LEVERAGING SOCIO-CULTURAL NETWORKS

Local adaptation strategies to bring about flood resilience in Chennai Metropolitan Area, India

Nilofer Afza Tajuddin

Faculty of Architecture and the Built Environment, Technical University of Delft

COLOPHON

Leveraging socio-cultural networks
Local adaptation strategies to bring about flood resilience in Chennai Metropolitan Area, India.

Graduation Thesis Report:
Nilofer Afza Tajuddin
M. Sc. Urbanism
Faculty of Architecture and the Built Environment

Research Group:
Complex Cities - Inclusive Cities of the Global South

First Mentor:
Dr. Marcin Dabrowski (Spatial Planning and Strategy)

Second Mentor:
Dr.ir. Taneha Kuzniecow Bacchin (Urban Design Theory & Methods)

Third Mentor:
Dr. ir. Diego Sepulveda Carmona, D.A. (Spatial Planning & Strategy)

Cover page image:
https://commons.wikimedia.org/wiki/File%3AAerial_view_of_Chennai_during_floods_-_2.jpg

Complex Cities

TU Delft Delft University of Technology

ACKNOWLEDGEMENT

This project is the outcome of the graduation thesis conducted at the Faculty of Architecture and the Built Environment, TU Delft.

The last year has been a truly enriching one and this project could not have been possible without my expert mentors guiding me along the way. Thank you, Marcin Dabrowski, Taneha Kuzniecow Bacchin and Diego Sepulveda Carmona for the exciting discussions, critiques and especially the diverse perspectives that each of you offered.

Fieldwork which was an important step of this process could not have been possible without the participation of the stakeholders based in Chennai. I would especially like to thank Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH and Mr. K.S. Sudhakar (CFCC) for supporting the two week field visit and for providing me with access to key stakeholders currently working in Chennai.

The community co-evaluation workshop was one the most special accomplishments of the project and it would not have been possible without The Backyard, Chennai, the venue of the event. Special thanks to all the participants who made the three hour session extremely fruitful.

On a personal note, I would like to thank my friends, both in the Netherlands and India, who have constantly supported me over the last one year. Lastly, I would like to thank my parents for their unconditional love and especially all their efforts to make this Masters at TU Delft, a reality.

SUMMARY

This project is set in the Chennai Metropolitan Area (CMA) in the state of Tamil Nadu in India. Currently spanning 1189 sq.-km, the region forms a unique delta with three rivers, namely, the Koshashtalaiyar, Coovum and Adyar. The three rivers are placed in the north, centre and south, respectively, of the CMA and wind through the land-form to meet the Bay of Bengal on the eastern coast. With an estimated population of 10 million and a population density of 9900 per sq. Km, the CMA is the fourth largest metropolitan region in India and forms the country's fourth largest economy (Statistics, 2017). The region bears a distinct reputation in the country, as a haven for automobile industries and has also been popularly referred to as the 'Detroit of India'. The region has undergone substantial industrial growth in the last two decades and is still rapidly urbanizing. The region due to its deltaic nature has historically been prone to floods. In recent years, the city has faced increased risk of flooding and in 2015 was devastated by a 100-year flood event. The frequency and intensity of these events are projected to increase due to climate change. Set in this context, this project addresses local adaptation strategies by building socio-ecological resilience at the neighbourhood level. Rapid urbanisation has led to the rupture of the traditional drainage network which was once the flat terrain region's flood defence mechanism. The main problem recognised was that of a conflict between human and nature.

During the course of the project, the relevance of social capital was identified as a crucial link to design for local resilience. Hence, social and cultural networks were used as leverage to link economic aspirations and environmental restoration. This was set within a theoretical framework comprising of the works of Davoudi (2012) and Wilson (2012). To recognise the spatial manifestation of this conflict and to tap into social capital, the edges and community infrastructure were identified respectively. The water edges which are the transition zone from the human to the natural environment were mismanaged and left untreated, in turn influencing perception and it subsequent neglect from regional functionalities. In order to tackle this neglect and reintegrate these hydrological elements with daily life, community infrastructure was used as the tangible medium to bring people together, engage them and in turn create a sense of ownership and responsibility. Hence the strategies used were that of first designing an integrated water network across multiple scales, second, identifying community infrastructure and open spaces that can support the functioning of the system and third, designing interaction between people and the environmental to motivate them to engage and maintain the network. Together the project made a strong case for using socio-cultural networks and contextually grounded strategies to bring about a collective community based restoration process.

Contents

Chennai Floods 2015
Source: https://farm9.staticflickr.com/8564/28745915880_949e2828d5_h.jpg

Introduction

Urban areas are sensitive environments where various physical, social and political processes take place. The trends of population growth, urbanization and migration, economic and technological development and social and political processes have triggered irreversible changes in the natural environment. These changes weaken the ability of urban ecosystems and built environments to cope with climate related disasters like flooding, heat waves, cyclones, rising sea levels etc. With growing changes in climate patterns, addressing the twin challenges of climate change mitigation and adaptation at the urban scale has become an 'urgent agenda' (Cities and Climate Change: An Urgent Agenda., 2010; Zevenbergen et al., 2010). Within the different types of urban regions around the world, delta areas are most vulnerable to the changing climate patterns. In fact, they face additional risks due to their location and unique relationships with water and have been regarded as climate change 'hotspots' (McGranahan, Balk, & Anderson, 2007).

While cities continue to urbanize in uncontrollable manners, especially in developing countries where the demands in urban areas are very high, the concentration of population and economic activity tend to make it vulnerable to climate change impacts. Consequently, the ways in which cities develop and manage their urban growth are keys to understanding how they would become resilient to climate change in the future (Hallegatte & Corfee-Morlot, 2011). However, studies have shown that developing countries often tend to overlook climate adaptation and resilience as part of their growth processes. Instead they respond to immediate issues such as population growth, economic development, unemployment and infrastructure. However, this in turn has put these countries at risk to the increasing effects of climate change. Notable researchers in the field have suggested that addressing climate resilience in the context of the global south is crucial because not only is the south more vulnerable to climate change but it is also the least capable of coping with it (Adger, Huq, Brown, Conway, & Hulme, 2003; Heinrichs, Krellenberg, & Fragkias, 2013). Hence climate change adaptation is a crucial need of the hour, especially in delta regions of the global south which face increasing risk. Interestingly, Hallegatte and Corfee-Morlot (2011) reveal a concept of 'no regret' which advocates that adaptation to climate change can be integrated into the developmental goals of the city, leading to holistic improvement that not only meets the basic urban needs but also prepares the city for the impacts of climate change.

This thesis investigates the case of the Chennai Metropolitan Area (CMA), a delta region on the southeast coast of India. Flood prone by nature, extreme weather events and urbanization driven by global aspirations has magnified the risk of flooding in the region. The implications of this risk are the most tangible and operable on the local scale and hence the project makes a strong case for the local scale. This project explores local adaptation strategies which focus on community building and civic engagement on a neighbourhood scale. The report first establishes the context and analyses the problem at hand.

Using methodological steps such as theoretical and analytical frameworks, research and fieldwork, the project then critically analyses the region and develops a project approach which is then used to formulate spatial strategies across various spatial and temporal scales.

Grocery runs during 2015 floods ; Source: Author

Motivation

Hailing from the Chennai Metropolitan Area (CMA), this thesis gives me the opportunity to delve deeper into the urban issues that contribute to flooding in the region. The CMA was devastated by floods in December 2015 which resulted in a huge loss of life and property. With 300 lives reported to be lost, the floods brought the region to a complete standstill and affected all walks of life. An estimate of 3-billion-dollar loss was reported, classifying the Chennai floods as the world's eight most expensive natural disasters in 2015. Having witnessed these floods first-hand and the region's dire need to address this issue have been a crucial factor in the choice of this project. The photograph to the left was captured by the author during the floods, while wading through the flooded areas to meet essential grocery needs when all basic infrastructures such as public transport and electricity were completely shut down.

In addition to this personal motivation, recent events have also played an important role in the drive to pursue this topic. Since 2015, there has been an increase in the awareness about the need for better urban planning and flood resilience. The floods have garnered a lot of interest amongst the common people as well as the State administration, with even the Central government recently stepping in to support transformation processes in the CMA region. This has further sparked discussions about the possible solutions that need to be integrated to prevent more such events in the future. This thesis is hence relevantly placed in these ongoing discussions and processes. In fact, a conversation with Sudhakar K.S., the technical advisor from Chennai for the Cities for Climate Change initiative by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, revealed that indeed there has been a considerable amount of action on ground, especially since 2015. The thesis in addition to providing tangible proposals to alleviate flooding will also de-construct the reasons behind the heightened flood vulnerability.

The Masters programme in Urbanism at TU Delft gives me a powerful and unique academic platform to work on this project. Driven by personal experience and a fascination for urban processes in developing countries, the Global South presented an exciting area of research with governance and spatial design playing a crucial role. Set in this context, the studio of Complex Cities and the sub-group of 'Inclusive cities in the Global South' was a natural choice for this project based in the Chennai, India. The research group empowers my approach, providing a strong planning foundation and the necessary tools to conduct the research.

Part I - Overview

Source: https://i.pinimg.com/originals/cb/61/e0/cb61e0463c6a0bd71dbb3428602d772e.jpg

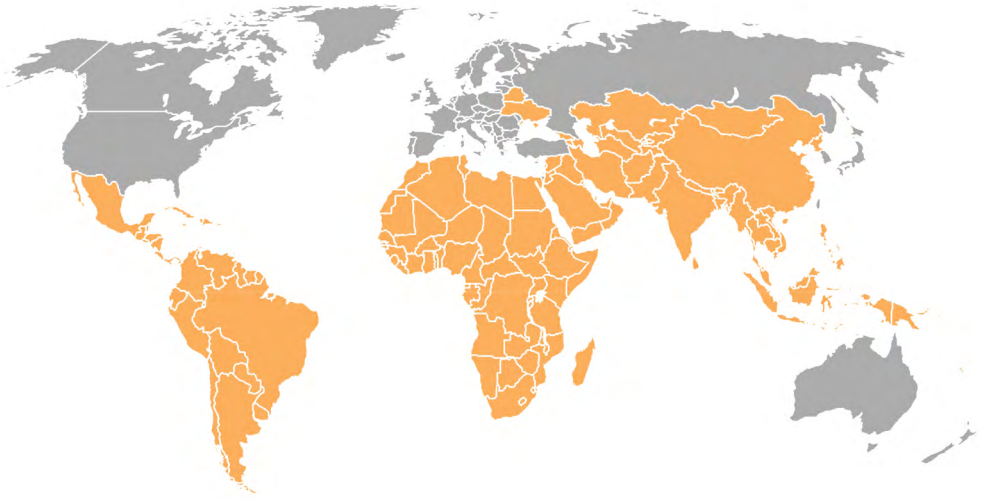


Figure 1.1: The Global South

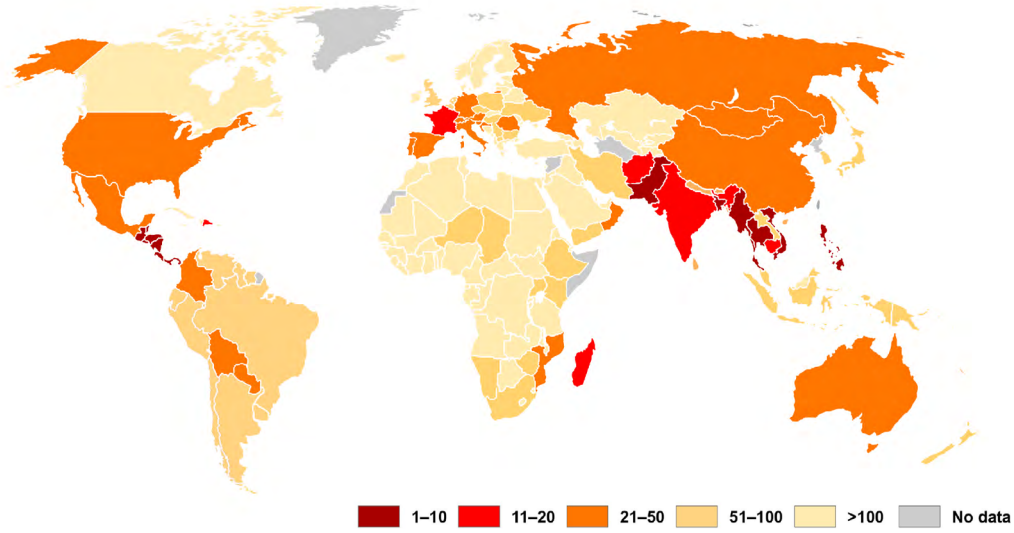


Figure 1.2: Climate Risk Index - Ranking - 1996-2015

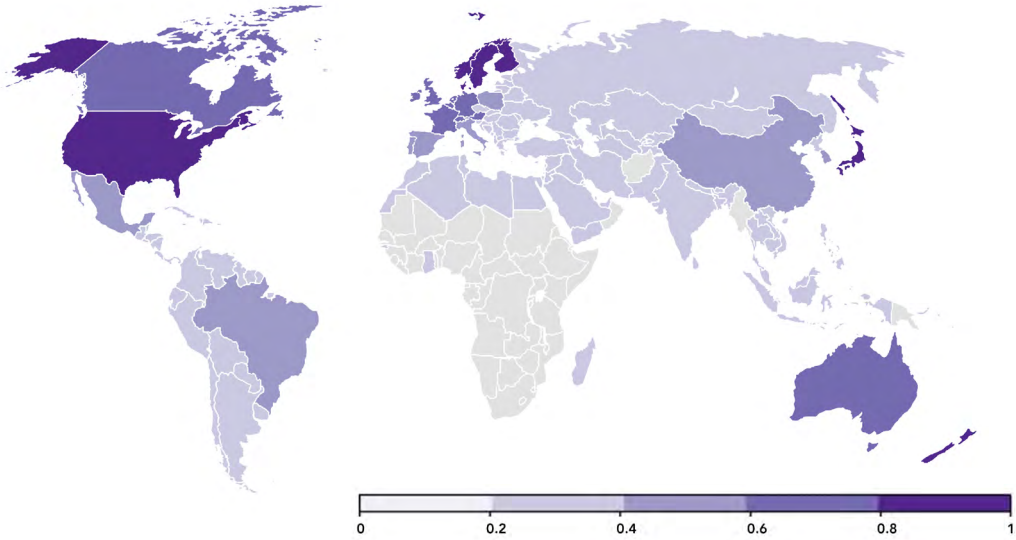


Figure 1.3: Adaptive Capacity Index 2014

1. Context

1.1. The Global South

The global south has come under the focus to urgently recognize the vulnerability and risks and prepare itself for the changes in climate patterns. This spotlight is a result of the urban conditions in the south that imply that the developing countries are not only most at risk, but also the least capable of mitigating and adapting to climate change (Adger et al., 2003). There is an increasing concern, especially, in developing countries about the implications of climate change owing to their rapid growth and high proportion of urban populations that are poor or otherwise vulnerable to climate disruptions (Tyler & Moench, 2012). There is a strong link between action and environmental problems that humanity faces and this link differs in the context of the global north and south. Cities particularly in the global north undertake large infrastructural measures as a strategic protection against climate change. They further invest and act towards being self-sufficient in terms of resource consumption and develop new urban agglomerations, for example, city networks and coalitions that enable them to pool their buying power, share best practices and deploy common measurement tools. But so far, the response in the global south has been more episodic and less strategic and integrative as economic resources are often limited and ecological security is not at the forefront of their political agenda. In fact, an urban agenda which looks at local and regional planning that prioritizes climate change adaptation has not been considered in these countries, implying that adaptation has been traditionally practised only for the exposed systems or sectors.

As a result, urban development has responded to other societal or economic needs rather than climate resilience (Heinrichs et al., 2013).

To make matters worse, the impacts of climate change are not evenly distributed (Heinrichs et al., 2013). Accessibility to resources and low economic conditions play an important role in fabricating a response to environmental risks in the south.

Resource and technology accessibility also distinguishes the resilience of the global north versus the global south. For example, despite similar risks, the Netherlands is more resilient to flooding due to its strong economic position and accessibility to resources as compared to Bangladesh which is a socio-economically weaker nation relative to the Netherlands (Adger et al., 2003).

Climate change resilience for the urban and the built environment in the Global South needs to be addressed by the respective governments of the developing nations. Though, on the other hand, it is also understandable that developing countries often neglect resilience from their developmental goals, as various other issues such as population explosion, economic growth, unemployment and poverty are considered more urgent priorities. In such cases, the 'no regret' attitude is highly appropriate, which suggests that climate change adaptation strategies could be implemented even today, as part of fundamental planning practices. This is especially relevant in the context of the global south (Heinrichs et al., 2013), since in many cases, basic infrastructural needs such as drainage systems are not met (Hallegatte & Corfee-Morlot, 2011). Hence responding to the essential needs of the society through the larger lens of urban climate change resilience becomes a guiding factor for the design and planning of urban developmental processes.

Figure 1.1: The Global South
Illustration: Author

Figure 1.2: Climate Risk Index Ranking - 1996-2015
Source: Germanwatch and Munich Re NatCatSERVICE

Figure 1.3: Adaptive capacity index 2014
Source: Godber, O.F. ; Wall, R. 2014

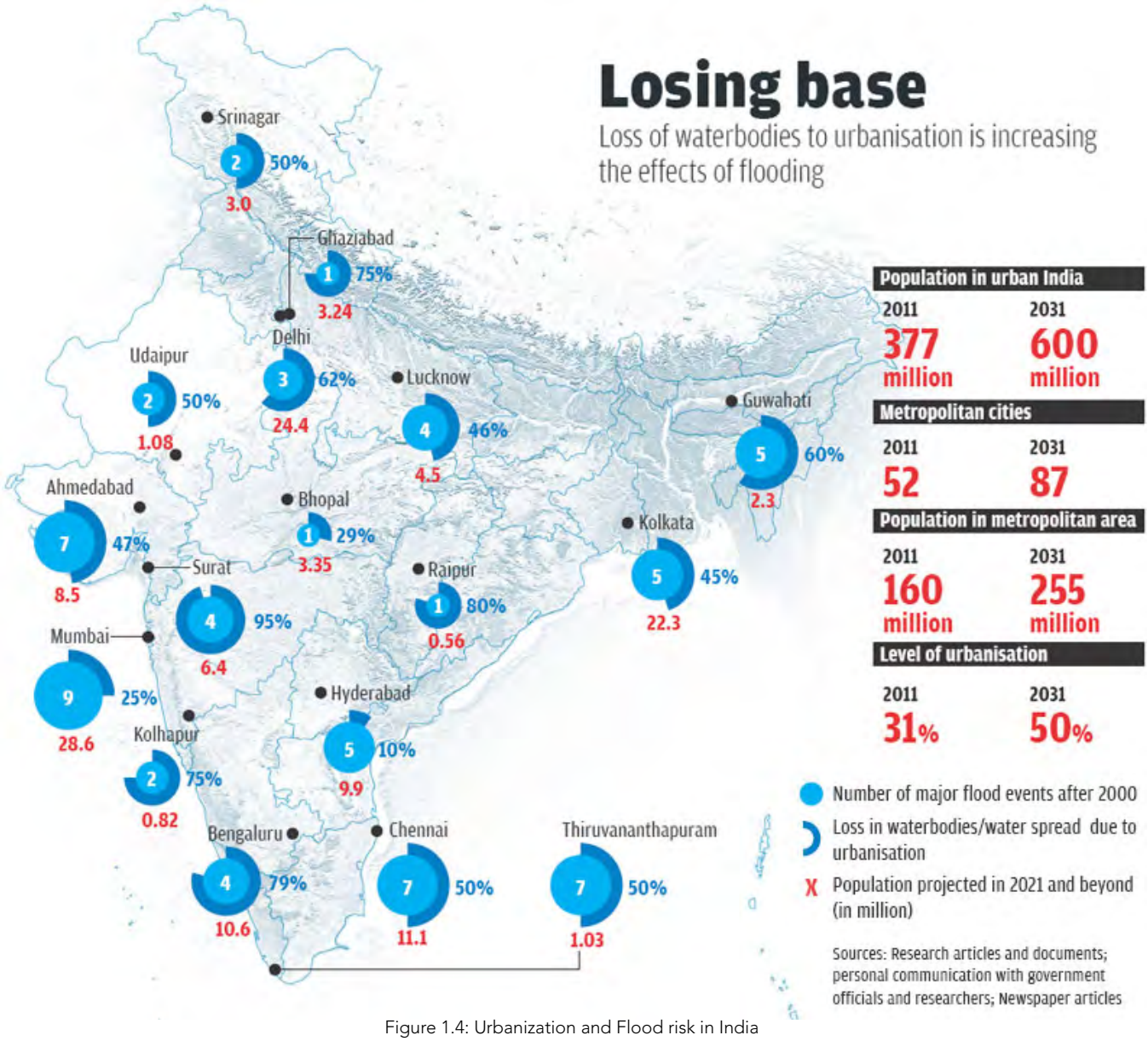


Figure 1.4: Urbanization and Flood risk in India

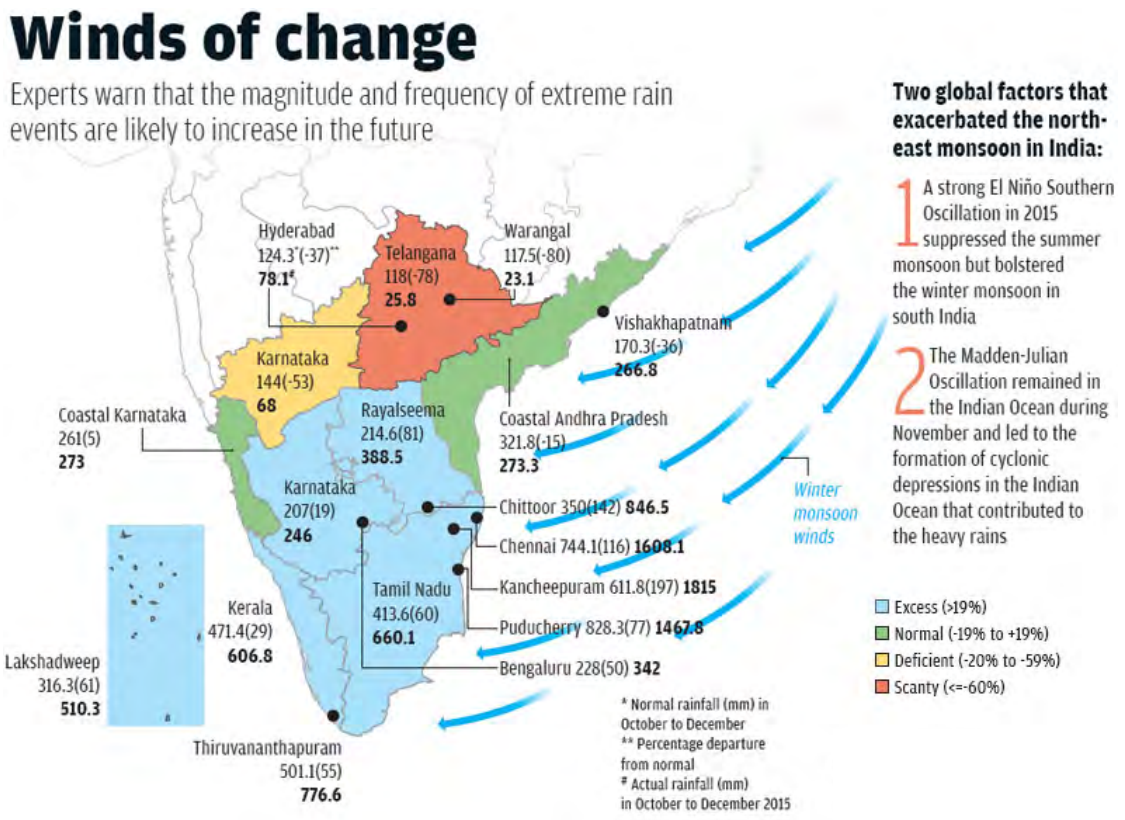


Figure 1.5: Climate risk in Coastal India

1.2. The Indian Context

Climate change impacts on urban systems are unavoidable, especially, in Asia where the cities are most exposed to the changes in climate patterns (Tyler & Moench, 2012). In fact, half of the world's urban population is in Asia (Habitat, 2011). Within the Asian context, India presents multiple urban precincts that need urgent attention. The country is being subjected to an increasing risk due to the climate change, with disasters such as flooding, drought and earthquakes on the rise. According to the World Resources Institute, India has been featured time and again amongst the 163 countries most affected by river floods. Every year, close to 4.85 million people are affected by this calamity, calling for an urgent need to address this issue.

Indian cities face challenges such as resource scarcity, inadequate infrastructure and poor quality of lifeline services. Old infrastructure is still being used which needs urgent updating, especially, in the old city areas since installing new infrastructure is nearly impossible due to very high densities and lack of space (ACCCRN). Climate change will most likely add additional stresses on the cities which are facing multiple urban issues. Developing India is painted with multiple urban centres expanding at exponential rates. As a result, unplanned urbanization, informality, poverty, extreme population density, infrastructural developments are the many characteristics that define its urban environments. Due to a fast pace of urbanization, there is already a gap between demand and supply for necessary infrastructure. The inefficiency of these urban systems hinders with their ability to adapt to climate change and affects the cities' resilience to it . This creates a negative feedback loop where climate change resilience becomes progressively more difficult because of existing inadequacies. An increasing population coupled with extreme events is worsening social and economic vulnerability and threatens the stability of the urban systems (Parikh, Sandal, & Jindal, 2016).

The main impacts of climate change that the country will face are floods, water scarcity and severe change in weather patterns. Coastal cities will face additional risks due to rising sea levels and an increasing cyclonic storm frequency (ACCCRN). These can disrupt urban economies and paralyse urban functionality. The sea level along the Indian coast has been rising at the rate of 1.3 mm/year and this is expected to continue in the future. Weather data projections indicate that the frequency of cyclones is likely to decrease in the 2030s, with an increase in cyclonic intensity (INCCA, 2010). With increasing climate induced risks, Indian cities are further affected as they lack effective storm water drainage systems and face additional problems due to unplanned development and encroachments due to building on natural areas and drainage systems. These increases incidences of flooding. There have been unprecedented floods of high intensity and flash floods in many cities in the last decade (Parikh et al., 2016).

With growing human-environment conflicts, recognizing the risks and vulnerabilities of these regions and in turn addressing the need for adaptation and mitigation to climate change as part of the urban development agenda is essential. In response to the need for urban climate adaptation in India, this thesis places its focus in the Chennai Metropolitan Area, on the southeast coast of India.

Figure 1.4: Urbanization and Flood risk in India
Source: http://www.downtoearth.org.in/news/chennai-apart-52265

Figure 1.5: Climate risk in Coastal India
Source: India Meteorological Department

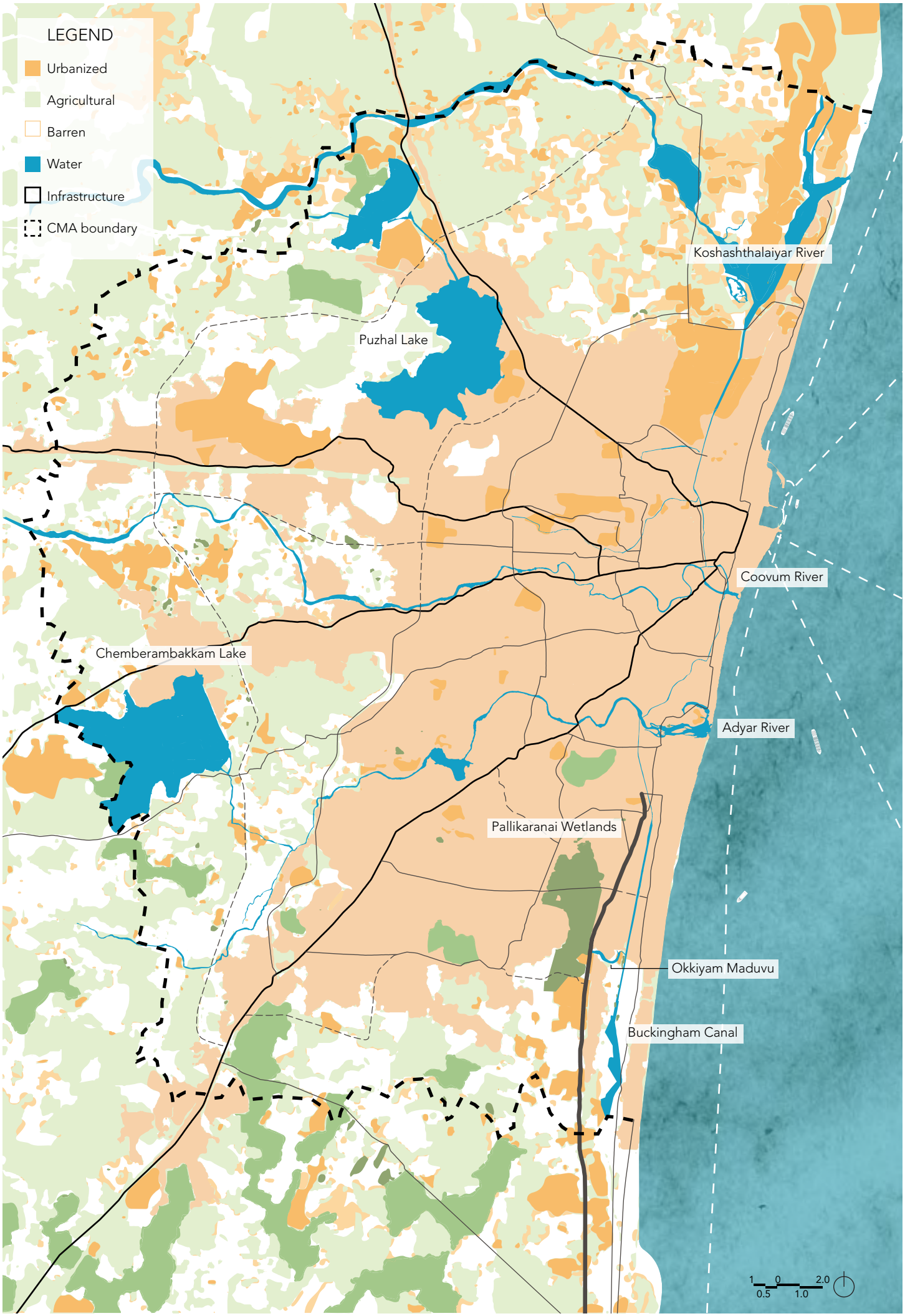


Figure 1.6: Ecologies of Chennai Metropolitan Area

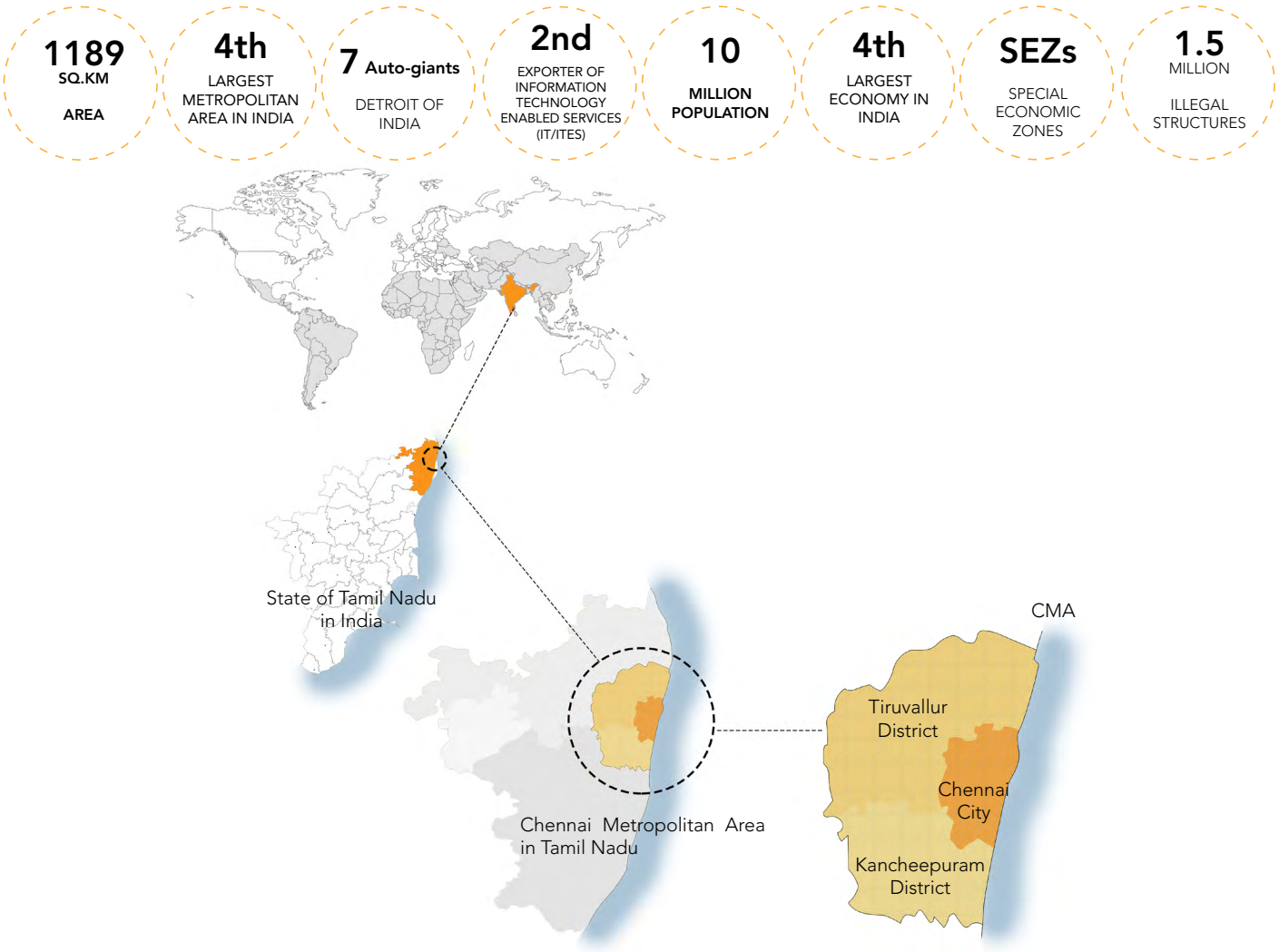


Figure 1.7: CMA - Background

1.3. Focus: Chennai Metropolitan Area (CMA)

The Chennai Metropolitan Area (CMA) is one such delta region in India which has become increasingly vulnerable to climate change induced disasters. Located in the southern state of Tamil Nadu, the third highest (GDP) grossing state in India, the region comprises of the Chennai city, the state's capital and parts of Tiruvallur and Kancheepuram districts (Statistics, 2017).

Currently spanning 1189 sq.-km, the region forms a unique delta with three rivers, namely, the Koshashtalaiyar, Coovum and Adyar. The three rivers are placed in the north, centre and south, respectively, of the CMA and wind through the land-form to meet the Bay of Bengal on the eastern coast. With an estimated population of 10 million and a population density of 9900 per sq. Km, CMA is India's fourth largest metropolitan region and forms the country's fourth largest economy (Statistics, 2017).

The region bears a distinct reputation in the country, as a haven for automobile industries and has also been popularly referred to as the 'Detroit of India'. The region has undergone substantial industrial growth in the last two decades and is still rapidly urbanizing. With a thriving automobile and Information Technology (IT) sector, the region is also subjected to considerable migration from neighbouring rural areas as well as other parts of India. In fact, the CMA is also the second largest exporter of Information Technology Enabled Services (ITES) in the country.

Figure 1.6: Ecologies of Chennai Metropolitan Area
Illustration: Author

Figure 1.7: CMA - Background
Illustration: Author

Figure 1.8: Chennai city from above

Figure 1.8: Chennai city from above
Source: https://www.indiatimes.com/news/india/15-stunning-images-of-chennai-from-10000-ft-above-sea-level-244693.html

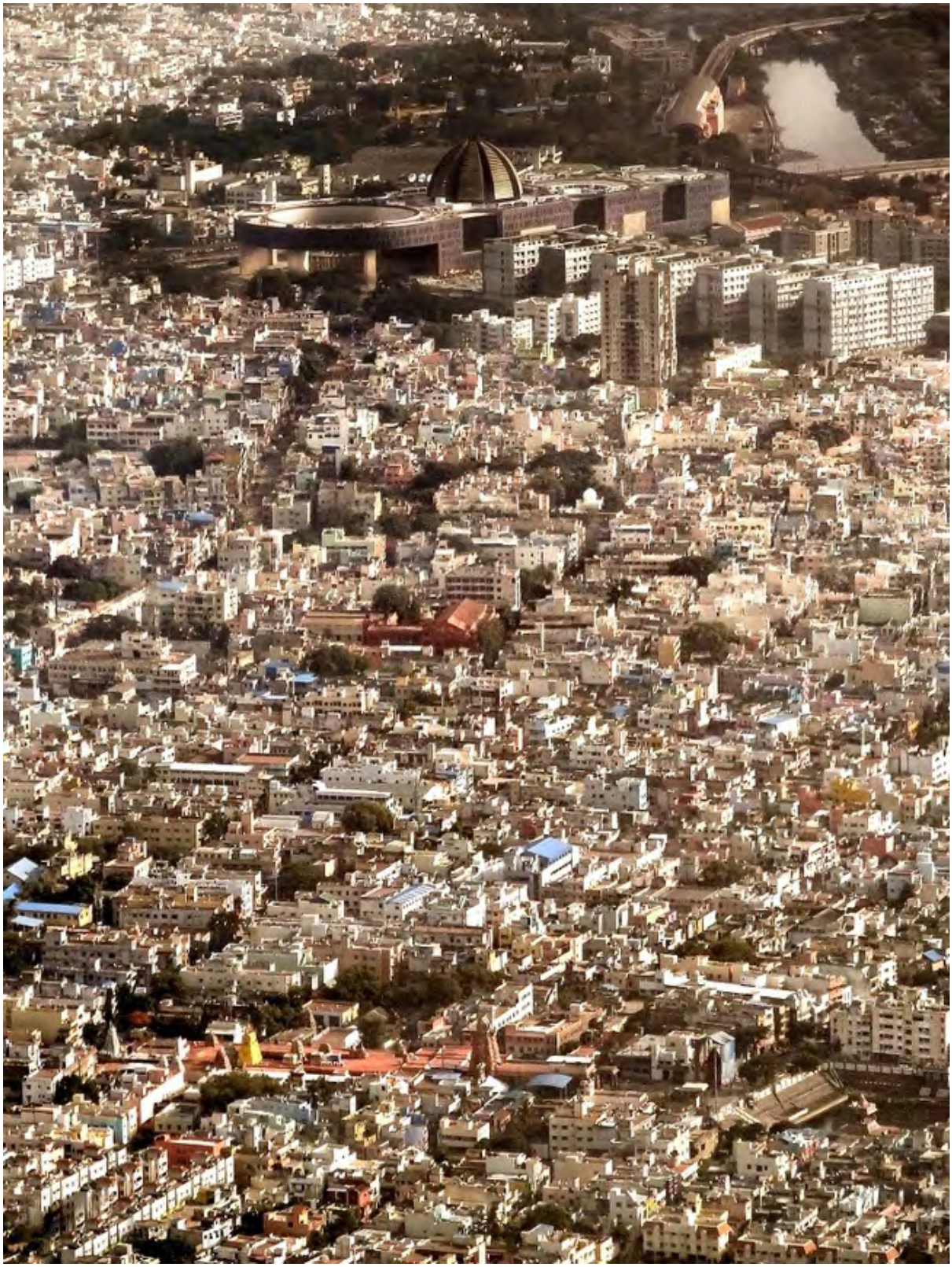


Figure 1.9: Chennai city from above

Above: Figure 1.9: Chennai city from above
Source: https://www.indiatimes.com/news/india/15-stunning-images-of-chennai-from-10000-ft-above-sea-level-244693.html

Figure 1.10 : Historic problem - Chennai Floods 1943

The region due to its deltaic nature has historically been prone to floods. However due to climate change, weather events ranging from extreme rainfall, cloudburst and cyclonic activity to low pressure differences in the Bay of Bengal have become persistent. While flood risk in the region is indeed inevitable, the degree of risk has increased tremendously due to the impacts of climate change. In addition, cyclones are also projected to increase considerably in intensity in the future. In an article featured on December 3rd, 2015 in the Times of India, a popular newspaper in India, rainfall intensity is projected to increase in future as stated by M. Rajeevan, director, Indian Institute of Tropical Meteorology, Pune. While the region now faces a severe risk of flooding, human action is also playing an intervening role in changing the magnitude of this risk.

The worst disaster in the last 100 years occurred in December 2015, when the region received 345mm of rainfall in a period of 48 hours (P. Arabindoo, 2016). While this cloudburst was an unusual occurrence, it also brought to light, the fundamental incapability of the urban fabric to deal with any uncertainty related to flood risk. Interestingly, in an article written by Joydeep Gupta on an online forum discussing Asia's water crisis (thethirdpole.net), the author states that despite the increase in precipitation, the region by virtue of being plagued by unplanned urbanization and encroachments has been unable to cope with its water woes. CMA is not new to this risk of flooding and has become increasingly vulnerable with major floods in 2005, 2008 and 2010 (Joerin, Shaw, Takeuchi, & Krishnamurthy, 2012).

There is hence a need to address this inherent risk and in turn explore the opportunities for flood resilience in the region. The link between urbanization, flood management and the ability of built environments to cope with natural disasters is quite tangible. Historical and structural development patterns of cities have been known to reveal the aspects of urban vulnerability towards climate change (Bulkeley, Edwards, & Fuller, 2014). It implies that the nature of urbanization and land-use change can have direct impacts on how the environment functions when disaster strikes. The conflict due to human interaction with natural processes forms the basis of the problem analysis.

Figure 1.10 : Historic problem - Chennai Floods 1943 Source: https://i.pinimg.com/

Encroachments along the Adyar River and the Bay of Bengal
Source: Google Earth

2. The Problem

Being deltaic in nature, the Chennai Metropolitan Area, is naturally prone to flooding. Climate change has further resulted increased the risk of flooding. In addition to this, human activities and urban development processes have worsened the vulnerability of the region to flooding. While floods have now become an annual occurrence, the response to it and modification of urban practices has not been addressed actively. In fact, the CMA has developed without reflecting on its natural physiography, by obstructing its natural hydrological system due to building over flood plains, marshes, lakes and ponds (Manohar & KT, 2016).

The growth pattern reveals noticeable violations of building over sensitive areas and in many cases clashes with the natural hydrology pattern. The vulnerability towards floods has been directly linked to the disruption of the natural drainage system and the encroachments of the catchment areas (Suriya & Mudgal, 2012). At its inception, the city was initially planned with a sophisticated water network, with synergy between the natural water bodies, catchment areas, river systems, marshlands and man-made dams. However, with rapid urbanization and the extension of city limits, this water network was gradually clogged and undermined due to encroachment of riverbank and water sensitive areas by informal settlements, industries, residential and institutional developments. The primary reason for this unprecedented urbanization was the lack of vigilance through systematic urban plans to overlook urban development processes (Tanner, Mitchell, Polack, & Guenther, 2009). According to Esther and Devadas (2016), with 90% of the open swamps taken over by built developments and approximately 150,000 illegal structures over riverbanks and dry channels, the region overall has become increasingly vulnerable to floods with the water-carrying capacity of the natural drainage system severely compromised.

Hence, the combination of climate change impacts and human induced vulnerabilities has made the region extremely prone to flooding (P. Arabindoo, 2016). The region is ill-equipped and continues to urbanize in its usual sense even when the flood risk is increasing. There is hence a conflict between human aspirations and nature's capacity. This conflict is elaborated using four aspects that deconstruct the issue at hand.

Figure 2.1: The Chennai Floods - December 2015

Top: Low-income settlements on the banks of the Adyar river
Bottom: The Adyar river flowing at its peak capacity. The Saidapet bridge (seen above), a primary connect between two sides of the river was eventually shut down as water levels crossed above the flyover.

Figure 2.2: The Chennai Floods - December 2015

Top: Boats as the only transport option during floods
Bottom: Flooding in the residential area, 'Velachery' in South Chennai. As the name suggests, 'eri' in Tamil means lake indicating that the area now sits on a once water body, hence increasingly flood prone.

Figure 2.1: The Chennai Floods - December 2015
Source : (top) https://images.thestar.com/content/dam/thestar/news/world/2015/12/02/chaos-as-huge-rainfall-swamps-chennai-india/chennai8.jpg
(bottom) http://edition.cnn.com/2015/12/03/asia/gallery/india-floods/index.html

Figure 2.2: The Chennai Floods - December 2015
Source: (top) https://www.pbs.org/newshour/app/uploads/2015/12/RTX-1WTOJ.jpg
(bottom) https://series.fountainink.in/who-let-the-water-into-my-city/

Figure 2.3: Large developments threaten the water system of the region

2.1. Problem Analysis

i. Conflict: Economic growth versus Nature's values

Fast Economic growth and the region's global aspirations

Chennai (initially named Madras) has always been of economic and political importance since its establishment as a major British port in the colonial era. Economic growth has always been in the forefront of the goals of the State of Tamil Nadu since the liberalization of the Indian economy in 1991. Citing an opportunity for industrial development, the then State administration actively promoted policies and regulations that enabled the inflow of Foreign Direct Investment (FDI) into the capital city, Chennai. Hence by the early 2000s, the ruling government sought to 'Globalise Chennai' and improve and develop its industrial sector by setting up Special Economic Zones (SEZ) and making economic laws in the region lenient to attract more investment from Multinational Companies (MNC).

SEZs are essentially geographic areas with economic laws more liberal than the country's domestic economic laws. This led to multiple industrial giants setting up base in Chennai and it soon became an automobile, industry and Information Technology / Information Technology Enables Services (IT/ITES) sector haven. The famous IT corridor along the Old Mahabalipuram Road (OMR), which runs parallel to the Buckingham Canal, was only set up in 2005. Known as the 'new Shenzhen', industrial nodes were developed across the region, triggering urban sprawl around these nodes (Ellis, 2012). The region today boasts of 55 Special Economic Zones, with dedicated zones for automobile, electronics and IT industries. An automobile industry sanctuary, companies such as Mahindra-Ford, Hyundai, Mitsubishi, Daimler, Nissan, Renault and BMW have set up base in Chennai, making Tamil Nadu the only state in India to have seven auto giants (Chandrachud & Gajalakshmi).

The Chennai Metropolitan Development Authority (CMDA) is currently the statutory body responsible for urban planning in the CMA. It was set up as part of the Tamil Nadu Town and Country Planning Act, in 1971. Driven by the ambition to become a global city, the CMDA was heavily influenced by capitalist needs of the MNCs and favoured market-driven urbanization. Even other para-state bodies which operated on the state level of Tamil Nadu, got influenced by the urban growth in the region. As a result, the Master plan drafted by the CMDA in 2006, which is also currently the functional one, exhibited land-use and policy planning which favoured fast economic development.

