/mumbai-mapped-by-a-city-designer/15576186
Mumbai Metropolitan Region's built-up area up 350% in 40 years: Study | Mumbai News—Times of India. (n.d.). Retrieved 14 January 2020, from https://timesofindia.indiatimes.com/city/mumbai/mumbai-metropolitan-regions-built-up-area-up-350-in-40-years-study/articleshow/70918285.cms
Mumbai paralysed after incessant rain; death toll rises to 35 in Maharashtra | Mumbai News—Times of India. (n.d.). The Times of India. Retrieved 16 May 2020, from https://timesofindia.indiatimes.com/city/mumbai/mumbai-paralysed-after-incessant-rain-maharashtra-toll-rises-to-35/articleshow/70044217.cms
Mumbai Port Trust Is Out to Evict Thousands of People Who Live and Work on Its Land. (n.d.). The Wire. Retrieved 17 April 2020, from https://m.thewire.in/article/urban/mumbai-port-trust-land-eviction
Mumbai Port Trust may go the mill land way. (2019, February 5). Hindustan Times. https://www.hindustantimes.com/mumbai-news/mumbai-port-trust-may-go-the-mill-land-way/story-oY1P9L2QtqhyOpEpvU7z6J.html
Mumbai Port Trust: Multiple issues, no easy solutions. (n.d.). Cnbctv18.Com. Retrieved 17 April 2020, from https://www.cnbctv18.com/real-estate/mumbai-port-trust-multiple-issues-no-easy-solutions-2476871.htm
Mumbai rain defies forecast, it's Monday as usual. (n.d.). NDTV.Com. Retrieved 16 May 2020, from https://www.ndtv.com/mumbai-news/mumbai-rain-defies-forecast-its-monday-as-usual-525655
Mumbai rains: Four days of torrential downpour derailed city's infrastructure, killed 10; BMC says new flood points emerge—Firstpost. (n.d.). Retrieved 29 January 2020, from https://www.firstpost.com/india/mumbai-rains-four-days-of-torrential-downpour-derailed-citys-civic-infrastructure-killed-10-bmc-says-new-flood-points-are-emerging-4720621.html
Mumbai rains: Why the city that never sleeps comes to a standstill. (2019, July 9). Mongabay-India. https://india.mongabay.com/2019/07/why-the-city-that-never-stops-comes-to-a-standstill-when-it-rains/
Mumbai Rains Wreck Havoc. Met Dept Issues Orange Alert To Commuters, Twitter Floods With Memes! (2019, September 4). Latest Breaking News | Celebrity News and Gossip | Stackumbrella. https://www.stackumbrella.com/mumbai-rains-wreck-havoc-met-dept-issues-orange-alert-to-commuters-twitter-floods-with-memes/
Mumbai slum-dwellers by the sea live at the mercy of climate change. (n.d.). Retrieved 29 January 2020, from https://www.preventionweb.net/go/69324
Mumbai: The. (n.d.-c). Retrieved 14 January 2020, from https://www.preventionweb.net/go/59852
Mumbai The Business Destination.pdf. (n.d.).
Mumbai warned of severe, dangerous flooding. (n.d.). Indian Weekender. Retrieved 9 January 2020, from https://www.indianweekender.co.nz//Pages/ArticleDetails/10/284/India/Mumbai-warned-of-severe-dangerous-flooding
Mumbai will drown if development is allowed on salt pans. (2019, August 21). Hindustan Times. https://www.hindustantimes.com/mumbai-news/mumbai-will-drown-if-devpt-is-allowed-on-salt-pans/story-OUUhQXtzTrDMjR7JXi288M.html
Mumbai will likely flood again – and nobody's doing much about it | Cities | The Guardian. (n.d.). Retrieved 5 July 2020, from https://www.theguardian.com/cities/2014/nov/27/mumbai-flood-rain-monsoon-city-planning
Mumbai-Carrying-Capacity-Report-2006.pdf. (n.d.).
MumbaiJune 9, V., June 9, 2018UPDATED:, & Ist, 2018 21:24. (n.d.). Mumbai inundated in just first rain. India Today. Retrieved 16 May 2020, from https://www.indiatoday.in/india/story/mumbai-submerges-in-water-in-just-first-rain-1256300-2018-06-09
Mumbai's rains they are a changin': Six days accounted for 40% of city's rain this year. (2017, September 21). Hindustan Times. https://www.hindustantimes.com/mumbai-news/mumbai-s-rains-they-are-a-changin-six-days-accounted-for-40-of-city-s-rain-this-year/story-nmXrAJomdbhMx9z9BEy9bO.html
Mumbai's salt pans may soon fall by in big BJP real estate plans—Quartz India. (n.d.). Retrieved 12 January 2020, from https://qz.com/india/1728907/mumbais-salt-pans-may-soon-fall-by-in-big-bjp-real-estate-plans/
Mumbai's stinking rivers. (2017, June 5). The Hindu. https://www.thehindu.com/news/cities/mumbai/mumbais-stinking-rivers/article18723255.ece
NAS Adaptation Tool. (n.d.). [Overzichtspagina]. Spatial Adaptation. Retrieved 7 May 2020, from https://ruimtelijkeadaptatie.nl/english/policy-programmes/nas/nas-adaptation-tool/
NAS-adaptatietool. (n.d.). [Overzichtspagina]. Ruimtelijke adaptatie. Retrieved 7 May 2020, from https://ruimtelijkeadaptatie.nl/overheden/nas/adaptatietool/
Nas_nl_up20182019_climate_scheme_wetter_v18.pdf. (n.d.).
New Section. (2009, July 24). The Times of India. https://timesofindia.indiatimes.com/city/mumbai/in-pics-mumbais-highest-tide-in-100-yrs/new-section/photostory/4815093.cms
One-space-two-worlds.pdf. (n.d.).
Online, S. B. (n.d.). Chapter 8: Communication - Making Projects Work: Effective Stakeholder and Communication Management. Retrieved 6 May 2020, from https://learning-oreilly-com.tudelft.idm.oclc.org/library/view/making-projects-work/9781498734752/K21519_C000.xhtml
Outlook. (n.d.). Global Wetland Outlook. Retrieved 2 June 2020, from https://www.global-wetland-outlook.ramsar.org/outlook
Page 2—Indian Drying Fish India High Resolution Stock Photography and Images—Alamy. (n.d.). Retrieved 5 July 2020, from https://www.alamy.com/stock-photo/indian-drying-fish-india.html?page=2
Pagett, R. (2020). Building Global Resilience to Climate Change. In W. Leal Filho, A. M. Azul, L. Brandli, P. G. Özuyar, & T. Wall (Eds.), Climate Action (pp. 78–86). Springer International Publishing. https://doi.org/10.1007/978-3-319-95885-9_96
Participatory Methods Toolkit: A Practitioner's Manual (Elliott et al. 2005). - Google Search. (n.d.). Retrieved 7 May 2020, from https://www.google.com/search?q=Participatory+Methods+Toolkit%3A+A+Practitioner%E2%80%99s+Manual+(Elliott+et+al.+2005).&oq=Participatory+Methods+Toolkit%3A+A+Practitioner%E2%80%99s+Manual+(Elliott+et+al.+2005).&aqs=chrome..69i57.800j0j7&sourceid=chrome&ie=UTF-8
Patankar, A. (n.d.). The Exposure, Vulnerability, and Ability to Respond of Poor Households to Recurrent Floods in Mumbai. 45.
P_Balasubramanian_4737946_P5report.pdf. (n.d.).
Peters, A., & Peters, A. (2019, June 21). This is one of the simplest and best climate change graphics we've ever seen. Fast Company. https://www.fastcompany.com/90367577/this-is-one-of-the-simplest-and-best-climate-change-graphics-weve-ever-seen
Pinterest. (n.d.). Pinterest. Retrieved 9 January 2020, from https://in.pinterest.com/pin/575897871102080437/
Pinto, D. (2011, June 30). Bandra Worli Sea Link: An environmental disaster that may destroy Mumbai? DNA India. https://www.dnaindia.com/mumbai/interview-bandra-worli-sea-link-an-environmental-disaster-that-may-destroy-mumbai-1560787
PRASAD, R. R. (2019, March 5). Helpless Mumbai Port Trust sits on 1,900-acre prime land. The Asian Age. https://www.asianage.com/business/autos/050319/helpless-mumbai-port-trust-sits-on-1900-acre-prime-land.html
Project undertaken by BRIMSTOWAD to stop water-logging: More underground drains soon in Hindmata area | Cities News,The Indian Express. (n.d.). Retrieved 13 January 2020, from https://indianexpress.com/article/cities/mumbai/project-undertaken-by-brimstowad-to-stop-water-logging-more-underground-drains-soon-in-hindmata-area-4977158/
PTI. (n.d.). Heavy rains paralyse Mumbai. @businessline. Retrieved 11 June 2020, from https://www.thehindubusinessline.com/economy/policy/Heavy-rains-paralyse-Mumbai/article20329057.ece
Ramesh, R., & Bhatt, J. R. (n.d.). THE VULNERABLE INDIAN COAST. 398.
Rani jadhav committee report nov 2014 (345 pages). (n.d.). Issuu. Retrieved 17 April 2020, from https://issuu.com/indrashilrao/docs/rani_jadhav_committee_report_-_nov_
Ravindran, S. (2014, November 27). Mumbai will likely flood again – and nobody's doing much about it. The Guardian. https://www.theguardian.com/cities/2014/nov/27/mumbai-flood-rain-monsoon-city-planning
Report: Flooded Future: Global vulnerability to sea level rise worse than previously understood. (n.d.). Retrieved 6 June 2020, from https://www.climatecentral.org/news/report-flooded-future-global-vulnerability-to-sea-level-rise-worse-than-previously-understood
REPORT OF THE PLANNING COMMITTEE ON THE DRAFT DEVELOPMENT PLAN – 2034 FOR GREATER MUMBAI. (n.d.). 100.
Report.pdf. (n.d.). Retrieved 29 June 2020, from https://www.goldmansachs.com/insights/pages/gs-research/taking-the-heat/report.pdf?utm_medium=website&utm_source=archdaily.com
Robot finds sewage line in flood drain | Mumbai News—Times of India. (n.d.). The Times of India. Retrieved 27 January 2020, from https://timesofindia.indiatimes.com/city/mumbai/robot-finds-sewage-line-in-flood-drain/articleshow/67630559.cms
Roka, K. (2020). Anthropocene and Climate Change. In W. Leal Filho, A. M. Azul, L. Brandli, P. G. Özuyar, & T. Wall (Eds.), Climate Action (pp. 20–32). Springer International Publishing. https://doi.org/10.1007/978-3-319-95885-9_26
Ruiz-Campillo, X. (2020). Aligning Circular Economy and Climate Policy in Europe. In W. Leal Filho, A. M. Azul, L. Brandli, P. G. Özuyar, & T. Wall (Eds.), Climate Action (pp. 10–20). Springer International Publishing. https://doi.org/10.1007/978-3-319-95885-9_111
Salt pans save Mumbai from floods. So why are they under threat? (2019, October 14). Mongabay-India. https://india.mongabay.com/2019/10/salt-pans-save-mumbai-from-floods-so-why-are-they-under-threat/
Sanghani, H., & Brokking, P. (n.d.). Supervisor: Peter Brokking. 114.
Sansare, D. A., & Mhaske, S. Y. (2020). Natural hazard assessment and mapping using remote sensing and QGIS tools for Mumbai city, India. Natural Hazards, 100(3), 1117–1136. https://doi.org/10.1007/s11069-019-03852-5
Scheltema, M. (n.d.). MAINSTREAMING URBAN CLIMATE ADAPTATION INTO URBAN PLANNING AND DESIGN. 270.
Schiffer, E. (n.d.). Tracing Power and Influence in Networks: Net-Map as a Tool for Research and Strategic Network Planning. 28.
SEZ, GORAI MANORI UTTAN, MUMBAI.pdf. (n.d.).
Shetty, P., Gupte, R., Patil, R., Parikh, A., Sabnis, N., & Menezes, B. (n.d.). CRIT would like to thank the Urban Age Programme, London School of Economics for providing financial support for this project. CRIT would also like to thank Yogita Lokhande, Chitra Venkatramani and Ubaid Ansari for their contributions in this project. 134.
Silent Voice | SILENT VOICE | Page 46. (n.d.). Retrieved 5 July 2020, from https://silentmaj.wordpress.com/author/4silentvoice/page/46/
Singh, A. P. (n.d.). Identification of flood risk on urban road network using Hydrodynamic Model. 105.
Slocum, D. N. (n.d.). PARTICIPATORY METHODS TOOLKIT. 167.
Social network analysis software. (2020). In Wikipedia. https://en.wikipedia.org/w/index.php?title=Social_network_analysis_software&oldid=951258342
Spatial disparities in India_ Introduction.pdf. (n.d.).
Sreevatsan, A. (2017, September 14). How much of India is actually urban? Livemint. https://www.livemint.com/Politics/4UjtdRPRikhpo8vAE0V4hK/How-much-of-India-is-actually-urban.html