However, fast economic development in turn resulted in a clash with the natural hydrological system of the region. Land which was the ultimate resource was heavily built upon, massively increasing the pressure on the ecosystem. Increase in demand resulted in the encroachment of land associated with water bodies and in more advanced cases, ponds, lakes, swamps and marshes were often filled in and built upon (P. Arabindoo, 2016; P. G. Arabindoo, 2008). A relevant example is that of the IT corridor which runs parallel to the Buckingham canal. This industrial corridor was set up in 2005 as a 2.1km long corridor of industries and commercial units to be built in two phases. The initial setup of the corridor in close proximity to the Pallikaranai wetlands and the setup of large corporate complexes along the corridor has led to a severe loss and shrinking of the wetlands as well as the ecosystem associated with it.

Figure 2.3: Large developments threaten the water system of the region

Source: https://thereddotman.files.wordpress.com/2012/07/building-and-bridge-reflection-broken-bridge-besant-nagar-wordpress.jpg

Figure 2.4: Clogging of Okkiyam maduvu - 2002-2015

The main channel draining the Pallikarnai wetlands is encroached upon resulting in flood risk

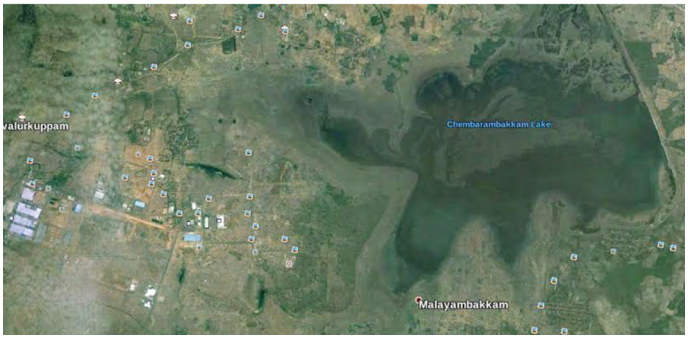
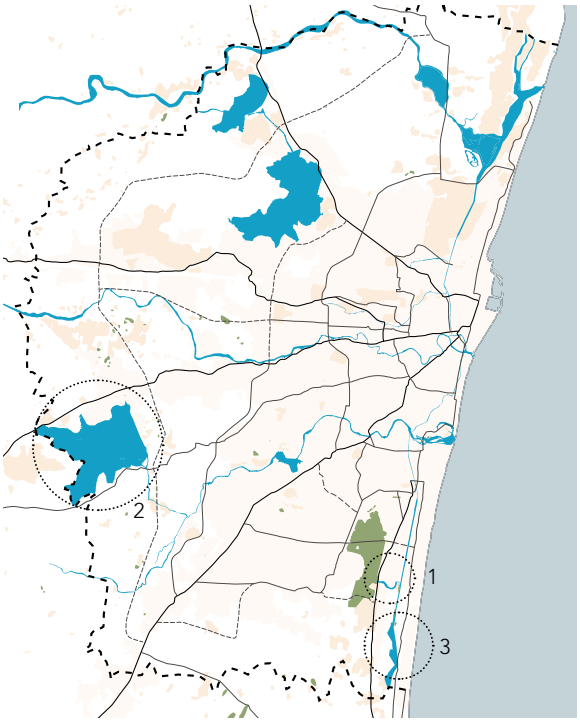


Figure 2.5: SEZs planned in Flood prone areas - Chemberambakkam Lake 2002-2015

Large scale industries have been setup in flood prone areas of the Chemberambakkam Lake, a crucial flood control reservoir as part of the adyar river watershed in the south of the CMA.

Figure 2.6: Housing and more housing! - Urban sprawl - 2002 - 2015

Shollinganallur - A popular residential area along the Buckingham canal in the south of CMA



In this manner, lack of planned expansions has led to the setup of large scale industrial, residential and commercial developments in flood prone areas. In addition to being zoned in sensitive areas such as flood banks and low-lying areas, these developments pose additional risks of pollution and further dilapidation of the water resources. For example, Okkiyam maduvu, which is an important channel draining the Pallikaranai wetlands into the Buckingham canal, is choked up with buildings on its flood banks, automatically putting these developments at risk during flood disasters. Also, the famous SIPCOT (State Industries Promotion Corporation of Tamil Nadu Limited), lauded as India's largest Corporate IT Park which is planned along the IT corridor, sits dangerously close to the Pallikaranai Wetlands, making it vulnerable to flooding automatically.

In addition to this, urban sprawl as a response around commercial and industrial cores has further magnified the planning issue. Large scale gated communities, high-rise buildings and housing neighbourhoods have sprung up across the region especially in the suburbs. The IT corridor again is a prime example in this case, with dedicated housing neighbourhoods like Shollinganallur being set-up adjacent to it. Residential neighbourhoods are constantly being developed on the flood banks resulting in the natural buffer zone of the Buckingham canal to slowly disappear. These buffer zones are of course the first to flood when the canal overflows during the monsoon period.
While there is a sharp increase in residential developments across the region and the middle-class groups actively investing in them, there is also a need for awareness amongst the locals about the reality of these construction sites. In many cases, home buyers are often oblivious to the fact that their properties sit on reclaimed water bodies. This trend collectively puts a massive proportion of the population at risk (P. Arabindoo, 2016). With an increase in demand for housing because of migration and a booming economy, this sprawl has now become widespread and exerts an additional urbanization pressure on the natural system of the region.

These issues essentially percolate down to lack of synergy between urbanization processes and the natural green-blue patterns of the region.

Figure 2.4: Clogging of Okkiyam maduvu - 2002-2015
Source: Google Earth

Figure 2.5: SEZs planned in Flood prone areas - Chemberambakkam Lake 2002-2015
Source: Google Earth

Figure 2.6: Housing and more housing! - Urban sprawl - 2002 - 2015
Source: Google Earth

Figure 2.7: Slums and Informal Settlements

Top: A slum on the banks of the Adyar river completely submerged; Bottom: Position of slums on the flood banks of the Adyar

ii. Conflict: Fast development versus varied vulnerability

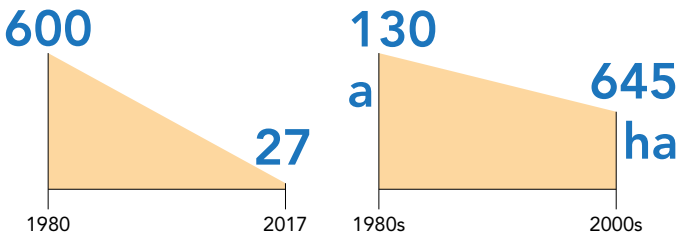
How inclusive is the region?

Low lying areas and flood plains of the rivers are designated as no-build areas according to the planning regulations. In fact, due to their natural vulnerability to inundation, they are also not viable for large constructions for real estate developers. Hence in many cases, they are the residual spaces in the city. These low-lying areas and flood plains of rivers have been massively encroached upon by the urban poor. An increase in poverty over the years has resulted in an increase in encroachment of these sensitive areas. This puts the socio-economically weaker sections at more risk as they tend to occupy the low-lying areas and the most flood prone zones. As a result, they are the worst affected during floods (P. Arabindoo, 2016). In addition, these encroachments also elevate overall flood vulnerability due to the loss of buffer zones such as the flood banks.

While the economic growth in the region was propelled forward because of the inflow of investment and industries, the cost of living and real estate became less affordable to the economically poor groups. On one hand the state administration promoted the capital as a 'global and slum-free' city, while poverty on the other hand increased because of this decrease in affordability. According to an article on January 18th, 2016 in The Times of India, a survey by Tamil Nadu Slum Clearance Board (TNSCB) revealed that in the period between 2001 and 2014, there was a 51.85% increase in the number of slums in the city. With 29% of the population living in these informal and slum settlements in the region (Chander, 2013), there have been multiple establishments which encroach on the banks of the river and pose additional flooding problems. These shanty towns are usually the first to be swept away especially in the event of flash floods when little or no warning is given. These slums are extremely dense, poorly maintained and structurally incapable of fighting floods, hence putting the inhabitants at risk. The exposure to risk seems worsened when put in the context of the urban poor that account for 65% of the households, and tend to occupy the most flood prone zones in the region (P. Arabindoo, 2016). Limited Accessibility to resources and services further puts this socio-economic group at risk, as in many cases, the structural quality of these households is of poor conditions. While the government has initiated slum clearance activities through the local Tamil Nadu Slum Clearance Board (TNSCB), relocations in many cases tend to exclude these groups away from the inner city and into the suburbs. This further increase their vulnerability due to unemployment as the city itself and basic health and education services become difficult to access. To exacerbate the situation, relocation sites often tend to be sites of previous water bodies which have been built upon. As a result, they are often relocated from one flood prone zone in the city to a flood prone zone outside the city (P. Arabindoo, 2016).

This section recognises a socio-economic group which experiences uneven risk due to location of settlement, deprivation of faculties, substandard living conditions and lack of access to governance processes. This in turn calls for just and unbiased flood solutions. This issue also brings to light the skewed target groups of the region's development so far. Especially in the case of flood resilience, it is crucial to bear this aspect in mind and pay attention to the need for inclusiveness of different social groups in decision making and planning.

Figure 2.7: Slums and Informal Settlements
Source : (top) http://edition.cnn.com/2015/12/03/asia/gallery/india-floods/index.html
(bottom) https://upload.wikimedia.org/wikipedia/commons/9/96/Saidapet.jpg



Water bodies in Chennai - (left) Number (right) Surface Area

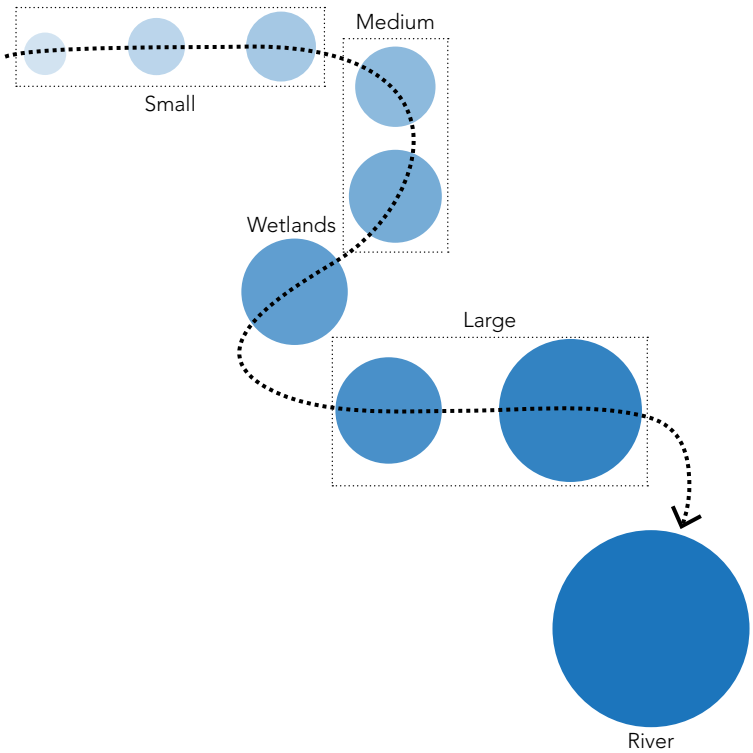


Figure 2.8: Loss of traditional water values

Top: Data; Middle: The almost level topography of CMA;
Bottom: Traditional hierarchal water harvesting system

iii. Implication: Ripple Effect

What is the current state of the water system?

Consequently, the change in land-use of water bodies across the region has resulted in the loss of the traditional water harvesting system. According to Manohar and KT (2016) this historic system was initially designed such that the water flowed through various hierarchal typologies, across large distances before eventually draining into the river. It consisted of a sophisticated network of stagnant and moving water elements with permeable surfaces such that they in turn recharged the ground water simultaneously as an added benefit.

The slow-moving water system is extremely significant in the case of CMA, due to its flat, almost level topography. Owing to the lack of natural slopes, a drainage system which was not reliant on gravity for the draining of its landforms was considered the optimum flood defense mechanism (P. Arabindoo, 2016). In this topographical condition, canals and channels are extremely important for flood defense. In fact, as Zevenbergen (2010) rightly points out, blue networks in the region, function as crucial areas of movement of water. In the case of the Chennai Metropolitan Area, this network has been disrupted at various levels.

In the absence of strict regulations against building over water bodies, uncontrolled urbanization and encroachments have taken place without reflecting on the natural hydrological system and by building over flood plains, marshes, lakes and ponds. This has resulted in a colossal loss of the region's water resources (Manohar & KT, 2016). Over 90% of open swamps have been taken over by urban developments, reducing the total number of water bodies from 600 in the 1980s to a mere 27 in 2017 as per the National Institute of Disaster Management (P. Arabindoo, 2016). While in the 1980s there existed 19 lakes with a surface area of 1130 hectares, the same had been reduced to 645 hectares by the early 2000s (P. Arabindoo, 2016).

Figure 2.8: Loss of traditional water values
Source: (top)Author (Data source : Arabindoo, 2016); (middle) http://www.acmissionz.org.nz/wp-content/uploads/2015/12/Chennai-floods.jpg ; (bottom) Author

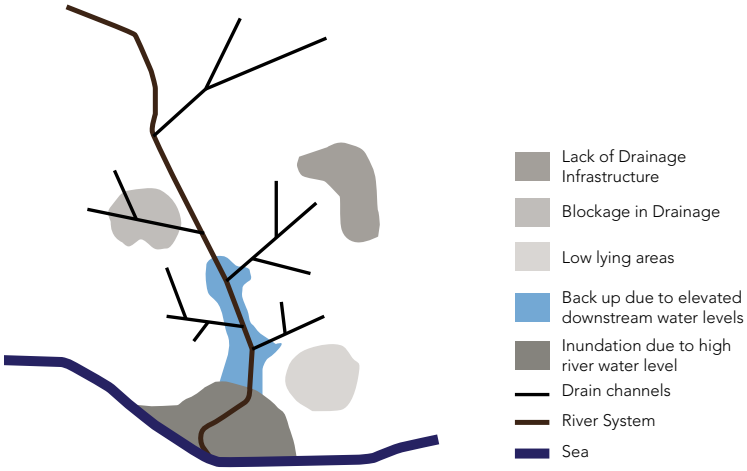


Figure 2.9: Storm water drainage system

Top: Concrete and impervious Stormwater drains and their current implementation; Middle: Inefficiencies of Stormwater drainage systems; Bottom: Blocked drains during floods

iv. Response: Inefficient urban drainage

How relevant is the current response for the risk?

As a response to floods, the region has currently undertaken Storm water drainage systems as its defence measure. These storm water drains are essentially composed of a vast network of concrete, underground drain channels that run along the roadways and work on the principle of gravity, intended for diverting water away from the inhabited areas into the rivers. The fundamental error in this system is that it relies on movement of water from higher to lowers points in a context which is flat. Nevertheless, these channels were implemented in the region without taking into consideration the natural contours and slopes of the topography. In a region which is in serious need of a flood defence strategy, this storm water drain network has been implemented to only 30% of its requirement. Only 7351 drains in the network have been established for 1896 km of roads, out of a total of 6000 km. Parkinson and Mark (2005) suggest possible errors in storm water drain systems and how they may often aggravate flooding than mitigate it. In many cases, important drainage outlets are clogged up with pollution or barriers. In addition to this the southern parts in general are more prone as the flat topography of these areas combined with higher run-ups facilitates inundation for longer distances and durations (Parkinson & Mark, 2005). The combination of a failed storm water drains system and a flat topography lead to persistence of inundation for several days at a stretch. This was evident during the floods of December 2015.

Figure 2.9: Loss of traditional water values
Source: Top: Image source: https://chennainked.wordpress.com/2015/03/20/rain-water-harvesting-in-chennai/, Data (Information sourced: Corporation of Chennai , Care India); Middle: Author (Information sourced: Parkinson & Mark, 2005) ; Bottom: http://www.thehindu.com/todays-paper/tp-national/tp-tamilnadu/broaching-the-british-legacy-of-arch-drains/article21384005.ece

Need for sustainable growth

Restoring water values

Need for inclusiveness

Need for better planning

Need for better climate responses

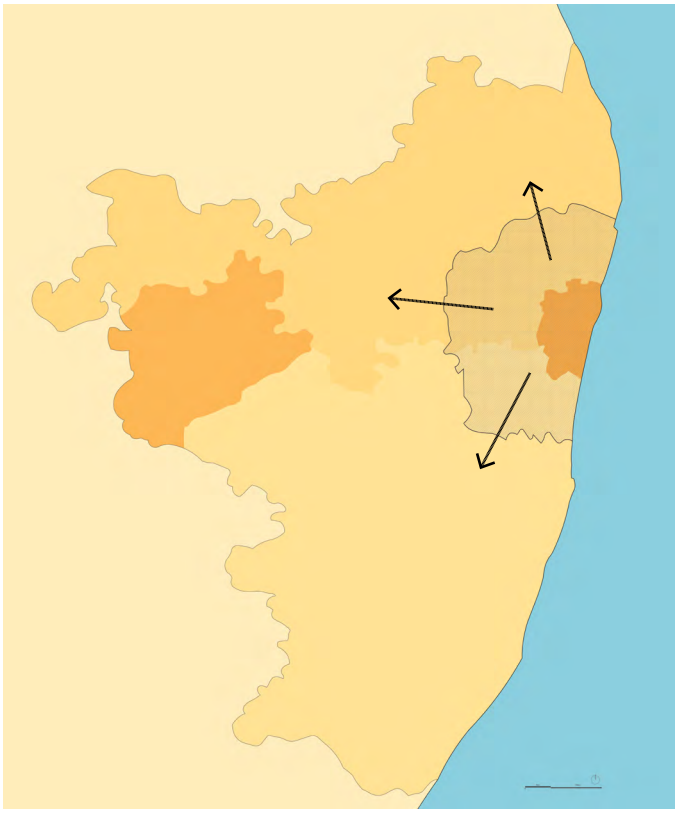


Figure 1.21: Region set to expand seven fold

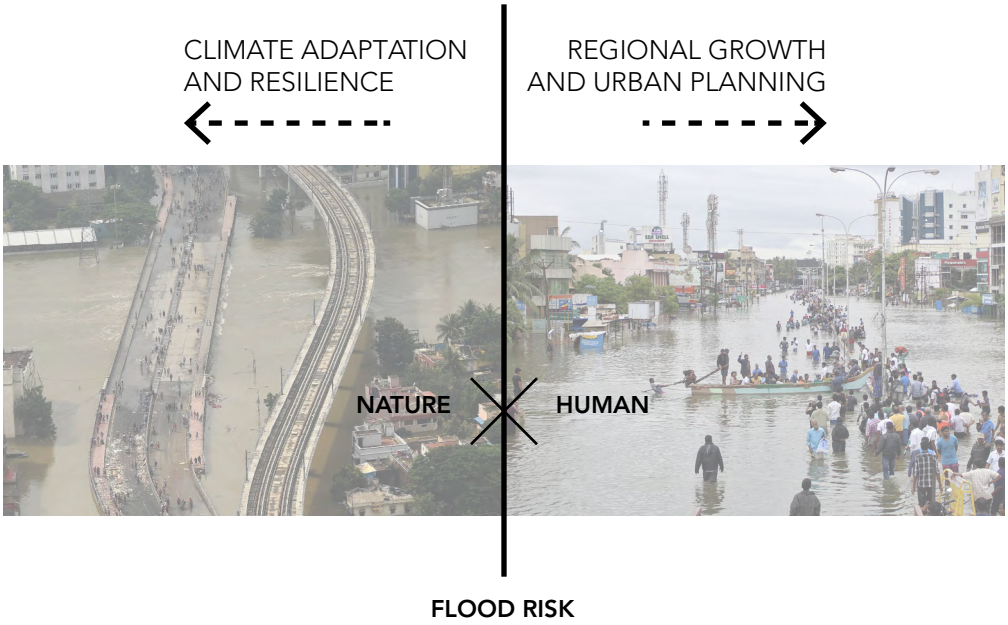


Figure 2.10: Human-Nature Conflict

2.2. Problem Statement

Urbanization patterns in Chennai Metropolitan Area have developed without reflecting on the natural hydrological system by building over floodplains, marshes, lakes, and ponds (Manohar & KT, 2016). This has resulted in a human versus nature conflict. Over 90% of open swamps have been taken over by developments, reducing the total number of water bodies from 600 in the 1980s to a mere 27 in 2017 according to the National Institute of Disaster Management (Arabindoo, 2016). Cumulatively, this has led to the loss of the traditional drainage network which was once the flood management system. This is mainly because planning processes have instead, responded to trends such infrastructure-led growth, market-led development, and capitalistic urbanization (Ellis, 2012). Further, encroachment of low lying areas and the floodplains of rivers by the socio-economically weaker groups have not only exasperated the flood risk but have also triggered uneven vulnerability of the weaker section of the society.

The result is an exclusive metropolitan area with increased flood risk and minimum participation of the local community. However, the region is still urbanizing rapidly and is set to expand multi-fold, without taking into consideration, flood resilience strategies as part of its urban agenda (Arabindoo, 2016).

On one hand, floods are inevitable and increasing in frequency and intensity due to the deltaic nature of the region and impacts of climate change. On the other hand, this risk is aggravated due to the lack of urban planning that integrates flood resilience. Hence, there is a need to revise the regional plans and visions that are currently in place. By responding to the existing trends and recognizing the local potentials and values, resilience towards flooding will be integrated through strategic planning across various spatial and temporal scales.

Figure 2.10: Region set to expand from 1189 sq.km to 8878 sq.km.
Source: Author

Figure 1.22: Human -nature conflict
Source: Author

Part II- Defining the Scope of the Research

Source: http://www.sheherazadenyc.com

An entire region at a stand still
Source: https://www.businesstimes.com.sg/government-economy/india-floods-swamp-airport-and-disrupt-bmw-ford-in-chennai

3. Research Focus

3.1. Aim

The aim of this research is to design local adaptation strategies to mitigate flooding in the Chennai Metropolitan Area. The approach adopted makes a strong case for socio-ecological resilience and addresses community engagement and capacity building in order to collectively restore balance to the human-nature conflict. Social capital, civic engagement and the relevance of tangible local scale strategies form the core of this project.

3.2. Research Question

How can local adaptation strategies be planned in order to reinforce socio-ecological resilience towards floods in the Chennai Metropolitan Area?

3.3. Sub-Research Questions

	Methods and Approaches
1. What are the drivers of spatial development at the regional scale? What are the characteristics of the urban form?	Problem Analysis Socio-spatial Analysis
2. What are the existing approaches to sustainable development in the region? How can they be integrated in the plan?	
3. What are the spatial manifestations of social, economic and environmental capital that can contribute to local adaptation strategies across various scales?	Spatial Analysis and potentials
4. How can social capital be used to activate interactions between environmental and economic capital for local adaptation to floods?	Spatial Design framework
5. How can these strategies be designed to accommodate socio-economically vulnerable groups to ensure social and climate justice?	Literature study Spatial design
6. How can various actors be involved in this process? What is the role of governance and how can institutions play a role in maximizing contribution and participation?	Actor analysis Multi-stakeholder approach Bottom-up strategies Incentives
7. How can these elements be made tangible into a strategic plan for the CMA?	Strategic Planning Multi-level approach

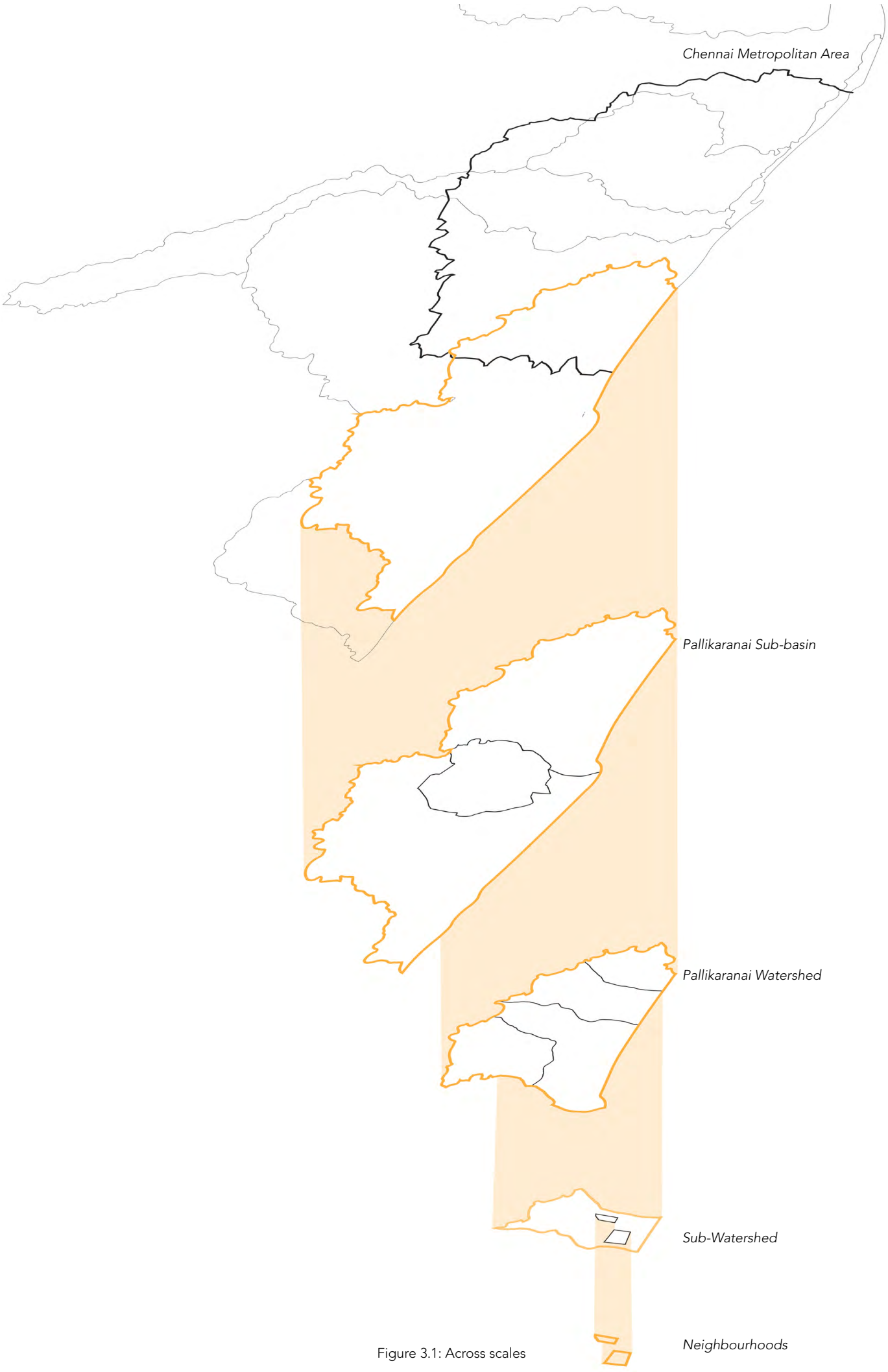
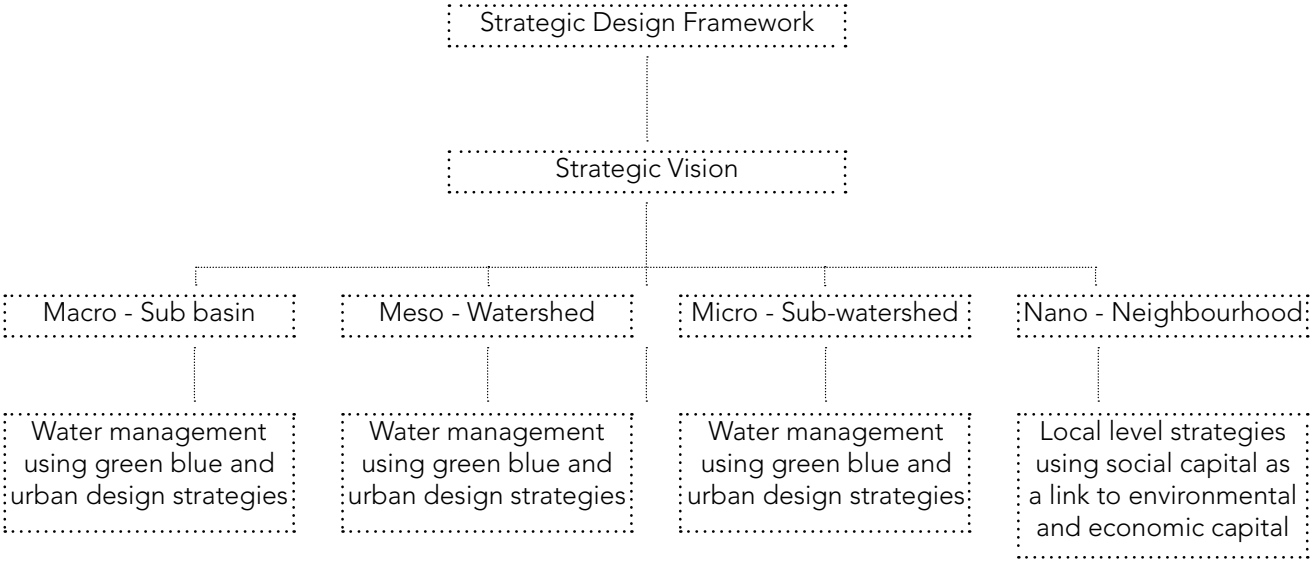


Figure 3.1: Across scales



3.4. Project Goals

This project places focus on neighbourhood level strategies while achieving integrated drainage across multiple scales. Community level interactions with the environment are sought to be designed for at the Nano scale while performance in spatial and hydrological aspects are delivered on the higher scales. Hence, the project focuses on the Neighbourhood as the Nano scale, Sub-watershed as the Micro scale, Watershed as the Meso scale and the Sub-Basin as the Macro scale.

These multi-scalar strategies can then be extended to the rest of the region's sub-basin, in order to move closer towards flood resilience on the regional scale.

Figure 3.1: Across scales
Source: Author

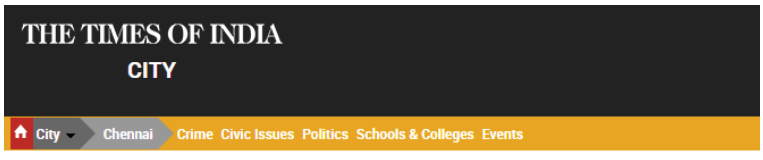


Fig 13.2: Social Relevance

3.5. Relevance

3.5.1. Scientific Relevance

Climate change and its impacts are increasingly being studied especially in the Global south where basic infrastructural needs are not met, let alone climate adaptation. In this case, the works of Hallegate and Corfee-Morlot (2011) suggests the relevance of the 'no regret' approach which seeks to respond to basic infrastructural needs through climate adaptation. In fact, notable researchers such as Adger (2003) have stressed on the need to consider climate adaptation as a basic approach to urban planning and processes. However, this area of research is extremely broad and has multiple contributions of varying nature. In the case of resilience, multiple definitions tend to make it more conceptual than operational hence resulting in a gap between theory and practice (Tyler & Moench, 2012). Recent works by the Rockefeller Foundation has made several attempts to make these vast concepts tangible. This paves the way for new ways to integrate resilience as a tangible concept in urban planning processes. Hence this project which looks at flood resilience as an approach attempts to bridge this gap between ongoing urban processes and adaptation to changes in climate patterns. Through this exploration, the project contributes to the ongoing discussion about adaptation and resilience in the Indian context and works on the gap between theory and practice.

3.5.2. Societal Relevance

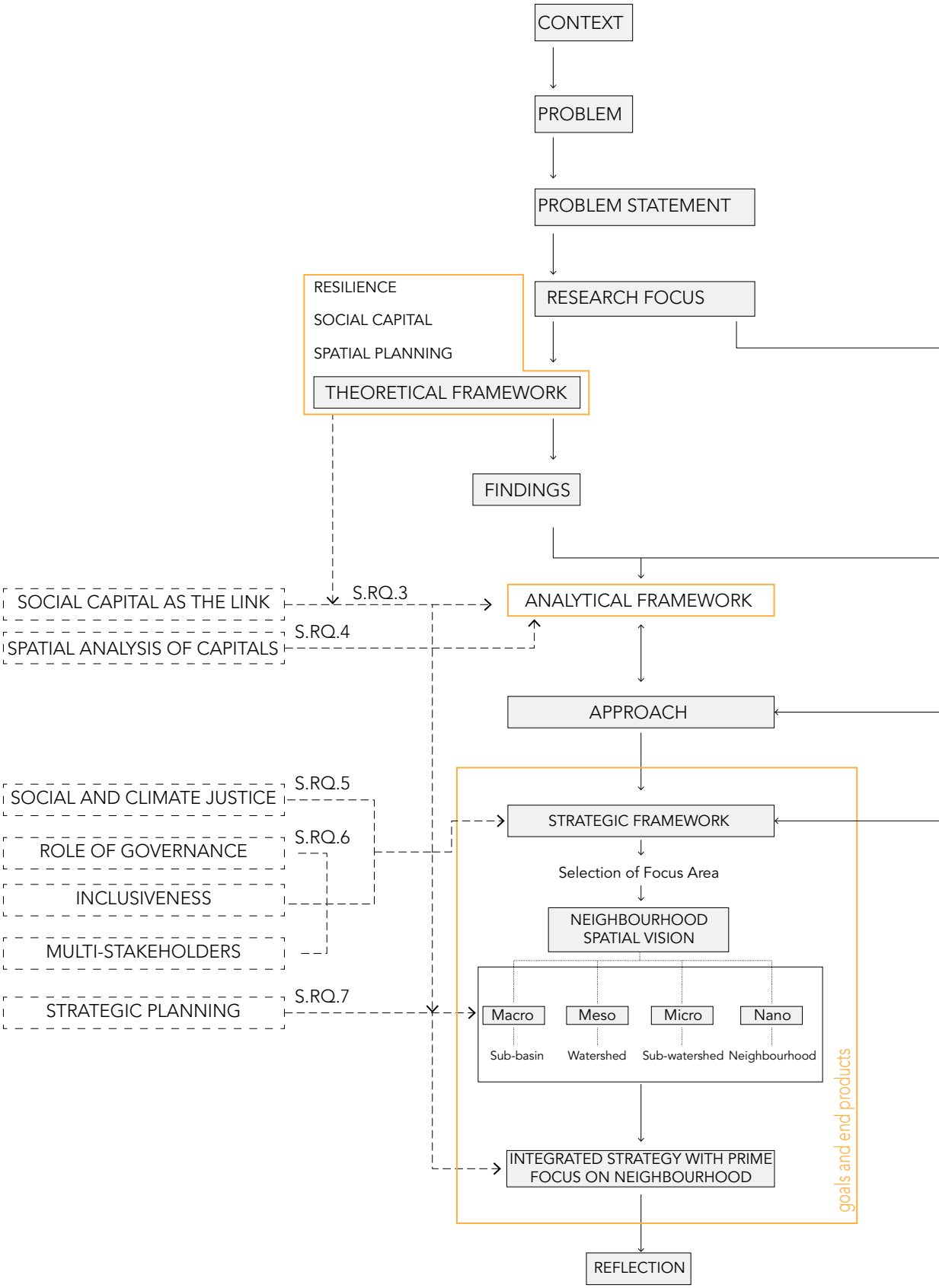
With growing risks and frequency of disasters, the local community in the city of Chennai is becoming vulnerable to the changes in climate pattern. The floods which devastated the region in 2015 claimed over 400 lives and paralyzed the city for nearly two weeks. The extreme event also resulted in an economic loss of $3 Billion Dollars making it the world's 8th most expensive disaster in 2015. With infrastructure failing and lack of access to resources the city undoubtedly faced one of the worst disasters in history. While the existing flood mitigation responses have been inadequate is responding the risk, this calls for the need to rethink how we plan our cities and ways to integrate the concepts of adaptation and resilience as part of the planning process. In such extreme cases, mitigation often only delivers short term solutions and hence adaptation plays an important role in not only responding to risk but also promoting sustainable urban growth.

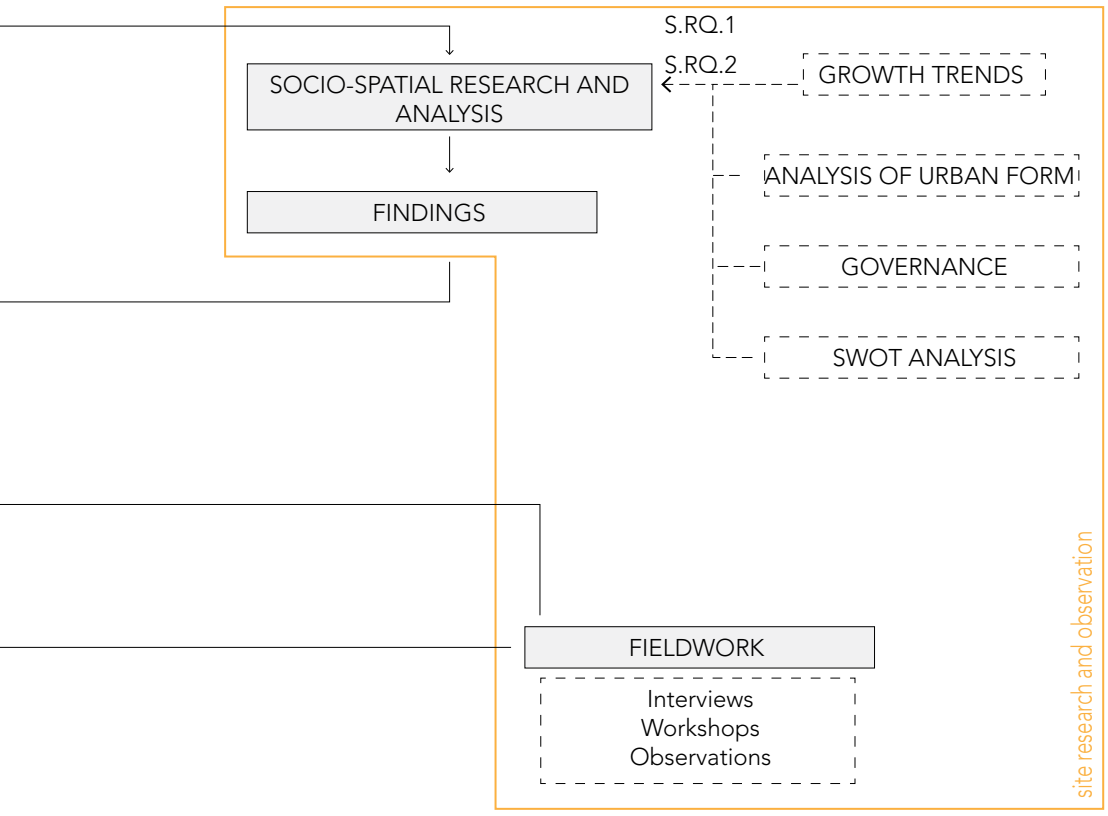
This discussion is also set in a time of increased awareness amongst the local citizens and practitioners, and hence it is highly relevant to address the need to rethink urban planning through the lens of flood resilience in the Chennai Metropolitan Area. Also, in the context of a developing country such as India, climate adaptation is the need of the hour, considering that the country features amongst the most at risk, but least capable of responding to it.

Figure 3.2:
Top: http://edition.cnn.com/2015/12/03/asia/gallery/india-floods/index.html

Middle: https://www.bloomberg.com/news/articles/2017-09-12/south-asia-cities-face-215-billion-worth-extreme-rainfall-risks

Bottom: https://timesofindia.indiatimes.com/city/chennai/Climate-change-Crisis-is-here-now/articleshow/48476412.cms


CONTEXT
PROBLEM
PROBLEM STATEMENT
RESEARCH FOCUS
RESILIENCE
SOCIAL CAPITAL
SPATIAL PLANNING
THEORETICAL FRAMEWORK
FINDINGS
SOCIAL CAPITAL AS THE LINK
S.RQ.3
SPATIAL ANALYSIS OF CAPITALS
S.RQ.4
ANALYTICAL FRAMEWORK
APPROACH
SOCIAL AND CLIMATE JUSTICE
S.RQ.5
ROLE OF GOVERNANCE
S.RQ.6
INCLUSIVENESS
MULTI-STAKEHOLDERS
STRATEGIC PLANNING
S.RQ.7
STRATEGIC FRAMEWORK
Selection of Focus Area
NEIGHBOURHOOD SPATIAL VISION
Macro
Meso
Micro
Nano
Sub-basin
Watershed
Sub-watershed
Neighbourhood
INTEGRATED STRATEGY WITH PRIME FOCUS ON NEIGHBOURHOOD
goals and end products
REFLECTION



4. Methodology

4.1. Organisation chart

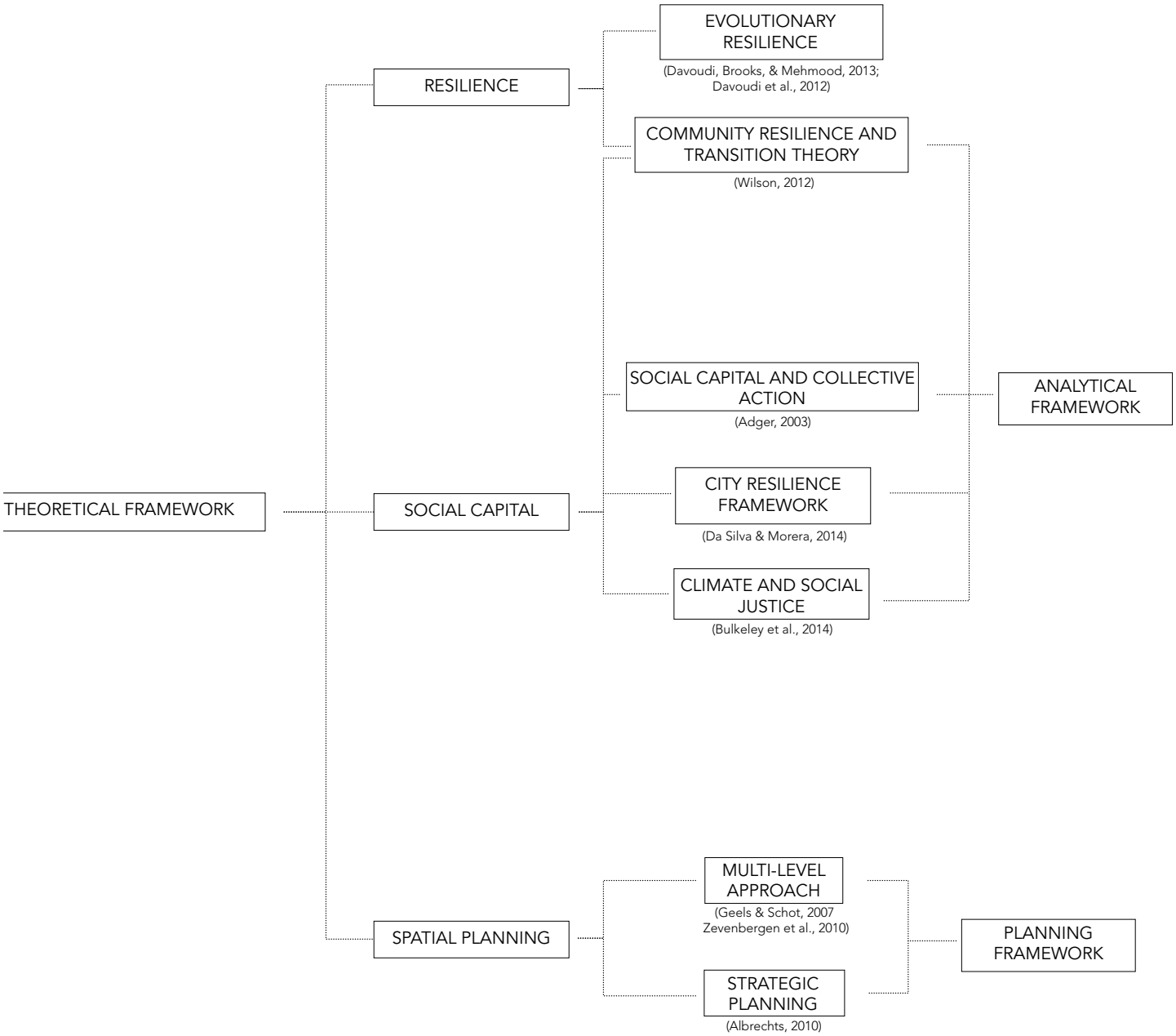


Figure 4.1: Theoretical framework

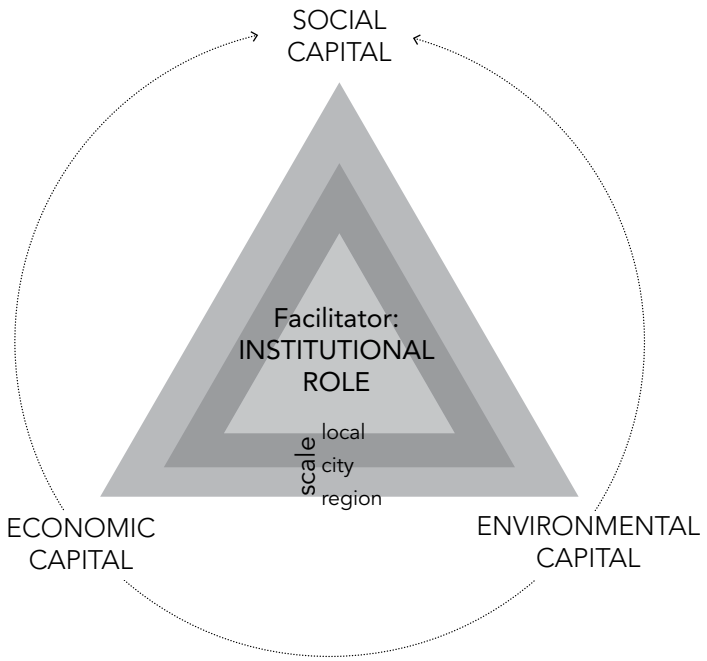


Figure 4.2: Capital assessment

4.2 Theoretical Framework

The theoretical framework defines a clear understanding of the direction and approach followed in this thesis project. The following concepts are used for guiding the research and the development of the project approach.

The Chennai Metropolitan Area is vulnerable to floods due to its deltaic nature. By recognizing that flooding is inevitable and the vulnerability to it is increasing with time, a continuous adaptation process is sought to be integrated through the concept of resilience. The IPCC defines resilience as the 'ability of a social and ecological system to absorb differences while retaining the same basic structure and ways of functioning, the capacity of self-organisation and the capacity to adapt to stress and change' (Bernstein et al., 2007).

In addition to this trend, the interaction between human and nature systems in the CMA has resulted in a conflict of the economic goals and hydrological system which in turn has increased the vulnerability to flooding. Resilience here is understood as a continuous adaptation process as well as that which influences human and nature interactions. Hence this thesis positions itself with the socio-ecological approach to resilience.

EVOLUTIONARY RESILIENCE (Davoudi, Brooks, & Mehmood, 2013; Davoudi et al., 2012)

Davoudi's (2012) evolutionary resilience is an approach that argues that resilience is beyond a return to normalcy (Pendall, Foster, & Cowell, 2010), and is rather envisioned as that which enables the complex socio-ecological systems to continuously change, adapt, learn and evolve in the face of increasing risk and vulnerability. Socio-ecological resilience here, understands nature and humans as interdependent systems (Davoudi et al., 2013).
When applied to the context of urban planning, evolutionary resilience highlights the importance of the link between social and institutional processes to that of the natural and biophysical processes in the context. This forms the basis of addressing different actors, institutions, and spatial and temporal scales. This multi-scalar approach of space and time is further elaborated by Davoudi et al. (2013) through the panarchy diagram, developed by Holling and Gunderson (2002) (See appendix). Essentially a system based approach, this concept explains that complex socio-ecological systems tend to function in nested cycles with continuous interactions between space (small and large) and time (slow and fast).

Through evolutionary resilience, emphasis is laid on the need to not only address the risk but also improve existing socio-ecological conditions through strategies across spatial and temporal scales. The approach further emphasises on the relevance of local values and capacities and changes in societal conditions that impact the interactions between human and natural systems. These local values can be recognised by understanding the socio-cultural context (Robinson & Carson, 2016; White & O'Hare, 2014). Hence focus is laid on the importance of local adaptation strategies that influence human-nature interactions through social changes.

COMMUNITY RESILIENCE AND TRANSITION THEORY (Wilson, 2012)

Building on these concepts, focus has been laid on the importance of local adaptation strategies that are capable of influencing human-nature interactions. Geoff Wilson (2012) in his book 'Community Resilience and Environmental Transitions' insists that local level actions are the most tangible in terms of influencing resilience. He hence argues in the favour of community resilience and its effectiveness in terms of building resilient human communities. (Wilson, 2012), in his work, makes a crucial link between resilience of socio-

Figure 4.1: Theoretical Framework
Source: Author

Figure 4.2: Capital Assessment
Source: Author

ecological systems with the importance of socio-cultural context and hence places focus on community driven resilience measures. This, he argues, is relevant for all scales, even to the macro scale of a region. In fact, he too argues for the adaptive cycle developed by Holling and Gunderson (2002) with respect to community resilience and highlights the ability of individuals and communities to self-organise and adapt as crucial to achieving resilience in complex socio-ecological systems.

He further elaborates that every community has an inherent 'capacity' to face risk, learn, adapt and evolve. This is termed as 'community capacity' and hence in order to build resilient communities, this capacity can be tapped into. For this capacity building process, Wilson (2012) uses 'capitals' as a starting point. Capitals here are the structural components that the human societies organise themselves in. They are the assets and community capabilities that can be understood and built upon. Wilson (2012) argues that a resilient community is that which exhibits well developed social, economic and environmental capital. Social capital here can be understood as that of the social, political and cultural assets and networks. Economic capital pertains to the financial and economic assets. Environmental capital can be understood as the biophysical and ecological assets and resources.

Together they form the three major arenas where community resilience can be developed. Wilson (2012) places special focus on the social capital, as that which binds the other environmental and economic capitals together.

Cumulatively, Wilson (2012) understands resilience as a process and hence recognises its transform-ability quotient. This transform-ability and notion of a process driven approach is further corroborated by Davoudi (2012).

Based on similar concepts, comes the transition theory, as illustrated in the work of Zevenbergen et. al (2010). The consolidation of urban flood management methods draws attention to transition as the step to integrating resilience into the urban environment. According to the author, transition theory is stated as:

"A transition is a structural change in the way a societal system operates and can be described as a long term process (20-25) years that results from a co-evolution of cultural, institutional, economic, ecological and technological processes and developments on various scale levels." (Zevenbergen et al., 2010)

This transition theory is hence a crucial link between community resilience and the process of change. Wilson (2012) further acknowledges this transition approach and defines it as societal and environmental transition in his work. He understands this widely studied theory as that of a 'gradual, continuous process of societal change where the structural character of the society (or a complex sub-system of society) transforms (Wilson, 2012). This hence establishes the need to define the temporal scales while addressing flood resilience.

SOCIAL CAPITAL AND COLLECTIVE ACTION (Adger, 2003)

As mentioned above, Wilson (2012) emphasised on the significance of social capital and its ability to link economic and environmental capital. Extending this notion, Adger (2003) also states that social capital can be linked to collective action and environmental management.
With observations similar to Wilson (2012), Adger (2003) suggests that human societies have an inherent capacity to adapt to climate change. This capacity, he suggests, can be

maximised in potential through collective action. Through this collective action, Adger (2003) argues for an interdependent relationship between different actors, institutions and the resources that they depend on. He further explains that these interdependencies and relationships need to also take into consideration various socio-economic groups and their interests. The institution plays an important role in mediating these interests and also maintaining fairness and justice. In the context of CMA, this collective action can be interpreted as an interdependent actor network for the management of the natural hydrological and green resources.

Through a case example in Tobago, Adger (2003) analyses how collective action between institutional actors and the local actors can lead to synergy and the sustainable use of resources through adaptive co-management. In this case, a protected marine area was co-managed by the institution as well as local groups which were dependent on the marine area for resources. To promote inclusiveness and to avoid the mismanagement of resources by one top level actor, the system was decentralised to accommodate those directly reliant on the resource. Hence in this manner, in the case of flood resilience, if the water network is crucial to realising long term adaptation, involving the local community dependent on that water source for their basic needs can be one way of promoting co-management and inclusiveness.

Adger (2003) further emphasises that the stability of societies and their actions are maximised through this collective approach and shape economic and environmental processes. Hence he suggests that social capital is key to interactions between economic and environment process and this relationship can be approached through a collective action. In fact, he aptly states that social capital is central to living and coping with risk (Adger, 2003).

CLIMATE AND SOCIAL JUSTICE (Bulkeley et al., 2014)

As an extension of collective action, Davoudi (2012) also sheds light on the need to accommodate socially vulnerable groups into processes of collective action and community development. Considering that social, economic and environmental capital also take into account the socio-economically weaker groups, it is important to also accommodate their interests and aspirations in the overall resilience plan. In many cases, poor sections of the society tend to be more at risk and the concept of climate justice provides a lens to plan resilience and climate adaptation for all. This concept is discussed in detail in the Appendix of this report. An excerpt is given below:
Firstly, climate justice addresses the need for participation of the most vulnerable and susceptible to climate disruption, to have a direct say or participation in governing practices that seek to strengthen adaptive capacity towards climate change. Secondly, articulation of weaker groups into policy making and implementation of climate policy and projects need to be done through the lens of justice. Thirdly, discussions on climate justice have time and again highlighted the inevitability of local participation and equal rights and access in decision making (Bulkeley, Carmin, Broto, Edwards, & Fuller, 2013).

RECOGNISING SOCIAL, ENVIRONMENTAL AND ECONOMIC CAPITAL (Da Silva & Morera, 2014)

Based on an evolutionary understanding of resilience and a system based approach, The Rockefeller Foundation in association with Arup formulated the City Resilience Framework in 2015. As part of the 100 Resilient Cities initiative, city resilience is defined as the capacity of cities to function, so that people living and working in cities – particularly the poor and

Figure 4.3: City Resilience Framework

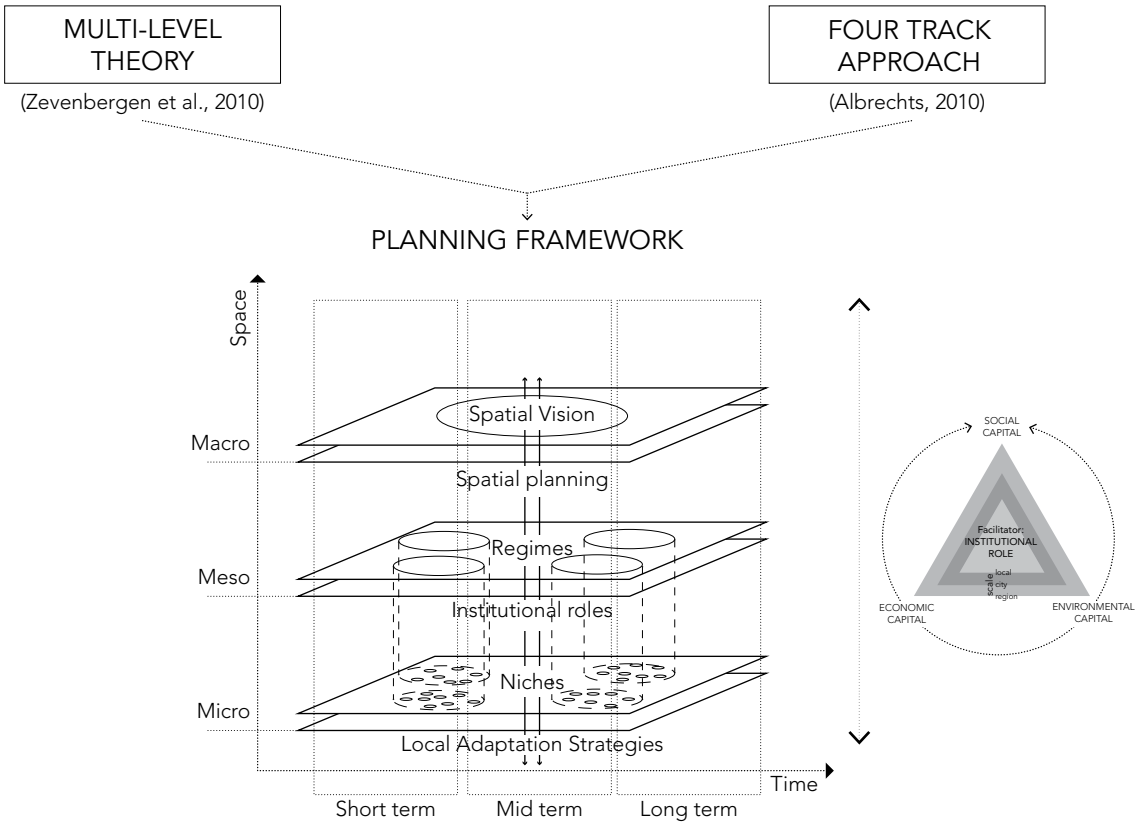


Figure 4.4: Planning Approach

vulnerable – survive and thrive no matter what stresses or shocks they encounter (Da Silva & Morera, 2014). Their definition of resilience recognises that social systems influence the physical system, resonating with that of evolutionary resilience.

Based on literature, case examples and fieldwork, a City Resilience Framework was developed as an operational framework to resilience. This framework is discussed in detail in the appendix of this report.

The framework illustrates 12 goals grouped into 4 categories of interventions for resilience building. These categories are defined as 'Leadership and Strategy', 'Health and Wellbeing', 'Economy and Society' and 'Infrastructure and Ecosystems'.

A detailed study of this framework and its components revealed similarities to the social, environmental and economic capital as theorised by Wilson (2012) and Adger (2003). Further, the importance of the institution and governance set up from the concept of collective action was also linked to the findings of the framework. Hence the capitals and categories are conceptualised as shown on the opposite page. Hence in this study, Health and well being is linked to social capital, Economy and society correlates to economic capital and infrastructure and ecosystem correlates to natural capital. By doing so, a set of goals are defined as parameters to assess the proposal. An interesting addition to this study of capitals is that of leadership and strategy which is conceptualised as the 'Institutional' Role. Hence this study further integrates institutional role as a crucial determinant to the implementation of local flood resilience strategies.

MULTI-LEVELAPPROACH (Geels & Schot, 2007; Zevenbergen et al., 2010):

Transition theory when defined for its practical applications can be conceptualised into a multi-level approach (Zevenbergen et al., 2010). This theory suggests that human societies function on three scales, namely, the Macro (landscape), Meso (Regime) and Micro (Niche). The macro scale is that of the societal trends such as economy, culture and politics that drive overall processes. The regime consists of the institutional set up and the link between the macro and micro scale. The Niche consists of local level composed of individuals, groups, organisation and projects. The local level is key to innovations that get magnified to the macro scale, shape and transform the landscape. An extended approach to this is that of the Socio-technical landscape, socio-technical regime and niche-innovations (Geels & Schot, 2007).
When interpreted in the context of urban planning and resilience, the multi-level approach can be conceptualised as Macro – Vision, Meso – Institution and Micro – local adaptation strategies. Institutions play an important role in mediating the interests between the micro level actors and provide a basic framework for the local level innovations to shape the macro level context.

This approach is crucial in establishing synergies between the bottom-up strategies and the top down spatial vision. In addition, the role of the governance institution is emphasised in this approach as the mediator between different actors and groups. Also, governance plays an important role in the design of suitable policies and large scale planning frameworks and regional spatial strategies that enhance and support local level actors and interventions.

STRATEGIC PLANNING (Albrechts, 2010):

According to Albrechts (2010), strategic spatial planning is 'a transformative and integrative, preferably public sector led, socio-spatial process through which a vision, coherent

Figure 4.3: City Resilience Framework
Source: Da Silva and Morera, 2014

Figure 4.4: Planning approach
Source: Author

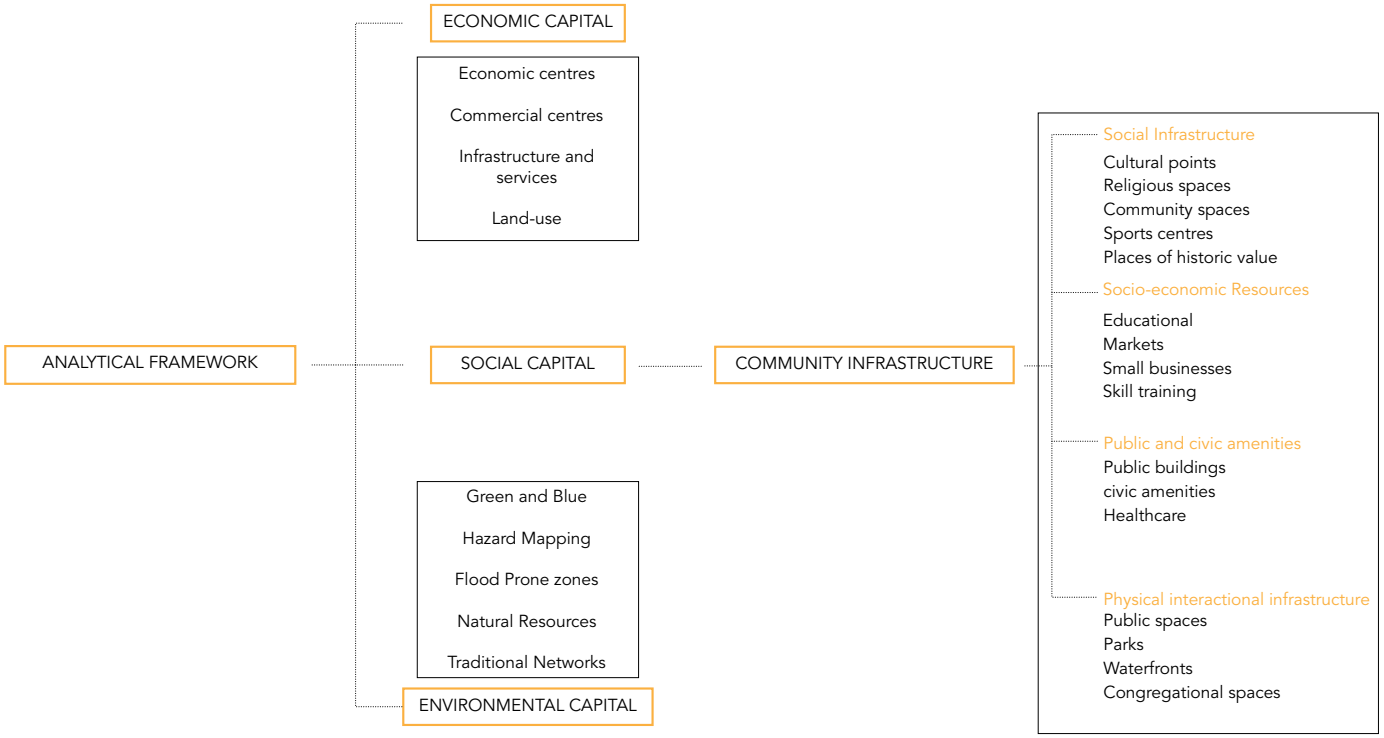


Figure 4.5: Analytical Framework

actions and means for implementation are produced. These may shape and frame what a place is and what it might become. This is adopted as the planning approach for the thesis. As illustrated by the author, the four track approach is adopted. This four track approach consists of the following elements - a vision, short term and long term actions, involvement of multiple key stakeholders and a local level permanent process involving the public (Albrechts, 2010). The first track consists of envisioning and imagining space-time relation. This resonates with the landscape element of the multi-level approach as part of the transition theory. The second track consists of addressing the goals through short term and long term strategies.

A more elaborate version consists of short-term, mid-term and long-term strategies. This track can be applied to address flood mitigation as well as long term adaptation strategies. The third track requires an integration of multiple actors and resonates well with the multi stakeholder approach. The fourth track suggests an inclusive and bottom up approach which empowers the local scale. This further emphasises the need for development of social capital and supports local strategies. This track indeed resonates with the theories laid out by Wilson (2012) and Adger (2003). The end product consists of an integrated vision, strategies across different spatial and temporal scales, multi-stakeholder analysis and local strategies for inclusiveness.

4.3. Analytical Framework

Based on the socio-ecological approach to resilience (Davoudi et al., 2013), the need for local adaptation strategies is established. This local strategy is further implemented to build community resilience. In addition to the social, environmental and economic capital, institutional role and its nature of promoting collective action and climate justice is considered a crucial component to planning flood resilience in this project.
Social capital is used as the link between economic and environmental capital in order to shape resilient communities. Hence, in order to extract and shape social capital, building community capacity is the way forward.

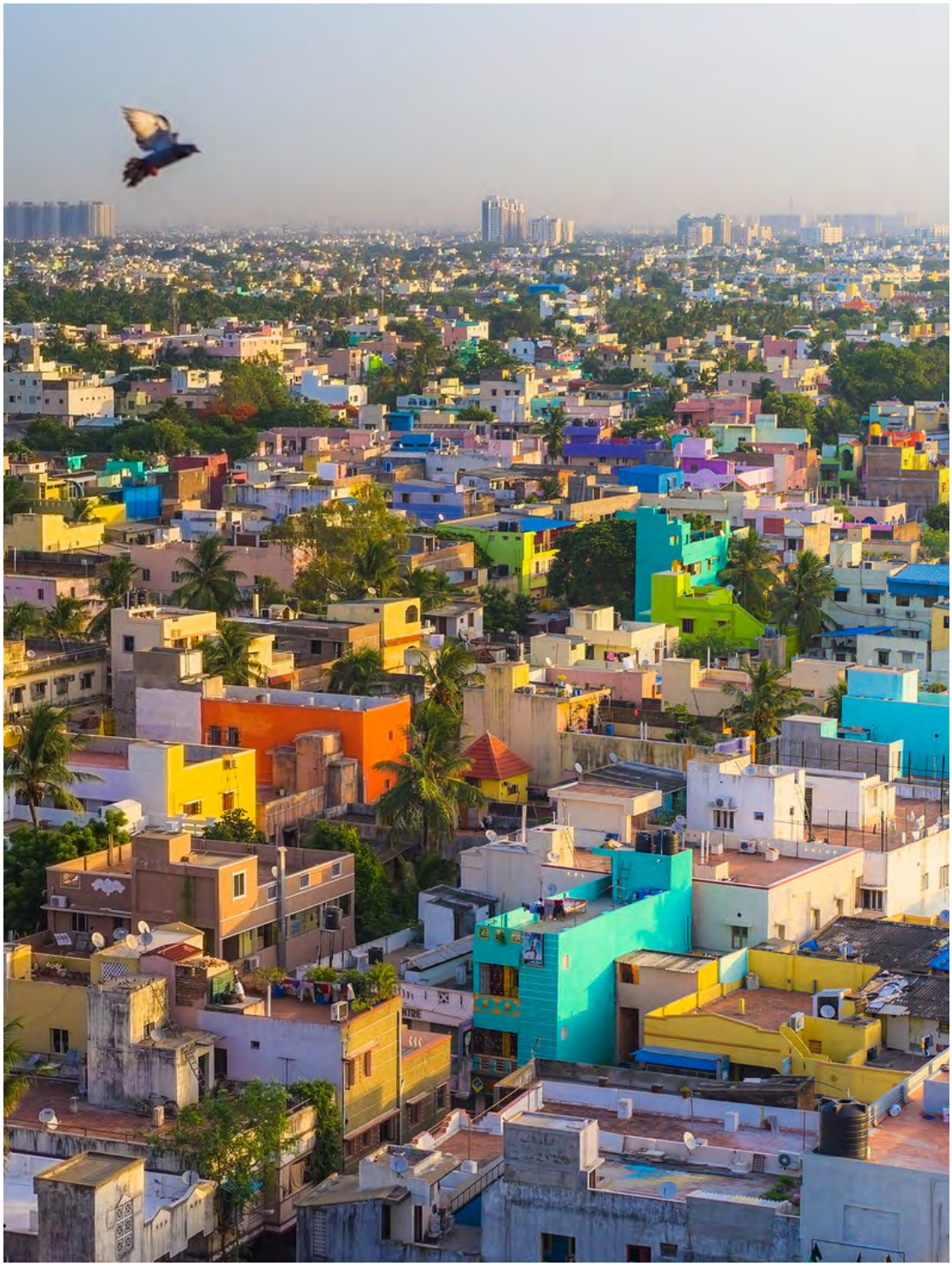
In order to make social capital networks tangible, the findings from Da Silva and Morera (2014) and Kilpatrick and Abbott-Chapman (2007) are analysed and social capital is defined as the spatial elements which promote human interactions and in turn act as the medium in which social networks build and grow. Hence, social capital is approached as community activity infrastructure (Kilpatrick & Abbott-Chapman, 2007) and is defined spatially in this project as elements of social infra-structure, Socio-economic resources, public and civic amenities and physical interactional infrastructure.

Economic capital is defined spatially as the economic centres, commercial centres, infrastructure and services and land-use characteristics. Environmental capital is defined in the context of this project as the biophysical elements such as green-blue elements, hazard and flood prone zones and natural resources.

The analysis is carried out in two parts. First the overall region is analysed through socio - spatial analysis. The hypothesis is formulated based on the findings of socio-spatial analysis and the theoretical findings.

Second, based on the analytical framework, different types of capital and their potentials are analysed. The findings are then plugged into each other to formulate strategies.

Figure 4.5: Analytical Framework
Source: Author



Part III- Investigations

Source: https://farm9.staticflickr.com/8564/28745915880_949e2828d5_h.jpg

The Adyar meeting the Bay of Bengal
Source: https://www.indiatimes.com/news/india/15-stunning-images-of-chennai-from-10000-ft-above-sea-level-244693.html

5. Socio-spatial research and analysis

This section studied the different socio-spatial characteristics of the region. This is carried out by the analysis of the growth trends, analysis of the urban forms, the existing urban growth model in place and the governance system.

For this purpose, the following layers were studied and the findings are presented using the SWOT method.

5.1. Madras - A Brief History

5.2. Post Independence in 1947

5.3. Liberalisation and Economic growth

5.4. Analysis of urban form- Infrastructure led growth model

5.5. Urban Sprawl and density analysis

5.6. Socio-economically vulnerable groups

5.7. Governance structure and existing strategies

5.8. Watersheds in the region

5.9. Loss of green and recreation values

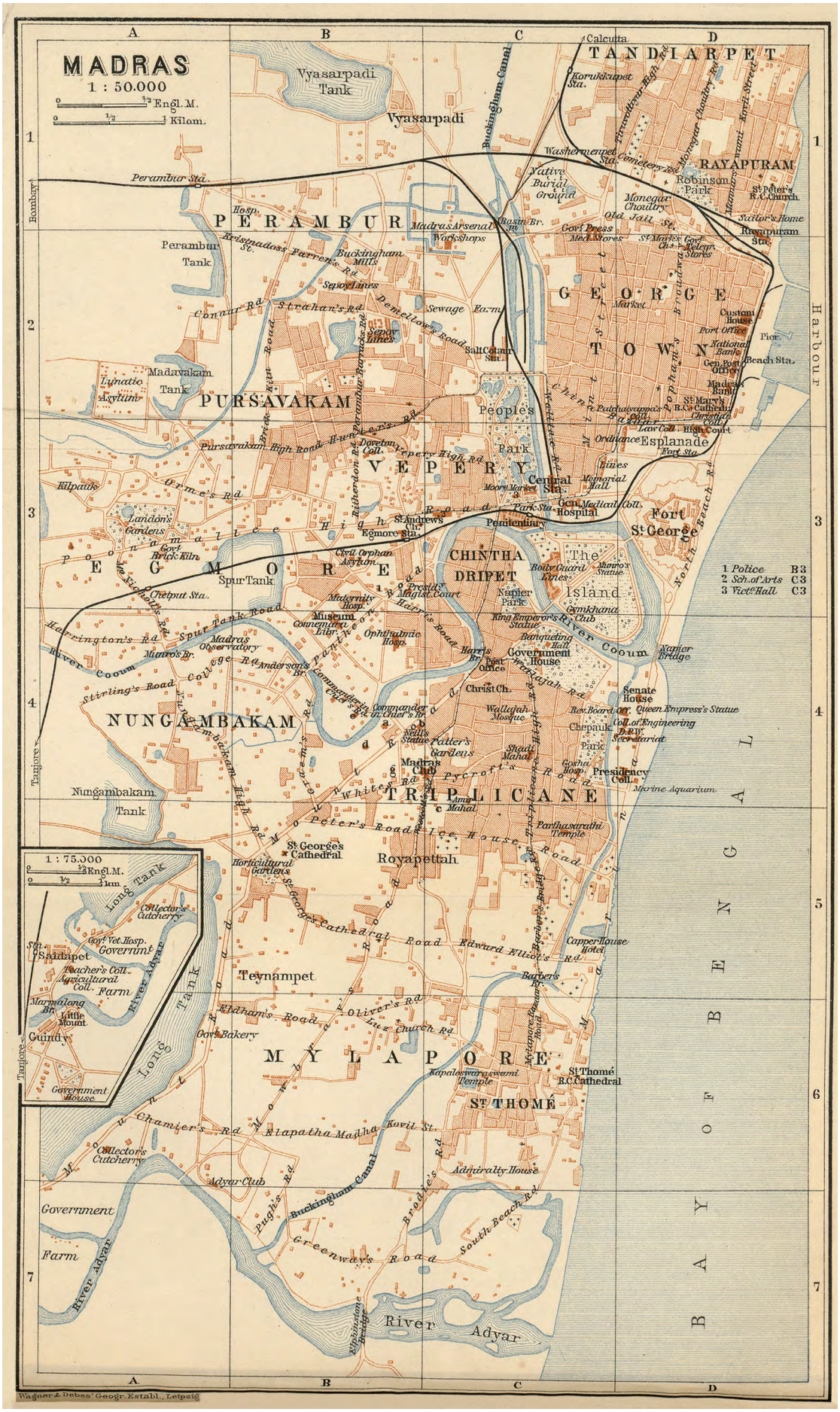


Figure 5.1: Madras 1914

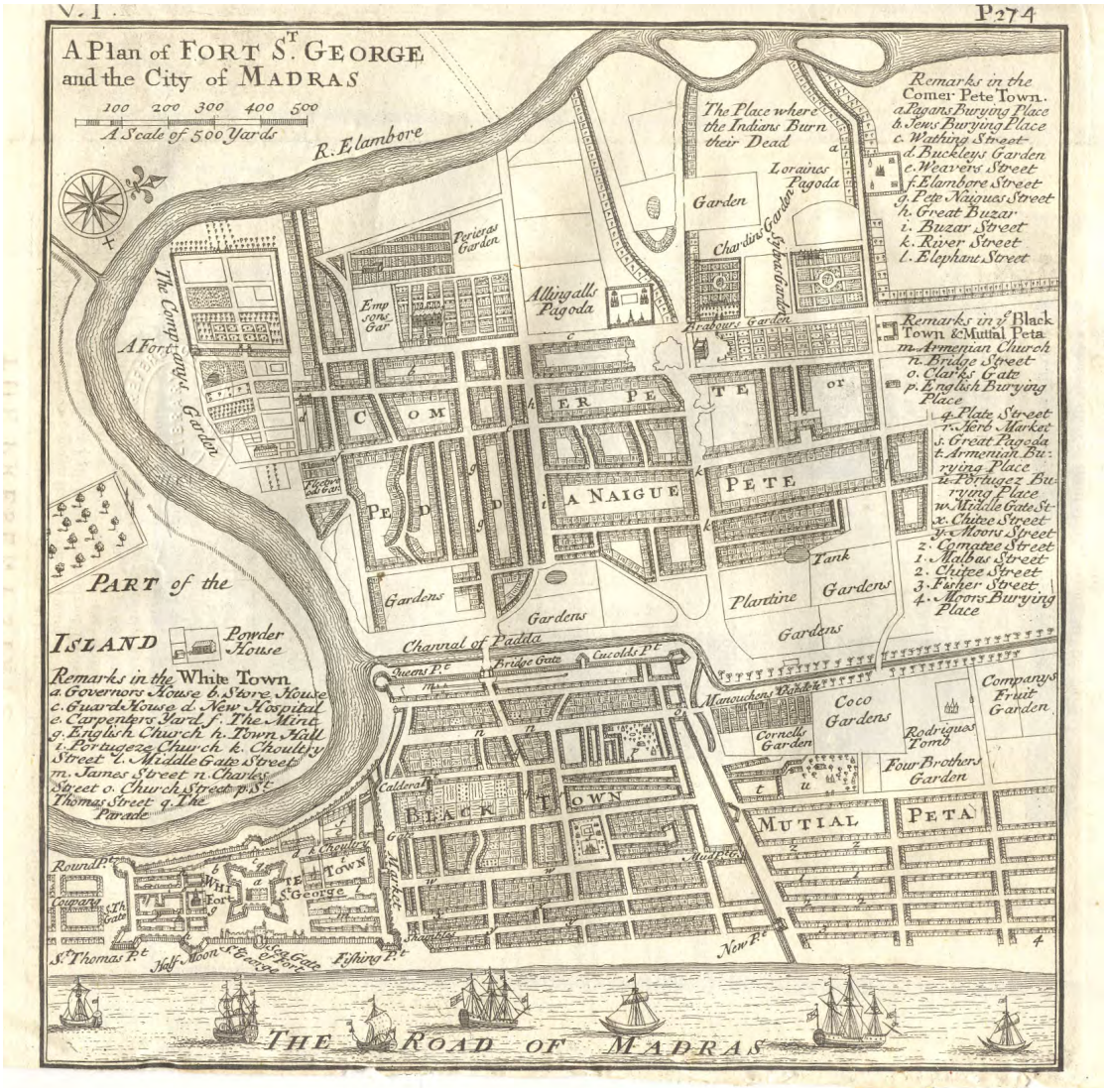


Figure 5.2: Madras 1726

5.1. Madras - A brief history

The name 'Chennai' is recently, adopted only from 1996. Previously the city was called Madras. During colonial rule, the Madras port was a crucial for trading activities by the British the East India Company. As one of the most important ports in the country, the economy was established through the trade of manufactured, raw and semi-finished goods. In this period, it was in fact established as a 'trading post economy' (Kennedy et al., 2014). During this time, the historic settlement of the north was the administrative centre but also was mainly regarded as the 'black town' or where the locals lived. Meanwhile the British began to set up their residential areas in the southern part of the city. This essentially led to the development of two distinct parts of the city which were connected by roadways and housed different socio-economic groups. This historic divide is seen even today, however manifests itself differently.

Figure 5.1: Madras 1914
Source: http://maplabindia.blogspot.nl/p/baedekers-maps-1914.html

Figure 5.2: Madras 1726
Source: https://upload.wikimedia.org/wikipedia/commons/3/31/Plan_of_Fort_St_George_and_the_City_of_Madras_1726.jpg

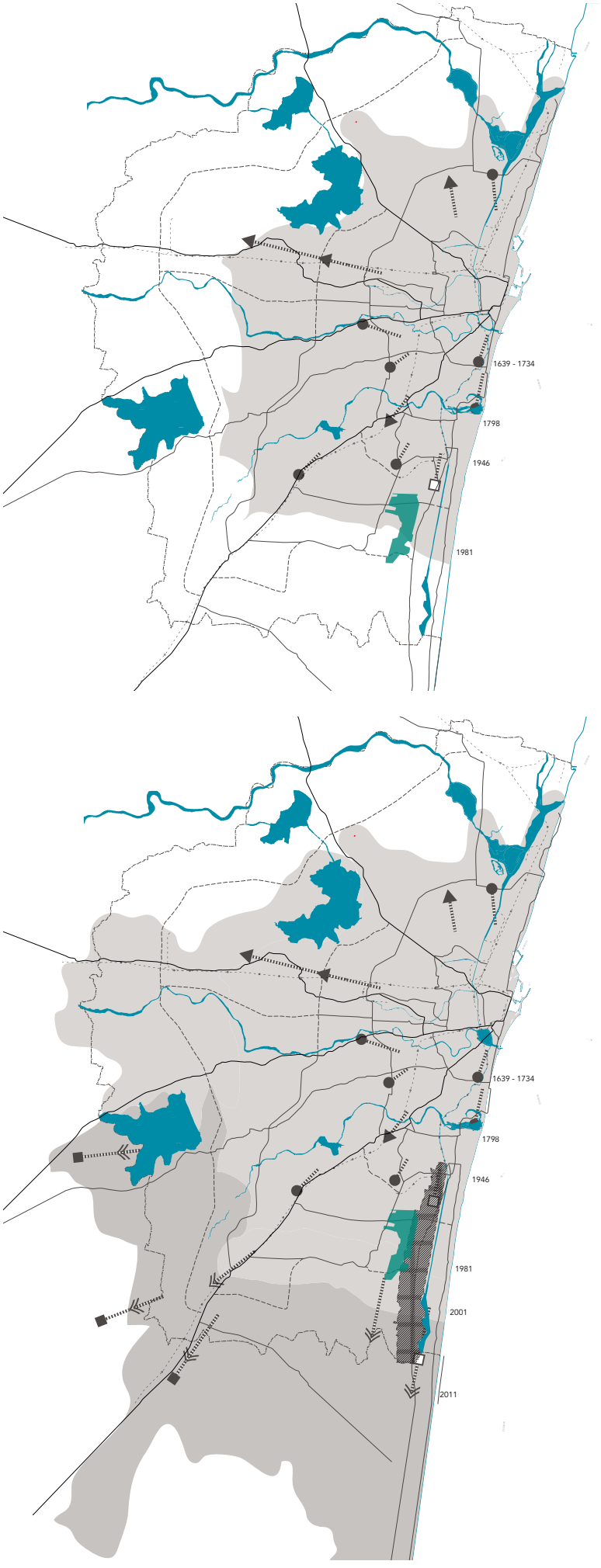
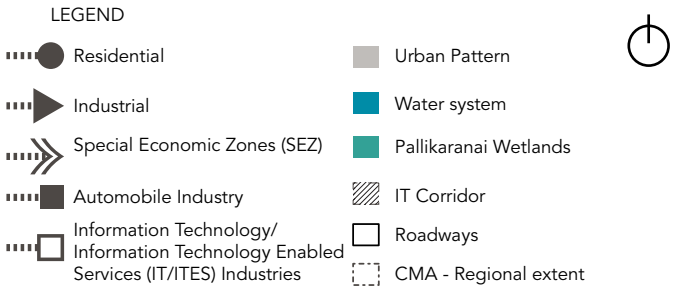


Figure 5.3: Urban growth factors



5.2. Post Independence in 1947

After the Indian independence in 1947, Madras continued to be a port of trade for manufactured goods which in turn led to the setting up of the respective industries along the northern part of the city, adjacent to the port areas. The nature of the economy remained hence largely manufacturing based (P. G. Arabindoo, 2008). While this trend did not have a significant impact on the urban form, the colonial trend of the north-south division still manifested itself spatially. With the 'black town' being regarded of lower standard, it was considered elitist to move to the south, in the areas where the British previously resided in. With larger plot sizes, lesser density and greener, the southern parts of the city saw an increase in demand. With more residential development in the south, real estate prices began to rise and over time, the south became more expensive and less affordable to the poorer sections of the society. In fact, even today, real estate in the south is more expensive and is perceived as 'high class' hence leading to further demand for housing (P. Arabindoo, 2009, 2016; Ellis, 2012). Until 1963, development took place within the limits of the Chennai city, with residential development being the primary growth factor. These residential developments responded primarily to the infrastructure system, visibly growing in a half star pattern. From the period of 1963 to 1971, multiple slum areas emerged across the city, increasing encroachments and informal growth. Incidentally around this time the city began to expand outside its extents into the suburbs.

In 1967, due to demographic growth and the boundary of the Madras Metropolitan Area (Now Chennai) was drawn and eventually finalised in 1974. It consisted of a total area of 1189 sq. km comprising of the Chennai district (176 sq.-km), part of Tiruvallur district in the north (637 sq.-km) and part of the Kancheepuram district in the south (376 sq.-km) (Kennedy et al., 2014). In 1974 the Madras Metropolitan Development Authority (MMDA) was elected to control and direct urbanization in city. This planning body developed short term and long-term goals and land use rules in the form of the first Madras Urban Development Plan in 1974 and later the Madras Metropolitan Plan in 1975 (Kennedy et al., 2014).

Figure 5.3 : Urban growth factors
Source; Author

Meanwhile, the economy continued to be largely manufacturing based and was crucially dependent on the harbour as an important node. However, as a state, Tamil Nadu performed among the bottom few in the country, with an annual growth rate of 5% and no significant improvement in water and services (P. G. Arabindoo, 2008). Further, weak institutions which did not focus on specific development goals lead to an overall 'slumber' of the city and the state. This changed significantly with the liberalization of the Indian economy in 1991.

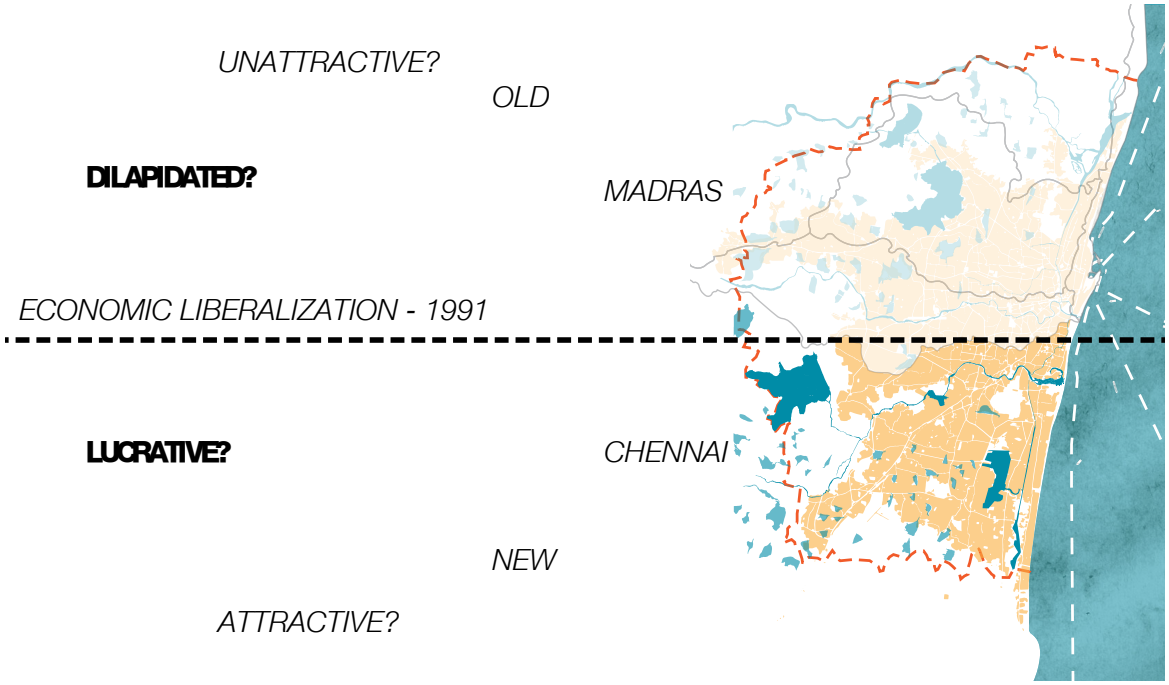


Figure 5.4: North - South divide

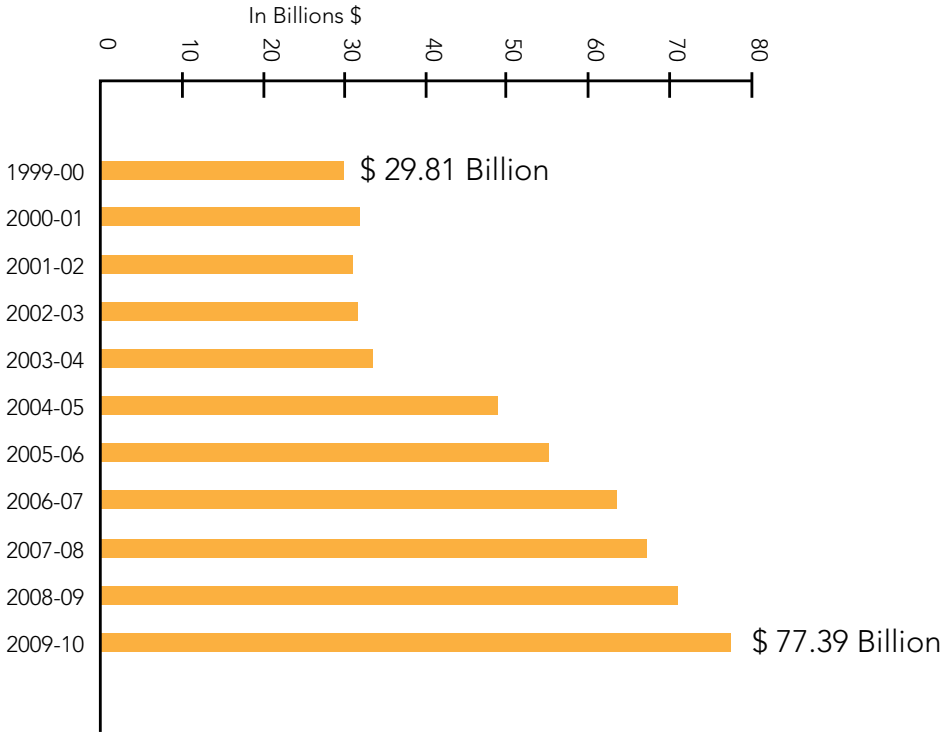


Figure 5.5: Tamil Nadu Economic Growth

5.3. Liberalisation and economic growth

With the liberalisation of the Indian economy in 1991, the State of Tamil Nadu saw significant economic growth through industrial development. This phenomenon brought in Foreign Direct Investment (FDI) through Multi-National Corporations (MNCs). These funds were directed towards industrial development in the capital city Chennai and the Metropolitan Area overall. Post-liberalisation, the economy of the CMA and the state of Tamil Nadu saw an increase in performance with the Gross Domestic Product (GDP) improving drastically (FIGURE). From one of the lowest performing states, the economy of Tamil Nadu was propelled forward and ranks today amongst the top 3 states of the country in terms of GDP. Today it is India's most urbanised state at 48% (Kennedy et al., 2014).

Hence, as P.G. Aranbindoo (2008) suggests, a 'regional strategy of liberalisation' was developed in the CMA. By 1996, the then ruling government envisioned a 'Global Chennai', a city which was modern and progressive and was recognised with the attributes of a 'world class city'. As a result of these aspirations, the city's name was changed to 'Chennai' officially in 1996. It was symbolic of leaving behind 'Madras' which was old, dilapidated and tainted with a colonial and post-independence era. Statistics from the period of 1995-2010 shows that the total share of private capital, both Indian and foreign combined, was higher in Chennai (59%) than in Delhi (36%) with the CMA registering a total of 62 Billion Euros (Kennedy et al., 2014). Hence the investments were an opportunity to develop this 'new' Chennai and the south was heavily invested in and built upon.

This further deepened the already existing distinction between the north and south leading to a visible impact on real estate and spatial quality of the region.

Figure 5.4: North South divide
Source: author

Figure 5.5: Tamil Nadu Economic Growth
Source: https://image.slidesharecdn.com/vodafonesecondaryresearchcountryprofiles-111117052458-phpapp02/95/vodafone-secondary-research-country-profiles-41-728.jpg?cb=1321507625


SRCL

Figure 5.6: Image-ability - Madras (old) versus Chennai (new)

Figure 5.6: Imageability - Madras (old) versus Chennai (new)

Source:
Top: https://upload.wikimedia.org/wikipedia/commons/thumb/1/13/Georgetown_panorama.jpg/700px-Georgetown_panorama.jpg

Middle: http://3.bp.blogspot.com/-91HMnVcoZV4/Uzgc93r7E5I/AAAAAAAABOM/QB9kvB8s6aE/s1600/Chennai_Skyline_CIPCOT_Siruseri.jpg

Bottom: https://upload.wikimedia.org/wikipedia/commons/d/dd/South_Chennai_Skyline.jpg

Figure 5.7: Infrastructure growth model

5.4. Analysis of Urban Form - Infrastructure-led Growth Model

In order to attract more foreign investment, the state administration modified its developmental goals and areas of focus. First, it invested heavily in the education and health sector. This was intended towards the development of human capital and basic services that ensured that good skilled labour was available for the industries that were to be set up by the multi-national companies (P. G. Arabindoo, 2008). Second, the government focused on revamping its existing infrastructural assets like the Harbour, Airport and existing infrastructure. This in turn became key parameters based on which Tamil Nadu was selected for investment. Third, the nature of the economy saw a shift, from a previously manufacturing based sector, towards a growth in automobile manufacturing, software services, hardware manufacturing, healthcare and financial services (Kennedy et al., 2014). Cumulatively, the government created attractive conditions such as skilled labour force, basic services, diverse economic opportunities and 'state of the art' infrastructure. Industries such as Information Technology (IT), Information Technology Enabled Services (ITES) and Automobile manufacturing were actively developed in the region.

Infrastructural Corridors based Development:

The urban development model of the region post liberalization shows clear characteristics of development through large infrastructural projects and infrastructural development corridors. These corridors were planned on a national and state scale with corridors connecting major metropolitan areas to one another as well as metropolitan areas to satellite towns. In the CMA, this type of development resulted in national connections to Bengaluru (Karnataka) and Vishakhapattanam (Andra Pradesh) – FIGURE. Further multiple satellite towns were connected through these corridors and key connection to the urban centres of Tiruvallur and Kancheepuram were made within the CMA. This led to a functional poly-centric model of the entire region (Burger & Meijers, 2012). This gave a strong spatial form to the region which had already acquired a half star pattern and began to expand along the corridors in a finger-like structure. The setting up of Special Economic Zones, Large scale industrial parks, corporate offices, State and Private Run office spaces dominated the land-use along these corridors. The interesting aspect is that infrastructure was heavily invested on by the respective political parties forming the state government in order to leave tangible traces of their regime behind. Hence each regime (State legislative elections are held every five years) invested in at least one infrastructural megaproject as a mark of achievement during their time in the administration (P. G. Arabindoo, 2008; Kennedy et al., 2014).