Srivastava, V. P., Sneha Alexander,Prachi. (2019, July 21). The growing threat of climate change in India. Livemint. https://www.livemint.com/news/india/the-growing-threat-of-climate-change-in-india-1563716968468.html
Staff, W. S. J. (2013, April 30). The Importance of Mumbai's Mangroves. WSJ. https://blogs.wsj.com/indiarealtime/2013/04/30/the-importance-of-mumbais-mangroves/
Static-kinetic-cities.pdf. (n.d.).
Suggestion-for-the-Revised-Draft-of-Mumbai's-Development-Plan_2014-2034.pdf. (n.d.-a). Retrieved 17 May 2020, from http://www.pkdas.com/published/Suggestion-for-the-Revised-Draft-of-Mumbai's-Development-Plan_2014-2034.pdf
Suggestion-for-the-Revised-Draft-of-Mumbai's-Development-Plan_2014-2034.pdf. (n.d.-b). Retrieved 17 May 2020, from http://www.pkdas.com/published/Suggestion-for-the-Revised-Draft-of-Mumbai's-Development-Plan_2014-2034.pdf
Suggestion-for-the-Revised-Draft-of-Mumbai's-Development-Plan_2014-2034.pdf. (n.d.-c). Retrieved 17 May 2020, from http://www.pkdas.com/published/Suggestion-for-the-Revised-Draft-of-Mumbai's-Development-Plan_2014-2034.pdf
Summary for Policymakers of IPCC Special Report on Global Warming of 1.5°C approved by governments—IPCC. (n.d.). Retrieved 9 June 2020, from https://www.ipcc.ch/2018/10/08/summary-for-policymakers-of-ipcc-special-report-on-global-warming-of-1-5c-approved-by-governments/
Tandon, K. S. & A. (n.d.). Another monsoon, another deluge: Why Mumbai gets inundated nearly every year [Text]. Scroll.In. Retrieved 29 January 2020, from https://scroll.in/article/929936/another-monsoon-another-deluge-why-mumbai-gets-inundated-nearly-every-year
Telescope: Telling a soggy tale. (2018, July 12). The Indian Express. https://indianexpress.com/article/opinion/columns/mumbai-rain-monsoon-imd-5255659/
The astonishing biodiversity of Mumbai. (n.d.). Https://Www.Outlookindia.Com/Outlooktraveller/. Retrieved 17 June 2020, from https://www.outlookindia.com/outlooktraveller/travelnews/story/46425/the-astonishing-biodiversity-of-mumbai
The biodiversity cost of our urban march. (2015, May 26). Hindustan Times. https://www.hindustantimes.com/mumbai/the-biodiversity-cost-of-our-urban-march/story-WepFP4Fy3lUcaF7rWV93JN.html
This Duo Is Creating Mumbai's First Dense Forest, Aims To Plant 10 Crore Trees By 2025 Across India. (2019, April 11). LifeBeyondNumbers. https://lifebeyondnumbers.com/green-yatra-ngo-pradeep-tripathi-durgesh-gupta-miyawaki-urban-dense-forest-mumbai/
Tiesdell, S., & Allmendinger, P. (2008). Planning Tools and Markets: Towards an Extended Conceptualisation. In D. Adams, C. Watkins, & M. White (Eds.), Planning, Public Policy & Property Markets (pp. 56–76). Blackwell Publishing Ltd. https://doi.org/10.1002/9780470757789.ch4
Tools. (n.d.). [Overzichtspagina]. Spatial Adaptation. Retrieved 7 May 2020, from https://ruimtelijkeadaptatie.nl/english/tools/
UN – 1995 to 2015, Flood Disasters Affected 2.3 Billion and Killed 157,000 – FloodList. (n.d.). Retrieved 29 June 2020, from http://floodlist.com/dealing-with-floods/flood-disaster-figures-1995-2015
UN-Habitat Global Activities Report 2013 , Our Presence and Partnerships | UN-Habitat. (n.d.). Retrieved 9 June 2020, from https://unhabitat.org/un-habitat-global-activities-report-2013-our-presence-and-partnerships
Urban Jungle. (n.d.). IAAC Blog. Retrieved 30 June 2020, from http://www.iaacblog.com/programs/urban-jungle/
Urbanization: No City-Dweller Left Behind » Pragati. (2019, March 26). Pragati. https://www.thinkpragati.com/think/manifesto/7495/urbanization-no-city-dweller-left-behind/
Varshney, A. (n.d.). How can Mumbai ease its flooding problem? By sparing land just 1% the size of Bandra-Kurla Complex [Text]. Scroll.In. Retrieved 9 February 2020, from https://scroll.in/article/932392/how-can-mumbai-ease-its-flooding-problem-by-sparing-land-just-1-the-size-of-bandra-kurla-complex
View of Research Design and Approach. (n.d.). Retrieved 22 January 2020, from https://journals.open.tudelft.nl/abe/article/view/4334/4232
Vyas, S. (2015, December 20). Tribal pocket near Mumbai readies first biodiversity map. The Hindu. https://www.thehindu.com/news/cities/mumbai/tribal-pocket-near-mumbai-readies-first-biodiversity-map/article8010623.ece
Wagh, S., & Indorewala, H. (n.d.). Mumbai's Coastal Road: Social & Environmental Impacts. 58.
Waldick, R., Bizikova, L., White, D., & Lindsay, K. (2017). An integrated decision-support process for adaptation planning: Climate change as impetus for scenario planning in an agricultural region of Canada. Regional Environmental Change, 17(1), 187–200. https://doi.org/10.1007/s10113-016-0992-5
Watch Changing Climate. (n.d.). BFI Player. Retrieved 2 June 2020, from https://player.bfi.org.uk/free/film/watch-changing-climate-1978-online
Water Security for Better Lives | READ online. (n.d.). OECD ILibrary. Retrieved 29 June 2020, from https://read.oecd-ilibrary.org/environment/water-security_9789264202405-en
Waterstaat, M. van I. en. (2015a, January 29). Spatial Adaptation—Delta Programme—Delta Commissioner [Webpagina]. Ministerie van Infrastructuur en Waterstaat. https://english.deltacommissaris.nl/delta-programme/regions-and-generic-topics/spatial-adaptation
Waterstaat, M. van I. en. (2015b, February 3). Delta Scenarios—Delta Programme—Delta Commissioner [Webpagina]. Ministerie van Infrastructuur en Waterstaat. https://english.deltacommissaris.nl/delta-programme/knowledge-programme/delta-scenarios
Welle (www.dw.com), D. (n.d.). Saving Mumbai's natural mangrove buffer against rising tides | DW | 27.03.2019. DW.COM. Retrieved 16 May 2020, from https://www.dw.com/en/saving-mumbais-natural-mangrove-buffer-against-rising-tides/a-47992557
Where are you really from? An art show traces the history of migration. (2017, July 7). Hindustan Times. https://www.hindustantimes.com/mumbai-news/where-are-you-really-from-an-art-show-traces-the-history-of-migration/story-70IqZb7DtgfpFYFbsmDtWP.html
While the world watches Storm Harvey, more than 1,000 people have been killed in floods in south Asia. (2017, August 30). Evening Standard. https://www.standard.co.uk/news/world/as-the-world-watches-storm-harvey-more-than-1000-people-have-been-killed-in-floods-in-india-nepal-a3622821.html
Why Mumbai's floods are an urban planning disaster. (2017, September 6). STEPS Centre. https://steps-centre.org/blog/mumbais-floods-also-disaster-urban-planning/
World Maps—Biological Hotspots. (n.d.). Retrieved 13 January 2020, from https://atlas-for-the-end-of-the-world.com/world_maps/world_maps_biological_hotspots.html
Worli high-rise in trouble for CRZ violations. (2011, August 30). Hindustan Times. https://www.hindustantimes.com/mumbai/worli-high-rise-in-trouble-for-crz-violations/story-4JufSY3KrJBijZCwpE4gxI.html
Živković, J. (2020). Urban Form and Function. In W. Leal Filho, A. M. Azul, L. Brandli, P. G. Özuyar, & T. Wall (Eds.), Climate Action (pp. 862–871). Springer International Publishing. https://doi.org/10.1007/978-3-319-95885-9_78
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Theory essay