Figure 5.7: Infrastructure growth model
Source: Google earth

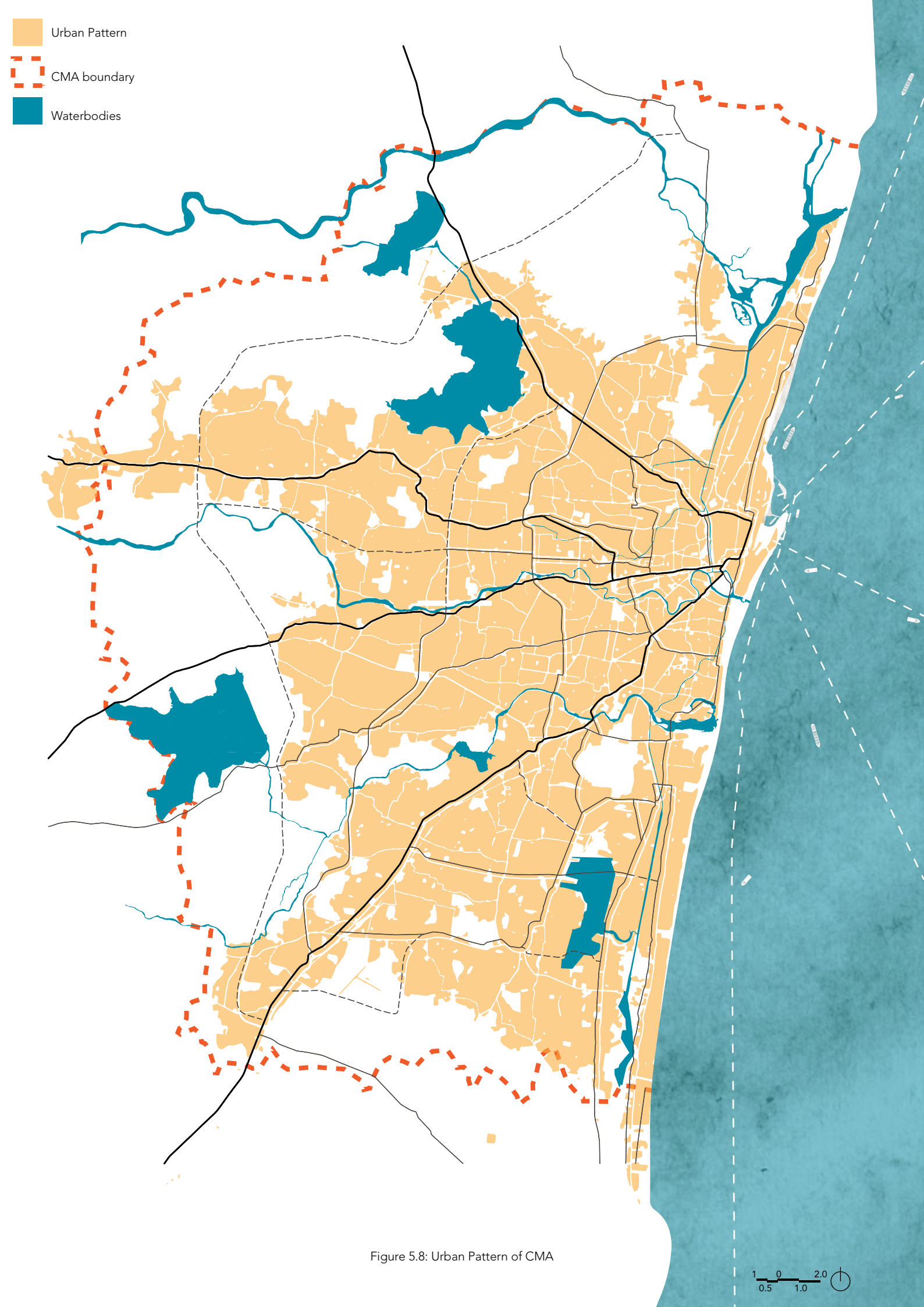


Figure 5.8: Urban Pattern of CMA

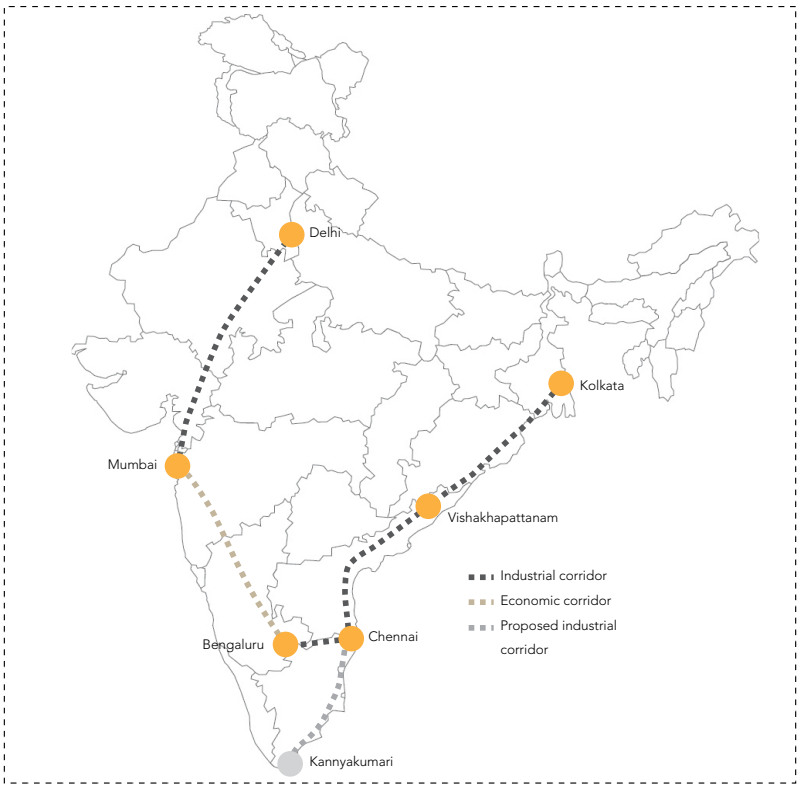


Figure 5.9: Development corridor planning in India

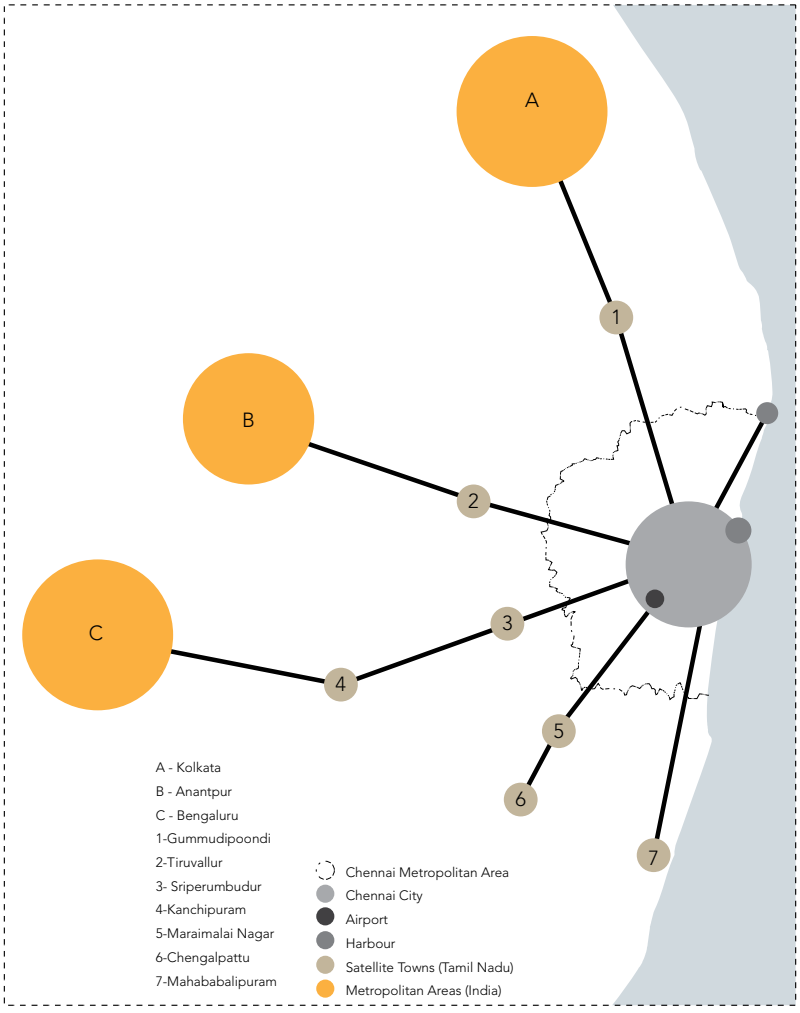
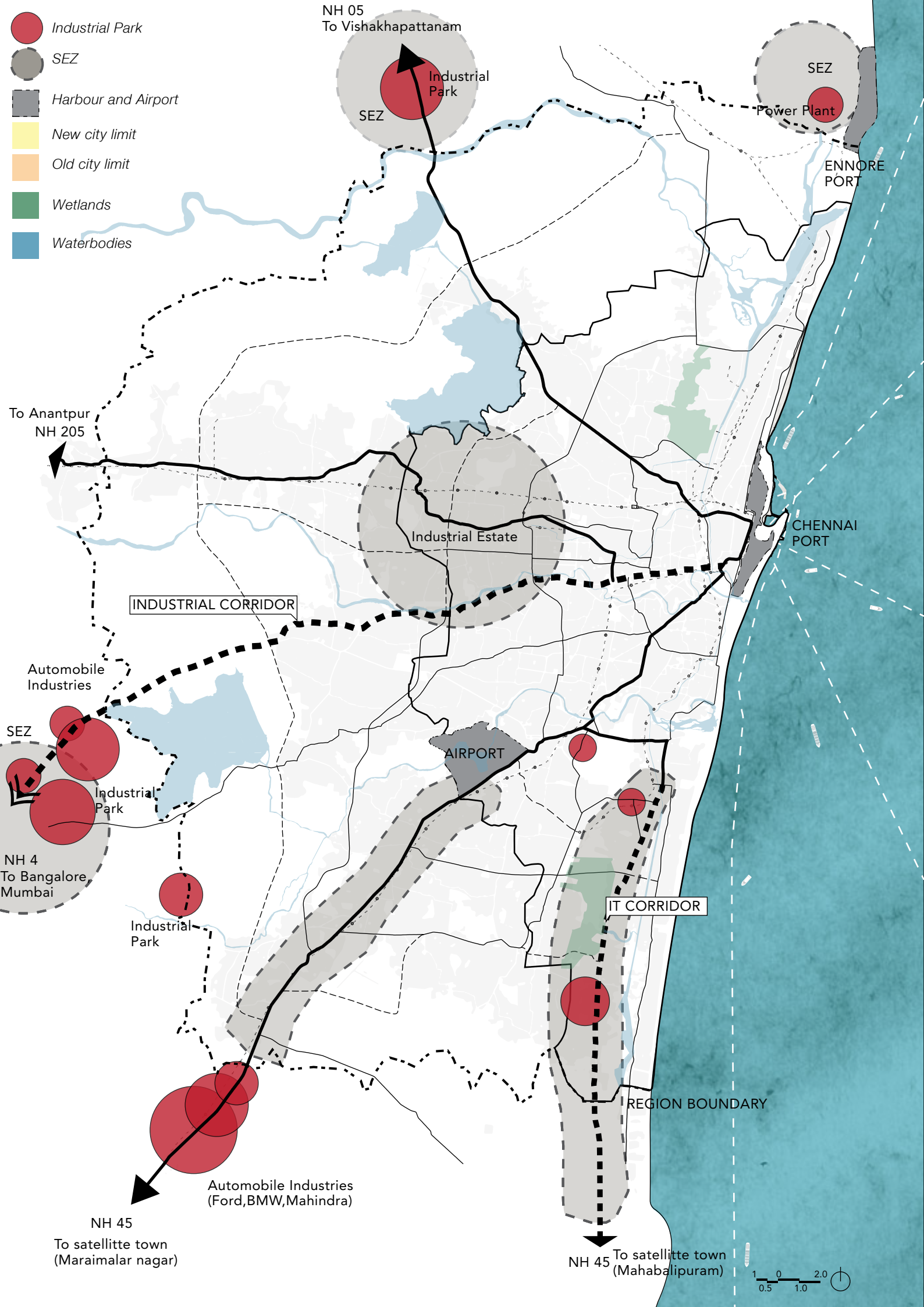


Figure 5.10: Polycentric region

Opposite page:
Figure 5.8: Urban pattern of CMA

Figure 5.9: Development corridor planning in India

Figure 5.10: Polycentric region
Source: Author


Industrial Park
SEZ
Harbour and Airport
New city limit
Old city limit
Wetlands
Waterbodies
NH 05
To Vishakhapattanam
Industrial Park
SEZ
SEZ
Power Plant
ENNORE PORT
To Anantpur
NH 205
Industrial Estate
CHENNAI PORT
INDUSTRIAL CORRIDOR
Automobile Industries
SEZ
Industrial Park
AIRPORT
NH 4
To Bangalore
Mumbai
Industrial Park
IT CORRIDOR
REGION BOUNDARY
Automobile Industries
(Ford,BMW,Mahindra)
NH 45
To satellitte town
(Maraimalar nagar)
NH 45
To satellitte town
(Mahabalipuram)
1 0 2.0
0.5 1.0

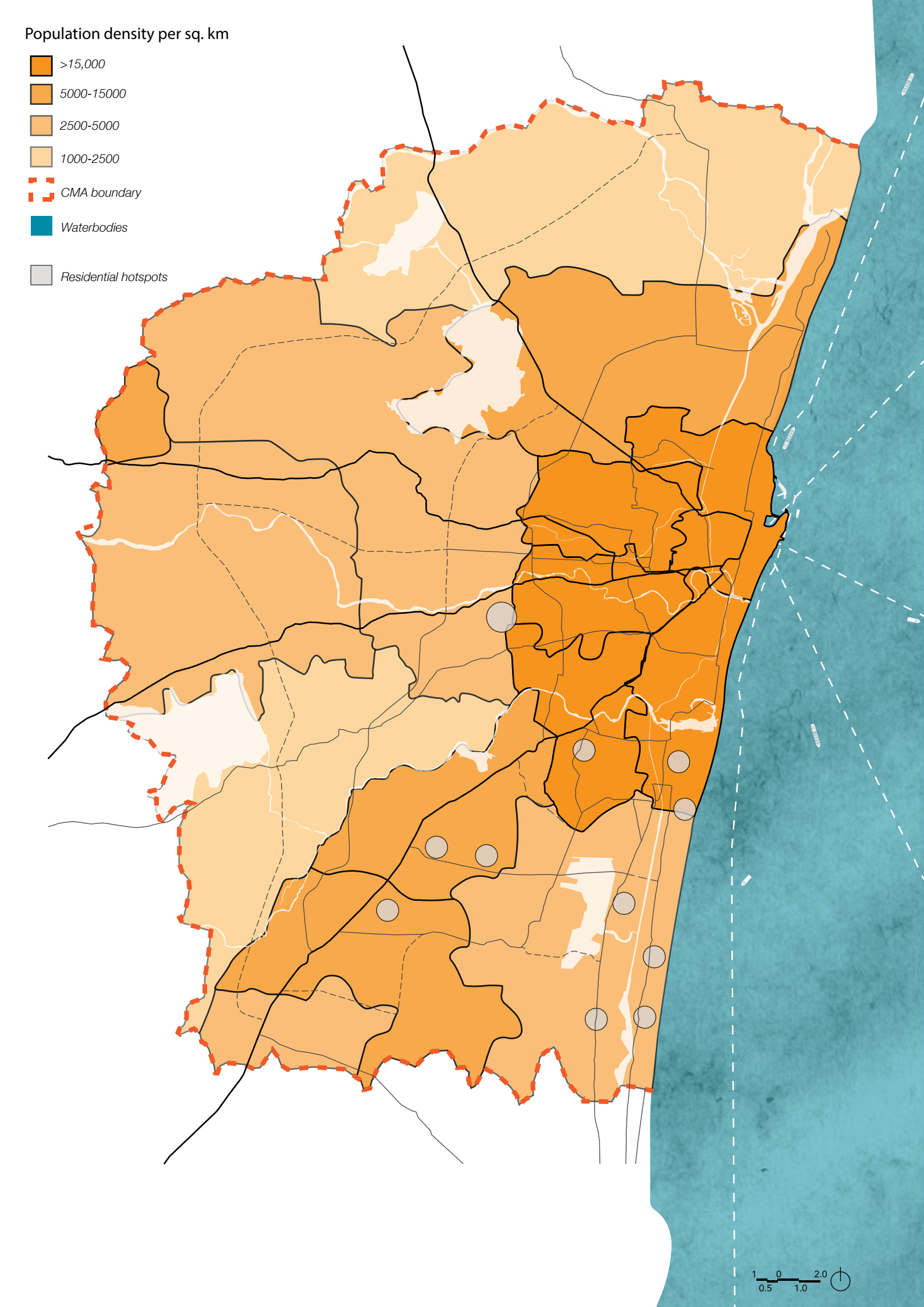
A special IT corridor was initiated in 2001 and is a 20 km long transit corridor which focuses on the IT/ITES industries. The industrial corridor along the Chennai-Bengaluru Highway and the Information Technology (IT) corridor along the Old Mahabalipuram Road are the two main spines of industrial development in the region. While the former shows a concentration of Automobile Industries due to its clear connection between the Bengaluru Metropolitan Area and the Chennai Harbour, the latter is a corridor that has been set up for purely IT/ITES industries and has played an important role in establishing the CMA as the second largest exporter of IT/ITES services in India. To enable ease of setting up large scale establishments for these purposes, the SEZ Act of 2005 was passed by the National government.

Special Economic Zone Act 2005:

This Act enabled the setting up of Special Economic Zones (SEZ) which are essentially geographic areas with economic laws more liberal than the country's domestic economic laws. This led to multiple industrial giants setting up base as Chennai became an automobile, industry and Information Technology / Information Technology Enables Services (IT/ITES) sector haven. The region today boasts of 55 Special Economic Zones, with dedicated zones for automobile, electronics and IT industries. An automobile industry sanctuary, companies such as Mahindra-Ford, Hyundai, Mitsubishi, Daimler, Nissan, Renault and BMW have set up base making Tamil Nadu the only state in India to have seven auto giants (Chandrachud & Gajalakshmi). Due to the spatial implications between North (madras) and South (Chennai), a general trend of more investments in the South has been observed. As a result, the SEZs are located predominantly in the Southern areas of the region. These zones were further planned along the infrastructural corridors that dominated the urban pattern. The FIGURE shows the major SEZs which have been set up along the major infrastructural corridors. Due to the concentration of multiple industries setup along the IT corridor, Kennedy et al. (2014) suggests that this area reflects similarities to the 'edge city' concept by Joel Garreau (1991) which defines a spatial planning concept of zoning high concentration of offices and residential areas on the fringes of the metropolitan and connecting them to the centre by road only. This is evident in the growth trends so far, with polycentricism linked through roadways as a noticeable urban pattern.

Opposite page:
Figure 5.11: Infrastructural model in spatial manifestation

Source: Author

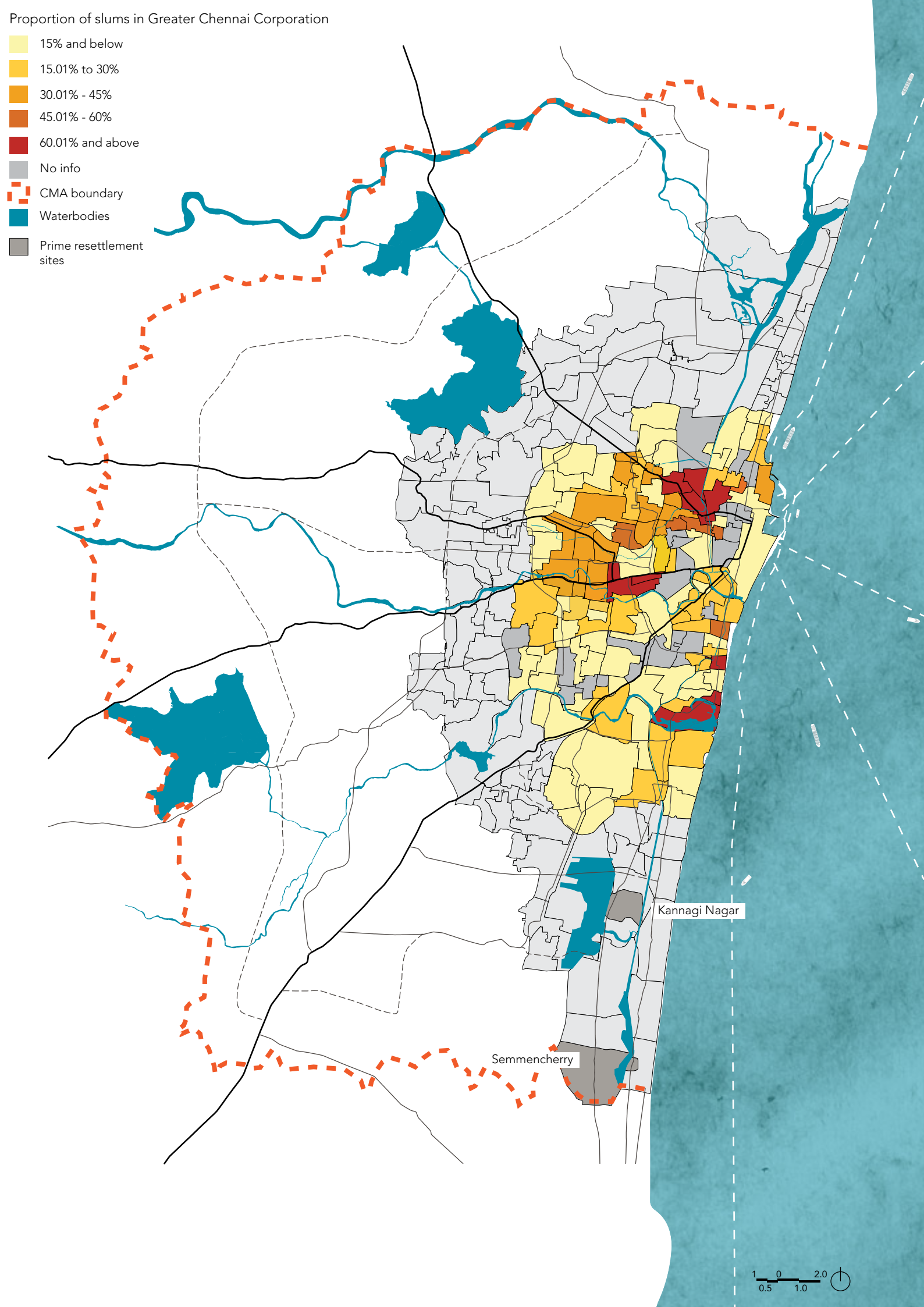

Population density per sq. km
>15,000
5000-15000
2500-5000
1000-2500
CMA boundary
Waterbodies
Residential hotspots
1
0
2.0
0.5
1.0

5.5. Urban sprawl and density analysis

With economic development at its peak and multiple sectors of opportunity such as education, health and industry, the region faced increased migration from urban and rural areas within Tamil Nadu as well as from different parts of India. With growing demand and migration, the city of Chennai experienced a high population density and remains the densest in the region. This is naturally due to the connection to the city centre, services, harbour, railway and airport and the commercial cores of the city. The areas outside the city and the suburbs experienced urban sprawl due to the development of residential areas and services to support the industrial cores that had been set up along infrastructural corridors. For example, the IT corridor experienced high density of residential services, restaurants, leisure and recreation in response to the development of multiple IT industries. In fact, the corridor is visited by nearly 200,000 employees every day, automatically generating development opportunities for real estate and services. Hence urban sprawl patterns have also been observed to follow the urban form defined by industrial cores and corridors.
According to the Census of India, a slum is defined as "(…) residential areas where dwellings are unfit for human habitation by reasons of dilapidation, overcrowding, faulty arrangements and design of such buildings, narrowness or faulty arrangement of street, lack of ventilation, light, or sanitation facilities or any combination of these factors which are detrimental to the safety and health. (…)" (Kennedy et al., 2014).

Opposite page:
Figure 5.12: Urban density and sprawl hot spots

Source: Author


Proportion of slums in Greater Chennai Corporation
15% and below
15.01% to 30%
30.01% - 45%
45.01% - 60%
60.01% and above
No info
CMA boundary
Waterbodies
Prime resettlement sites
Kannagi Nagar
Semmencherry
1 0 2.0
0.5 1.0

5.6. Socio-economically vulnerable groups

While the last two decades have experienced strong economic growth, however, only 30% of the total employment in the city falls under the formal sector, automatically implying that the rest 70% seeks employment through the informal sector. The report by Kennedy et al. (2014) observes this trend and suggests that the economy of the CMA is hence predominantly low-income and hence this sparks further debate on the inequalities and distribution of resources amongst the various socio-economic groups. Indeed, poverty levels in the region are high with 23% of the inhabitants living in informal settlements (Kennedy et al., 2014). Another statistic however points to a larger percentage of 29% (Chander, 2013).

While industrial growth has been at its peak, so has poverty level, with a recent article on January 18th, 2016 in The Times of India, a survey by Tamil Nadu Slum Clearance Board (TNSCB) pointing out that, there has been a 51.85% increase of slums in the city during the same time of rapid industrial growth.

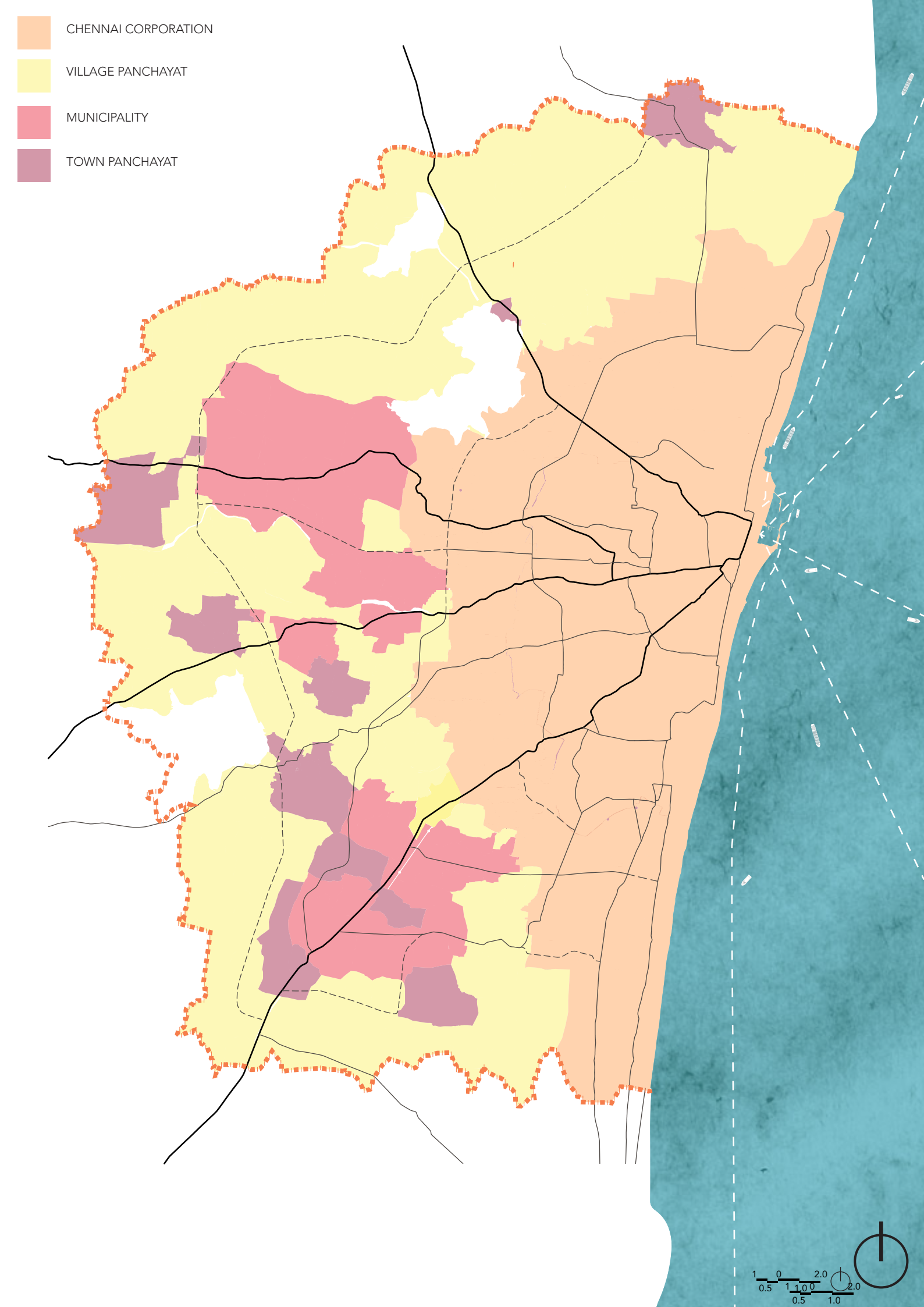
This throws light on the negative aspects of the growth model currently in place, due to the impacts of gentrification, lack of affordability and multiple deprivations of the socio-economically weaker sections of the society.

According to Kennedy et. al (2014) a survey by the TNSCB and Tamil Nadu Urban Infrastructure Financial Services limited (TNUIFSL) in 2003-04 identified 242 undeveloped slums within the Chennai Municipal Corporation (See Governance) which consists of the city limits and in the rest of CMA, 202 undeveloped slums were identified (Kennedy et al., 2014). While in the first case, 122 were identified as objectionable and in the second case, 90 were recognised as objectionable. According to the Chennai Metropolitan Authority, these objectionable slums are defined as those which are situated on river margins, road margins, seashores, railway margins and other areas required for public purpose. These hence also shed light on the encroachment of crucial waterways and drainage basins which have in turn increase the flood risk.

In-situ development, in situ reconstruction and rehabilitation and resettlement as various approaches carried out by the Tamil Nadu Slum Clearance Board. In-situ development means that basic infrastructure and services are provided on site to the slum area. In situ reconstruction consists of large scale tenements constructed on the same location of the slums. And Rehabilitation and Resettlement means shifting the inhabitants to another location where infrastructure needs and services have been provided through dwellings. The map on the opposite page maps the percentage of slums in the different wards of the Chennai Municipal Corporation and points out the major resettlement sites – Kannagi Nagar and Semmencherry.

Opposite page:
Figure 5.13: Distribution of socio-economically weaker groups

Source: Author


CHENNAI CORPORATION
VILLAGE PANCHAYAT
MUNICIPALITY
TOWN PANCHAYAT
1 0 2.0
0.5 1.0
2.0
0.5 1.0

5.7. Governance and existing strategies

Chennai is the capital city of Tami Nadu and houses the State Administration – Government of Tamil Nadu (GoTN). In terms of planning and governance, the FIGURE shows the basic set up of administration in the region.

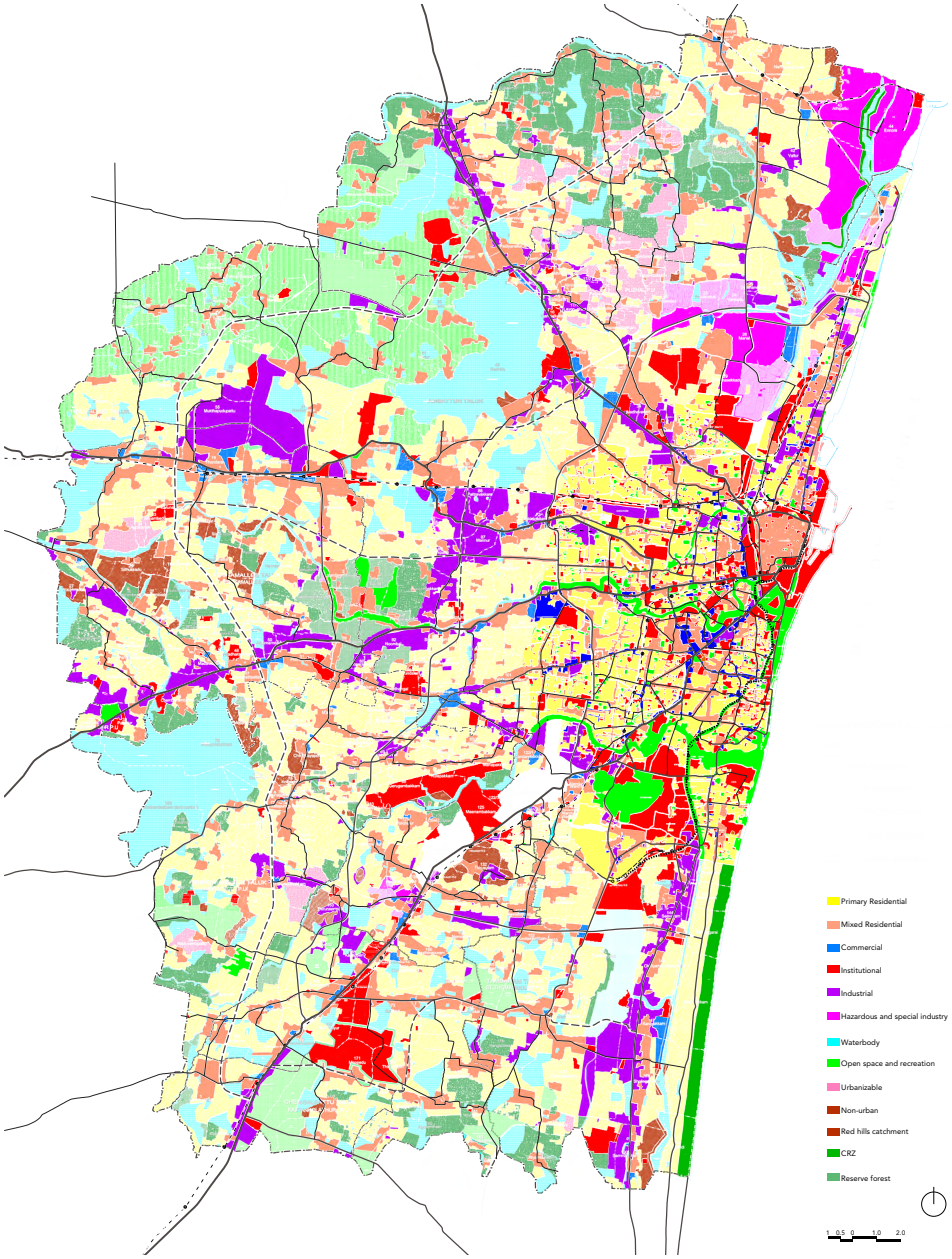
The Chennai Metropolitan Development Authority (CMDA) is the state appointed Planning body which responsible for urban and regional planning through the preparation of Master plans, Land Information systems (LIS), Development Control Rules (DCR) such as Floor Space Index (FSI) and other regulations such as the Coastal Regulation Zone (CRZ). The CMDA was first formed in 1974 (Then Madras Metropolitan Development Authority) and was established as a statutory body in 1975. The current Master plan 2026 which is the functional urban plan today was made finally public in 2008 despite being drafted in 1995 due to public scrutiny and inadequacies of soliciting public input (P. Arabindoo, 2016; Kennedy et al., 2014). The CMA initially planned only based on land-use through Master planning suffered through unregulated urbanization due to the lack of a 'vision' in its urban plans. It was not until 2008 when the Second Master Plan (Master Plan 2026) that an urban vision was integrated. Today the CMDA is operated by the State administration and hence its urban plans have been heavily influenced by the 'Globalise Chennai' agenda and the Infrastructural growth model which responds to capitalistic and market needs. The CMDA drafted Master plan 2026 is hence the guide for the respective authorities responsible for urban and regional development and infrastructure planning. While the CMDA is responsible for the overall urban planning of the CMDA, the region is further composed of three types of Urban Local Bodies (ULB) which are responsible for carrying out the plans made by the CMDA. Each ULB consists of an assigned area of jurisdiction and its own institutional setup. This structure of Urban Local Bodies was introduced as part of Fiscal Decentralisation in the 74th Constitutional Amendment of 1992 which provided more substance to the third tier of government at the local level (Kennedy et al., 2014).

The Chennai Municipal Corporation (CMC) which recently extended its limits in 2011, consists of the Chennai city area which is further divided into 15 zones (200 wards). Today it is also called the 'Greater Chennai Corporation' – FIGURE. Unlike other states in India, in Tamil Nadu, each Municipal Corporation has its own Governing Act (Kennedy et al., 2014).

The Municipalities are the second type of ULB and consist of the urban areas adjacent to the CMC. It consists of urban areas which have a population of more than 10,000 inhabitants. The Third type of ULB is that of the Town Panchayat which consists of rural areas transitioning into urban areas. An extension of the Town Panchayat is that of Village Panchayat which also consist of the rural areas in the CMA. While the CMC consists of

Opposite page:
Figure 5.14 Governance boundaries

Source: Author



Swacch Bharat
Smart Cities
MRTS
Metro

11th year Plan
Infrastructure

Better health and services
Slum alleviation

MoUD
Ministry of Urban Development

PCI
Planning Commission of India

Jnnurm (GOI)
Urban renewal scheme

CMDA

Landuse
Masterplan
DCR
Infrastructure

Chennai Corporation

Municipality
[Urban areas (>10000)]

Town Panchayat
[Rural to Urban Transition]

Village Panchayat
[Rural]

Regional

City

Wards

Municipality

TP

VP

Para-State Agencies

TNHB	LIG, EWS Housing
TNSCB	Slum Clearance & Resettlment
CMWSSB	Water and Waste
PWD	Storm water drains
TNRDC	Roadways
CRRT	River Restoration

TNHB - Tamil Nadu Housing Board
TNSCB - Tamil Nadu Slum Clearance Board
CMWSSB - Chennai Metro Water Supply and Sewage Board
PWD - Public Works Department
TNRDC - Tamil Nadu Road Development Corporation
CRRT - Chennai River Restoration Trust

the urban areas from the Chennai District of Tamil Nadu, the municipalities and Town and Village Panchayat consist of areas from the Tiruvallur and Kancheepuram Districts (CMA is an agglomeration of Chennai district and parts of Tiruvallur and Kancheepuram districts). While these ULBs have their own administrative and economic command functions. They are further responsible for administering basic services such as maintenance of roads and pathways, solid waste collection and management micro drainage and parks. However, these ULBs are less dominant in land planning and regulation, hence emphasising the role of the CMDA which in turn is highly influence by private actors and para-state agencies.

Para-State agencies are those which come under the State administration and practice their jurisdiction across the entire state of Tamil Nadu. In the specific areas they function in, they also function exclusively to the ULBs in place. These are illustrated in the FIGURE.

In addition to these Para-State agencies, specific agencies were further set up to drive the economic growth model in place. The Tamil Nadu Road Development Corporation (TNRDC) was set up in 1198 to attract private investments for road infrastructure and to build roads under the Public-Private Partnership framework (Kennedy et al., 2014). Similarly, river restoration was carried out by the Chennai River Restoration Trust which functioned exclusively to the already existing para-state bodies.

EXISTING POLICIES AND DEVELOPMENT STRATEGIES:
MASTER PLANS:

This section elaborates on the existing policies and trends that influence urban and regional planning in the CMA.

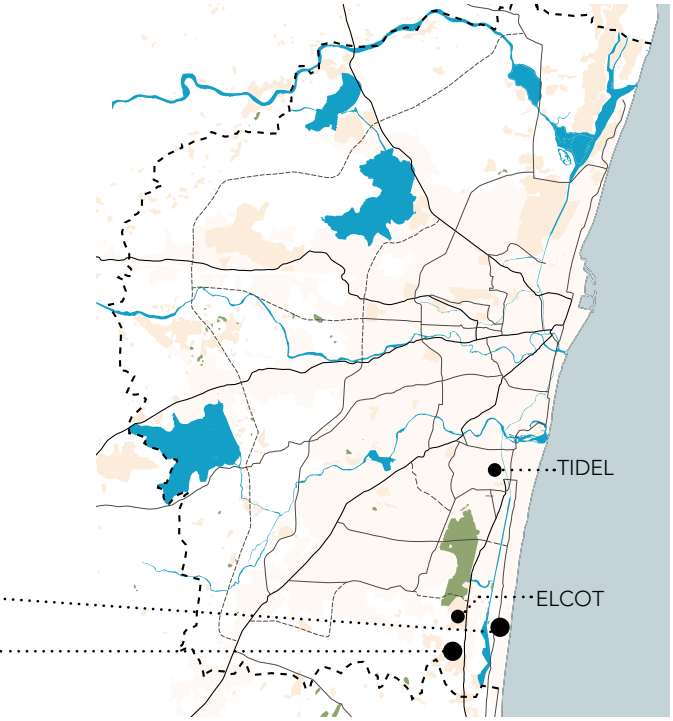
The Master plan 2026 which was made public in 2008 expresses a vision for the region as "The vision of Chennai Metropolitan Development Area is to make Chennai a prime metropolis which will become more liveable, economically vibrant, environmentally sustainable and with better assets for the future generations" (Kennedy et al., 2014).

Through the framework of the JNNURM (JawaharLal Nehru National Urban Renewal Mission), focus on growth and strategic planning has been placed by scheme by the Government of India. Strategies for infrastructural development and basic services have been framed through the JNNURM. In addition to these, National scale schemes such the

Opposite page:
Top: Figure 5.15: Master plan 2026
Source: Second Master plan - CMDA

Bottom: Figure 5.16: Institutional setup
Source: Author

Figure 5.17: Vision Tamil Nadu 2023



Smart Cities Mission, Swachh Bharat Mission (Clean India), Metro Project and the Mass Rapid Transit System (MRTS) are being carried out by the Ministry of Urban Development (MoUD). As National scale plan, the 11th Five Year Plan (focuses on 5 year developmental goals and strategies) by the Planning Commission of India (PCI) also focuses on infrastructural development and basic services. These schemes have been analysed from the Second Master Plan Document 2008 drafted by the CMDA.
Tamil Nadu Vision 2023:

The Vision Tamil Nadu 2023 was inaugurated in 2012 and laid out the strategies and goals to be achieved in the state. In addition to envisioning an increase in per capita income, high social development and focus on the Human Development Index, the vision emphasises on the Infrastructure-led growth model and the importance of high quality infrastructure as the key to achieving higher economic growth (Kennedy et al., 2014). Seven sectors of development have been highlighted namely, energy, transport, industrial and commercial, urban infrastructure, agriculture and human development. Within the focus on urban infrastructure, developing the CMA as a 'megapolis' has been the focal point.

The development of large and megaprojects have been recurrent strategies in the vision. It consists of large scale infrastructural projects such as Ennore Deep port, Nemeli desalination plant, elevated highways, outer ring road and the Metro service. These projects have been designed to support the thriving industrial sector through state of the art services. For instance, the Ennore deep port is aimed at the export oriented sector, the outer ring road and the elevated highways serve as crucial roadways for navigation through the region and serve as convenient connections to the port as well as other satellite towns and the Metro services have been aimed at a 'global' image to Chennai (Kennedy et al., 2014). Each of these megaprojects are aimed at the State and metropolitan economy and transforming CMA into a hub of economic and industrial growth. Similarly, the IT sector has also been addressed through the setting up of dedicated Special Economic Zones which house megaprojects such as TIDCO's TIDEL Park (TIDCO – Tamil Nadu Industrial Development Corporation) in Taramani, ELCOT (Electronics Corporation of Tamil Nadu) Park in Shollinganallur and the SIPCOT (State Industries Promotion Corporation of Tamil Nadu) Park in Siruseri.

Figure 5.17: Vision Tamil Nadu 2023

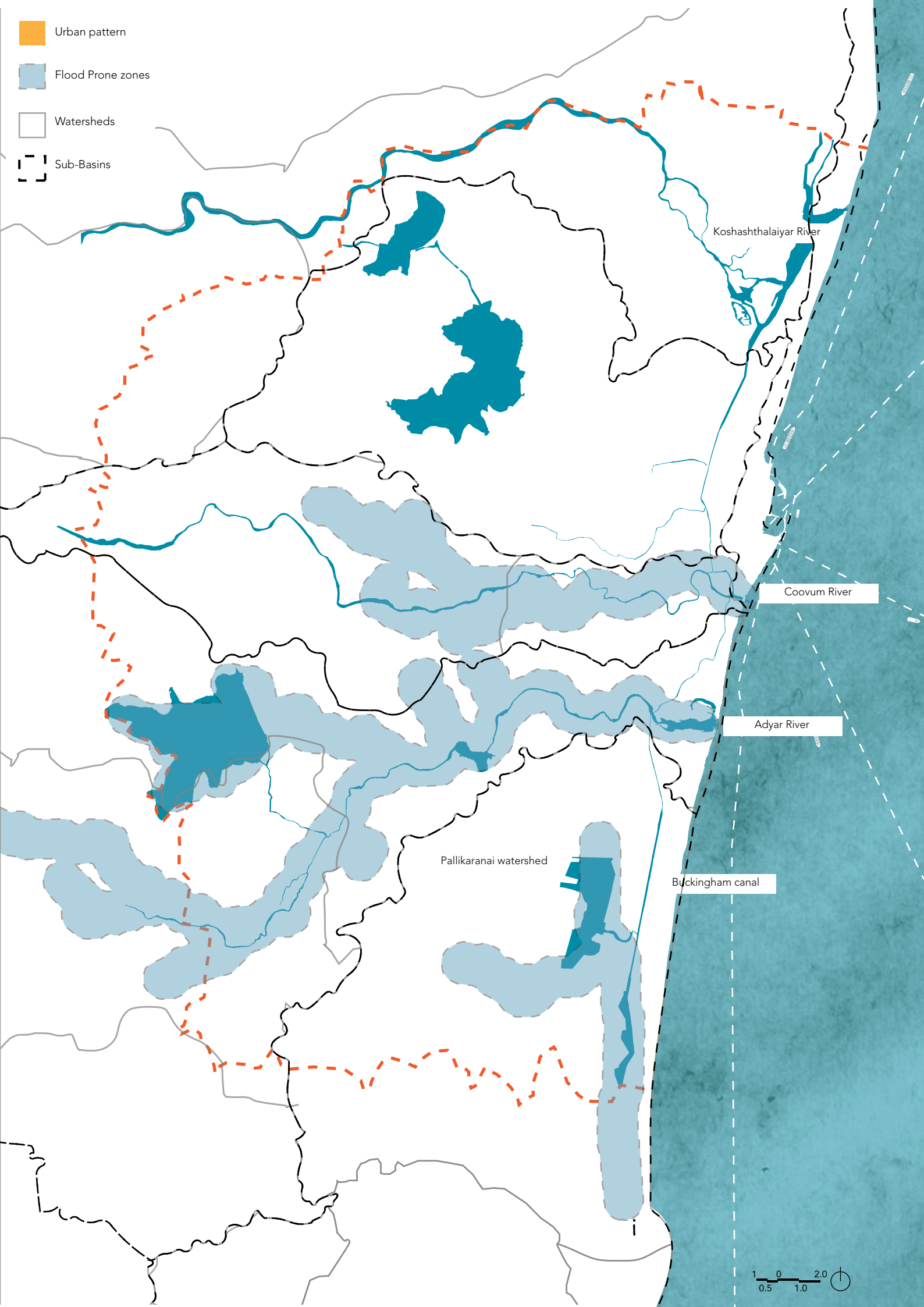
Top left: Cover of the planning document
Source: Vision Tamil Nadu 2023

Top right: Nemeli Desalination Plant
Source: http://aemstatic-ww1.azureedge.net/content/dam/ww/online-articles/2013/10/taweelah_AUMA%20web.jpg

Second row from top: Metro rail project underway
Source: https://s3.ap-south-east-1.amazonaws.com/images.deccanchronicle.com/dc-Cover-tatfoie5g53rjg8l0gg02e-7ad1-20161122065824.Medi.jpeg

Third row from top: SIPCOT IT Park
Source: https://www.sipcot.com/images/slider1a.jpg

Bottom: Tamil Nadu's strong position in India
Source: https://upload.wikimedia.org/wikipedia/commons/a/af/Tamil_Nadu_-_India%27s_Economic_Powerhouse.JPG


Urban pattern
Flood Prone zones
Watersheds
Sub-Basins
Koshashthalaiyar River
Coovum River
Adyar River
Pallikaranai watershed
Buckingham canal
1
0
2.0
0.5
1.0

5.8. Watersheds in the region

The CMA is composed of four watersheds of its three rivers, Koshashtalaiyar, Coovum and Adyar and the only remaining natural wetlands, Pallikaranai. Over the last decade, as a result of increased demand in the south (discussed above), there has been a massive overhaul of its geographic features to make way for developments. As explained by Chennai ecologist Jayshree Vencatesan, a large part of the south was traditionally a flood plain as evidenced by the soil type in the region. The Pallikaranai wetlands play a crucial role in the geography of the south, draining 250 sq.km around the 50sq.km wet-land (Vencatesan, 2007).

Coovum and Adayar constitute the two most important rivers in the city and have two different watershed characteristics. Coovum, 72 km long has a macro drainage of 502 sq.km with 75 tanks feeding into it while Adyar, 42km has a much larger macro drainage of 720 sq.km. With 450 tanks feeding into it (Narasimhan, Bhallamudi, Mondal, Ghosh, & Mujumdar, 2016). With a much larger watershed and surface area, flooding is more severe in the Adyar watershed.

While the south is definitely more prone to floods than the north and topography affirming persistence of flooding in the south, it is peculiar and quite paradoxical as to why the region continues to grow into the south despite increased risk. In addition, the Chemberambakkam Lake/Reservoir which is part of the Adyar watershed was initially built as an irrigation reservoir to support agriculture in the pre-urbanized CMA. Post urbanization its function was later modified to that of a flood control reservoir with tanks and channels feeding into it. The fundamental risk in this change of purpose was that irrigation reservoirs in general have one outlet with overflow across maximum surface area while flood control reservoirs need multiple outlets with overflow over minimum surface area. This reservoir is crucial to the Adyar river sub-basin, as the river depends on the reservoir to retain 40% of its run-off upstream. Hence in the time of heavy rainfall, the Chemberam-bakkam eventually overflows, causing water to be released downstream into the Adyar, eventually flooding the entire watershed (P. Arabindoo, 2016).

Another important element in the south is that of the last remaining natural wetlands – the Pallikaranai wetlands (popularly known as Pallikaranai marsh). A hub of biodiversity within the region, it has been threatened in recent years due to encroachments and its usage as a dump yard. These wetlands served as resources for irrigation initially but however have now become a popular residential site where developers often advertise 'nature views' to market their properties (Vencatesan, 2007). From 2450 hectares in 1991, the Pallikaranai marsh has reduced to a mere 500 hectares in 2015. While the water carrying capacity has reduced by 70% flood risk in and around the wetlands has increased tremendously (Earth, 2010). In fact, the proposed master plan for 2026 also shows various developments planned within the extents of the wet-lands highlighting an urgent revision of the plans and need to restore and conserve the important biodiversity associated with it.

Opposite page:
Figure 5.18: Watersheds and flood prone zones
Source: Author

2002

2016

Chennai loses green space as urbanization goes up: study

Chennai has lost more than one-fifth of its greenery in 20 years as the city urbanized rapidly, according to a study by IISc

Last Published: Tue, Mar 15 2016. 02 02 PM IST

Figure 5.19: Green values under threat

Existing Land use 2006				
	Chennai city		Rest of CMA	
	Extent in Hectares	Percentage	Extent in Hectares	Percentage
Residential	9523.18	54.25	22876.51	21.87
Commercial	1244.81	7.09	390.04	0.37
Industrial	908.42	5.17	6563.4	6.28
Institutional	3243.39	18.48	3144.35	3.01
Open space & Recreation	366.43	2.09	200.26	0.19
Agricultural	99.29	0.57	12469.65	11.92
Non Urban	82.46	0.47	2433.3	2.33
Others (Vacant, Forest, Hills, Low lying, Water bodies etc.,)	2086.93	11.89	56506.6	54.03

Proposed Land use 2026				
	Chennai city		Rest of CMA	
	Extent in Hectares	Percentage	Extent in Hectares	Percentage
Primary residenial use zone	5916.35	33.58	29705.21	29.32
Mixed residential use zone	2426.9	13.78	12392.07	12.23
Commercial use zone	714.24	4.05	746.08	0.74
Insitutional use zone	2868.97	16.28	3238.5	3.2
Industrial use zone	691.83	3.93	6678.86	6.59
Special and hazardous industrial use zone	130.67	0.74	3355.09	3.31
Open space and recreational use zone	1000.65	5.68	416.45	0.41
Non Urban	113.31	0.64	11019.6	10.88
Urbanisable			1882.01	1.86
Others (Roads, hills, Redhills, catchment areas, , Forest, Water bodies etc.,)	3754.79	21.31	31864.54	31.46
Total	17617.7	100	101298.42	100

Figure 5.20: Planning and Open and recreation spaces

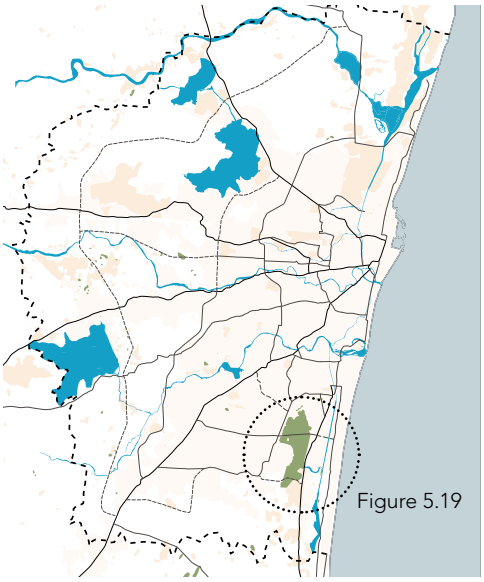


Figure 5.19

5.9. Opportunity - Loss of green and recreation value

As a result of rapid urbanisation over the last two decades, the green-blue values across the region have been threatened. In comparison to the other major metropolitan areas in India, Chennai features amongst the least in green cover at a meagre 9.5%. According to an article on a local website (www.livemint.com), a study carried out by the Indian Institute of Science (IISc) revealed that while urbanisation increased from 1.46% to 18.55% in the period between 1991 and 2012, vegetation cover fell by 22%. In fact, if this trend continues, the loss might increase to 36% by 2026.

As per the regulations in the 1996 Urban Development Plans Formulation and Implementation guideline of the Urban Development ministry, a metropolitan city is required to have 20-25% of recreational spaces. These recreational spaces are those that are classified as parks, playgrounds, botanical garden and open spaces. However, while analysing data of the Master plan 2006 and Master plan 2026 drafted by the CMDA, Open space and recreation in the city is just about 5.68% in the Master plan 2026 which is currently the urban plan in operation. This figure is even lower in the rest of the CMA at 0.41%.

This when connected to the loss of the natural drainage system, brings the need for green-blue infrastructure to the focus. In fact, green-blue infrastructure is crucial for flood resilience. In fact, as Zevenbergen (2010) aptly argues, blue infrastructures are moving spaces for water in urban environments.

5.10. Findings presented as SWOT

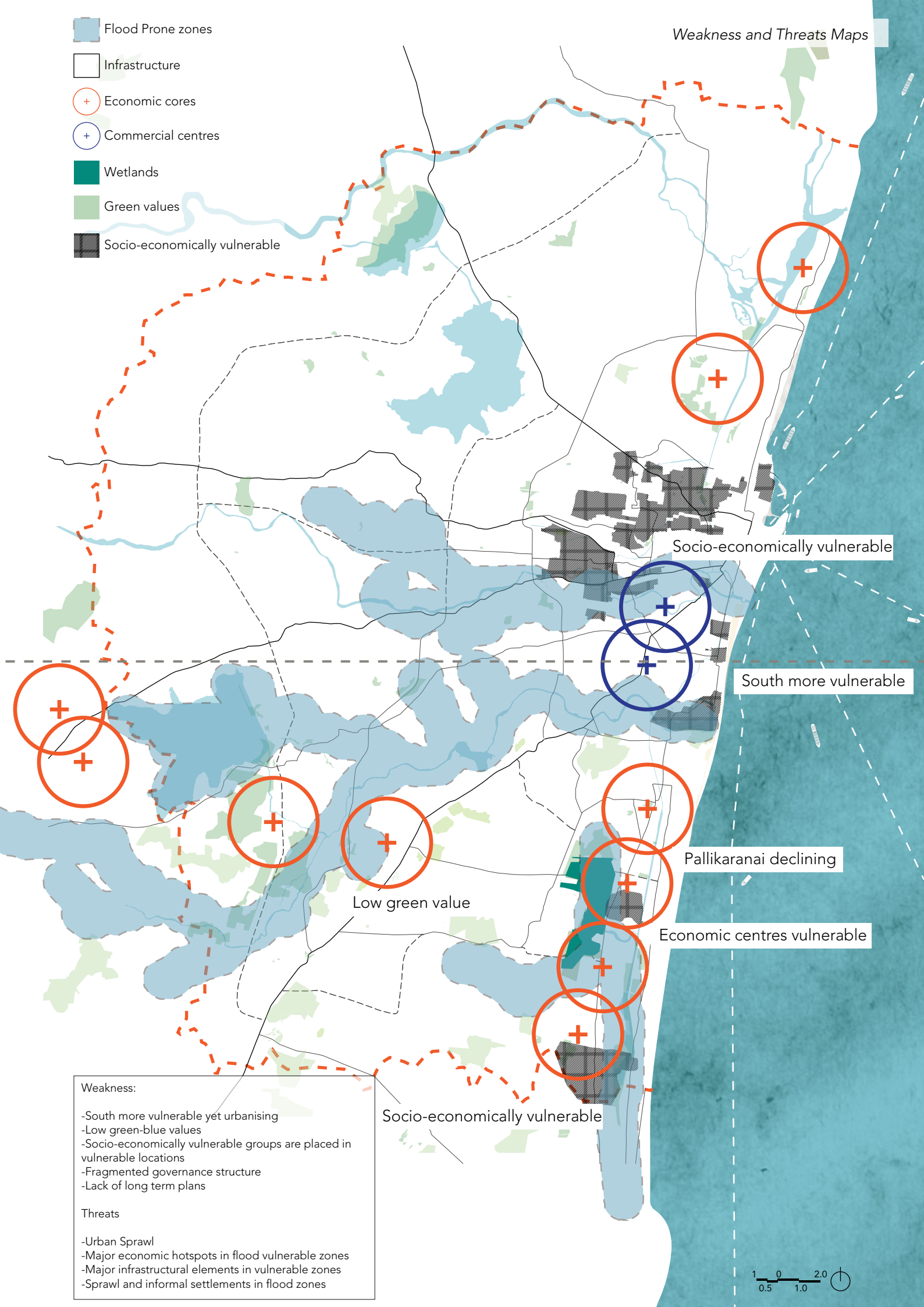
Based on this extensive study and analysis, a SWOT analysis is conducted to frame regional potentials and weaknesses. This is illustrated through mapping. On the regional scale, infrastructure, strong economic centres and the presence of diverse stakeholders are identified as strengths. Meanwhile, the need for open and recreational spaces and restoration of existing water networks and the de-sign for an integrated water network are identified as the main opportunities. In addition to this, in contrast to the well-developed formal economy, the small scale and informal economy has received lesser focus but could hold opportunities for the engagement of local scale actors. These opportunities could respond to the weakness identified as the low blue-green values, which are largely a result of the urbanisation processes rendering large scale environmental damage. Finally, the apparent placement of the region's physical and infrastructural assets in flood prone zones are identified as the main threats. Further, the institutional structure which is highly fragmented is identified as a threat as the institution should ideally play the crucial role in facilitating regional level plans and visions.

Figure 5.19: Green values under threat
Source: Top: Google earth
Bottom : http://www.livemint.com/Politics/N2gDWLiHiHFiqZa7wvrT2J/Chennai-loses-green-space-as-urbanization-goes-up-study.html

Figure 5.20: Planning and open and recreation spaces
Sources: Second Master plan - CMDA

Next page:
Figure 5.21Weaknesses and Threats
Source: Author

Figure 5.22: Strengths and Opportunities
Source: Author

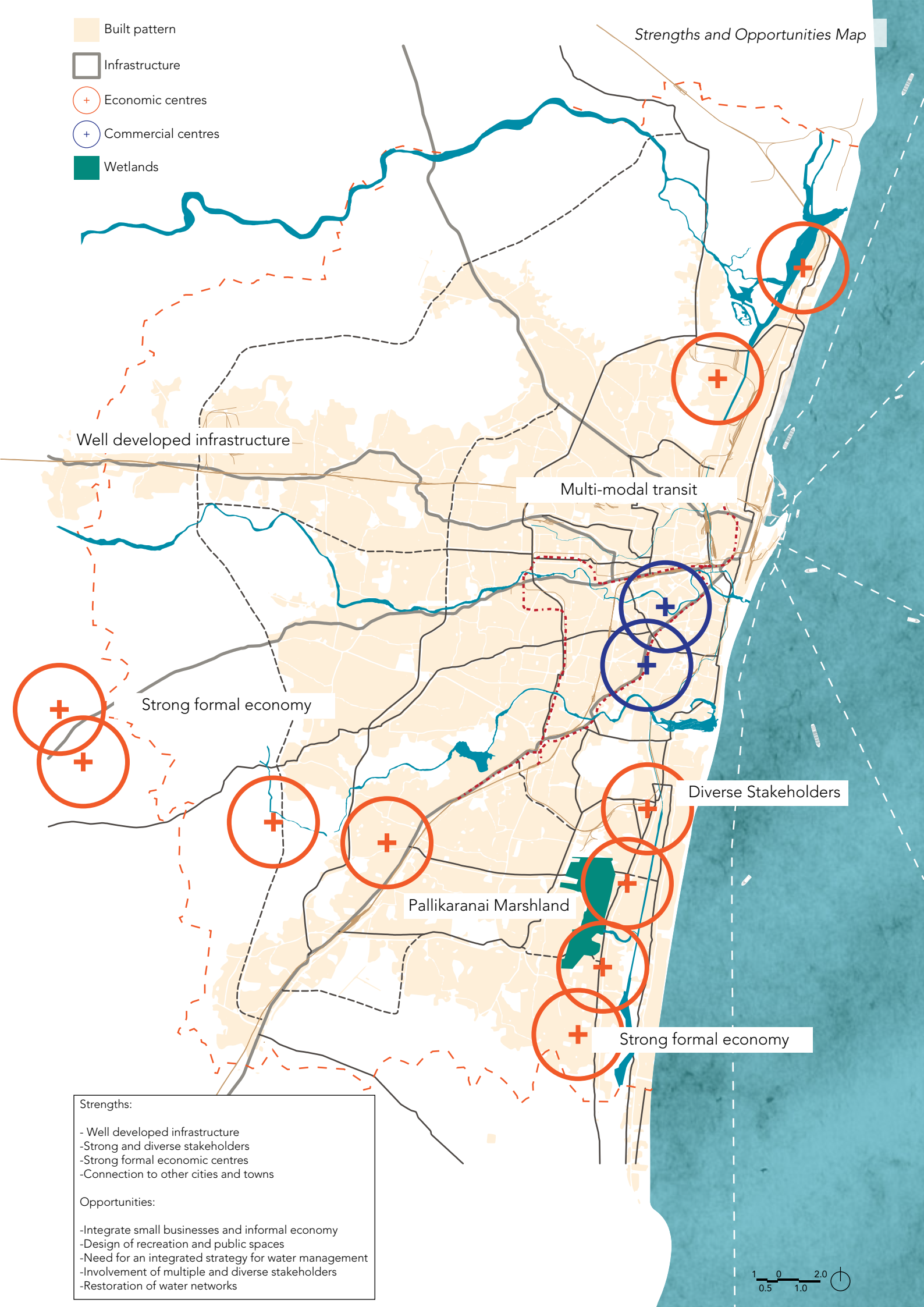


Weakness:

-South more vulnerable yet urbanising
-Low green-blue values
-Socio-economically vulnerable groups are placed in vulnerable locations
-Fragmented governance structure
-Lack of long term plans

Threats

-Urban Sprawl
-Major economic hotspots in flood vulnerable zones
-Major infrastructural elements in vulnerable zones
-Sprawl and informal settlements in flood zones


Built pattern
Infrastructure
Economic centres
Commercial centres
Wetlands
Strengths and Opportunities Map
Well developed infrastructure
Multi-modal transit
Strong formal economy
Diverse Stakeholders
Pallikaranai Marshland
Strong formal economy
Strengths:
- Well developed infrastructure
-Strong and diverse stakeholders
-Strong formal economic centres
-Connection to other cities and towns
Opportunities:
-Integrate small businesses and informal economy
-Design of recreation and public spaces
-Need for an integrated strategy for water management
-Involvement of multiple and diverse stakeholders
-Restoration of water networks
1 0 2.0
0.5 1.0

The Adyar river
Source: https://cdn.explara.com/chennai-0220160713193436.jpg

6. Investigating the Three Capitals

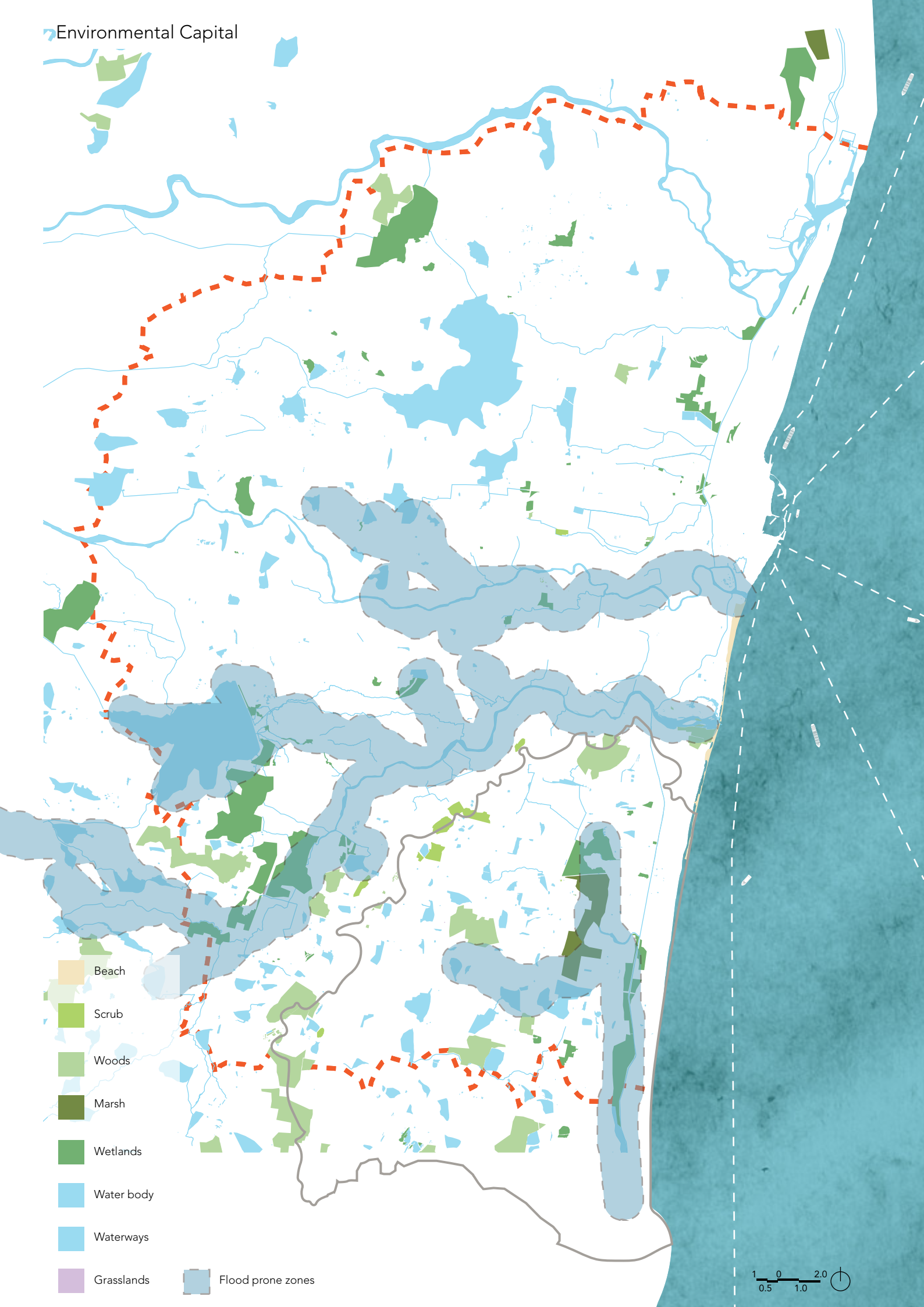
6.1. Regional Scale : Economic and Environmental Capitals

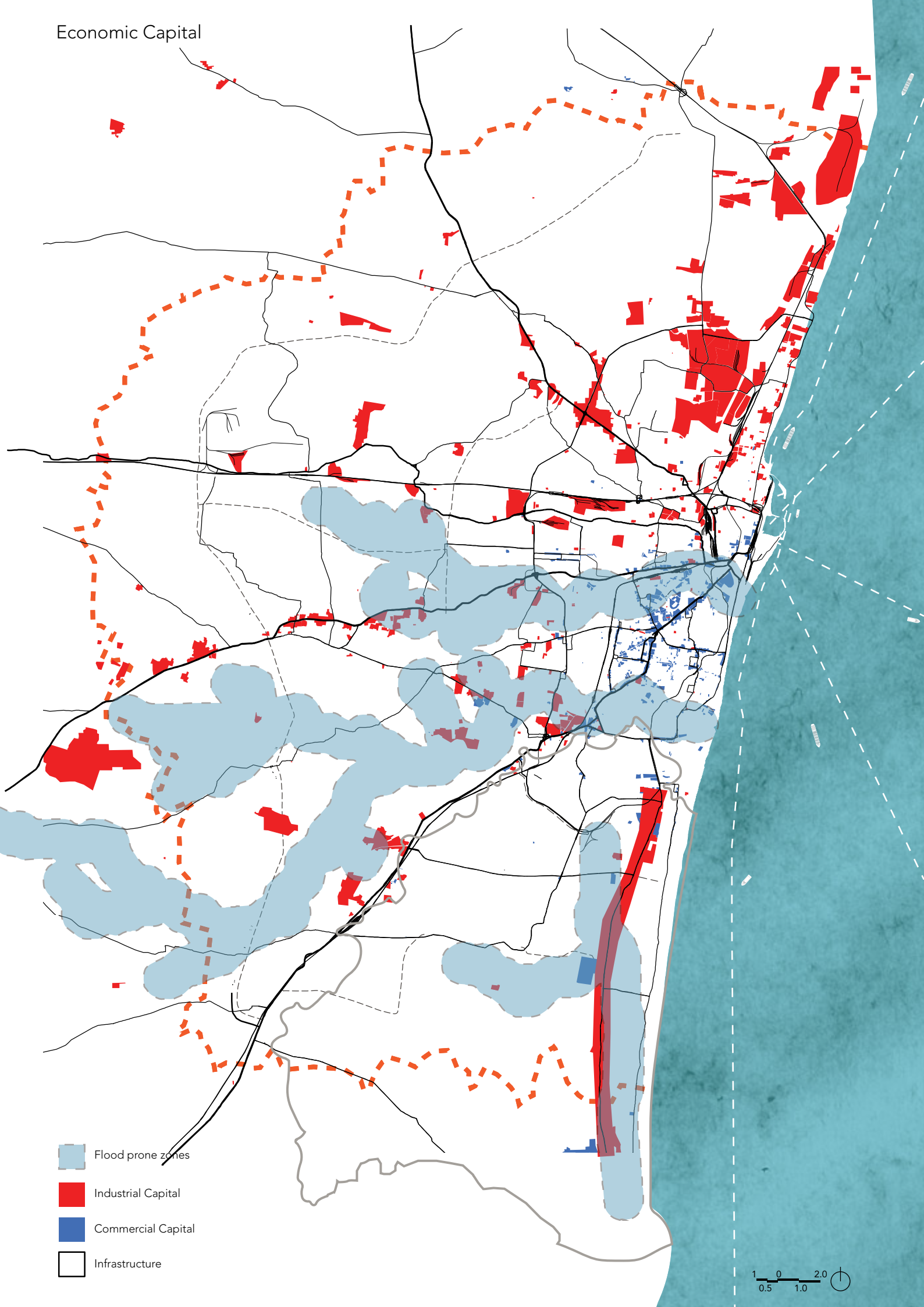
The capitals are mapped and analysed on a regional scale first, to make tangible and spatial, the various environmental and economic components identified as part of the analytical framework. In the process of mapping environmental capitals, a diverse variety of natural resources were identified. Furthermore, flood prone zones were identified as part of this research process. GIS was used a crucial method to sieve through the various datasets. This process revealed the available resources, connections and hydrological components that further formed the database for this project.

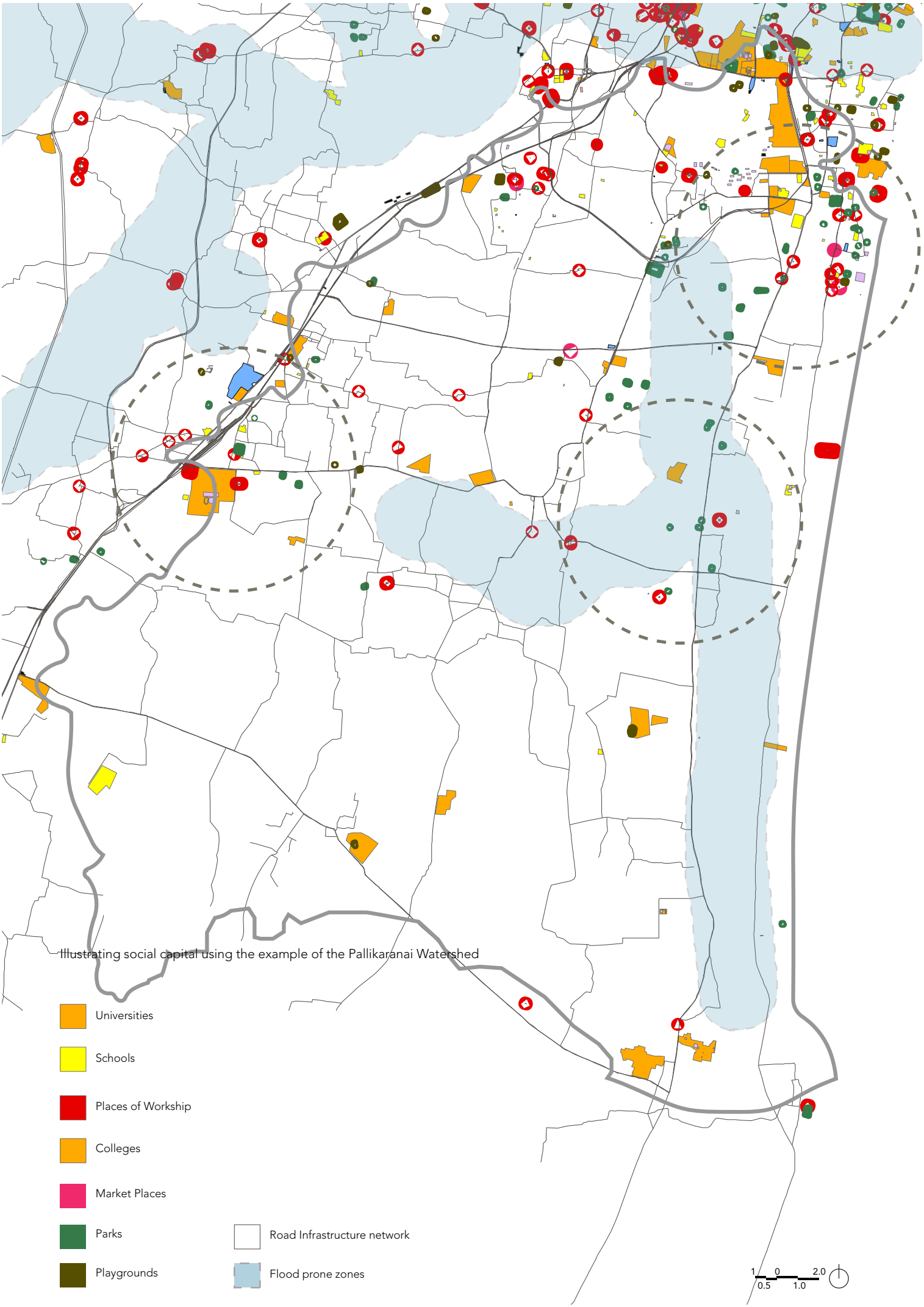
A similar mapping process was carried out for the economic capital investigations. Using land-use maps drafted by the CMDA and through GIS mapping techniques, transport infrastructure and economic and commercial centres were identified on a regional scale. In this process, large private, public and semi-public actors which together form these centres could then be later tapped into for multi-stakeholder engagement strategies.

Next page
Left - Figure 6.1: Environmental capital - regional scale
Source: Author

Right- Figure 6.2: Economic capital - regional scale
Source: Author


Beach
Scrub
Woods
Marsh
Wetlands
Water body
Waterways
Grasslands
Flood prone zones
1
0
2.0
0.5
1.0


Economic Capital
Flood prone zones
Industrial Capital
Commercial Capital
Infrastructure
1
0
2.0
0.5
1.0


Illustrating social capital using the example of the Pallikaranai Watershed
Universities
Schools
Places of Worship
Colleges
Market Places
Parks
Playgrounds
Road Infrastructure network
Flood prone zones
1 0 2.0
0.5 1.0

6.2. Scaling down for social capital

While the regional scale capital investigation revealed the important environmental and economic aspect, the social capital was the most tangible at the smaller scales. Hence as a starting point, the first investigation of social capital was carried out at the watershed level. The Pallikaranai watershed was chosen to illustrate the diversity of social amenities and community infrastructure available in Chennai. To focus the spatial manifestations of this infrastructure, schools, colleges, places of workshop, parks and recreation zones, marketplaces and playground were identified.

Interesting clusters and compositions of social infrastructure was identified on this scale. While this investigation was conducted to mainly identify the community infrastructure on the watershed level, the resultant clusters identified operate on the neighbourhood scale and hence these neighbourhood becomes the spatial focus of the project. Based on the relationships between the three capitals on this scale, the project approach and strategies are developed.

Opposite page
Figure 6.3: Community infrastructure - Pallikaranai Watershed
Source: Author

Part IV- The Approach

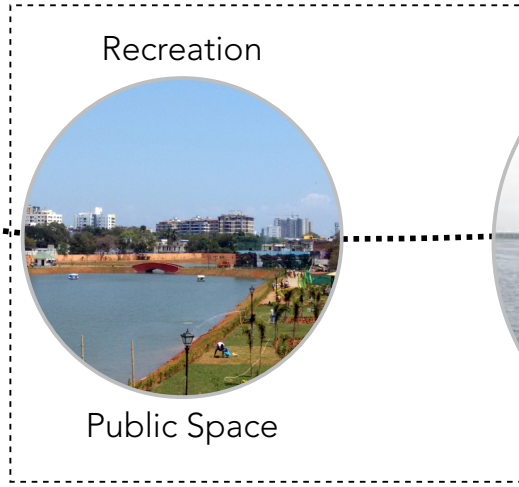
Source: https://i1.wp.com/farm3.staticflickr.com

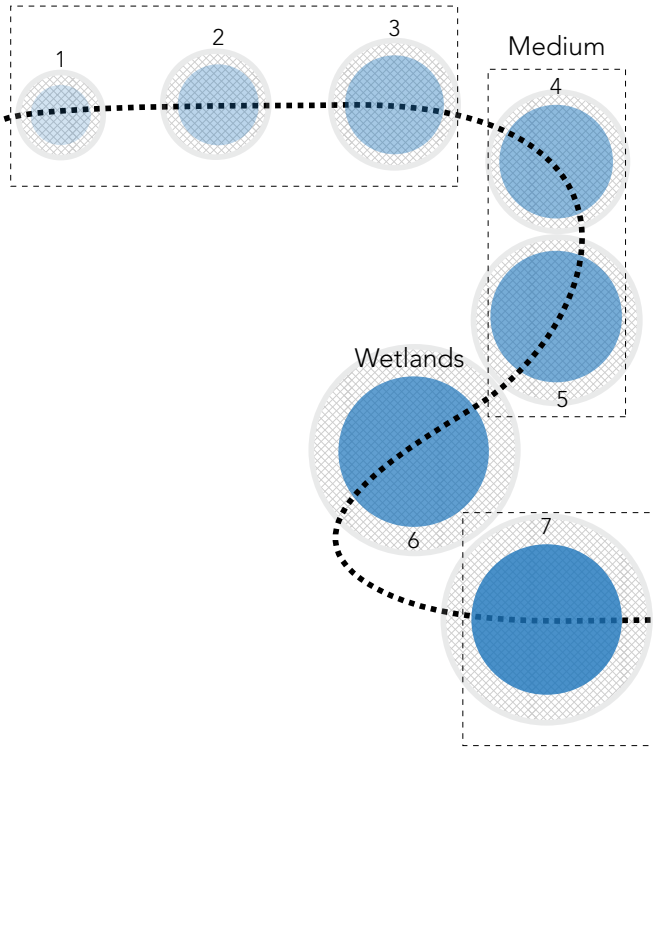
The Adyar river and the City
Source: https://www.indiatimes.com/news/india/15-stunning-images-of-chennai-from-10000-ft-above-sea-level-244693.html

7. The Building Blocks of the Approach

Four crucial steps framed the final design approach of the project. First, socio-spatial analysis of the region pointed towards well developed transport infrastructure and formal economic cores as the biggest strengths. Second, the theoretical framework played a crucial role in making a strong case for community participatory design proposals and the relevance of social capital as the link to harmonise economic aspirations and environmental capacities. Capitals are essentially the building blocks of any society and help organise communities (Wilson, 2012). The theories further highlighted the role of the institution in bringing about communication and facilitating this change across different scales and actors. These theories which recognised the capital approach, resulted in an analytical framework which identified the spatial manifestations and made a crucial link of social capital with community infrastructure to address tangible solutions. The third step was the relevance of ecosystem services. This finding was based out of the local context and the currently ruptured traditional drainage network. This network which once consisted of hierarchical water bodies also harboured a network of socio-cultural and recreational qualities, which in the case of India makes water systems to be valued for more than just their hydrological performances. This ecosystem service based hydrological network is hence termed as value-added green-blue networks. The fourth and final step in this process was that of recognising the 'edges' as a currently conflicted zone and is present spatially across all scales. These edges are hence envisioned to be active, by either programming them with relevant community activities or by treating them such that they are actively part of a larger hydrological system. These will be discussed in detail in this section.

Bio diversity and urban sponge





7.1. Learning from Traditions: Relevance of Ecosystem services

Traditionally, in the Chennai Metropolitan Area, the blue infrastructure which was the flood mitigation mechanism was that of a hierarchical slow moving system which carried water through progressive scales of channels and water-bodies, eventually draining into the river. This system was characteristic of each watershed, which had its unique set of water network. However these networks have been disrupted due to the urbanisation processes and hence reviving them can be seen as an opportunity.

Hence the concept of ecosystem services is highly relevant in the case of Chennai. Not only is this relevant based on the study of the traditional network, but it also relevant to make this concept highly contextual by the use of traditional water tanks, reservoirs and retention models.

For example, temples which play an important social and cultural role in the society as places of worship and congregation were initially integrated in to the network via temple tanks. Water has been a crucial element in places of worship and hence people share a deep meaning to it. In this way places of worship often help build human interactions through way of culture and identity. In addition to this social value, the temple tank plays a much larger role in the drainage network by acting as a node in the hierarchical system.

A deeper study into this network revealed that each water body in the hierarchical network had a larger value in the social context. These values were categorised as recreation, culture and leisure. In addition to these social values, they served as urban drainage, water storages and contributed to the local biodiversity.

This ecosystem service based hydrological network is hence termed as value-added green-blue networks.

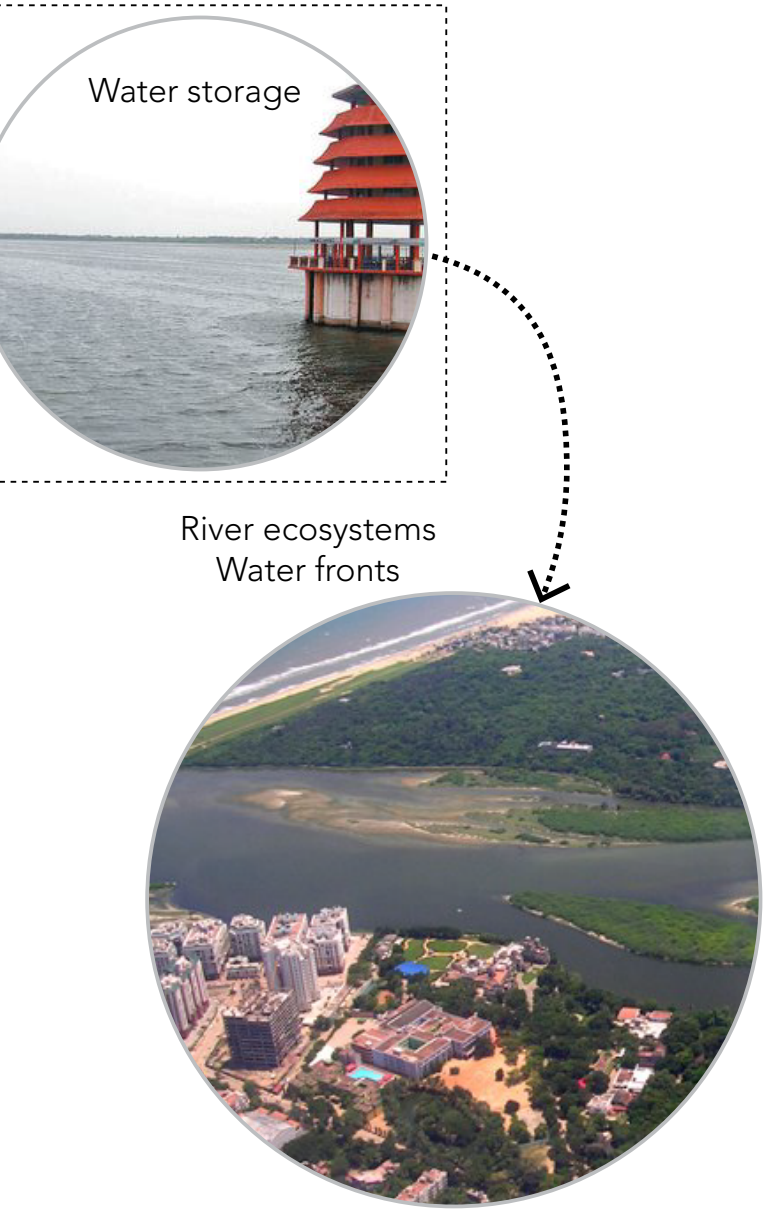


Figure 7.1: Hierarchal water network with associated social values

Source: Author

7.2. Reading the edges as transitional spaces

As part of fieldwork, the author used observation and photography as a means to understand and document the spatial nature of the problem at hand. The main takeaway from this segment is that of the mismanaged edges of the water bodies. These edges which have been treated as leftover spaces in most cases, further widen the gap between citizen perception and environmental restoration. What this essentially means is that, due to the lack of designed and legible edges, there is a lack of perception of the natural environment further increasing the disconnect between man and nature. Hence the edges are key to perception and play a crucial role in spatial design.

Series of edge conditions were documented with respect to different water bodies and rivers. While in most cases, the edges were untreated, the treated edges of temple pond and local pond (see below) showed two different conditions. While the temple tank was paved with stone and induced high activity with the presence of a street next to it, the ponds however were designed with hard and definite edges, which were devoid of engagement. While on one hand, edge conditions need to facilitate participation and human activity, on the other hand, the vulnerability to floods demands relevant drainage infrastructure that is capable of not only accommodating activity but also water percolation and infiltration. A middle ground is hence proposed, through the design of soft, legible and accessible edges which are in turn activated and maintained by the citizens. As a way to engage and being people together, community infrastructure is used as an important activator of these edges. These in turn can take up the role of the 'agencies of change' and can play a direct role in motivating and bringing people together for the restoration of the water network on the whole.

Unmaintained. Forgotten. Misused.

Untreated. Misplaced. Blurred.

Treated yet restricted.

Taken for granted.

Redundant. Missed opportunity. Shunned.

Out of sight. Out of mind.

Mistreated. Restrictive. Non-interactive.

Restricted. Amorphous. Mismanaged.

Defined yet non-engaging.

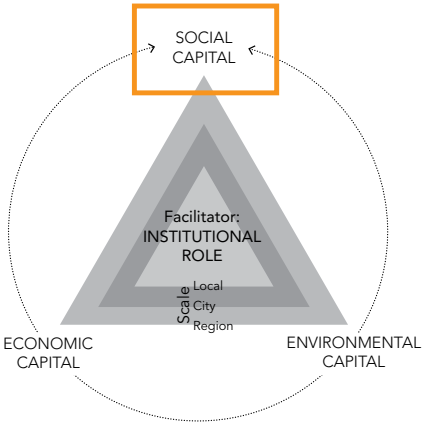
Well treated. Imageable. Interactive.

Doomed.

'Coovum' now synonymous to filthy.

Figure 7.2: Documenting the edges
Source: Author

Strong social and cultural networks can act as a leverage for environmental transformation and restoration



Social capital is seen as the link in this case where economic aspirations are in conflict with environmental capacities

Social Capital

Social and community infrastructure

Civic Engagement

The Edge

Integrated drainage network

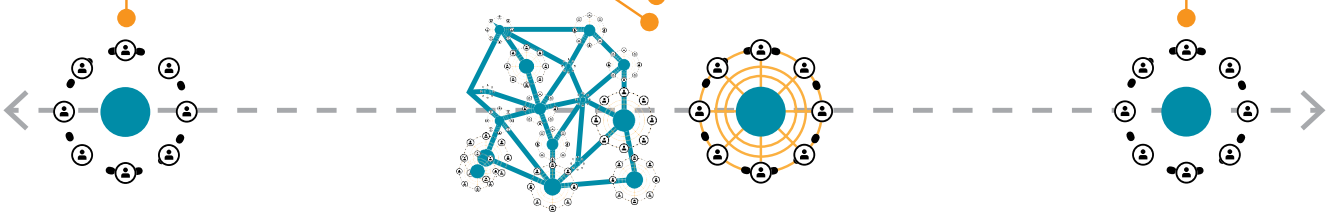
Retrofitting of drainage infrastructure

Restoring tanks and water bodies

The Edge

Encouraging Small scale Economies

Tapping into Corporate Social Responsibilities



ACTIVATING USING COMMUNITY INFRASTRUCTURE

INTEGRATED DRAINAGE NETWORK

FACILITATING EDGE INTERACTIONS

ACTIVATING USING COMMUNITY INFRASTRUCTURE

7.3. Framing the approach

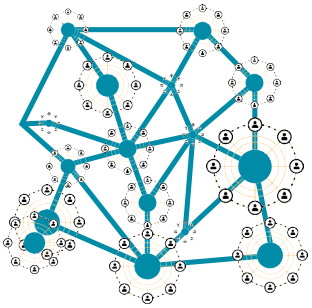
Based on these four building blocks, three main strategies are formulated. First, the integrated drainage network, which is crucial for water conveyance and performance. This strategy takes inspiration from the traditional drainage network and is also envisioned as a network of water tanks, reservoirs and retention areas. In order to enhance drainage capacities, in addition to the natural water channels, retrofitting of infrastructural corridors with storm-water drainage infrastructure is also proposed. Second, is the activation of the water network through the engagement of socio-cultural and economic actors that reinforce the environmental connections. Here, community infrastructure, small scale economies and private actors can be directly integrated in order to appropriate, maintain and restore the water network. Third, is that of the edge interactions, which becomes the main spatial medium in which people engage and appropriate the spaces adjacent to the water component.

The edge is hence seen as the mediator between the different components of the project and becomes the field where humans interact with nature.

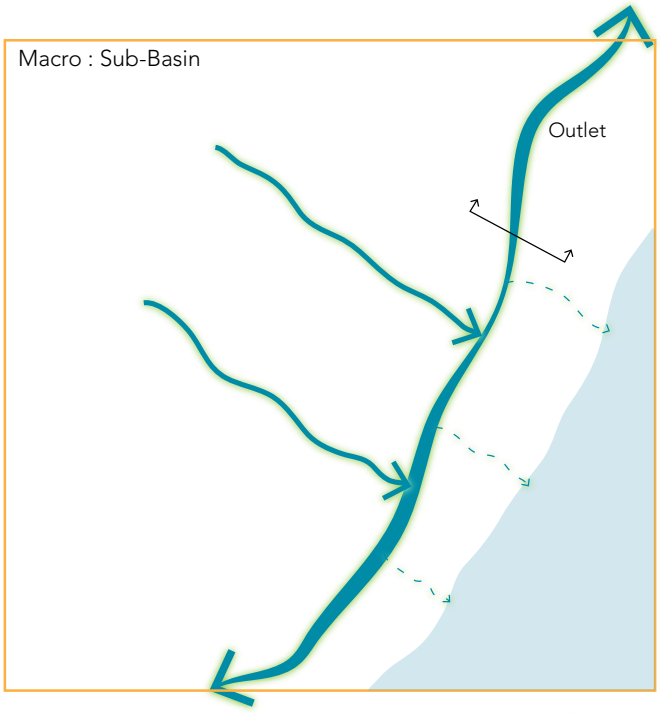
The final project approach is hence formulated as 'Using socio-cultural networks as a leverage for environmental transformation and restoration. Social capital hence forms the crucial link between economic aspirations and environmental capacities.'