Extending the definition of [Mega]regions / Macroregions
A relational geographical construct for future development
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Abstract:
The past few decades have seen a shift in global economic trends, from Nation-states being the economic drivers of the global economy to the diffusion of these borders in the globalised world, and to see the emergence of 'Region-states' as the new economic units. These region-states termed as 'Megaregions', are the new urban form of globalisation which includes agglomeration of cities and their supporting hinterlands.
This paper presents an understanding of this new paradigm as a product of the quicksilver global economy, by comprehending the dialectics of its emergence. There is a need for reinforcing and understanding the epistemology of this spatial concept as 'Megaregions' being widely used by multiple actors is in danger to be misinterpreted and overextended to become an orthodoxy rather than a spatial potential for positive transformative and generative force. The present context of rapid urbanisation, climate change, globalisation, increased interconnectivity and new infrastructure technologies highlights the need for spatial strategy formation and implementation at the Regional scale. This paper contributes to the discussion of the Regional urbanisation which elaborates further on the relational construct of this spatial scale formed by multiple linkages. It establishes the need for comprehensive planning and design to develop Megaregion as a spatial analytical and strategic tool that involves an understanding of megaregion(spaces) and megaregionality(processes).
Further, through the consideration of Mumbai, India, the paper attempts to contextualise this conception of [Mega] regions/Macro-regions to understand the challenges to be tackled. In conclusion, the spatial implications and considerations of this political-economic phenomenon will be deduced.

Keywords: Megaregion, Relational construct, spatial planning, megaregionality(processes)

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Introduction
The current world embodies a multiplicity of differential webs connecting people, firms and non-human processes through space and time which transects and intersects across geopolitical borders. With these changing processes, our lens of scale for understanding the same needs to be adapted concomitantly leading to an emerging understanding of a restructured spatial scale called 'Megaregions'. The extent of urbanisation in a technologically advancing globalised world is inordinately expanding until the dissolution of the dichotomy or urban/rural or city/country-side. Geographers and planners have been comprehending this phenomenon of sprawling urbanised landscapes comprising functional networks through: ' megalopolis, archipelago economy, galactic city, string city, limitless city, endless city, liquid city, global city-region, world city-region, mega-city region, polycentric metropolis, new megalopolis, megapolitan region, metro region, polynuclear urban region, super urban region, super-region...megaregion.' (Harrison & Hoyler, 2015) Each variant is intended to make this macro-region more intelligible and to help one grasp the rapidly changing realities. The realities of urban are complex and polychromatic; however, the conception of this macro region has intellectual and practical consequences making it an imperative task to be undertaken. (Neuman & Hull, 2009) 'Megaregions are a new spatial and temporal entity, a polycentric multi metropolis \of shifting and dynamic multi-scalar and multi-speed architecture whose development logics respond to a new set of conditions.' (Neuman & Hull, 2009) Since the Twentieth Century, urban and regional debates have been dealing with understanding the complex, multi-dimensional, multi-scalar processes in urban space. This networked concept has been both developed in pedagogy and practice. This paper seeks to comprehend this 'imagined' spatiality of relational geographic construct through a comprehensive understanding of selected works of literature in this urban regional discourse which would be constructive in this processual understanding. In this process, the paper would try to answer or raise relevant questions regarding this discourse. First, why is there a need for the epistemology of Megaregion? Second, what is a megaregion, and how could we understand it? Third, understanding the spatial implications and challenges of using Megaregion as a spatial tool to deduce how could we use Megaregion as a spatial (scalar) tool? Fourth, how to contextualise 'Megaregion' understanding in Mumbai, India. The conclusions are drawn in the final section, raising relevant questions for the purpose of advancing further in the graduation project undertaken.

1. Why do we need to study Megaregion?

This section will help to establish the need for developing an epistemology of Megaregion by giving a summary of the evolution of this concept over space and time and by understanding the benefits of it. With a vast amount of deliberations and implementation over urban and regional understanding both in pedagogy and practice, it is essential to mention here, that due to the limitation of space and time, the essay would only be discussing a few of the relevant (pedagogical)theories on the topic.

Since the beginning of the 20th Century, with urbanisation picking its pace, observation of expansion of urban spatial scales began. It was first Patrick Geddes (1915) who coined the term 'conurbation' for a new spatial configuration of urban. Later, Lewis Mumford (1938) defined the term 'Megalopolis' to define the fourth stage of a city after the first three stages- ' eopolis'(village), 'polis' (city) and 'metropolis' (capital city) where the great cities overdevelop and a period of descent begins. Geddes (1915) and Mumford's (1938) narratives framed this urban spatial expansion in a negative light referring to the development of the city as the problem.(Harrison & Hoyler, 2015) However, Gottmann's (1961) perception of the foreboding megalopolises was contrary, he describes the late 20th Century as a 'new order in the organisation of inhabited space' involving an urban economic expansion that commits social and economic prosperity, providing people with better housing, jobs and other amenities. (Gottmann, 1961; Harrison & Hoyler, 2015)

"Megalopolis stands indeed at the threshold of a new way of life, and upon [the] solution of its problems will rest civilization's ability to survive.' (Gottmann, 1961, p.16) Therefore, Megalopolis became the bedrock for a research laboratory for urban spatial growth assimilating the advancing globalising forces. The intensification and extension of urbanisation with evolving economic structure have led to the evolution of urban to an urban-regional spatial configuration which began with cities evolved to metropolitan cities then to metropolitan regions, afterwards to global city-regions and now to - Megaregions. Three types of urban regional spatial configuration that relate to the global economy include global city-regions/ mega-city regions/ metro(-politan) region which relates to one urban system, a megaregion constituting two or more urban systems and planetary urbanization representing the reach of the global urban system across geographic space. (Harrison & Hoyler, 2015) There are four key aspects as pointed out by Harrison & Hoyler(2015) from these spatial concepts which need to be taken into account in the discussion further and some of these points will be taken up in further sections. First, understanding the geographical context in which these spatial concepts have their cognitive origins and the specific intention for which they were developed. Second, differing perceptions on this discourse with the American perspective based on form-dominant spatial planning tradition while European perspective currently associated with functionally dominant global-city inspired network approaches. The type of Megaregion space with its boundaries varies depending on form(urbanisation) or function (global economic integration) being the starting point on this endeavour to unravel the complexity of this globalised urbanisation. (Harrison & Hoyler, 2015)
Third, identification of megaregional spaces as planning, governance and economic spaces. Also, the distinction between megaregional space and spaces of the megaregion where the latter represents the heterogeneity in megaregionality(processes) played out in the local spaces within a defined megaregion space. The Fourth point implies the relational geography of this concept since the [mega]regions only exist in relation to certain criteria. (Harrison & Hoyler, 2015) They are spatial constructs based on our comprehension of processes. This leads to an important question of how megaregional spaces are constructed, which would be dealt with in the third section.

'Megaregions are the spatial manifestation of economic activity and are fast becoming the new engines of global and regional economies.' (UN Habitat,2010) The past few decades have seen a shift in the economic drivers- from nation-states to Region-states being the new 'natural' economic unit in the current borderless world where a reallocation of labour and capital is occurring guided by prevailing economic processes. (Florida et al., 2007) This region-state embodies densest clusters of socio-economic activity which are becoming the command centres or strategic posts in the current global economy. (Harrison & Hoyler, 2015) It requires political and economic systems to acknowledge the actuality and potentiality of this geographic scale and align themselves to its prospective capacity. This new 'natural' economic unit which is the product of the concentration of innovation, production and consumer markets, if planned efficiently and effectively assures future competitiveness. (Florida et al, 2007; Dewar & Epstein, 2007)

Megaregions have become the ‘latest episode of long-running economic-political drama searching for a spatial scalar fix for global economies’ (Harrison & Hoyler, 2015) which faces the threat of turning into an orthodoxy to be stretched and overextended by multiple actors that it gets distanced from its foundations. Just as Hecksher expressed his concern regarding ‘Megalopolis’ to become a transient spatial concept when he said, ‘I hope that his own definition will be heeded; for the term is so awe-inspiring, and the phenomenon it describes so dramatic and novel that it is very easy for misconceptions to take root.’ (Hecksher, 1964) Thus, it is important to discuss and extend the understanding of this spatial concept to make profound its use as a spatial tool for planning to achieve the goal that this concept was constructed to attain.

The Megaregions have a pervading notion of megaregions(space) and megaregionality (process) (Schafran, 2015) but lacks the extent of research to completely unfold the complexity it embodies. The challenges on the local scale are also due to the consequences of the processes that play out on a larger regional scale. This presses the need for spatial planning at a scale larger than the administrative boundaries of the urban agglomeration rather to be dealt at the processual spatial scale. For example, flooding in a local area could be a consequential outcome of the lack in climate adaptive capacity of the region to absorb the fluvial flooding.
In addition, the ‘Mega regional’ approach can benefit both small and large urban agglomerations. For larger cities, the continuous concentration of socio-economic activity in a single centre can produce negative externalities due to spatial economic reasons, such as over pressurisation of infrastructure, incremental land and property costs, institutional barriers to expansion, and increase in social inequality in large cities.(Florida, 2017; Cardoso & Meijers, 2019) Benefits of cumulative agglomeration that mitigate some of these costs must be tested. The smaller or comparable cities in this spatial construct also benefit from the concept of borrowed size by performing better due to their access to proximate agglomeration benefits than in isolation. They retain the advantages of smaller or medium size and simultaneously enjoy the benefits of larger size, due to accessibility and connection to the nearby centre. The Megaregion if integrated along the three dimensions of function, culture, and institutions can resemble a single large agglomeration in terms of flow and help better their performance. (Cardoso & Meijers, 2019) This process of integration called ‘Metropolisation’ (Cardoso & Meijers, 2019) is taken up in section.3. explaining how Megaregion could be used as a spatial tool.

2. What is a Megaregion and how could the definition be extended?

The slight consensus to the definition of Megaregions could be partly attributed to the plethora of related terms- ‘megapolitan region’, ‘polycentric mega-city region’...and so on developed - and to the geographic and disciplinary diversity of megaregional comprehension. (Schafran, 2015)
The author would expand on a certain understanding of ‘megaregion’ and position the paper in this wide range of terminology and definitions of this common spatial concept. The author would use the theory of Megaregions, city-regions and Megalopolis by experts and scholars like Michael Neuman, Patsy Healey, Peter Hall, Robert Lang & Knox and Dewar & Epstein to understand the multidimensionality and interactional nature of the construction of this space. (Healey, 2009; Hall, 2009; Lang & Knox, 2009; Neuman & Hull, 2009)

‘Megaregions’ are the new urban form of globalisation which includes agglomeration of cities and their supporting hinterlands. It is a trans-metropolitan landscape which involves a large combination of urban agglomerations-cities and metropolitan areas but along with it the ‘operationalizing landscapes’ as theorised by Planetary Urbanisation. (Brenner, 2013) This has been an outcome of the new forms of networks and spatial connectivity that reintegrates urban spaces through advanced infrastructure defining patterns of spatial-economic integration. (Lang & Knox, 2009)

The urban infrastructure and communication networks spread across national landscapes extend urbanisation beyond city boundaries which corresponds to the perceived ‘functional’ regions. (Healey, 2009) These regions coincide with a ‘functional reality’ of integrated economic, political and social relations and have a potential for harnessing critical socio-environmental relations to develop strategies for steering a sustainable urban development. (Ravetz, 2000). The layers of infrastructure, economic, ecological, topographic, cultural and historic linkages that together define a shared space can be used to organise policy decisions. (Dewar & Epstein, 2009). Regional planners and development analysts have pursued the idea that ‘functional’ realities should be aligned with administrative jurisdictions, to create planning areas – functional urban areas or megaregions, which engenders future development trajectories. (Healey, 2009) Although these regions could take multiple forms from these ‘spatially overlapping or convergent urban areas with a surrounding hinterland’ or ‘geographically distinct but proximate urban centres working together to harvest benefits of mutual cooperation.’(Scott, 2001) Nonetheless, multiple actors in different contexts have tried to define the specificity to delineate these boundaries with various methods. The major three categories implemented in the United States describe the distinction in boundary limits: fuzzy boundary plans, multiple-boundary plans, and single boundary plans (Dewar & Epstein, 2007); however, it leads to the conclusion that the details of the boundaries are insignificant for a better understanding of the development of this huge concentration. These boundaries of megaregions should be adaptable to the purpose of the plan. (Dewar & Epstein, 2007) Departing from the idea of regional boundaries, Dewar and Epstein hypothesized 3 categories of ‘[spatial] models of regional definition’, each with its characteristic spatial flows- linkage, gradient and bounded. (Dewar & Epstein, 2007, p.116) The linkage model reflects a network understanding which captures the movement of people, information and capital. Second, the gradient model provides a topological understanding of a dynamic spatial system, and the bounded model equates to the cartographic approaches of the enclosed territorial unit. (Dewar & Epstein, 2007; Neuman & Hull, 2009)