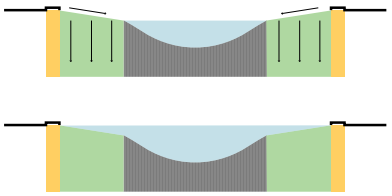
I

Integrated Drainage Network

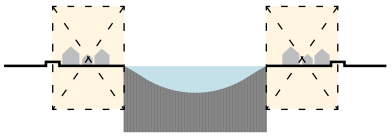


Blue Corridor
Outlet (proposed)
Bay of Bengal (Sea)
Primary infrastructure
Secondary infrastructure
Tertiary infrastructure
Edge demarcation (bund)
Public green
Permeable surfaces
Bioswales

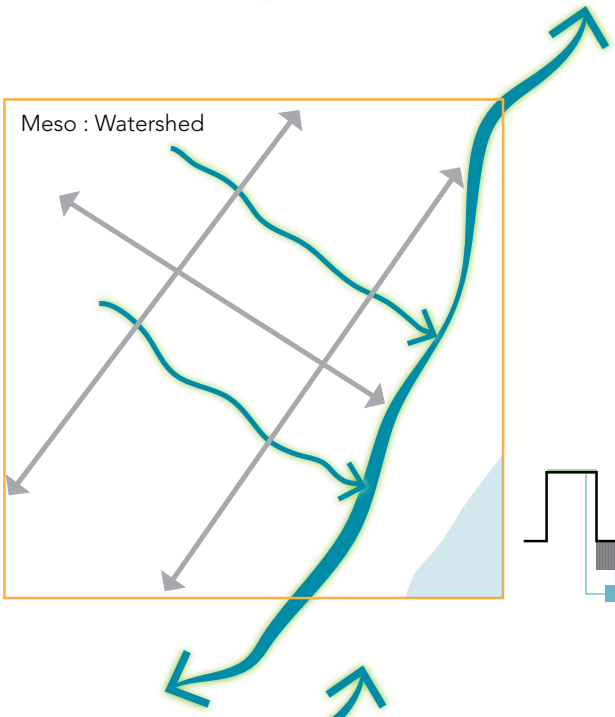


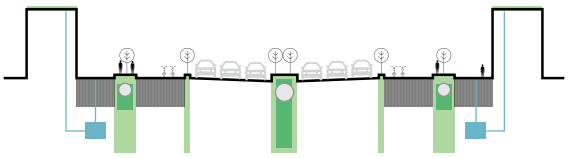


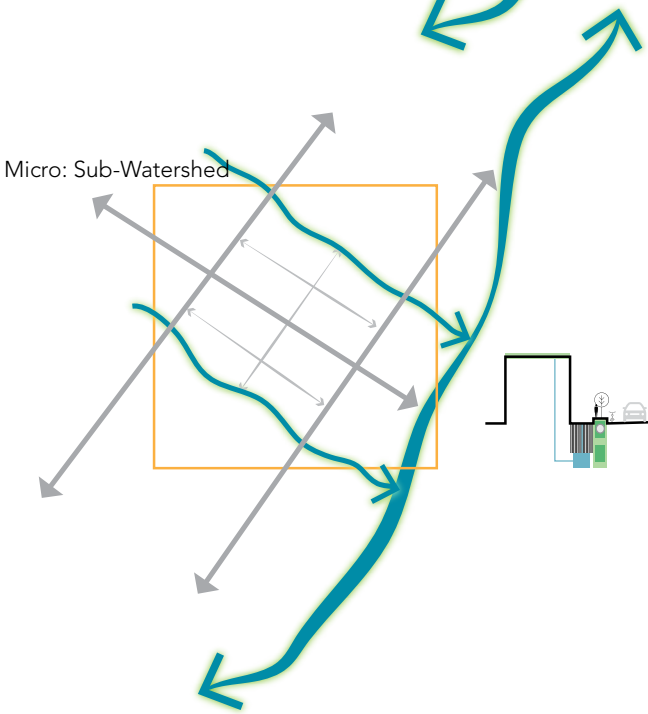
Infiltration and Floodable green areas

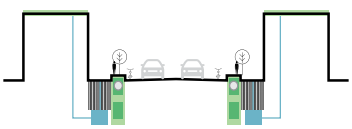


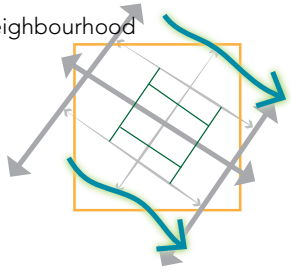
All settlements within coastal regulation zone of 100m on both sides will be relocated

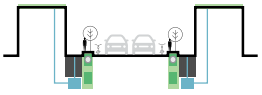












i. Integrated drainage network

This consists of the water network design. The Chennai Metropolitan Region, has a low drainage density meaning that the ratio of the drainage area to the drainage channels is skewed. Hence the available water channels need to be optimised and enhanced for higher carrying capacity in order to function more efficiently with respect to stormwater and water management on the whole.

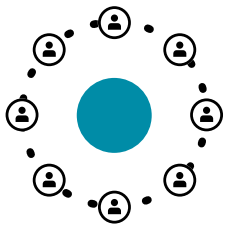
As part of this strategy, blue corridors are created using existing channels, drains and creeks. To further support urban drainage, infrastructural lines are considered and roadways are retrofitted with green-blue strategies for sustainable urban drainage. This is further applied across various scales, with each green-blue corridor playing a crucial role and having a definite image and section attached to it.

Green-blue elements such as permeable pavement design, urban parks, green cycling and pedestrian strips, bio-swales and green medians are designed. The unifying element is that of water conveyance and retention landscapes which not only manage storm-water runoff during floods but also recharge ground water systems in order to tackle water scarcity and demand.

Opposite page:
Figure 7.3: Integrated Drainage network
Source: Author

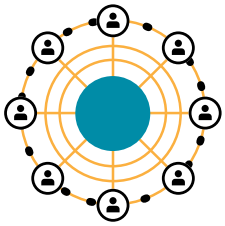
II

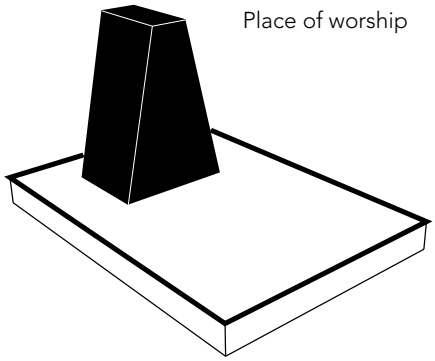
Activating through community infrastructure

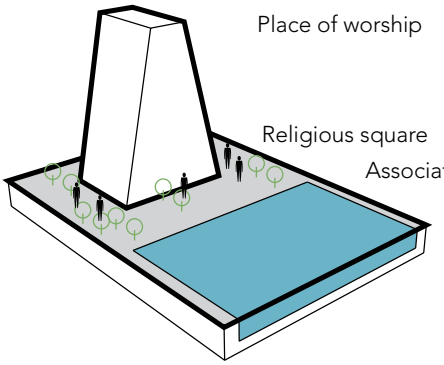


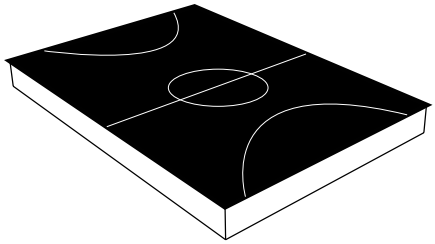
III

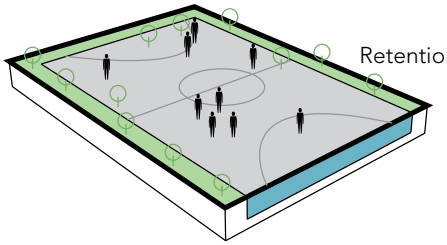
Facilitating edge interactions

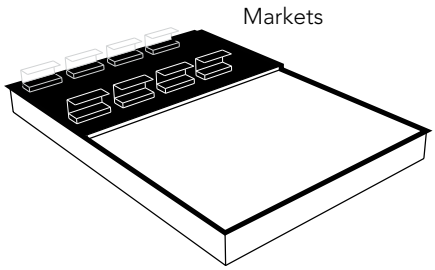


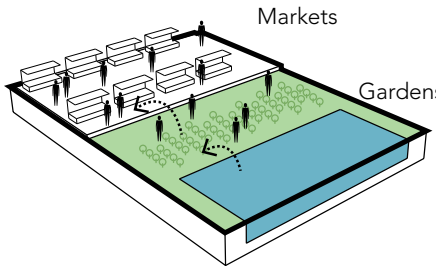


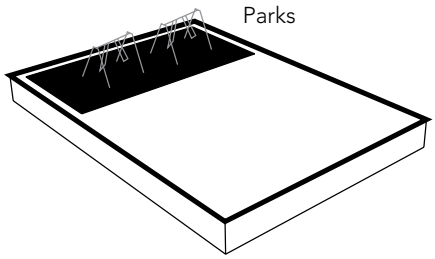


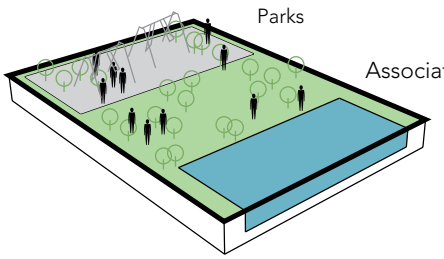


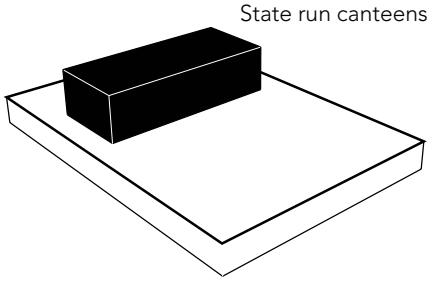


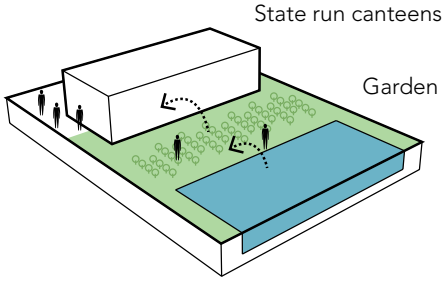












ii. Activating through community infrastructure

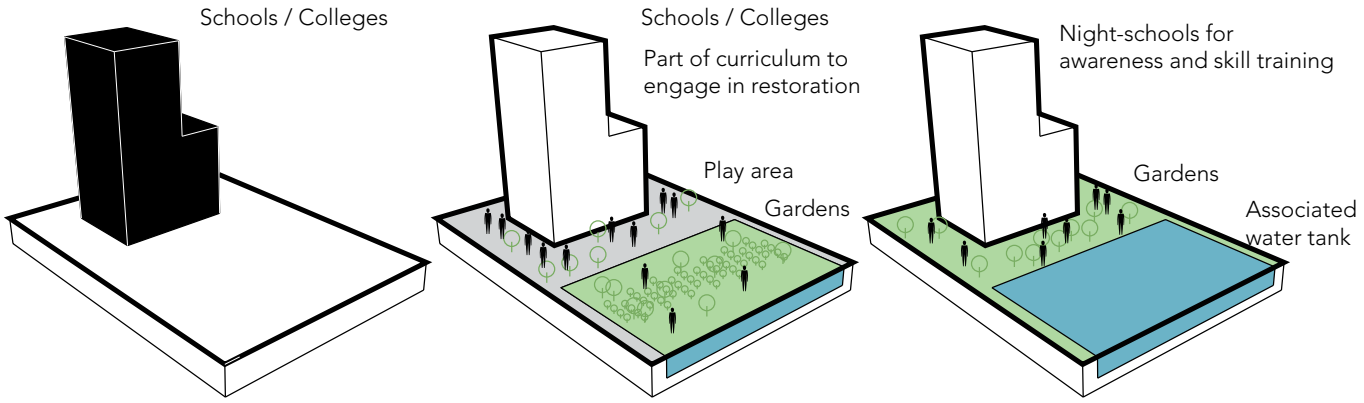
The community infrastructure such as schools, temples, playgrounds, markets, parks, business parks, social amenities and public amenities are identified. These are the socio-cultural and economic drivers which activate the water network and bring about environmental transformation and restoration. These are the agents of change and play a crucial role in re-stitching the currently ruptured ecosystem. Each agent has a role to play and together, they collective restore the lost water network.

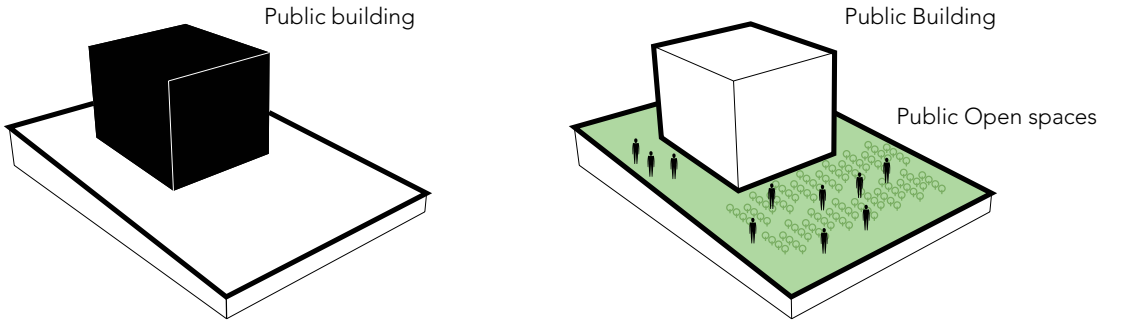
They play the role of spreading awareness, engaging in direct restoration efforts, creating a sense of ownership and essentially become collectively responsible for their environment. These actors make up the decentralised water system and become the main players. The types of activators are illustrated accordingly.

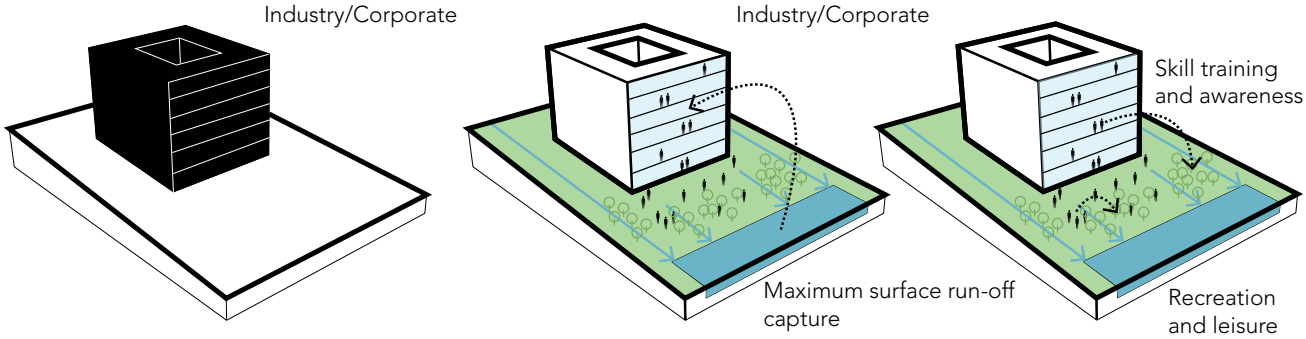
iii. Facilitating edge interactions

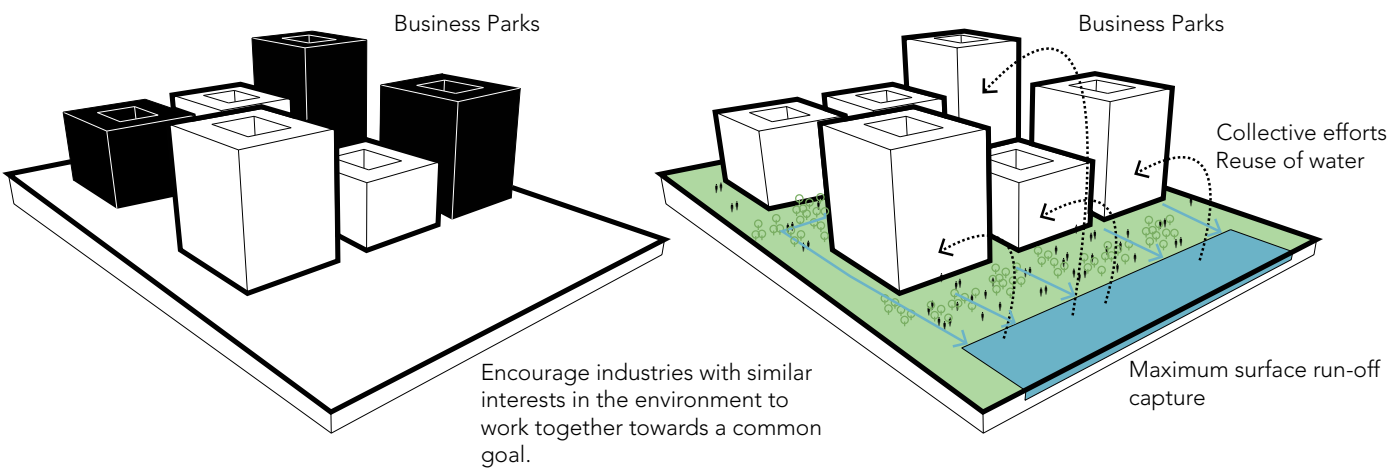
The edge is visualized as the face of the project, connecting the larger macro ideas to the nano level. These are the spaces that are the medium of interaction between human and nature. These consist of programmes associated with the community infrastructure. These spaces are designed such that they integrate blue-green values with everyday activities in order to facilitate direct civic engagement and connections.

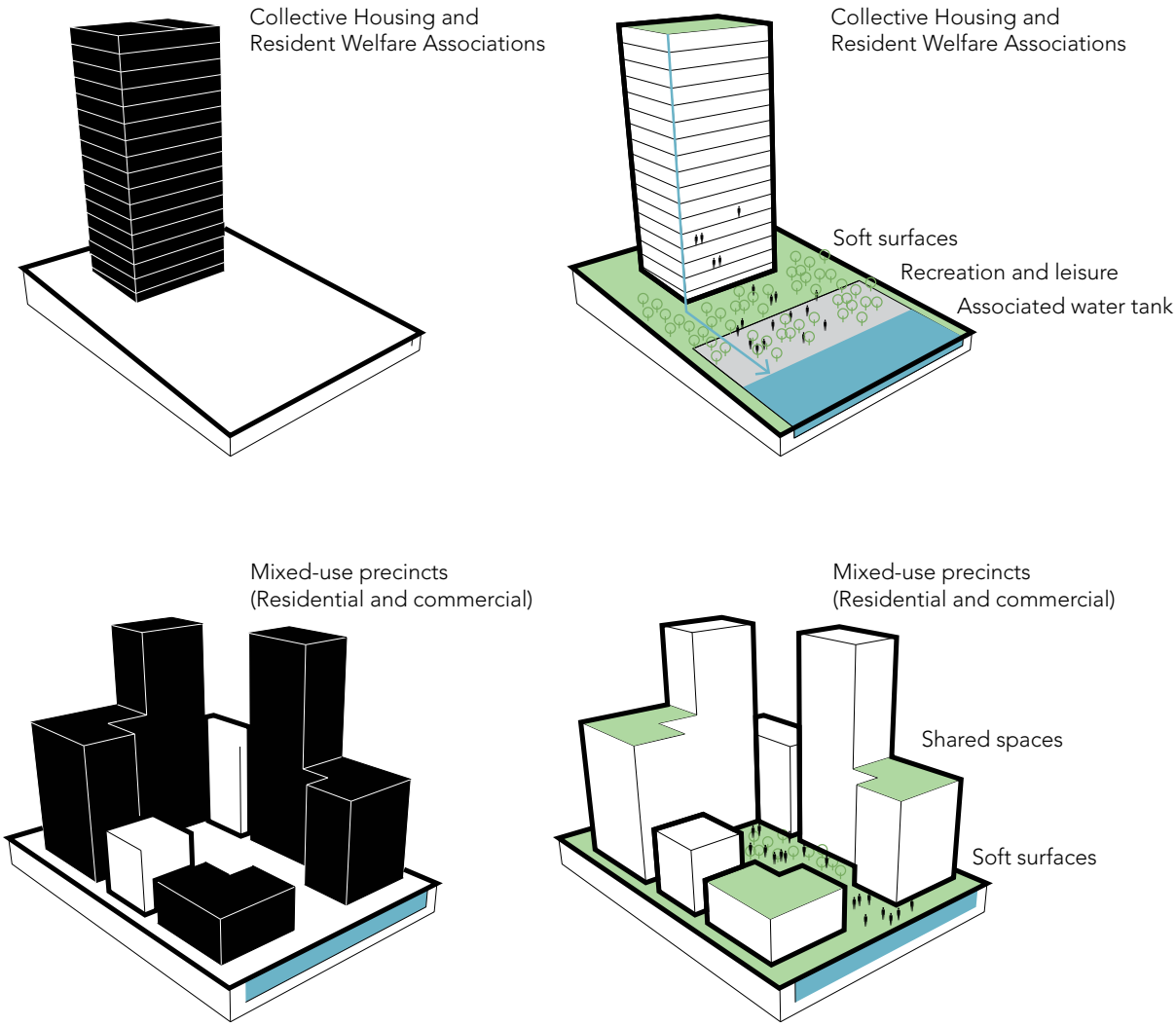
Opposite page:
Exploring Configurations
Figure 7.4: Activating through community infrastructure + Facilitating edge interactions
Source: Author


Schools / Colleges
Schools / Colleges
Part of curriculum to
engage in restoration
Play area
Gardens
Night-schools for
awareness and skill training
Gardens
Associated
water tank


Public building
Public Building
Public Open spaces


Industry/Corporate
Industry/Corporate
Skill training
and awareness
Maximum surface run-off
capture
Recreation
and leisure

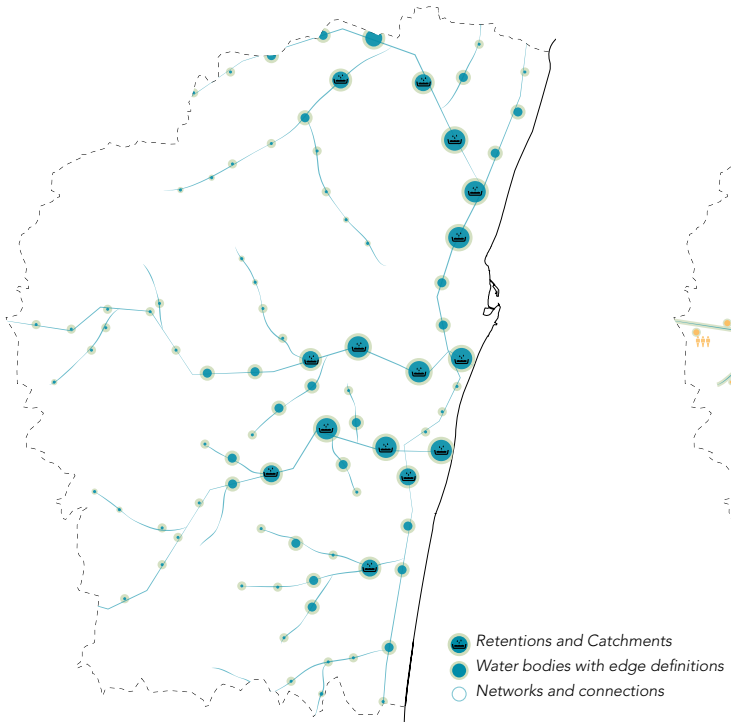

Business Parks
Business Parks
Collective efforts
Reuse of water
Encourage industries with similar
interests in the environment to
work together towards a common
goal.
Maximum surface run-off
capture



Opposite page:
Exploring configurations
Figure 7.5: Activating through community infrastructure + Facilitating edge interactions
Source: Author

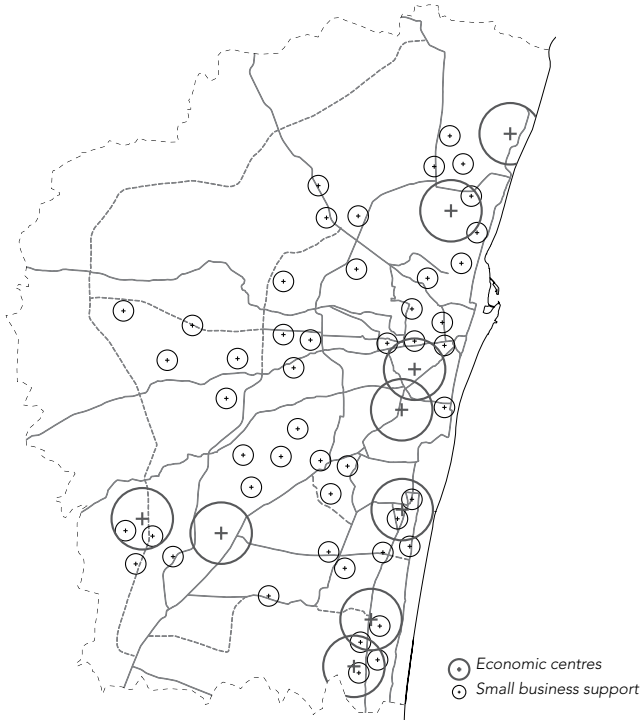
Above:
Exploring configurations
Figure 7.6: Activating through community infrastructure + Facilitating edge interactions
Source: Author

Integrated water network

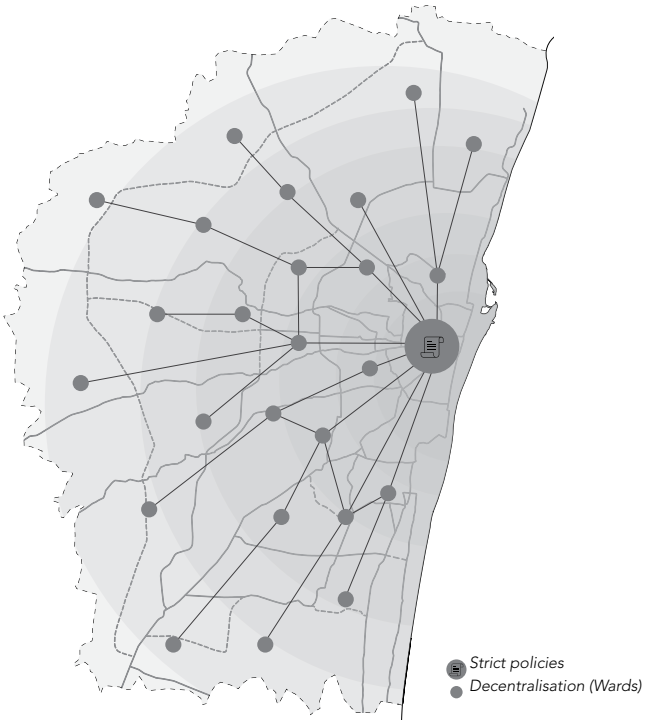


Open space + community infrastructure to activate network

Retrofitting transport infrastructure + supporting small scale economies



Decentralised decision making and institution as the facilitator



7.4. Strategies Applied

i. Designing an integrated hydrological network which consists of traditional tanks, ponds, reservoirs etc. connected by existing and new blue corridors and by retrofitting major infrastructural lines with contextually relevant storm-water infrastructure that bring about efficient drainage.

ii. Activating these networks by identifying community infrastructure and adjacent open spaces that can support the maintenance and functioning of the system. This is crucial to collectively rebuild the ruptured network by directly engaging the local citizens.

iii. Programming the spaces of interaction between community and water/open space through place-making strategies, civic engagement strategies, local cultural movements and activities, awareness building, training and vocational activities, leisure and recreation, markets to support small scale economies and religious programmes such as festival spaces.

iv. Decentralised decision making and water management at the local scale. A autonomous body is proposed at the Regional level to mediate development aspiration with environmental capacities. This body called the 'Resilience Chennai Organisation' is responsible for the implementation of the different strategies and also to bring about efficient communication between the different departments of the government. This is to make sure that there is a dedicated body that mediates and makes possible, the vision proposed in this project.

Opposite page:
Figure 7.7: Strategies used
Source: Author

Let's Talk Floods - Community Participation workshop organised in Chennai in February 2018
Source: Author

8. Fieldwork

8.1. Overview

The fieldwork and site visit as part of the project was conducted from the period of 27th January 2018 to February 2018. The aim of the fieldwork was to reinforce the potentials of social capital as an important driver of change in the context of Chennai. The potential links between social, environmental and economic capital were also looked into as part of the visit.

In order to respond to these intentions, the fieldwork was conducted in the form of Stakeholder interviews, Individual citizen questionnaires and interviews, on-site observations and finally, a community co-evaluation workshop in order to explore in its true essence, the strength of community interactions and building community resilience. This section consists of a detailed documentation of the two week long visit and consolidates the findings and in turn shaped the strategy approach.

MADRAS OFFICE OF ARCHITECTURE AND DESIGN (MOAD)

Architecture and Urban Design

Non-Governmental Organisations

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Madras Chamber of Commerce and Industry (Private)

Global Climate change agencies (works in collaboration with government)

Indo-German Centre for Sustainability (Research)

Chennai Rivers Restoration Trust

(Wholly owned by Government of Tamil Nadu)

8.2. Stakeholder Interviews

Stakeholder interviews were conducted in a semi-structured to structured manner in order to assess involvement of different actors, their strengths and interest in the resilient Chennai as envisioned for the project. A total of 12 stakeholders were interviewed, from various backgrounds such as government, non-government, private, global climate agencies, research, architecture and urban design. Inputs from the sources were then formulated into the 'Problem-Potential-Challenge' table in order to compare and assess the most recurrent views as well as those in sync with the project's ideals. These are highlighted in the tables listed below.

The most common inputs were that of the fragmented institutional structure and the lack of a strong statutory organisation overseeing all environmental violations with respect to flood risk. In addition to this, stakeholders expressed the need to look into water efficiency in the sense of not only designing for floods but also designing for maximum holding and retention capacity owing to the growing water scarcity in the region. Hence, a prime takeaway from the interviews is that of increased need for water retention and efficient landscapes rich in blue-green values which in turn enhance liveability and increased standards of living.

Owing to the lack of civic engagement and minimum participation in decision making, decentralised water management was further proposed in the interviews. The medium in which these interactions can take place is through public spaces that are active and inclusive.

In addition to the 'Problem-Potential-Challenge' Approach, questions that investigate the relevance of social capital, public participation and community resilience were also posed. All Stakeholders expressed concern over the lack of environmental awareness amongst the citizens, and hence this was recognised a the biggest challenge in building community resilience. 'Capacity Building' was recognised as an approach to bridge this gap through vocational training, civic engagement, awareness programmes and so on.

Further suggestions were made for overall community development through the design of inclusive public spaces, activities such as urban farming, horticulture and tapping into local knowledge and integrating daily activities into spatial design. The local 'Tamil Culture' was recognised as the region's biggest asset and was time and again emphasised on. This tamil culture, sets Chennai apart as a deeply rooted metropolitan and hence this social and cultural network can be tapped into as a potential.

Opposite page:
Figure 8.1: Logos
Source: Google

Webe Design Lab
Architecture and Urban Design Studio

"

Problems perceived:
-Too many stakeholders within the government
-Collective action by citizens not planned for
-Commoditisation of ecologically sensitive areas is a major concern

Potentials:
- Strong sense of social cohesion that can be tapped into
- Tapping into daily activities and economies
- Need for integrated water management
-Public spaces to induce more activity
-Need to recognise breathing spaces – such as open spaces

Challenges:
-Need to break the perception of 'humans being disjoined from nature'
-Addressing flood-drought extremities

"

C40 Cities
Cities Climate Leadership Group

"

Problems perceived:
-Institutional disconnect
-The biggest conflict is that of who owns the water and who manages it
-Master plans needs to be revised more often due to the rapidly changing urban setting

Potentials:
- Implementation through public input
-2500+ acres of water however there is not system that recognises the land value capture of water; lack of policy that protects water bodies
- New guidelines for urban and building development

Challenges:
-Need to bring about change in mentality of how people can make a difference
-Lack of data availability
-Lack of awareness

"

MOAD
Architecture and Urban Design Studio

"

Problem perceived:
- Lack of long term visions which ensure that the risk is catered and responded to

Potentials:
- Development and participation based on incentives
-Tanks and water bodies should be designed as catchments
-Roads as drains? If yes, what would be the way to design roads? How can roads be further connected to storage areas?

Challenges:
-Each micro context is different from the other
-There is a considerable gap between people and power

"

100 Resilient Cities
Civic & Social Organization

"

Problem perceived:
- Encroachment and unplanned urbanisation

Potentials:
- Concept of healthy urbanisation – with respect with water bodies
-Decentralised water treatment methods – all natural and on site and such that water is let back into the rivers to revive them
-Tapping into Corporate Social Responsibilities

Challenges:
- Lack of the 'big picture' or the vision
-Cross interaction between different departments and disciplines

"

Care Earth Trust
Non-Governmental Organisation

"

Problem Perceived:
- There is no core or expert group that works in Chennai – this expert group should consist of urban planners, architects, sociologists, ecologists etc.
-Local communities, Resident welfare associations etc have not been actively considered

Potentials:
- In fact we need to consider solutions from all aspects such as social, ecological, economic etc have to also be considered in addition to technological solutions.

Challenges:
-Poor awareness of environment

"

Cities Development Initiative Asia
International partnership initiative

"

Problem Perceived:
- Instead of piecemeal projects, we need to bring a certain order into how we develop our cities and regions
-No integrated water planning – micro and macro drainage is not integrated together

Potentials:
-Integrated water management
-Institutional development

Challenges:
-Peri-urban areas also lack infrastructure and need to be focussed on
-No catchments contributing to water storage

"

GIZ - Deutsche Gesellschaft für Internationale Zusammenarbeit Development Agency

Problems perceived:
-No coordination among the different departments - Separate departments for everything; Fragmented institution
-Lack of development vision

Potentials:
- Civic Engagement - For the longest time, people have been excluded from ecology by conscious efforts in building barriers that do not enable interaction
-Ownership as a result of interaction with ecosystem
-Decentralised water management and restoration

Challenges:
-Chennai is water starved as well flood prone

Chennai River Restoration Trust Governmental Department

Problems perceived:
- Inundation – lack of drainage
- Carrying capacity is reduced - clogging of rivers
-Back flow of storm water drains

Potentials:
-Public consultations and integrating NGOs
-Traditional drainage networks exist in the form of the temple tanks, ponds and standalone water bodies
-Giving river back to the people; indirect benefits – wellness and happiness to people through good environment

Challenges:
-Gaining the interest and support of the citizens
-Coordination among department – institution is scattered

Madras Chamber of Commerce and Industry
Non-governmental, industry-led and industry-managed organisation

Problem perceived:
- Storm water drains are inefficient
- Economic and industrial development was unchecked

Potentials:
- Corporate social responsibility (CSR)
-Setting up skill training and development
-Increasing awareness and to strengthen rules
-Organised workshops and programmes that focus on human development through training

Challenges:
-Small businesses are less aware of the risk and need to be brought together

Smart City India Governmental Department

Problem perceived:
-Storm water drains inefficient
-Lack of focus on public spaces and their value

Potentials:
- Improving liveability
-Retrofitting existing green areas
-Area based water restoration

Challenges:
- Awareness among citizens
-Aging of system already in place
-Integrating all departments and making them work together

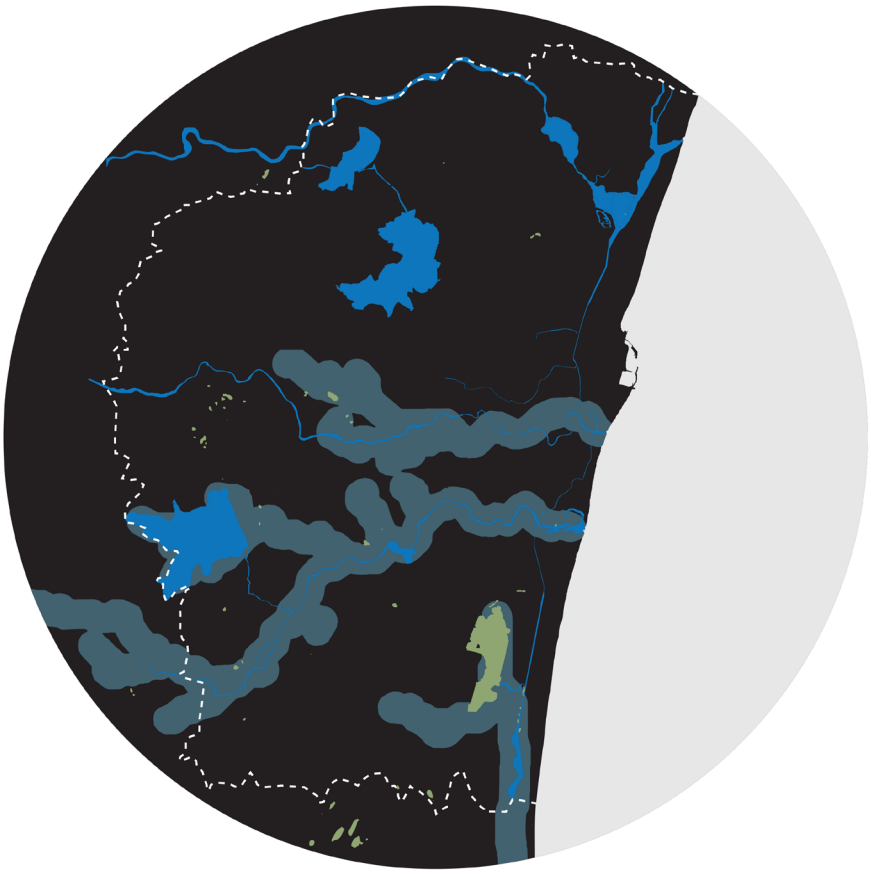
Care Earth Trust
Non-Governmental Organisation

Problem Perceived:
- There is a gap between research and practice – multiple research conducted yet data availability is poor
-Inefficient storm water drain system
-The current approach to flood protection is that of disaster management rather than resilience

Potentials:
- Social resilience is more relevant in the case of the context of Chennai
-Water retention landscapes

Challenges:
-Poor awareness at the local scale
- We need to consider extreme situations with respect to water in Chennai
- Lack of availability of data with respect to missing channels and canals

Let's talk floods!



Workshop and Presentation

as part of Master Thesis with TU Delft, titled 'Keeping your feet dry : Rethinking Urban Planning and Flood Resilience in the Chennai Metropolitan Area, India.

Saturday, 10th February 2018
10:30 - 13:30 hrs

Backyard
53/23, 3rd Main road, Gandhi Nagar, Adyar, Chennai

DOORS OPEN anniversary weekend

TU Delft

8.3. Community co-evaluation workshop

In order to conduct a brainstorming session for ideas as well as to assess local awareness and interest, a community participatory workshop was conducted as part of the fieldwork. The motive of this workshop was to demonstrate possibilities and direct outcomes of public participation for the purpose of co-evaluation and co-ideation of urban solutions. In addition to supporting this research, it also showcased the feasibility of public participatory initiatives for future implementation of the project.

The format for the workshop was a short presentation of the ongoing research, 60 minutes of debate and discussion and finally a 90 minute session of co-evaluation. The 'problem tree' was used to integrate perception of the problems, its spatial and functional implications, potential solutions and finally the process of its realisation on ground. A total of 15 participants attended the workshop and were organised into 3 groups of 5 each. The backgrounds of the participants were that of students of the age group 20-23, working professionals from the field of engineering, architects, urban planners and a government consultant from GIZ. Each group was asked to present few ideas, hence kick starting an intense discussion on the various possibilities. These results are documented below.

The results from the workshop further corroborated the project research as well as views expressed by the different stakeholders. The highlighted inputs are those which support the project approach and shape the strategy making process.

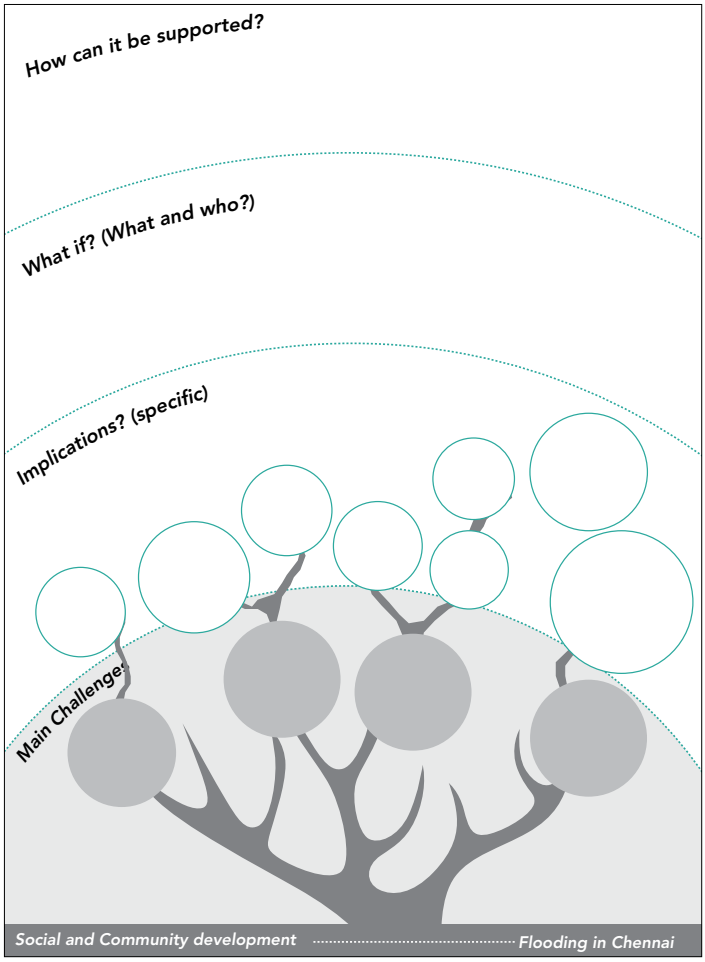
In addition to the workshop, participants also filled out questionnaires similar to the ones of the stakeholders but more elaborate on the social and community aspects. The turn over rate of the questionnaires (8/15) was 53%. A detailed account of the workshop and individual questionnaires can be found in Appendix 2.

Interesting observations were made about the perception of the problem and the feeling of community, with each participant expressing different points of views.

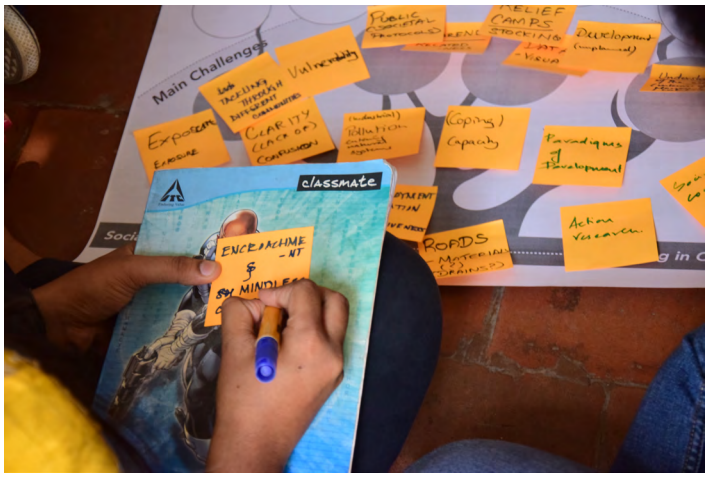
Opposite page:
Figure 8.2: Workshop Poster
Source: Author

Next page:
Top left: Figure 8.3: Workshop format

All photographs sourced from the Author


How can it be supported?
What if? (What and who?)
Implications? (specific)
Main Challenge
Social and Community development
Flooding in Chennai


collaborate


Main Challenge
classmate


Presentation of ideas and discussion

Group 1

“ Problems perceived:
-Bylaws for flood resilience lacking
-Chennai city – more reactive and not preparatory by planning for future
-Lack of real time data - More creative and transparent depiction of data
-Bridging the gap between different sectors

Potentials:
-Rain water harvesting – decentralised scale
-Designing roads as drains - Can we create a model road section for flood defence?
-Spatial design - Multi-functional public spaces
-Policy – regarding open space reservations
-Local bodies – vested with more powers
-Water retaining landscapes
”

Group 2

“ Problems perceived:
-Lack of community awareness
-Gap between research and decision makers
-Clogging of water bodies and Reduction in Carrying capacity
-Need for more responsibility to their surroundings

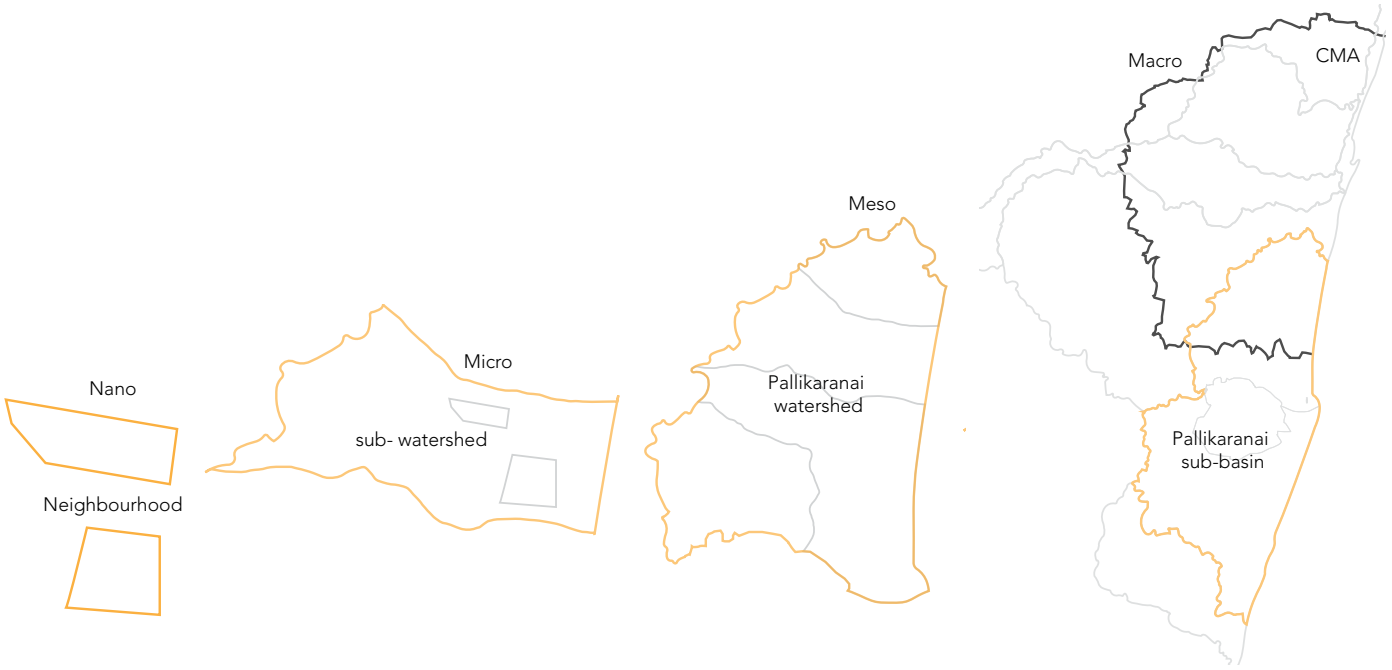
Potentials:
- Community engagement in decision and policy making
-Create local economic opportunities
-Incentive based initiatives
-Ecosystem services
-Three main elements of urban planning – Public, private and Community work together
”

Group 3

“ Problems perceived:
-Lack of integrated development
-Unplanned development
-No involvement of different age groups

Potentials:
- Environmental revival connected to cultural revival
-Storage of rainwater – using public spaces
-Awareness programmes at schools
-Designing better human-nature relationships
-Increased taxation policies for water sensitive and disputed areas
-Small economic services - revival, economic incentives
”


CMA
Focus area:
Pallikaranai Watershed
Pallikaranai
sub-basin


Macro
CMA
Meso
Micro
Nano
Pallikaranai
watershed
sub- watershed
Neighbourhood
Pallikaranai
sub-basin

9. Potentials

9.1. Focus area : Pallikaranai watershed of the Pallikaranai Sub-basin

To illustrate and test the strategies, the Pallikaranai watershed is chosen as the focus area. This is chosen due to the following reasons:

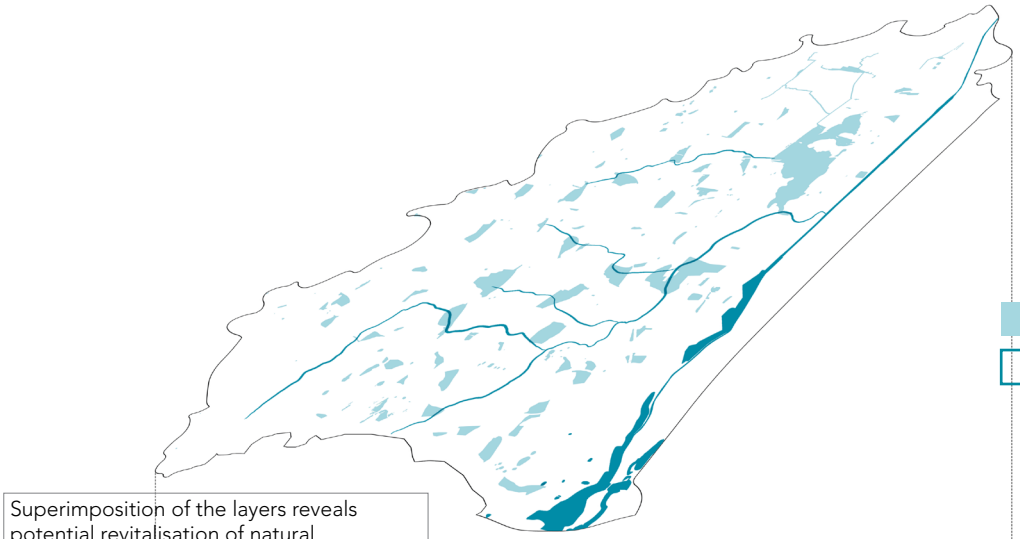
- Presence of IT Corridor
-Diverse and powerful stakeholders
-Flood prone zone overlap with crucial infrastructure

-Pallikaranai wetlands
-Opportunities for green-blue design
-Buckingham canal

-Presence of diverse citizen groups - socio-economically vulnerable groups, working class and middle class groups - diverse actors
-Opportunity to tap into community infrastructure

As this watershed is part of the Pallikaranai sub-basin, the macro scale strategies take into account the entire sub-basin and designs strategies for the Macro - sub-basin, Meso-watershed, Micro-sub-watershed and Nano-neighbourhood scales.