The advent of defining these ‘megaregional spaces’ also lead to researchers prioritising megaregional form to start marking out space by investigating the physical landscape, whereas others prioritising megaregional function by identifying less visible or even invisible patterns in the physical landscape, for example, flows of knowledge and capital. (Harrison & Hoyler, 2015) Both macro and micro-level analysis of megaregional space begin to depict the unevenness of megaregionality processes over megaregional space. (Sassen, 2007) The processes of megaregionality impact different spaces, places and people unevenly across megaregional space induced by the complexity and diversity of the socio-spatial relations that synergise in space and time. (Healey, 2009). This leads to an important question that how megaregion concept could help in analysing the different processes that are played out in local spaces? (Harrison & Hoyler, 2015) Also, we urgently need to investigate who defines the Megaregion-in whose interest megaregion are being constructed and how do actors defend this construct for their specific interests as highlighted by Florida that there is also a ‘spiky world of megaregional interest’. Ultimately, making this ‘a question of governance.’ (Harrison & Hoyler, 2015)

3. How can Megaregion be used as a spatial analytical or strategic tool?

‘The Megaregion has become a critically important scale of analysis for contemporary geography.’ (Schafran, 2015) Formation of these Megaregions as established earlier in the paper is essential for socio-economic and environmental reasons making it an important aspect of research concern as an analytical tool but at the same time as a ‘strategic aim’ to achieve the advantages it encompasses. The concept of ‘Metropolisation’, defined by Cardoso and Meijers could be used as a strategic planning tool which involves the synergies of interaction between spatial-functional, political-institutional and cultural-symbolic integration processes across regions to create coherent regions. (Cardoso & Meijers, 2019) Metropolisation processes emerge from regional territories marked by extensive urbanisation where different forms of closer spatial, cultural and institutional integration, and agglomeration benefits are extended across urban networks while not being spatially confined to their concentration centres. (Cardoso & Meijers, 2019) In this concept, the urban forms, resources, activities and flows have regionalised spatial spread and socio-economic sphere of influence. (Cardoso & Meijers, 2018; Soja, 2011) It is a zonal concept with functional, economic, political or morphological ‘centres’ as concentrations in a gradient of an ‘urban field’ (Friedmann & Miller, 1965). In addition, it makes the process inclusive by shifting the focus only from the nodes where a huge number of the population and institutions operate to the voices of the people in between who should also be a part of the the debates about the future development of the region. (Harrison & Heley, 2015; Cardoso & Meijers, 2019) Metropolisation is engendered by forces highly influenced by context and acts not only as an analytical lens to interpret the spatial, functional and institutional integration happening in city-regions but also a tool to outline development strategies focussed on steering these processes. (Cardoso & Meijers, 2019)

Functional integration in this process is represented by transport infrastructure where these functional linkages have connected urban spaces together. (Cardoso & Meijers, 2019) Peter Hall states that the current economic processes are an outcome of the infrastructural evolution in the physical landscape. Infrastructure drives the transformation of spatial-temporal relations in megaregional spaces and influences the distribution of urban form, and dynamic processes. Spatial planners should use the transformative power of this physical infrastructure development as a key structuring element in regional spatial strategies. (Neuman & Hull, 2009; Hall, 2009).

To operationalise this strategic tool further, the concept needs to be captured by the people for cultural integration. People always used images to construct their understanding of space, urban or otherwise, to the place they inhabit which attributes to the identities that they relate to. However, the complexity and scale of megaregion and its multiple

intersections with virtual spaces and flows of globalisation has not only diffused the image of the city but also has affected the ability to construct an image of the megaregion. (Neuman & Hull, 2009) The idea of the place of a 'megaregion' must become embedded in significant relations and imaginations within the place itself in order to act as an identity-shaping force to mobilise attention both internally(local) and externally (nationally & internationally). (Healey, 2009) This implies that the promotion of a 'megaregion' as a generalised policy idea needs to be reinforced with more focalised and localised 'place development' projects. (Healey, 2009) This would involve analysing the diversity of the society and daily trajectories, and to capture the imaginative and cultural dimensions of people's place attachments. (Healey,2009) With metropolisation process, megaregions can become the 'integrators of spaces of flow.' (Neuman & Hull, 2009)

The concept of megaregion being an imaginative construct comes from the epistemology which recognises that ideas of the city, city-region, of place, as not objectively 'there', but are imagined concepts, constructed in particular times and places for specific reasons (Healey, 2002) This raises questions about the intentions of such construction and the institutional work carried out by them. Healey analysed the relations and identities that are carried within the concept of 'region' associated with the mobilisation forces and with the potential consequences. She assimilated that this concept contributes to the form and content of place development. (Healey, 2009; Neuman & Hull, 2009)
Economic and administrative interests have dominated the deliberations of Megaregions and it has been interpreted as a step towards the search for sub-national re-configuration. (Healey, 2009) In regard to the institutional structure, this means devolving state power to regional and local levels, and developing horizontal collaborations between actors, to replace the vertical hierarchical institutional structure. (Healey, 2009) 'Megaregion' could become the crucial institutional arena both for identifying and selecting projects in a new configuration of government and for encouraging the promotion of endogenous economic development where the focus shifts from government to governance. (Healey, 2009) A 'megaregion' arena may be promoted to draw the different networks of provision together, to enable better coordination and delivery of services and infrastructures in the region. (Healey, 2009) How could insertion of 'megaregion' institutional arena reconfigure governance and help to create institutional spaces for an assertive 'politics of place' which draws attention to the relational nexuses that intersect and co-exist in localities? (Healey, 2009) Healey explains with the example of The Netherlands, where a flexible informal regional arena emerged as a locally developed response to change national funding arrangements, in which prioritising projects became a critical activity. The development of this arena was fuelled by an understanding of a 'network society' where 'soft institutional form' was developed based on the functional linkages considered for a project. (Healey, 2009) This would mobilise the dynamics of the complex intersecting and co-existing multiple relations in particular places for potential development. Therefore, government reconfiguration needs to build upon the 'locally specific, endogenously grounded but exogenously positioned place development strategies.' These place development strategies mobilise and coordinate forces in developing more horizontal governance forms, open to influences from economic and civil society relational nexuses. (Healey, 2009)

The relational geography with the interplay between urban spaces and processes that produce that space involves interactions at multiple scales. The patterns of interactions within regions and between individuals and institutions in an attempt to govern regions occur through networks in physical and non-physical(digital) environments. This shows that the institutionally networked space reflects the urban network space, a phenomenon called 'spatial-institutional isomorphism' by Neuman & Hull. Spatial-institutional isomorphism can be comprehended as the dynamics of spatial, institutional, and virtual network phenomena which influences the space-society relations and indicate on a reconfigured analytical approach. (Neuman & Hull, 2009) Institutional networks govern infrastructural networks that are the eventual shapers (and shapes) of space at all scales. This implies a relational approach to institutional design and points to the relational agency where the process mechanisms include coordination, collaboration, consensus building and facilitation. (Neuman & Hull, 2009)
The dynamic flow patterns, indeterminate boundaries, and the multi-scalar properties of spatial conditions and institutional actions do not correspond to the kind of institutional fixity that responds to the spatially based levels of government and even governance at a single scale. Part of the problem, as Hall and Pain (2006) points out is the 'mismatch between functional and territorial logic.' (Hall & Pain, 2006; Neuman & Hull, 2009) Planners and scholars interested in Megaregion planning assert that governance rather than government is needed to plan for megaregion because no government exists to match the megaregion scale and the possible megaregion boundaries. (Dewar & Epstein, 2007)

4. Contextualising Megaregion in Mumbai, India

'We should collectively invest in the plural of regional logics, tailoring usage to the problems at hand, rather than in a singular logic that simply replaces the romance of nation-state with an equally simple and one-size-fits-all alternative geographical unit of account such as...the global city region. (Agnew, 2013, p.15)

The implication that Agnew highlights could be applied to 'megaregion' as well. This quote indicates the significance of the geographical location and that megaregion could signify different things to different actors with different visions. (Agnew, 2013) Therefore, 'Geography and context matters.' (Harrison & Hoyler, 2015)
Considering the case of Mumbai in India, which locates itself between global and local identity being a global megalopolis with a post-colonial reality. Mumbai as a global city region and the financial capital of the country has developed at a tremendous pace with adapting its economy to the quicksilver global economy resulting in the concentration of jobs that have created a centripetal force and mobilised human resources through large scale internal migration within the country. The incapacity of this topographic coastal geography to absorb this large number of migrants with limited land resources and uneven allocation of resources and capital has led to huge disparities in social processes. Especially leading to the proliferation of slums which constitutes fifty-five per cent of the population and the informal sector jobs. However, the concept of Megaregion if applied in this context and geography as a strategic tool could change the socio-economic dynamics of the region and could build relational geography with economic and functional linkages with different agglomerations in the megaregion.
Considering the ecological dimension, the crunch for space has exacerbated the conflict between the environment and urban development. The latter has usually won, but the costs have been disastrous with Mumbai and neighbouring region witnessing recurring floods. Nevertheless, Megaregion as a spatial analytical tool could be used to analyse the larger ecological system which traverses through administrative boundaries in order to reduce environmental stresses by intervening at the appropriate scale to harness a systemic change.
Therefore, this transformative and generative power of urbanisation in megaregions needs to be utilised by using megaregion as an appropriate spatial analytical and strategic tool that needs to be calibrated to plan for future development in the context of Mumbai. Governance becomes a key calibrator to be considered to implement this spatial construct as a planning tool.

Conclusions

Megaregion concept may be useful both to focus attention on a range of social, environmental and economic relations, and as an institutional possibility. The threat to this concept is that it becomes a generalised solution, interpolated into a 're-organisation of sub-national government which is unlikely to produce the local mobilisation and embedding which could energise and focus a vigorous, locally-specific, multifaceted politics of place.' (Healey, 2009) Planning should involve the provision of 'soft and flexible' government form where the capacity of governance needs to constitute a megaregional arena driven by projects rather than a rigid vertical inclusion of government structure; an arena that could subsume differential collaborations.

Megaregion is not the complete answer to all the problems, but it forms a part of the solution. It is important to critically analyse future and current development at multiple scales where this becomes a new scalar lens that needs to be critically examined with, at the same time correct its deficiencies with consideration of other scales. It is a relational construct, relational to the processes occurring specific geography and context. The articulation of a megaregion should change depending on the appropriate geography for addressing specific policy issues. Planners should try to understand regions with increased attention to connections between places compared to the character of specific places. These conclusions raise the question of the scope of Megaregion as a planning tool, and the calibration of this tool in order to be implemented in Mumbai region.
The author would like to end with the note that the prefix 'mega' of this concept could be dismissed altogether because the essence of the idea lies in the relational construct of this spatial concept and the irrelevance of 'mega' or 'metropolitan-' or others. These regions could be called 'macroregions' or just 'regions' to convey the idea.

References

- Agnew, J. A. (2013). Arguing with Regions. Regional Studies, 47(1), 6–17. https://doi.org/10.1080/00343404.2012.676738
- Axinte, L. F., Mehmood, A., Marsden, T., & Roep, D. (2019). Regenerative city-regions: A new conceptual framework. Regional Studies, Regional Science, 6(1), 117–129. https://doi.org/10.1080/21681376.2019.1584542

- Brenner, N. J. (Ed.). (2014). Implosions/Explosions: Towards a Study of Planetary Urbanization. Berlin: Jovis.
- Cardoso, R, & Meijers, E. (2019). The process of Metropolisation in megacity-regions. Unpublished Manuscript.
- Editorial: Whither Regional Studies? Regional Studies: Vol 41, No 9. (n.d.). Retrieved 19 November 2019, from https://www-tandfonline-com.ezp.lib.unimelb.edu.au/doi/full/10.1080/00343400701675587
- Florida et al. - 2008—The rise of the mega-region.pdf. (n.d.). Retrieved from https://www.creativeclass.com/rfcgdb/articles/Florida,%20Gulden,%20Mellander_Mega-Regions.pdf
- Florida, R., Gulden, T., & Mellander, C. (2008). The rise of the mega-region. Cambridge Journal of Regions, Economy and Society, 1(3), 459–476. https://doi.org/10.1093/cjres/rsn018
- Friedmann, J. (1986). The World City Hypothesis. Development and Change, 17(1), 69–83. https://doi.org/10.1111/j.1467-7660.1986.tb00231.x
- Friedmann, J., & Miller, J. (1965). The Urban Field. Journal of the American Institute of Planners, 31(4), 312–320. https://doi.org/10.1080/01944366508978185
- Gottmann, J. (1957). Megalopolis or the Urbanization of the Northeastern Seaboard. Economic Geography, 33(3), 189–200. https://doi.org/10.2307/142307
- Gottmann, Jean. (1967). Megalopolis: The urbanized Northeastern seaboard of the United States. Cambridge, Mass: MIT Press.
- Hall, P. (2009). Looking Backward, Looking Forward: The City Region of the Mid-21st Century. Regional Studies, 43(6), 803–817. https://doi.org/10.1080/00343400903039673
- Harrison, J., & Heley, J. (2015). Governing beyond the metropolis: Placing the rural in city-region development. Urban Studies, 52(6), 1113–1133. https://doi.org/10.1177/0042098014532853
- Harrison, J., & Hoyler, M. (2015). Megaregions: Globalization's New Urban Form? Cheltenham, UK: Edward Elgar Pub.
- Healey, P. (2009). City Regions and Place Development. Regional Studies, 43(6), 831–843. https://doi.org/10.1080/00343400701861336
- Hecksher,A. (1964). Foreward.in Gottmann, Jean. (1967). Megalopolis: The urbanized Northeastern seaboard of the United States. Cambridge, Mass: MIT Press
- Lang, R., & Knox, P. K. (2009). The New Metropolis: Rethinking Megalopolis. Regional Studies, 43(6), 789–802. https://doi.org/10.1080/00343400701654251
- Meijers, E. (2008). Summing Small Cities Does Not Make a Large City: Polycentric Urban Regions and the Provision of Cultural, Leisure and Sports Amenities. Urban Studies, 45(11), 2323–2342. https://doi.org/10.1177/0042098008095870
- Neuman, M., & Hull, A. (2009). The Futures of the City Region. Regional Studies, 43(6), 777–787. https://doi.org/10.1080/00343400903037511
- Ravetz, J. (2000). City-Region 2020: Integrated planning for a sustainable environment (with forward by Secretary of State for the Environment). Retrieved from https://www.research.manchester.ac.uk/portal/en/publications/cityregion-2020-integrated-planning-for-a-sustainable-environment-with-forward-by-secretary-of-state-for-the-environment(e8d6e451-d228-4f47-90a1-9cad80939e56)/export.html
- Roy, A. (2009). The 21st-Century Metropolis: New Geographies of Theory. Regional Studies, 43(6), 819–830. https://doi.org/10.1080/00343400701809665
- Sassen (2007). Megaregion: benefits beyond sharing trains and parking lits? in Goldfeld, K. S. (2007). The Economic Geography of Megaregions. 98, Princeton,NJ: The policy Research Institute for the Region,pp. 59-83
- Schafran, A. (2015). Beyond globalization: A historical urban development approach to understanding megaregions. Megaregions. Retrieved from https://www.elgaronline.com/view/edcoll/9781782547891/9781782547891.00010.xml
- Scott, A. J. (2001). Globalization and the Rise of City-regions. European Planning Studies, 9(7), 813–826. https://doi.org/10.1080/09654310120079788
- Segbers, K. (Ed.). (2007). The Making of Global City Regions: Johannesburg, Mumbai/Bombay, São Paulo, and Shanghai. Baltimore: Johns Hopkins University Press.
- UN-HABITAT. (n.d.-a). Retrieved 27 November 2019, from http://mirror.unhabitat.org/pmss/listItemDetails.aspx?publicationID=2917