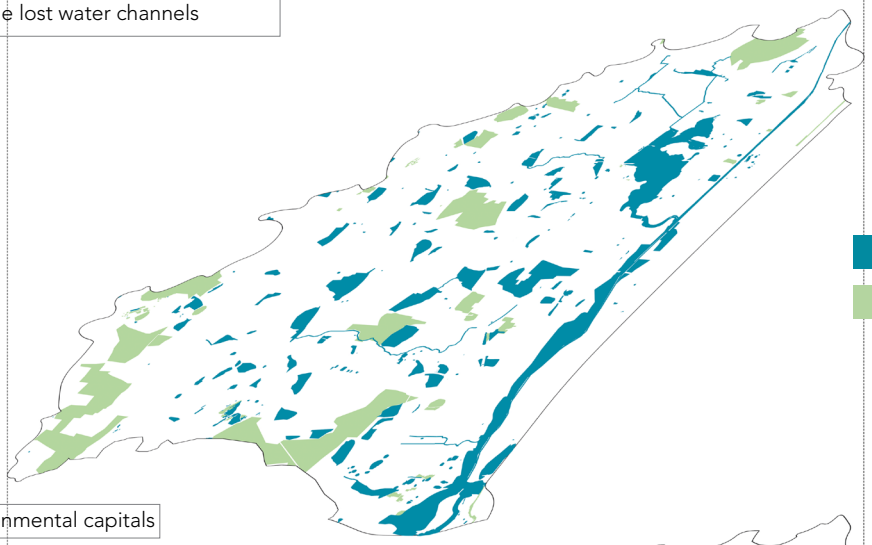
Above:
Figure 9.1. Selection of test case
Source: Author



Water bodies

Potential blue connections

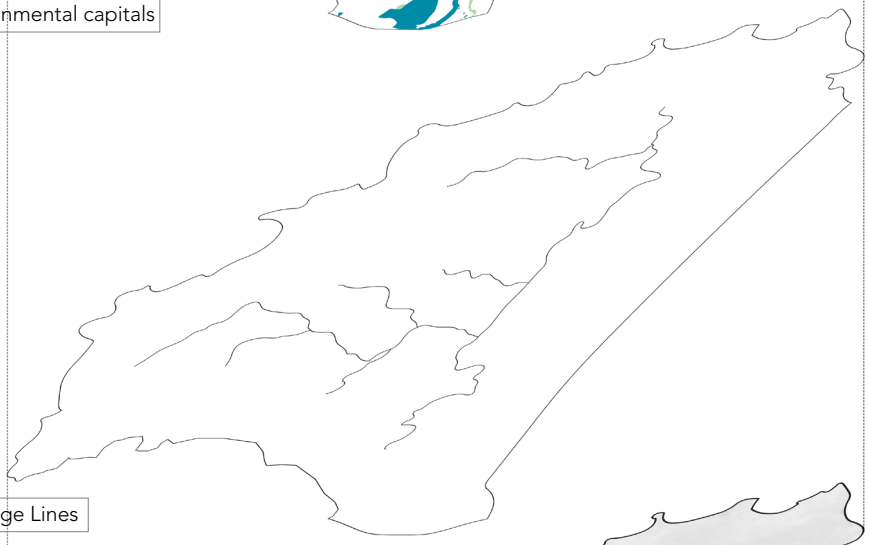
Superimposition of the layers reveals potential revitalisation of natural hydrological network by preserving existing and reviving the lost water channels



Water resources

Green resources

Existing Environmental capitals



Natural Drainage Lines

High 680 m

Low -18m

Elevation and Contours

1 0 2.0

0.5 1.0

9.2. Mapping potentials

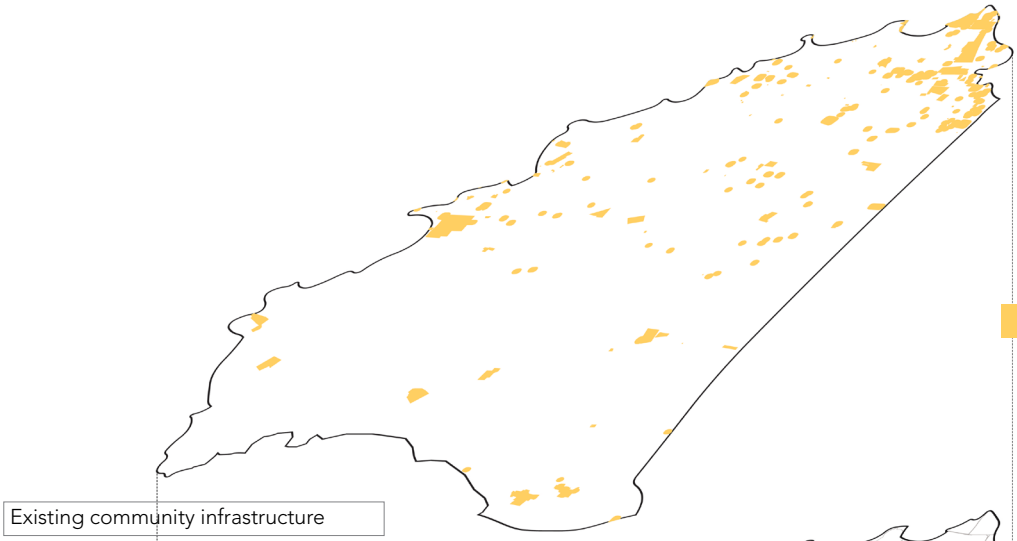
Based on the strategic framework and components of the approach, the potentials for the focus area were analysed and identified. The urban structure and capitals were analysed in depth and potential neighbourhood clusters were identified.

The underlying elevation layer revealed the natural drainage lines. Although the terrain is extremely flat, the drainage lines give insight into the natural direction of flow and the idea is to use these drainage lines as reference to direct water into the lowest points. When superimposed with the existing environmental capitals, water channels are identified and these channels correlate with the natural drainage directions. However due to the expanding urban patterns, most of these channels are under threat and have lost their footprint due to overexploitation. Hence one of the potentials here is to revive the natural drainage channels. To further support these natural channels, infrastructural corridors could provide access for water especially in already dense neighbourhoods. Hence, in addition to the natural channels, retrofitting of storm water drainage infrastructure into the road network could provide much needed drainage especially in the areas where drainage is insufficient.

These networks are activated by superimposing the community infrastructure layer. This community infrastructure consisting of schools, places of worship etc. maintain and engage with the water networks and take responsibility of their surroundings. In addition to this, the economic centres can also be integrated as they are the large-scale actors who can be directly engaged through Public-Private partnerships.

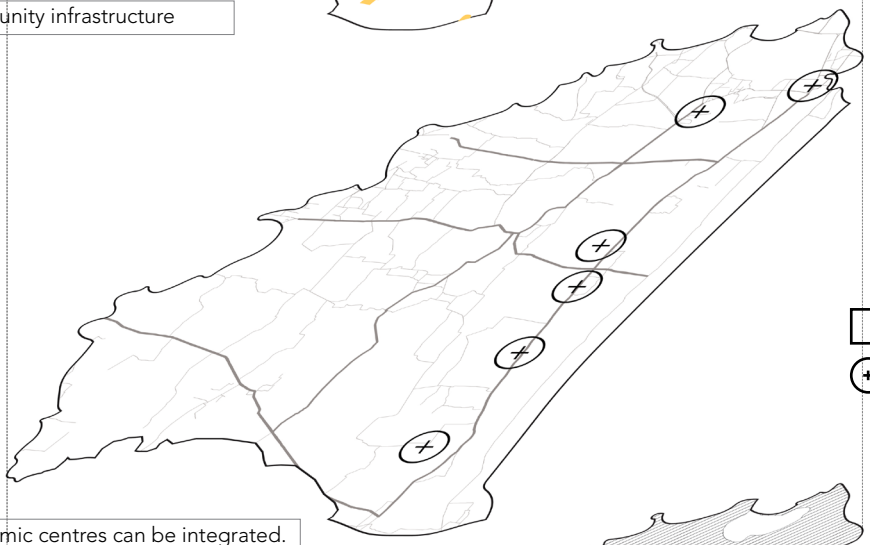
By superimposing the three layers: natural water channels, infrastructure and economy and community infrastructure, potential connections where all three capitals meet, were identified. These are further clustered to form unique hydrological connections activated by community infrastructure and private actors. These strategies are the most operable on the neighbourhood scale and multiple such connections can be designed across the city and region. The neighbourhood is hence the nucleus of the project and the vision is intended for the neighbourhood scale.

Opposite page:
Figure 9.2. Potentials - Environmental capital
Source: Author



Community infrastructure

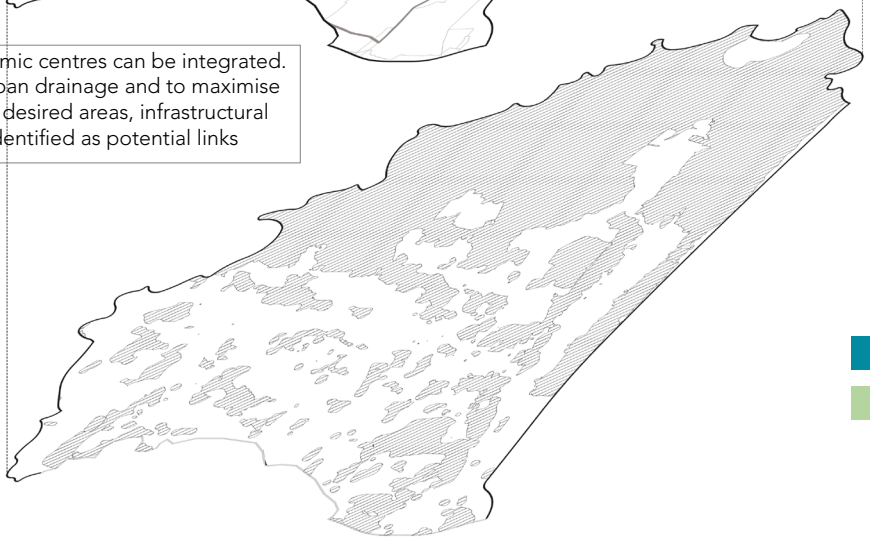
Existing community infrastructure



Infrastructure lines

Economic centres

Existing economic centres can be integrated. To enhance urban drainage and to maximise conveyance to desired areas, infrastructural corridors are identified as potential links



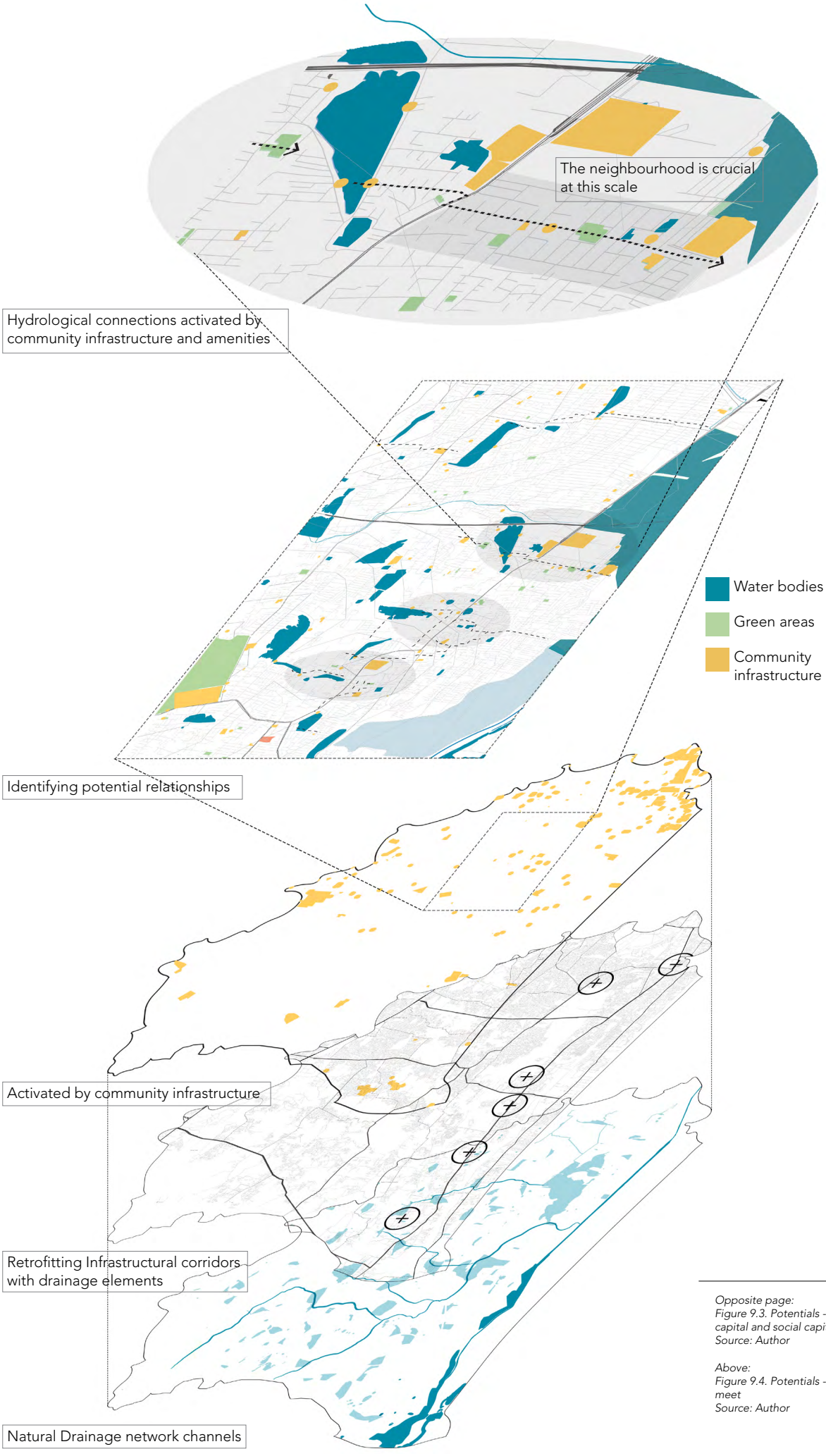
Water resources

Green resources

Existing settlement pattern

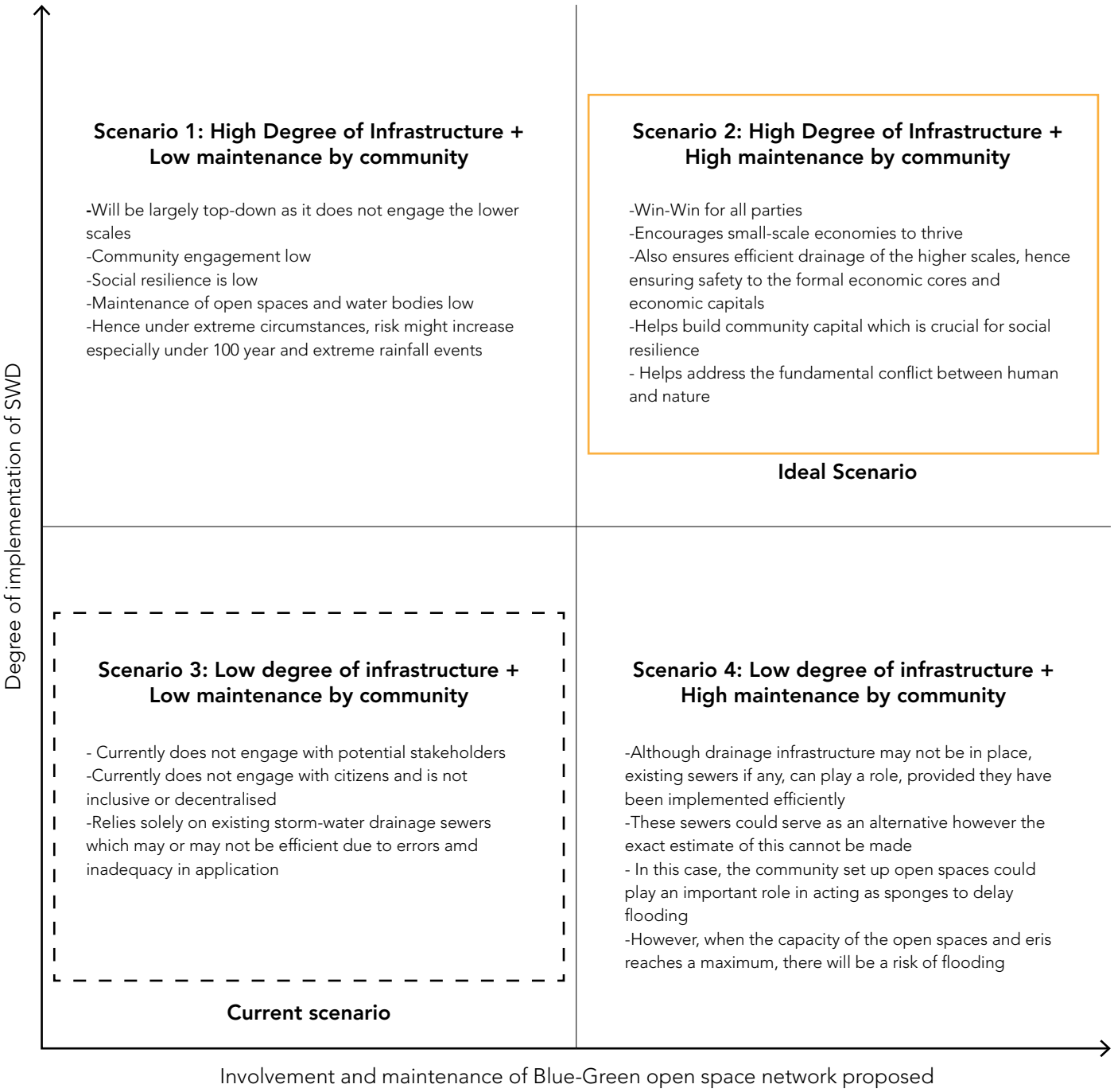
1 0 2.0

0.5 1.0



Opposite page:
Figure 9.3. Potentials - Economic capital and social capital
Source: Author

Above:
Figure 9.4. Potentials - All capitals meet
Source: Author


Scenario 1: High Degree of Infrastructure + Low maintenance by community
-Will be largely top-down as it does not engage the lower scales
-Community engagement low
-Social resilience is low
-Maintenance of open spaces and water bodies low
-Hence under extreme circumstances, risk might increase especially under 100 year and extreme rainfall events
Scenario 2: High Degree of Infrastructure + High maintenance by community
-Win-Win for all parties
-Encourages small-scale economies to thrive
-Also ensures efficient drainage of the higher scales, hence ensuring safety to the formal economic cores and economic capitals
-Helps build community capital which is crucial for social resilience
- Helps address the fundamental conflict between human and nature
Ideal Scenario
Scenario 3: Low degree of infrastructure + Low maintenance by community
- Currently does not engage with potential stakeholders
-Currently does not engage with citizens and is not inclusive or decentralised
-Relies solely on existing storm-water drainage sewers which may or may not be efficient due to errors amd inadequacy in application
Current scenario
Scenario 4: Low degree of infrastructure + High maintenance by community
-Although drainage infrastructure may not be in place, existing sewers if any, can play a role, provided they have been implemented efficiently
-These sewers could serve as an alternative however the exact estimate of this cannot be made
- In this case, the community set up open spaces could play an important role in acting as sponges to delay flooding
-However, when the capacity of the open spaces and eris reaches a maximum, there will be a risk of flooding
Degree of implementation of SWD
Involvement and maintenance of Blue-Green open space network proposed

10. Designing for the best case scenario

The 2x2 approach was used as a tool to envision different scenarios of the proposal. The most important and the least predictable components of the strategic framework was used to formulate 4 scenarios and understand the implications of each. The most important is that of the implementation of hydrological networks and drainage design strategies, which are crucial to achieving flood resilience. The least predictable is the maintenance by the community and their direct involvement in the restoration efforts.

Especially in the case of uncertainty, situations may not play out as planned and hence this method, gives a simple insight into future scenarios.

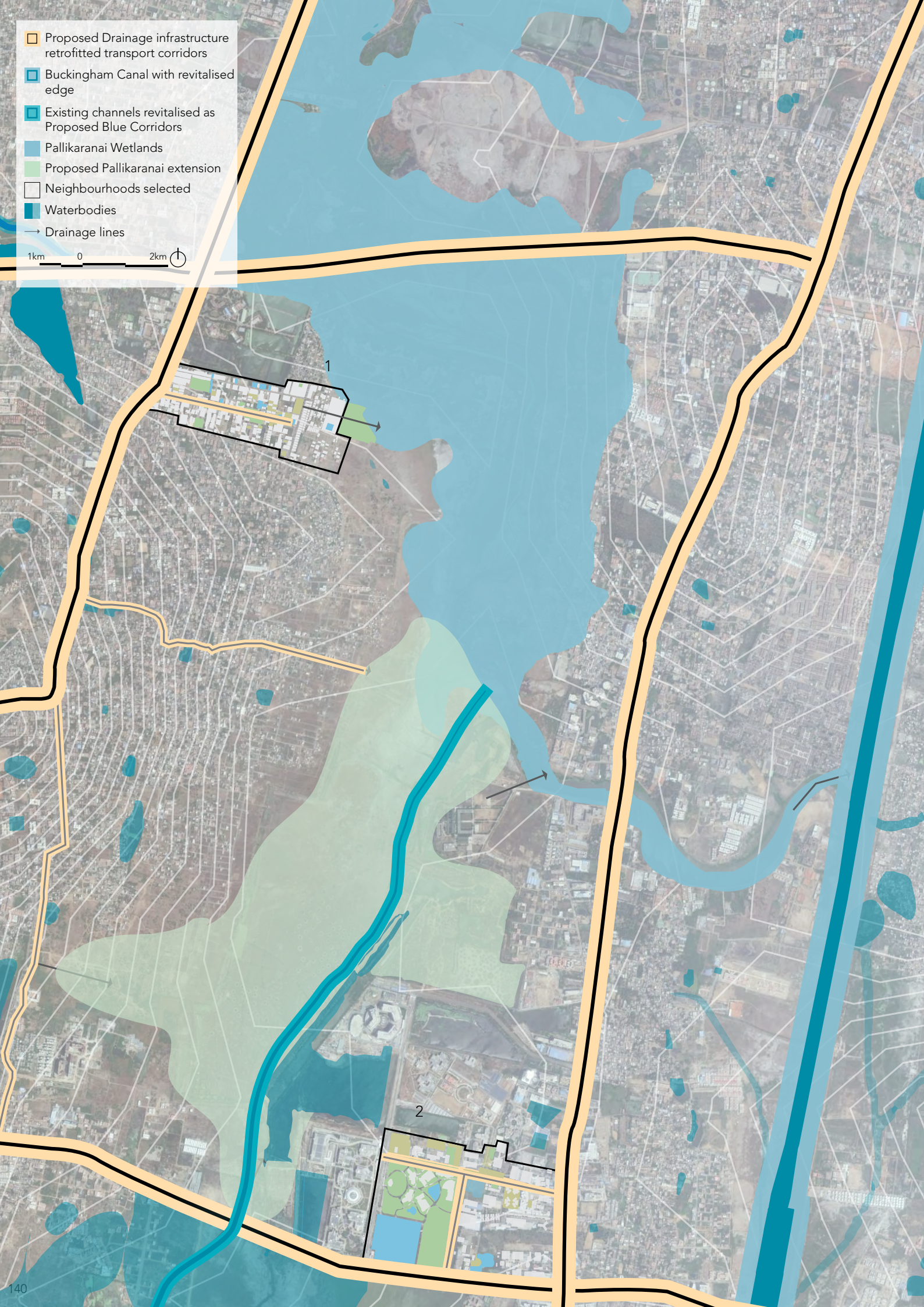
This project proposes a vision and design strategies for the best case scenario in which high degree of implementation of infrastructure and high maintenance of the community managed open spaces is expected.

In order to respond to these two parameters, drainage infrastructure has been design across all scales and their technical abilities has been worked out using the Rational Method. Further, keeping in mind that community involvement is crucial yet unpredictable, civic engagement strategies and behavioural change aspects and appropriation techniques have also been designed and detailed.

Opposite page:
Figure 10.1. Designing for the best case scenario
Source: Author

Part V- The Proposal

Source: https://pbs.twimg.com/media/DCpwRlBV0AAGIcT.jpg


Proposed Drainage infrastructure retrofitted transport corridors
Buckingham Canal with revitalised edge
Existing channels revitalised as Proposed Blue Corridors
Pallikaranai Wetlands
Proposed Pallikaranai extension
Neighbourhoods selected
Waterbodies
Drainage lines
1km
0
2km
1
2

11. Spatial Vision for the Neighbourhood

An integrated water management network activated by the retrofitting of social, economic and environmental functions at the local scale is envisioned n the Sub-Basin Level.

Social and cultural networks are hence used as a leverage to balance economic aspirations with environmental restoration. Together, the region restores its ruptured hydrological system by redefining its green-blue values.

On the neighbourhood scale this network is activated by community functions and human-nature interaction is made possible by the design of the edge as a spatial medium of interaction between the people and the environment. The vision is designed across various scales, the macro being the sub-basin level, meso being the watershed level, micro being the sub-watershed level and finally the neighbourhood being the nano level. For this vision, the two neighbourhoods as part of the vision are intended as pilot project that kick start the process and eventually spread across to other neighbourhoods.

The vision is hence, a collaborative and inclusive restoration process which seeks to resolve the currently existing conflict between human and nature. Together the community on the whole becomes adaptive to the growing risk and socio-ecologically resilient.

Opposite page:
Figure 11.1. Neighbourhood vision
Source: Author

Above:
Figure 11.2. Impressions
Source: Author

Students participating in a clean-up in Chennai
Source: http://www.opindia.com/2017/11/30-students-from-iit-madras-join-sri-sris-art-of-living-in-cleaning-423-water-bodies-in-chennai/

12. Strategies

12.1. Neighbourhoods

The Neighbourhoods are the core areas where the strategies are most effective. By applying the strategic framework and conducting a detailed mapping and analysis of the neighbourhood, the proposal is made. Each neighbourhood proposal is complete with spatial reconfigurations, open space and water-body specifications, programmatic rejuvenation, civic engagement and activity planning.

Two neighbourhoods are chosen. First, Kamkotti nagar, a primarily residential neighbourhood and second, Elcot SEZ area which is highly industrial.

12.1.1. Neighbourhood 1 - Kamkotti Nagar

In the first neighbourhood, the different layers were first mapped and their potentials were identified. In this scale, unmanaged and derelict open spaces are considered as a layer which can contribute to the hydrological performance of the neighbourhood.

By using mapping as a methodology, distinct clusters and patterns of open spaces, both managed and unmanaged were recognised. When superimposed with the street pattern, a main neighbourhood level street is identified. This is the largest and widest of the streets and houses multiple functions related to daily-needs, leisure, commercial and religious.

Hence, this main neighbourhood street was termed the 'Connector Street' and consisted of the primary spine at the neighbourhood level. This connector street becomes the main physical link between the different social, environmental and economic strategies planned at the nano scale.

Based on this connector street, the different layers are configured in order to design a pattern of community functions, small scale commercial activity, managed open spaces for leisure and recreation, water bodies for retention and unmanaged open spaces for bio-retention.

In this neighbourhood, the community functions and small-scale commercial are identified as activators. These activators further facilitate interaction with the environment through the connector street which is designed as a continuous EDGE wrapping around the various social, environmental and economic functions. Hence the pedestrian areas in the connector street, which are the edges, are brought to life through the different activities spilling over it.

In addition to the social significance of the connector street, this also becomes the drainage channel which carries run-off and conveys it to the nearest infrastructural corridor, wetland or blue-corridor on the micro, meso and macro scales. Hence this connector street plays the role of the integrator. This corridor is retrofitted with relevant storm water infrastructure such as bio-swales, permeable pavements and sub-surface drainage channels.

In order to achieve neighbourhood functionality, the proposed programmes are then further detailed to house specific civic engagement strategies in order to make better places and facilitate human-nature interaction. This interaction is crucial for the larger intention of building social capital, creating awareness and creating a sense of ownership within the residents. This is crucial especially in this decentralised water management network which is proposed to be closely knit into the daily lives of the residents.

Together the connector street and adjacent functions form the nano segment of the integrate storm water drainage network.

The different layers, their significance, subsequent configuration, proposed scheme and proposed engagement strategies are as follows.

All figures in this section drawn by the Author, unless stated otherwise.

Figure 12.1 Source: Google Earth

The available open spaces along the connector street are integrated directly into the scheme.

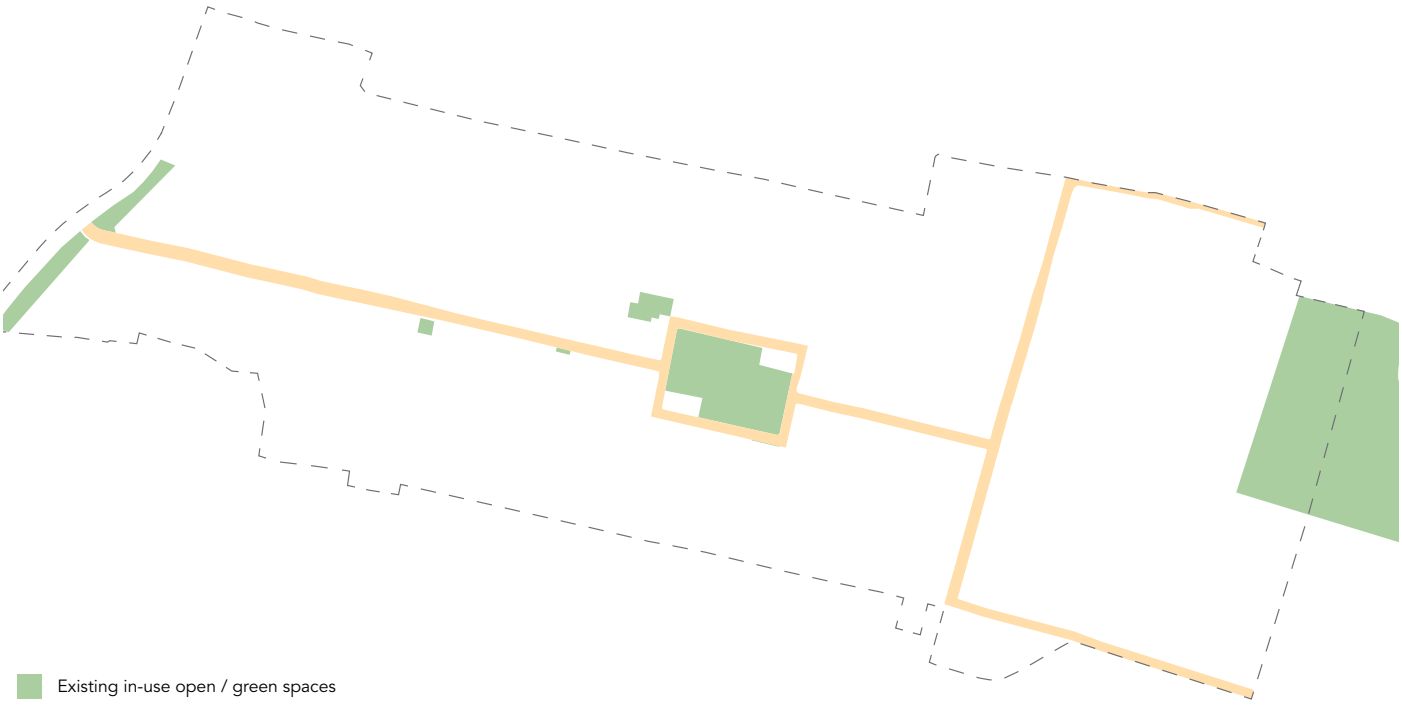


Figure 12.2

The buildings along the Connector Street will de designed to accommodate small scale commercial functions on the ground level. These activities further spill-over onto the pedestrian area and activate the space.

Figure 12.3

The community infrastructure that occur along the connector street are intended to be the drivers of change and play an important role in engaging the citizens through its own resources and outreach. For example, schools target their students while temples target their devotees.

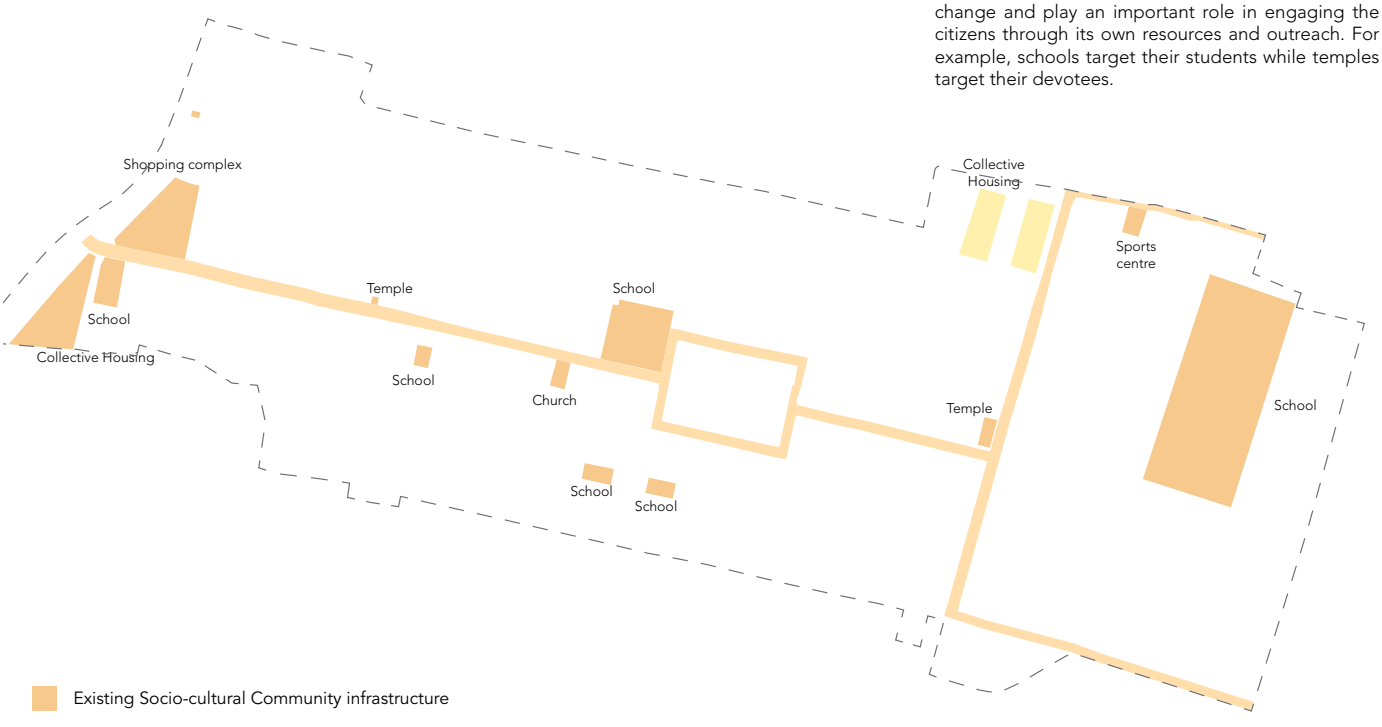


Figure 12.4

The water bodies along the connector streets are integrated directly into the scheme.

Figure 12.5

The available open spaces and derelict open spaces that occur within the neighbourhood block and that are adjacent to the street are connected to the scheme through underground drainage networks.

Figure 12.6

The derelict or unmanaged open spaces that occur along the connector street are integrated into the scheme directly.

Figure 12.7

The water bodies that occur within the neighbourhood block and that are adjacent to the street are connected to the scheme through underground drainage networks.

Figure 12.8


g
1
Shopping complex
2
3
School
Collective Housing
4
5
a
6
Temple
7
School
8
Park
b
A'
A
9
Church
10
11
School
Park
14
School
School
Proposed Connector Street retrofitted with SWD infrastructure
Primary green-blue transit corridor
Residential streets with trench to direct water to main corridor
Existing Built-up Areas
Proposed Mixed-use activated facades
Existing Socio-cultural Community infrastructure
Proposed Water tanks (Retrofitting of existing swamps)
Pallikaranai wetlands
Existing in-use open / green spaces
Unmanaged open spaces retrofitted with bio-retention gardens and public accessible spaces
0
60m
30m

Figure 12.9

Typical Section AA': Connector street (Neighbourhood 1)

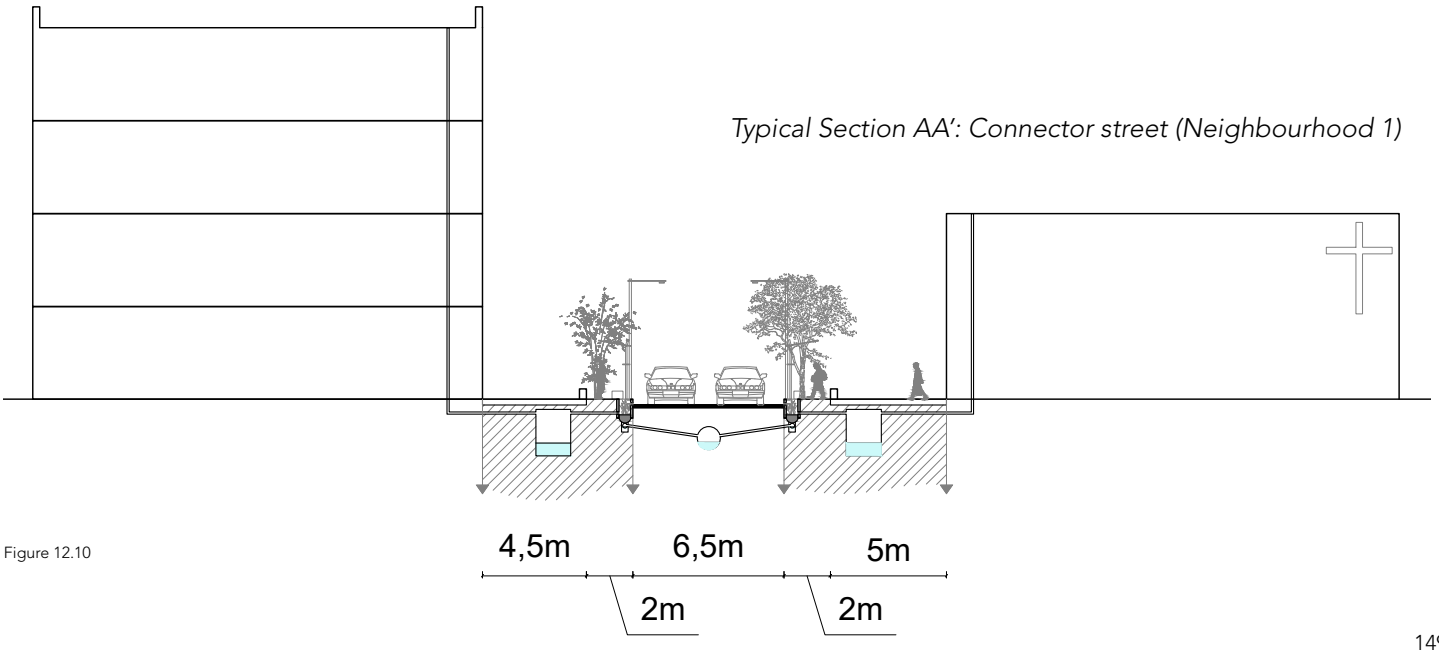


Figure 12.10

AVAILABLE OPEN SPACE FOR USE

These spaces are those which can be programmed for public access and activity. These are mainly designed with a specific purpose and mandatorily accommodate soft surface landscape for infiltration.

Sq. m	1	2	3	4	5
Size	1116.73	1722.90	272.92	518.46	6950.73
Shape	Linear	Linear	Square	Square	Rectangular
Activity	Entrance square and spillover space to public building	Entrance park and spillover space to residential building	Bio-rentention Pond	Bio-rentention Garden with basic street furniture	Cemetery designed as Permeable landscape
Hydrology	Infiltration	Infiltration	Bio-retention + Infiltration	Bio-retention + Infiltration	Infiltration
Quality	Paved to green design transition	Paved to green design transition	Unmanaged currently - shift to green design	Unmanaged currently - shift to green design	Unmanaged currently - shift to green design
Maintenance	Maintained by public building authority	Maintained by residents	Maintained by residents	Maintained by residents	Maintained by cemetery organization
Soil type	Clayey	Clayey	Clayey	Clayey	Clayey

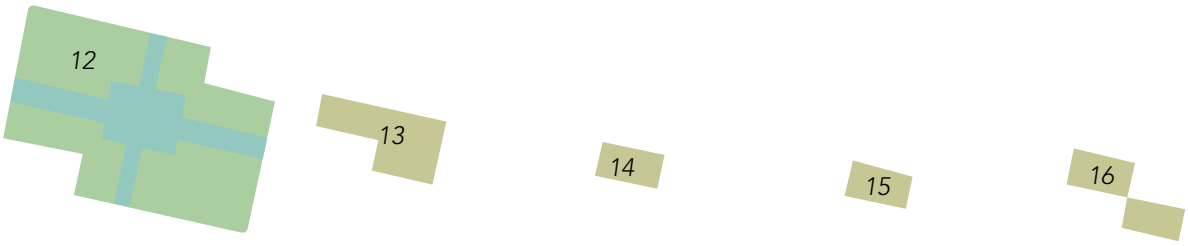
DERELICT / UNMANAGED OPEN SPACE

These spaces are currently unmanaged and will be redesigned as community maintained bio-retention gardens. These are reclaimed from the existing urban fabric and reintegrated into the fabric for the purpose of bringing about water resilience. When this space occurs next to a water body, it functions as a public space.

711.68	*176.84*	*2551.60*	*47.43*	*611.03*	*756.73*
Square	*Square*	*Square*	*Linear*	*Square*	*Irregular*
Bio-rentention Garden with basic street furniture	*Playground design*	*Park designed with permeable landscapes*	*Awareness - Entrance to church complex*	*Bio-rentention Garden with basic street furniture*	*Part of school's open space*
Bio-retention + Infiltration	*Infiltration*	*Infiltration*	*Infiltration*	*Bio-retention + Infiltration*	*Infiltration*
Unmanaged currently - shift to green design	*Green area*	*Paved to green design transition*	*Paved to green design transition*	*Unmanaged currently - shift to green design*	*Designed as garden and playground*
Maintained by residents	*Maintained by school*	*Maintained by residents*	*Maintained by Church*	*Maintained by residents*	*Maintained by School - part of skill training*
Clayey	*Clayey*	*Clayey*	*Clayey*	*Clayey*	*Clayey*

AVAILABLE OPEN SPACE FOR USE

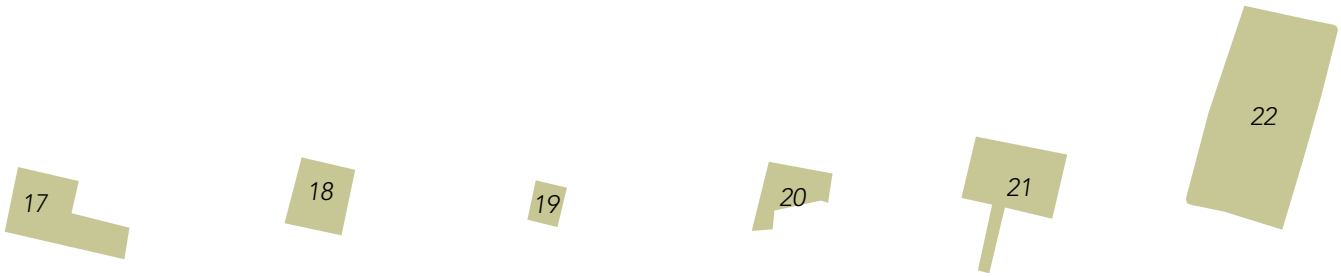
These spaces are those which can be programmed for public access and activity. These are mainly designed with a specific purpose and mandatorily accommodate soft surface landscape for infiltration.