Part of Fieldwork

Imaginaries







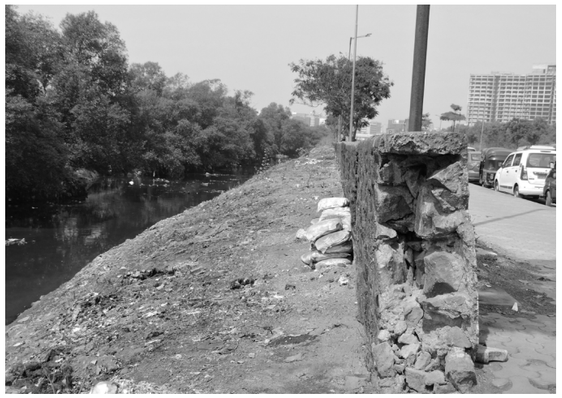


Scale of Design Intervention

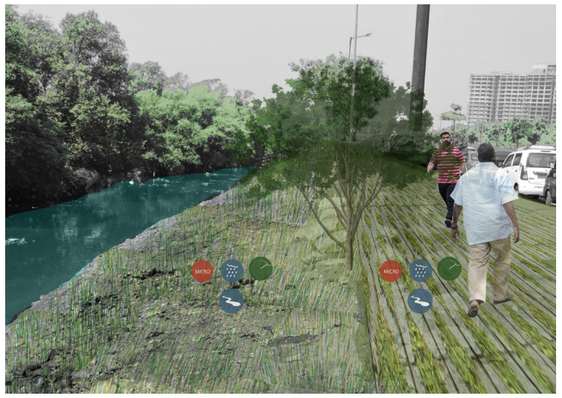
Type of flooding

Timeline consideration









Scale of Design Intervention

Type of flooding

Timeline consideration

Part of Fieldwork

Impressions

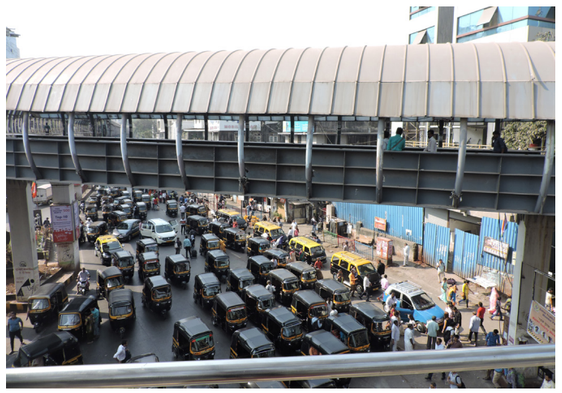










Survey response

Aim of the survey was to guide the formulation of planning framework. This survey along with the discussions with the officals , researchesr and academician were helpful in informing the choices in the project.

Questions Responses 1

1 response

Accepting responses

Summary Question Individual

What are the means of communication in your department with other departments/ sectors in MCGM? Which departments are these?

1 response

Letters and calls

What point does this communication occur? Who is involved in this communication?

1 response

During Analysing the project work of respective dept which can affect SWD DEPARTMENT work

What part of the planning process are you involved with?

1 response

Defining sizes and slopes of SWD

What do you think are the causes for delay in the project?

1 response

Non cooperation of public

What would you say are the best practices and pitfalls in the planning process?

1 response

Existing network is surveyed and mapped in documents, helps to get overview in glance.

Multiple underground utilities existing in urban areas, which causes difficulty. Also encroachment is hurdle

Is the carrying capacity of the existing and new drainage infrastructure design to cope with storms of 10, 25 and 50 years return period?

1 response

0.5

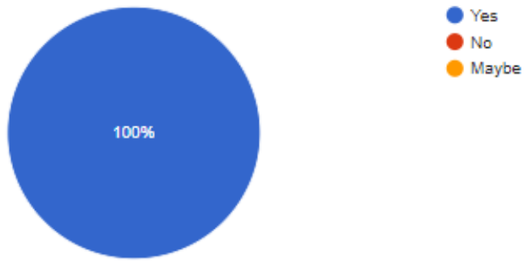
Is there a feedback or reflection period during the work of the ongoing project? If yes then when does this happen?

1 response

No idea

Is coastal flooding a big threat to Mumbai?

1 response



Survey response

What are the ways in which measurement of loss (income, livelihood, infrastructural damage) during such events take place?

0 responses

No responses yet for this question.

By when do you think Mumbai can be Flood resilient?

0 responses

No responses yet for this question.

Do you think we need more tools for flooding assessment modelling in Mumbai?

1 response

Real time mapping and forecast

Is there involvement of citizens in any part of this process? If yes, when?

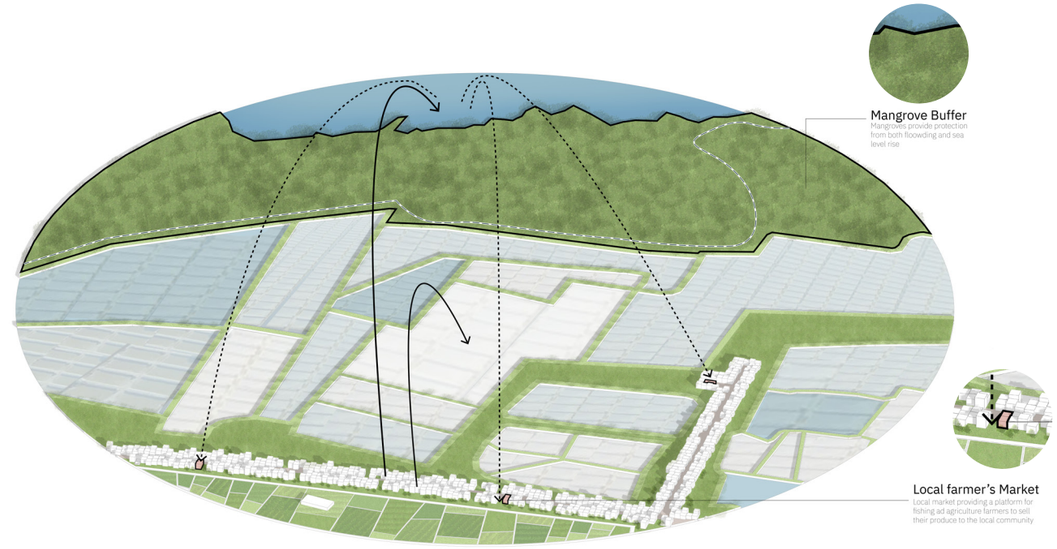
1 response

Nalla place shall not be encroach. Awareness of not throwing garbage and other waste water in SWD water body

Process design sections and views

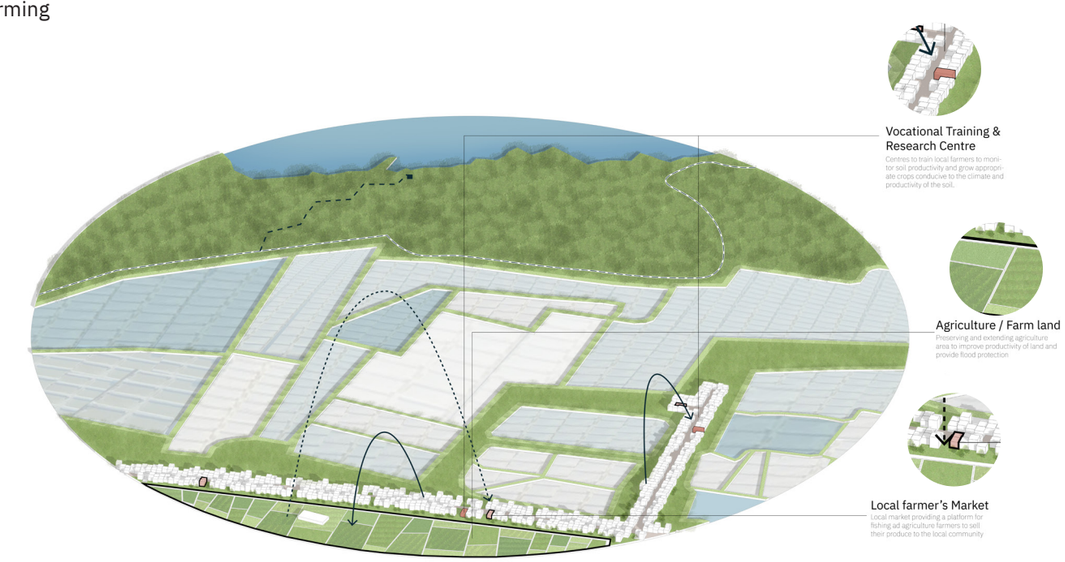
Urban metabolism

Fishing

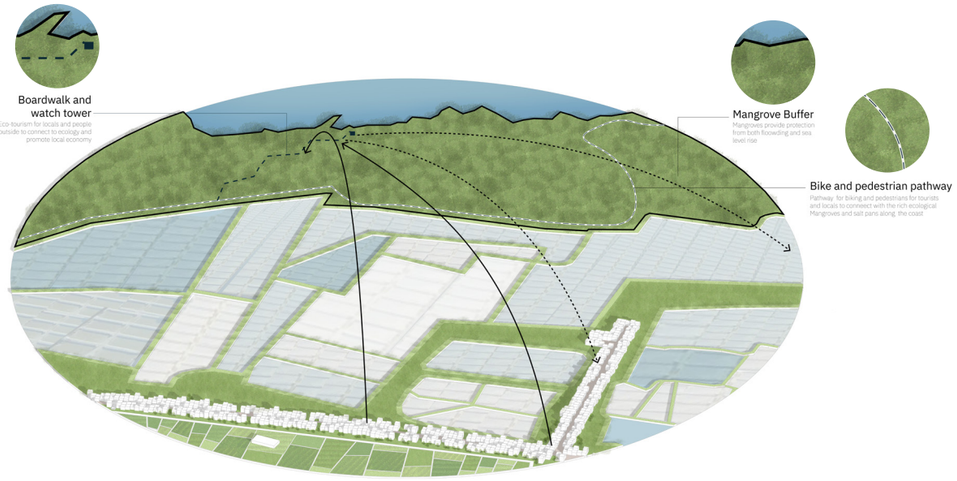


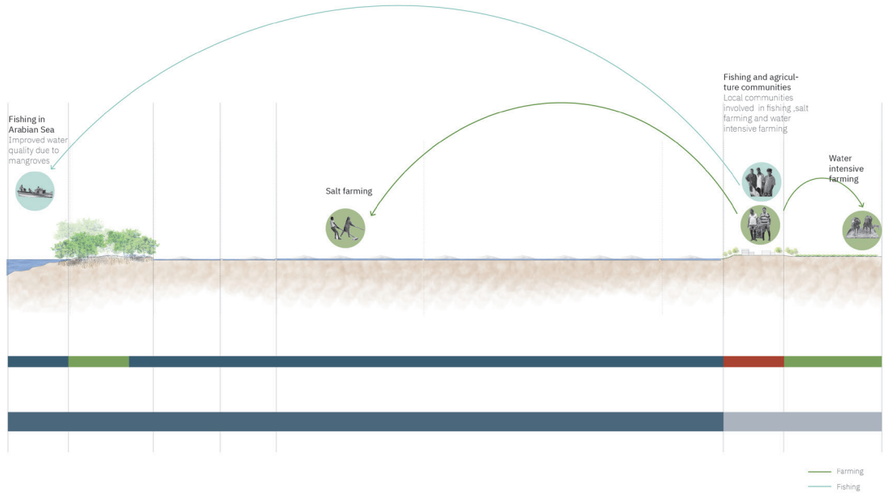
Urban metabolism

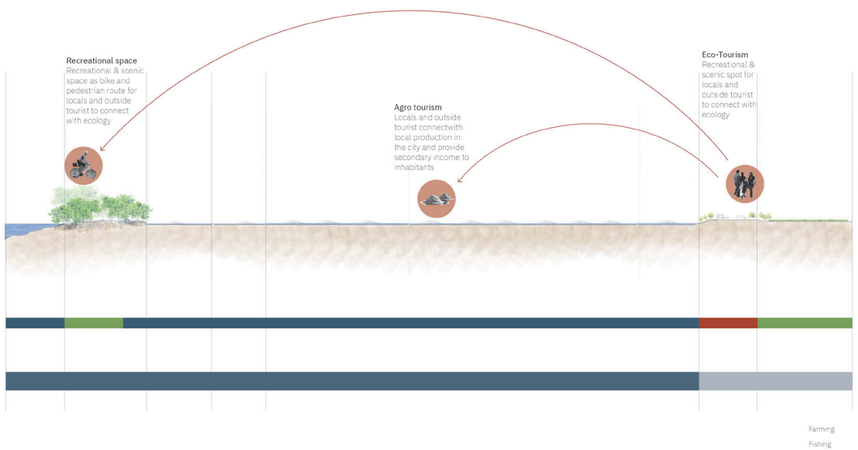
Farming



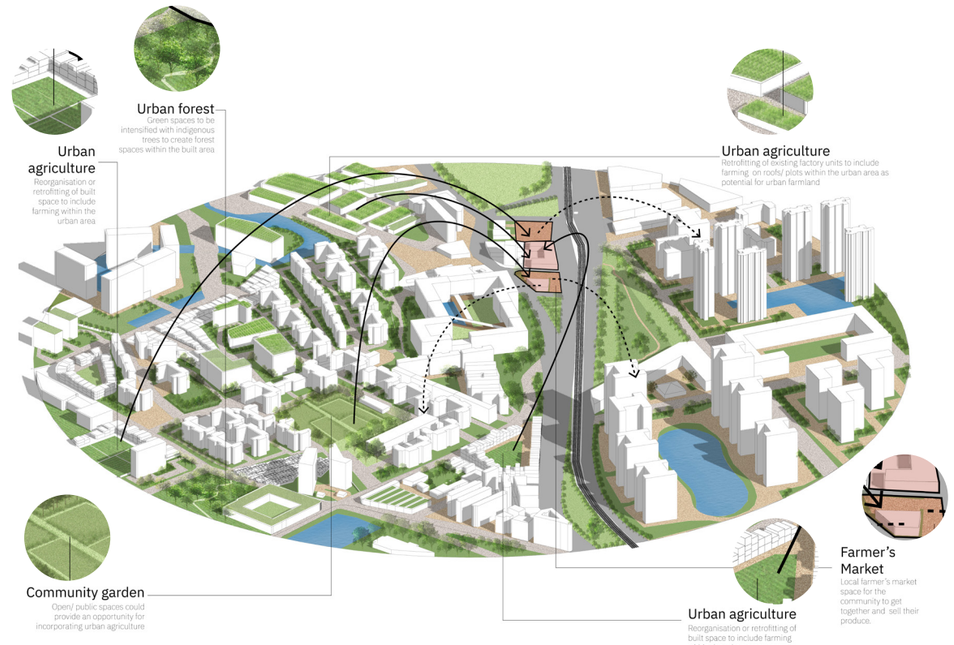
Urban metabolism
Recreation & Tourism



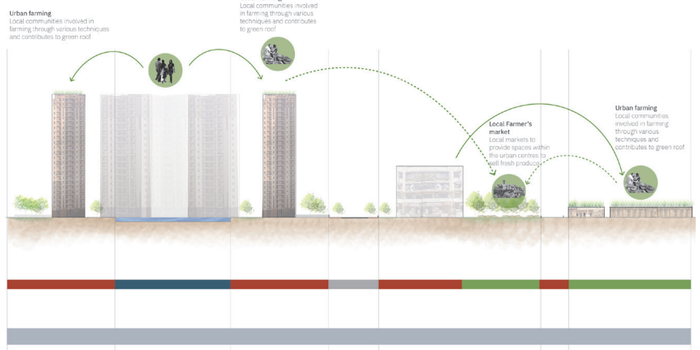


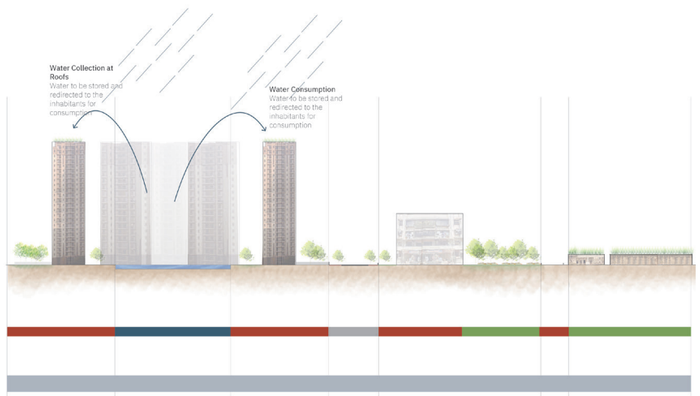


Urban metabolism
Farming



Urban metabolism
Farming





Report | Surabhi Khandelwal


TOWARDS A FLOOD RESILIENT MUMBAI METROPOLITAN REGION