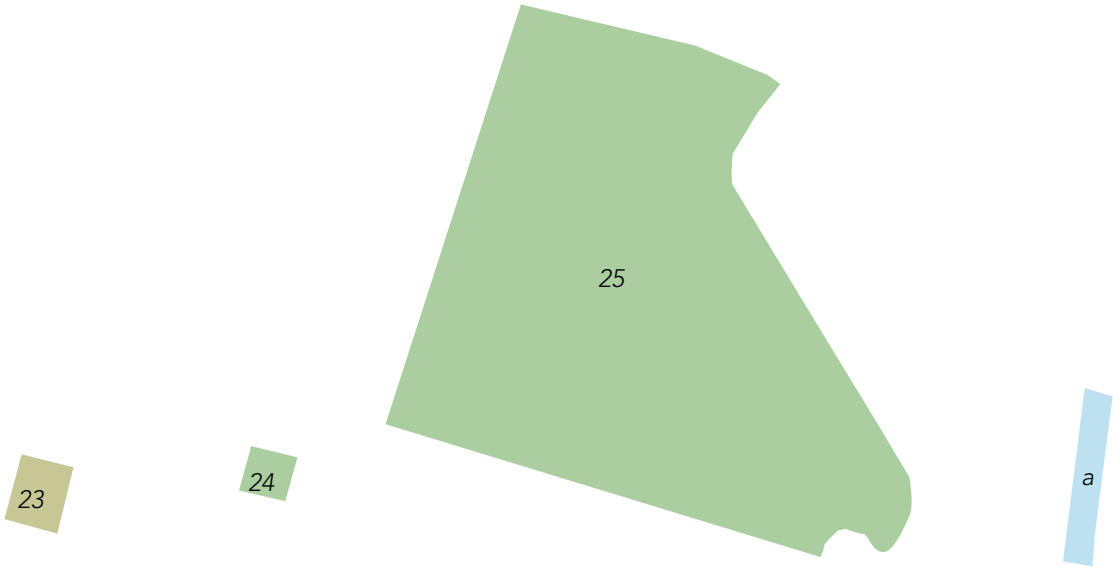
Sq. m	12	13	14	15	16
Size	*7090.06*	*1107.02*	*397.33*	*399.73*	*744.09*
Shape	*Irregular*	*Square*	*Square*	*Square*	*Irregular*
Activity	*Main public space of boulevard - weekly markets, festivals, workshops*	*Bio-rentention Garden with basic street furniture*	*Bio-rentention Garden with basic street furniture*	*Bio-rentention Garden with basic street furniture*	*Bio-rentention Garden with basic street furniture*
Hydrology	*Infiltrate Convey*	*Bio-retention + Infiltration*	*Bio-retention + Infiltration*	*Bio-retention + Infiltration*	*Bio-retention + Infiltration*
Quality	*Designed as urban garden and public space with retention ponds*	*Unmanaged currently - shift to green design*	*Unmanaged currently - shift to green design*	*Unmanaged currently - shift to green design*	*Unmanaged currently - shift to green design*
Maintenance	*Maintained by residents and resident welfare associations*	*Maintained by residents*	*Maintained by residents*	*Maintained by residents*	*Maintained by residents*
Soil type	*Clayey*	*Clayey*	*Clayey*	*Clayey*	*Clayey*

DERELICT / UNMANAGED OPEN SPACE

These spaces are currently unmanaged and will be redesigned as community maintained bio-retention gardens. These are reclaimed from the existing urban fabric and reintegrated into the fabric for the purpose of bringing about water resilience. When this space occurs next to a water body, it functions as a public space.



1092.09	*678.87*	*678.87*	*712.77*	*1241.22*	*3808.60*
Square	*Square*	*Square*	*Irregular*	*Square*	*Rectangular*
Bio-rentention Garden with basic street furniture	*Bio-rentention Garden with basic street furniture*	*Bio-rentention Garden with basic street furniture*	*Recreational space adjacent to waterbody*	*Temple Square and exhibition area adjacent to temple retention pond*	*Bio-retention pond - designed for public access due to its size*
Bio-retention + Infiltration	*Bio-retention + Infiltration*	*Bio-retention + Infiltration*	*Infiltration*	*Infiltration*	*Bio-retention + Infiltration*
Unmanaged currently - shift to green design	*Unmanaged currently - shift to green design*	*Unmanaged currently - shift to green design*	*Unmanaged currently - shift to green design*	*Designed as festive and culturally significant place*	*Designed as community activity space*
Maintained by residents	*Maintained by residents*	*Maintained by residents*	*Shared and Maintained by residents and temple association*	*Maintained by temple association*	*Maintained by residents and resident welfare associations*
Clayey	*Clayey*	*Clayey*	*Clayey*	*Clayey*	*Clayey*



Sq. m Size	653.53	395.18	30743.39	900.83
Shape	Square	Square	Irregular	Linear
Activity	Recreational space adjacent to waterbody	Residential open + shared space	End of boulevard - existing bird watching area designed as attraction	Catchment Tank
Hydrology	Bio-retention + Infiltration	Infiltration	Infiltrate Convey	Retain, Infiltrate
Quality	Unmanaged currently - shift to green design	Residential shared space	Designed as urban recreation spot	Needs to be strengthened - currently a swamp
Maintenance	Maintained by residents	Maintained by residents	Maintained by governmental bodies	Part of cemetery organization
Soil type	Clayey	Clayey	Clayey	Clayey

WATER BODY

These water bodies are designed to retain water and the edges are designed as an extension of the pedestrian spine

841.99	*1652.66*	*1339.25*	*1346.78*	*1379.04*	
Linear	*Irregular*	*Irregular*	*Rectangular*	*Square*	*Irregular*
Retention Tank	*Retention Tank*	*Part of temple complex - retention*	*Part of temple complex - retention*	*Retention tank and public space next to school*	*Wetland - Main collection and catchment points before draining into outlet*
Retain, Infiltrate	*Retain, Infiltrate*	*Retain, Infiltrate*	*Retain, Infiltrate*	*Retain, Infiltrate*	*Infiltrate Convey*
Needs to be strengthened - currently a swamp	*Designed as retention landscape*	*Designed as retention landscape*	*Designed as retention landscape*	*Needs to be strengthened - currently a swamp*	*Designed as urban lung - biodiversity hub*
Part of boulevard's responsibility	*Shared and Maintained by residents*	*Shared and Maintained by residents and temple association*	*Maintained by temple association*	*Maintained by School - part of skill training*	*Maintained by governmental bodies*
Clayey	*Clayey*	*Clayey*	*Clayey*	*Clayey*	*Clayey*

Proposed Civic engagement strategies and landscape surfaces connected to it , each with a specific purpose.

1. Collaborate

Maintenance and restoration of the environment and water network


CLEAN-UP ACTIVITY


PLANTATION ACTIVITY

2. Interact

Build feeling of community and social capital - crucial for community resilience


SIT-OUTS


INTERACTIVE SPACES


PUBLIC SPACES


PLAYGROUNDS


SMALL MARKETS AND COMMERCIAL


CONGREGATIONS


COMMUNITY ACTIVITIES


PEDESTRIAN ACTIVITY


PEDESTRIAN FRIENDLY SPACES


INTERACTIVE SPACES


COMMERCIAL FACADE


SPORTS

3. Participate

Take part in ongoing processes and decision making. Making the process more inclusive


EMPOWERING CIVIC BODIES

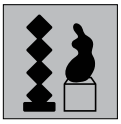

EXPRESSION / PARTICIPATION

4. Educate

Spreading awareness about the environment and the importance of the different components of the water network


INFORMATION BOARDS

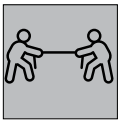

GRAFFITI FESTIVALS


ART INSTALLATIONS


CULTURE FESTIVALS


PAINTING FESTIVALS


STUDENT CLUBS


COMPETITIONS


WORKSHOPS


PERFORMANCE / FESTIVALS


RELIGIOUS ORGANISATIONS


PERFORMANCES


SCHOOL PROGRAMMES

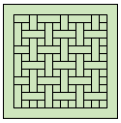

DRINKING WATER POINTS


VOCATIONAL / SKILL TRAINING

Landscaping Surfaces


BIO-SWALES


PERMEABLE SURFACE


PERMEABLE PAVEMENT


BIO-RETENTION GARDENS

Proposed Civic engagement strategies

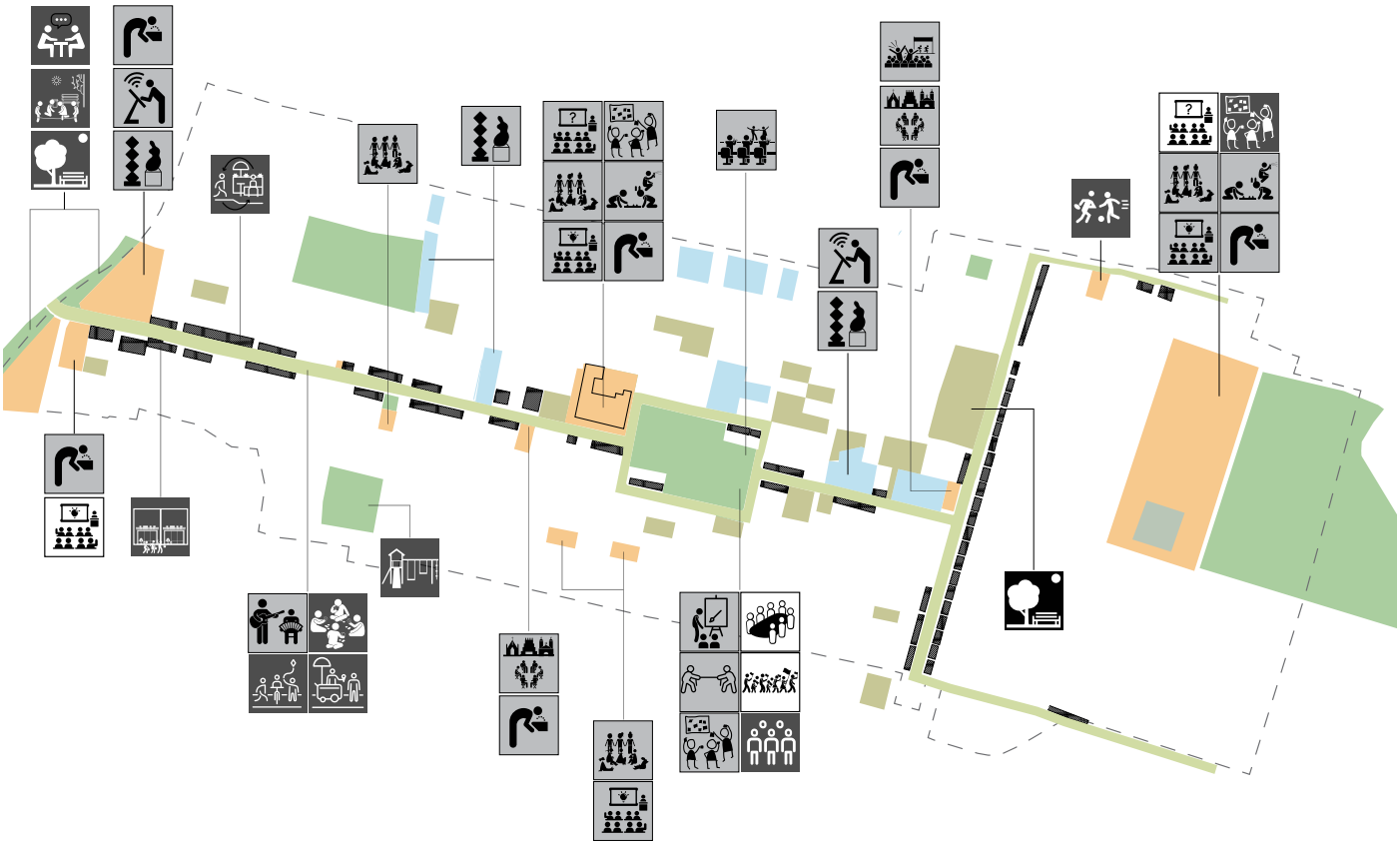


Figure 12.11

Proposed Civic engagement strategies and landscape surfaces connected to it

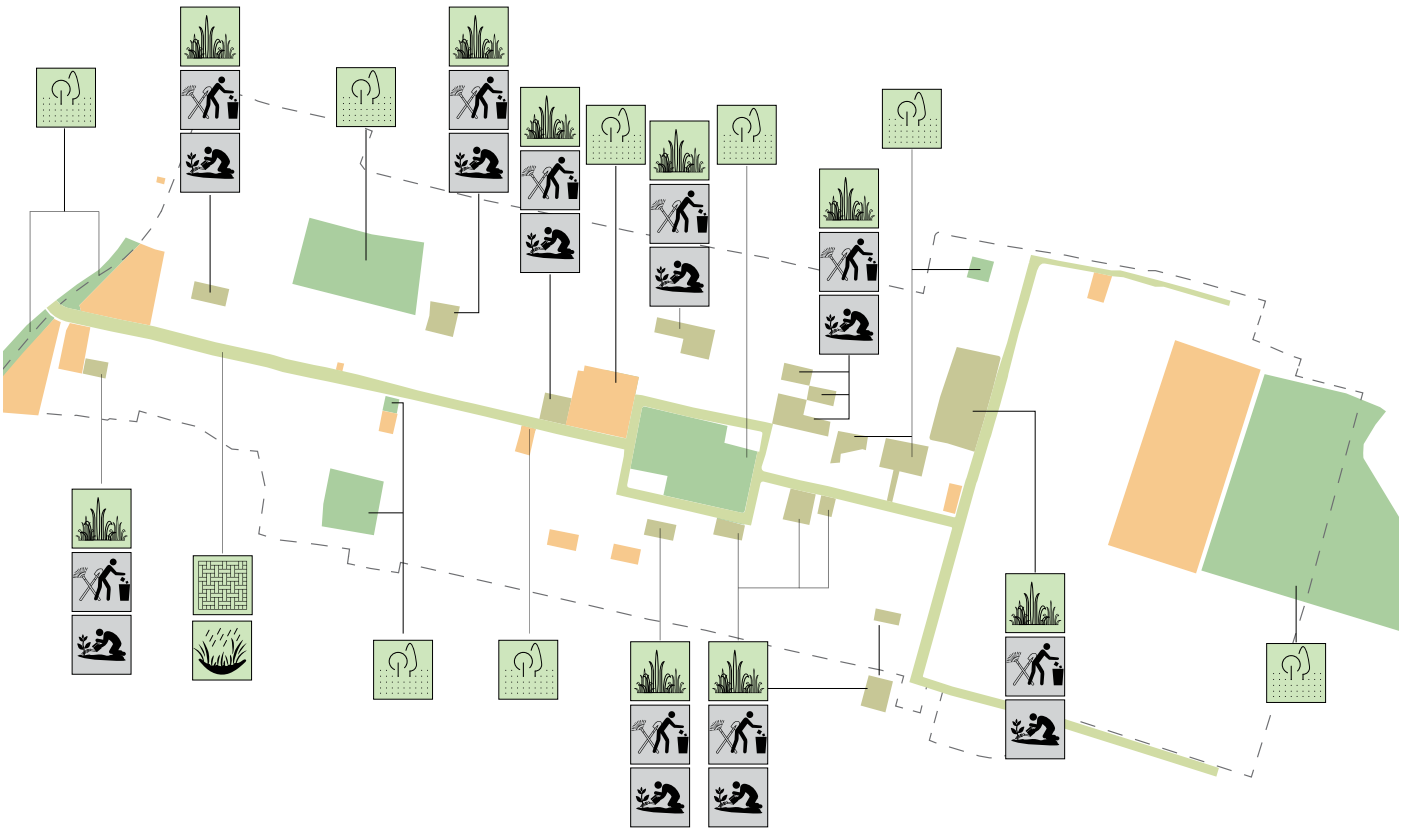


Figure 12.12

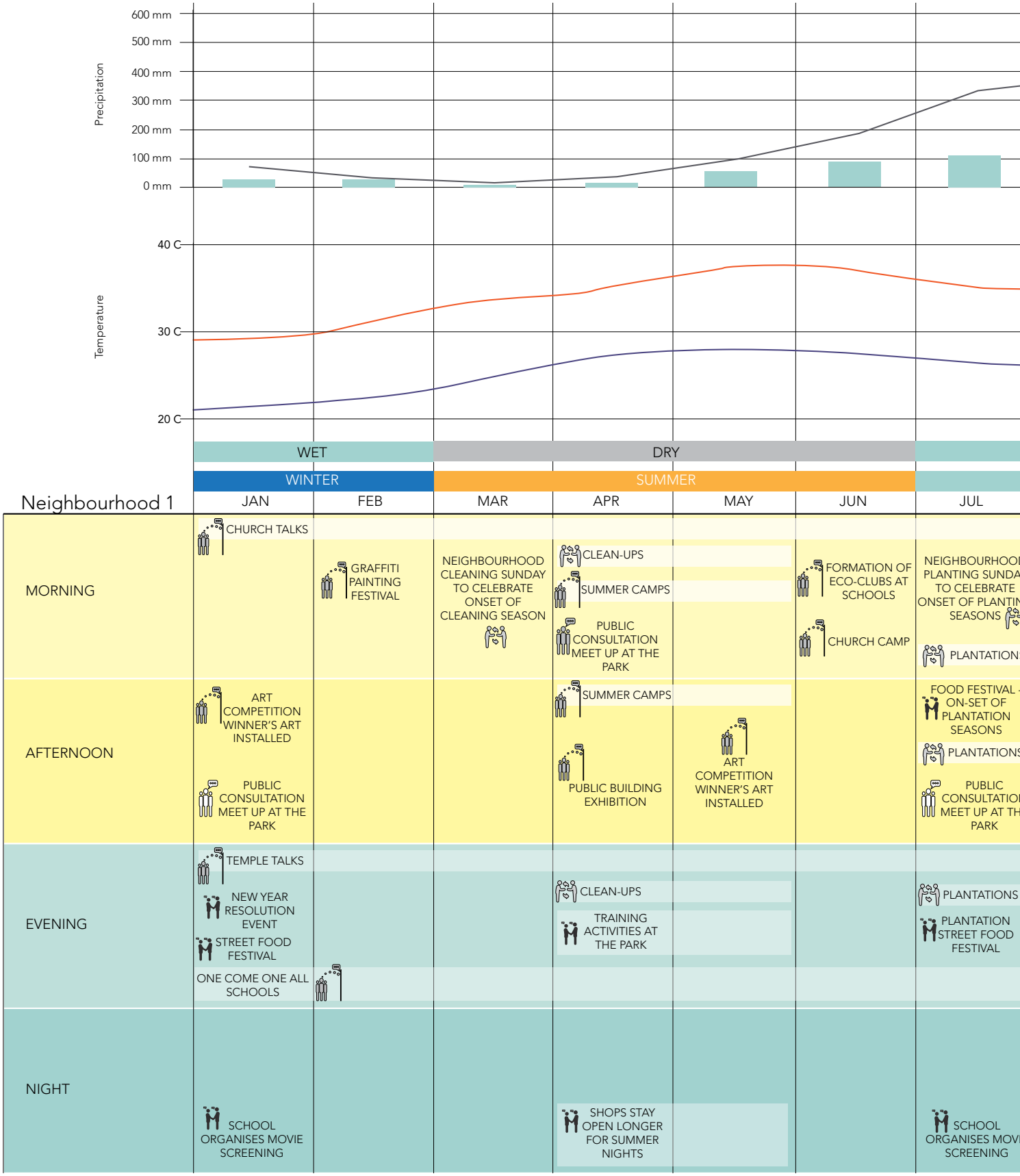
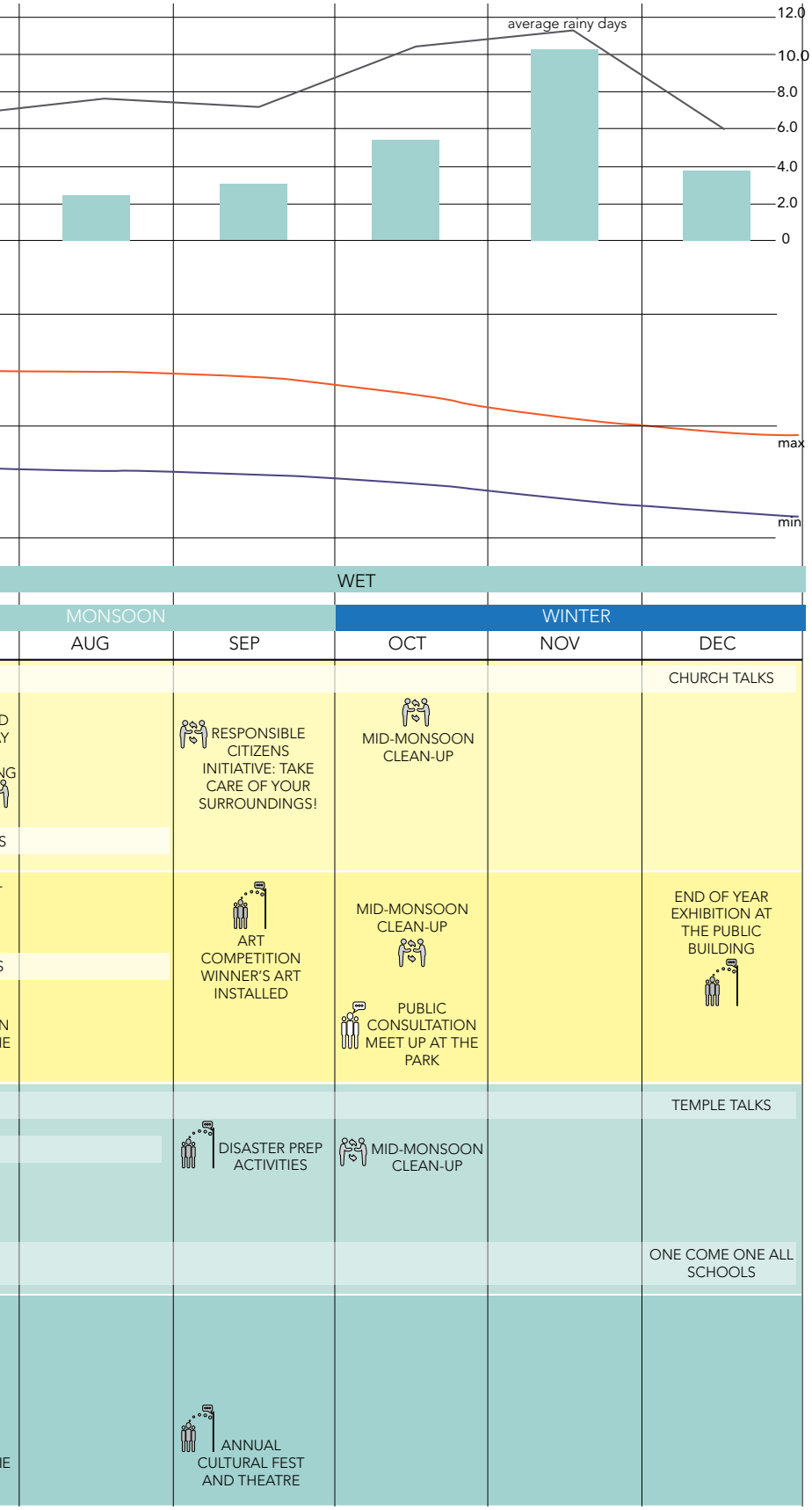

Precipitation
600 mm
500 mm
400 mm
300 mm
200 mm
100 mm
0 mm
Temperature
40 C
30 C
20 C
WET
DRY
WINTER
SUMMER
Neighbourhood 1
JAN
FEB
MAR
APR
MAY
JUN
JUL
MORNING
CHURCH TALKS
GRAFFITI PAINTING FESTIVAL
NEIGHBOURHOOD CLEANING SUNDAY TO CELEBRATE ONSET OF CLEANING SEASON
CLEAN-UPS
SUMMER CAMPS
PUBLIC CONSULTATION MEET UP AT THE PARK
FORMATION OF ECO-CLUBS AT SCHOOLS
CHURCH CAMP
NEIGHBOURHOOD PLANTING SUNDA TO CELEBRATE ONSET OF PLANTIN SEASONS
PLANTATION
AFTERNOON
ART COMPETITION WINNER'S ART INSTALLED
PUBLIC CONSULTATION MEET UP AT THE PARK
SUMMER CAMPS
PUBLIC BUILDING EXHIBITION
ART COMPETITION WINNER'S ART INSTALLED
FOOD FESTIVAL - ON-SET OF PLANTATION SEASONS
PLANTATIONS
PUBLIC CONSULTATIO MEET UP AT TH PARK
EVENING
TEMPLE TALKS
NEW YEAR RESOLUTION EVENT
STREET FOOD FESTIVAL
ONE COME ONE ALL SCHOOLS
CLEAN-UPS
TRAINING ACTIVITIES AT THE PARK
PLANTATIONS
PLANTATION STREET FOOD FESTIVAL
NIGHT
SCHOOL ORGANISES MOVIE SCREENING
SHOPS STAY OPEN LONGER FOR SUMMER NIGHTS
SCHOOL ORGANISES MOVI SCREENING

Figure 12.13

Event Programming based on climate data



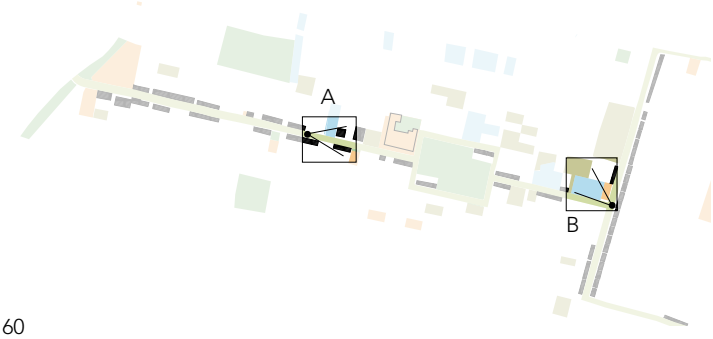
Based on Climate data and seasonal variations, civic engagement activities are planned across the year to ensure maximum efficiency.

Festivals and calendar dates can further be detailed to mark specific occasions and milestones. These are mainly to maximize engagement and to make the local citizens aware of the activities taking place. Further, these can be linked to regular and seasonal activities such as summer camps, church days, religious festivals etc.

In addition to weather and seasons, day and night activities can further respond to the ongoing activities and daily routines of the people. The idea of this activity planning to interweave together as much as possible, restoration, awareness and community building activities.

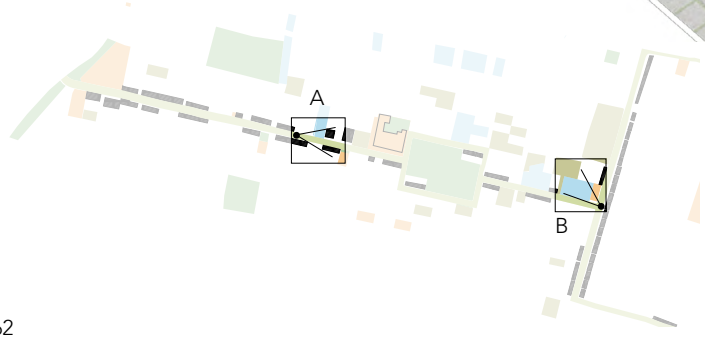

We have to keep our premises clean to attract more people!
I will come back here next weekend for the clean up!
So convenient to have all daily needs
Look at
piece nex
Wond
m
Inner Wear Shop
Women
Kids
SKS ENTERPRISES
JOCKEY
SALE
50%
FRUIT SHOP

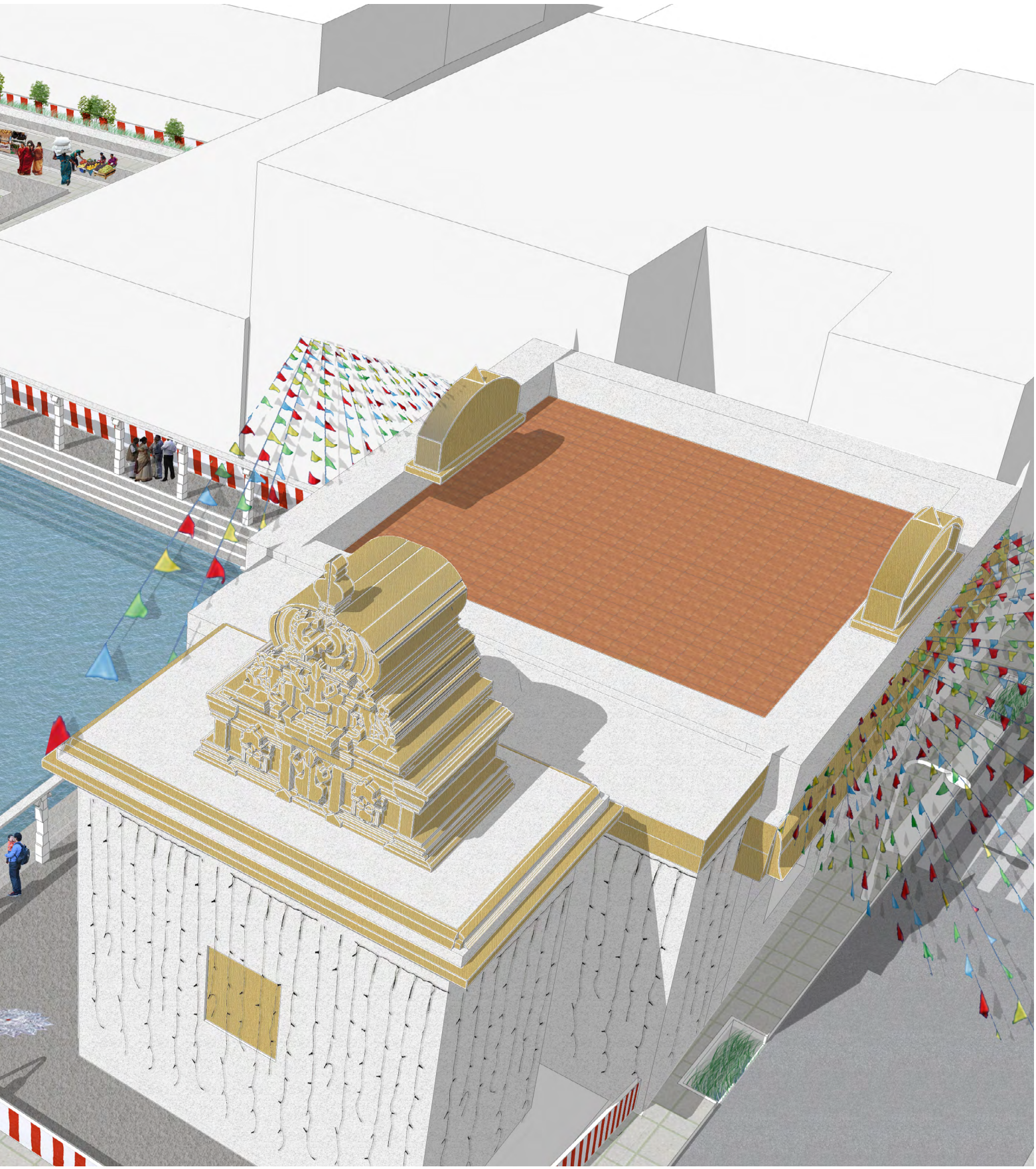
Figure 12.14


A
B

Residential neighbourhood with main connector street retrofitted with social-economic functions in order to make citizens more aware of their surroundings and in turn engage with the environment.

Figure 12.15

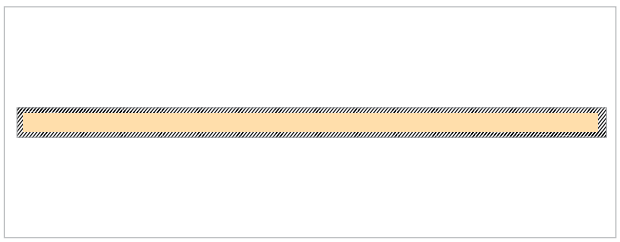




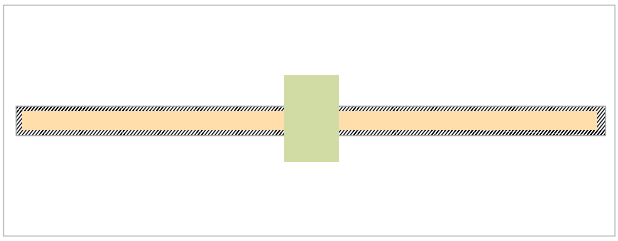
Spatial impression showing proposed conversion of swamp into a water tank activated by the temple complex, derelict open space redesigned as an extended temple festival and market space and relationship to storm water infrastructure and bio-swales.

Step-by-step mapping methodology for resultant scheme

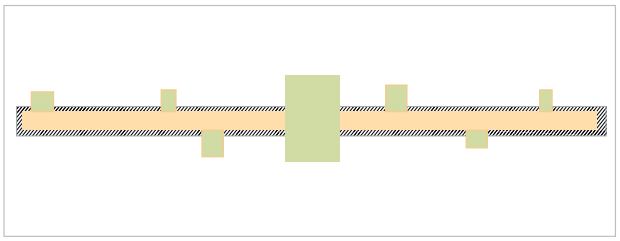
1. The main neighbourhood level connector street is recognised as the main street. This main street forms the main pedestrian spine



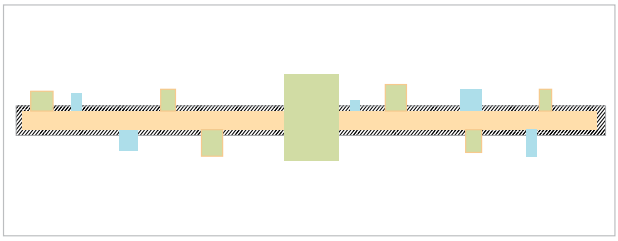
2. Programmes planned along street to in order to spillover activity onto pedestrian area



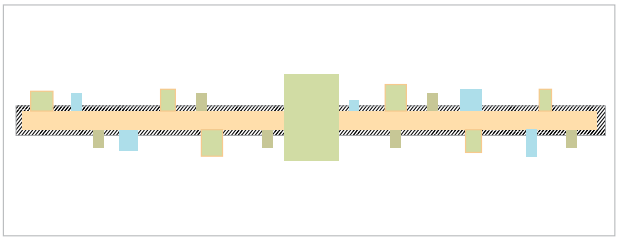
3. Primary public park which houses multiple activities in identified



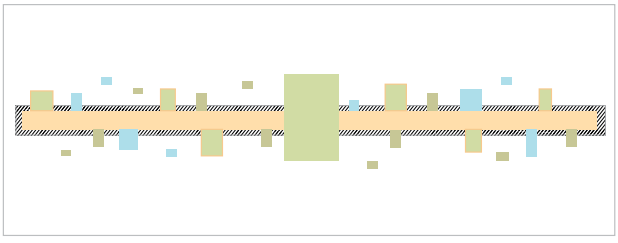
4. Community infrastructure along the connector street identified



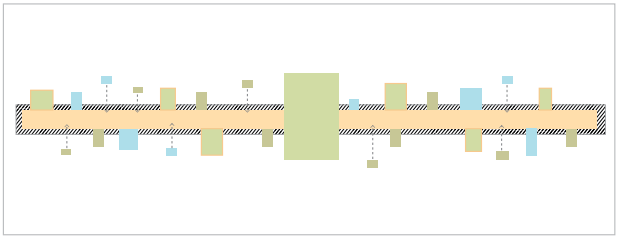
5. Water bodies along the connector street are identified



6. Unmanaged and derelict open spaces along the connector street are identified



7. Waterbodies and unmanaged open spaces in close proximity to the connector street are identified



8. Trenches are designed for streets that directly meet the connector street and close-by waterbodies and unmanaged open spaces are also integrated through these trenches

Figure 12.16

12.1.2. Neighbourhood 2 - ELCOT Special Economic Zone

One of the learnings from the design process of the first neighbourhood was that of a step-by-step methodology which can be used to replicated similar configurations in other neighbourhoods in the region. This methodology could hence be proposed as a strategy to be followed for the design at the nano scale.

Through this strategy, while the principle remain the same, place specificity can be achieved by responding to the direct nature of the neighbourhood. For example, the first neighbourhood was primarily residential and hence the programmes were shaped into those that tap into the daily lives of the residents.

To test this strategy further, a second neighbourhood which mainly industrial was chosen. The methodology from the neighbourhood 1 was applied while responding to the industrial and corporate values of the neighbourhood.

This resulted in a similar configuration of spaces, in term of the recognition of a connector street. In this case, the connector street was in the form of a 'T' as against the linear street in neighbourhood 1.

In this neighbourhood, the activators are identified based on the land-use and functions abutting the connector street. Corporate buildings, playgrounds, parking and corporate housing establishments were identified as possible activators of the connector street. The edge of this connector street was then designed as a pedestrian realm that was specific to its surrounding activities in order to facilitate interaction.

In this connector street, the resultant pattern of programmes and open spaces consisted of community functions, managed open spaces to reflect corporate social responsibilities of corporate stakeholders, managed open spaces for leisure and recreation, water bodies for retention and unmanaged open spaces for bio-retention.

Like in neighbourhood 1, in addition to the social significance of the connector street, this also becomes the drainage channel which carries run-off and conveys it to the nearest infrastructural corridor, wetland or blue-corridor on the micro, meso and macro scales. Hence this connector street plays the role of the integrator. This corridor is retrofitted with relevant storm water infrastructure such as bio-swales, permeable pavements and sub-surface drainage channels.

In order to achieve neighbourhood functionality, the proposed programmes are then further detailed to house specific civic engagement strategies in order to make better places and facilitate human-nature interaction. This interaction is crucial for the larger intention of building social capital, creating awareness and creating a sense of ownership within the residents. In comparison to the first neighbourhood, this one had activities planned based on the values of corporate social responsibilities. This hence played an important role on a city level, where this neighbourhood also gives back to the city through its activities.

The different layers, their significance, subsequent configuration, proposed scheme and proposed engagement strategies are as follows.

Figure 12.17

The available open spaces along the connector street are integrated directly into the scheme.

The derelict or unmanaged open spaces that occur along the connector street are integrated into the scheme directly.

Figure 12.18

In the industrial neighbourhood, the connector street takes the shape of a T. The buildings along the Connector Street are first mapped and their land-use is understood.

Figure 12.19

The water bodies along the connector streets are integrated directly into the scheme.

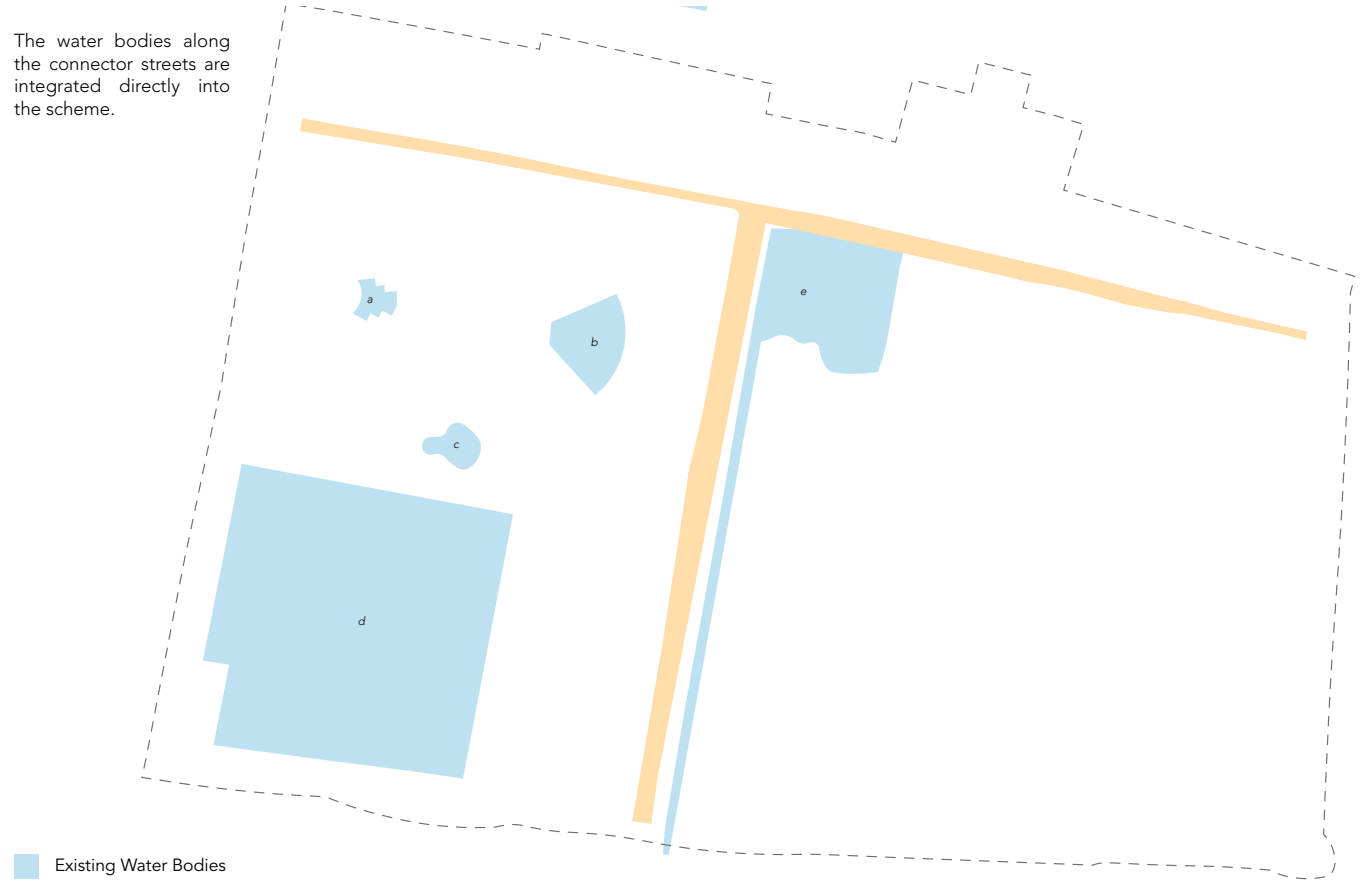


Figure 12.20

The four main land-uses along the connector street are mapped out.

Figure 12.21

Typical Section BB': Connector street (Neighbourhood 2)

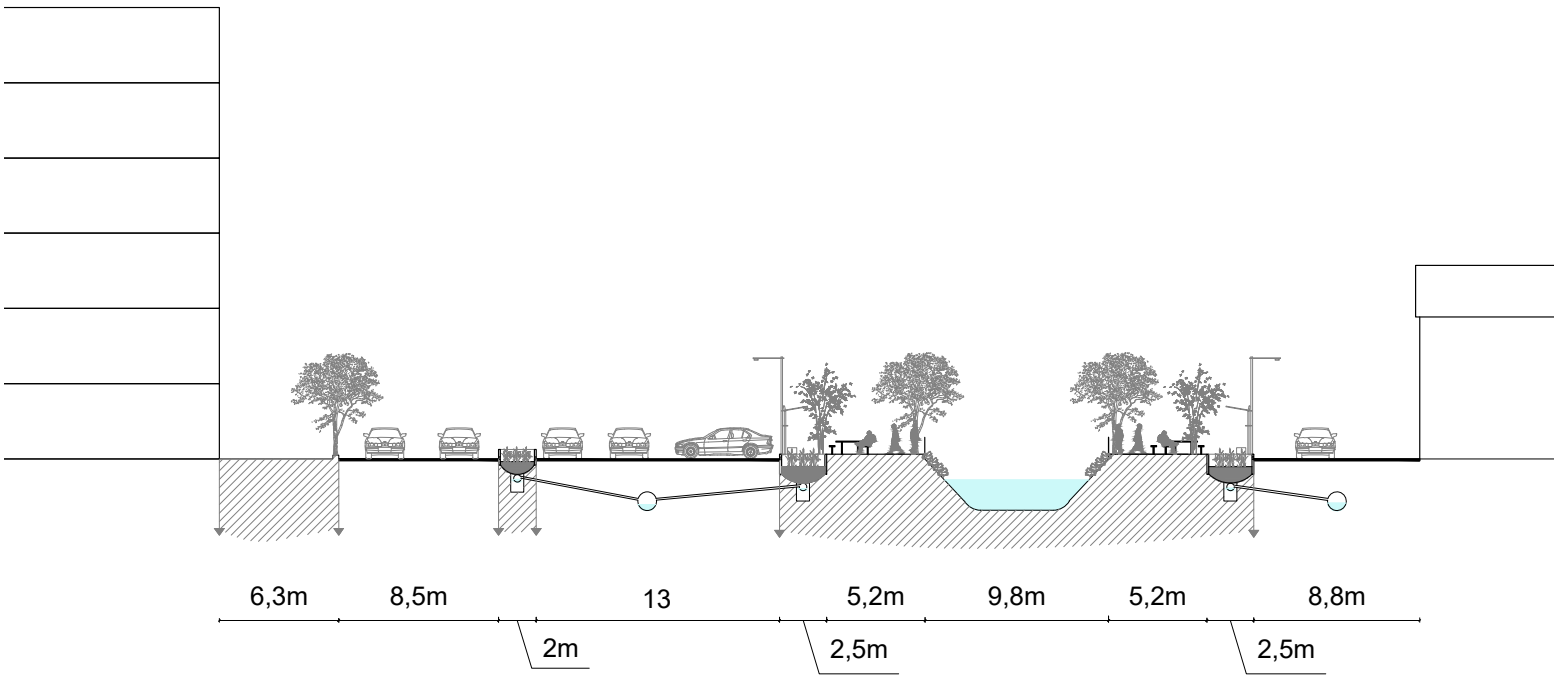


Figure 12.22

The available open spaces and derelict open spaces that occur within the neighbourhood block and that are adjacent to the street are connected to the scheme through underground drainage networks.

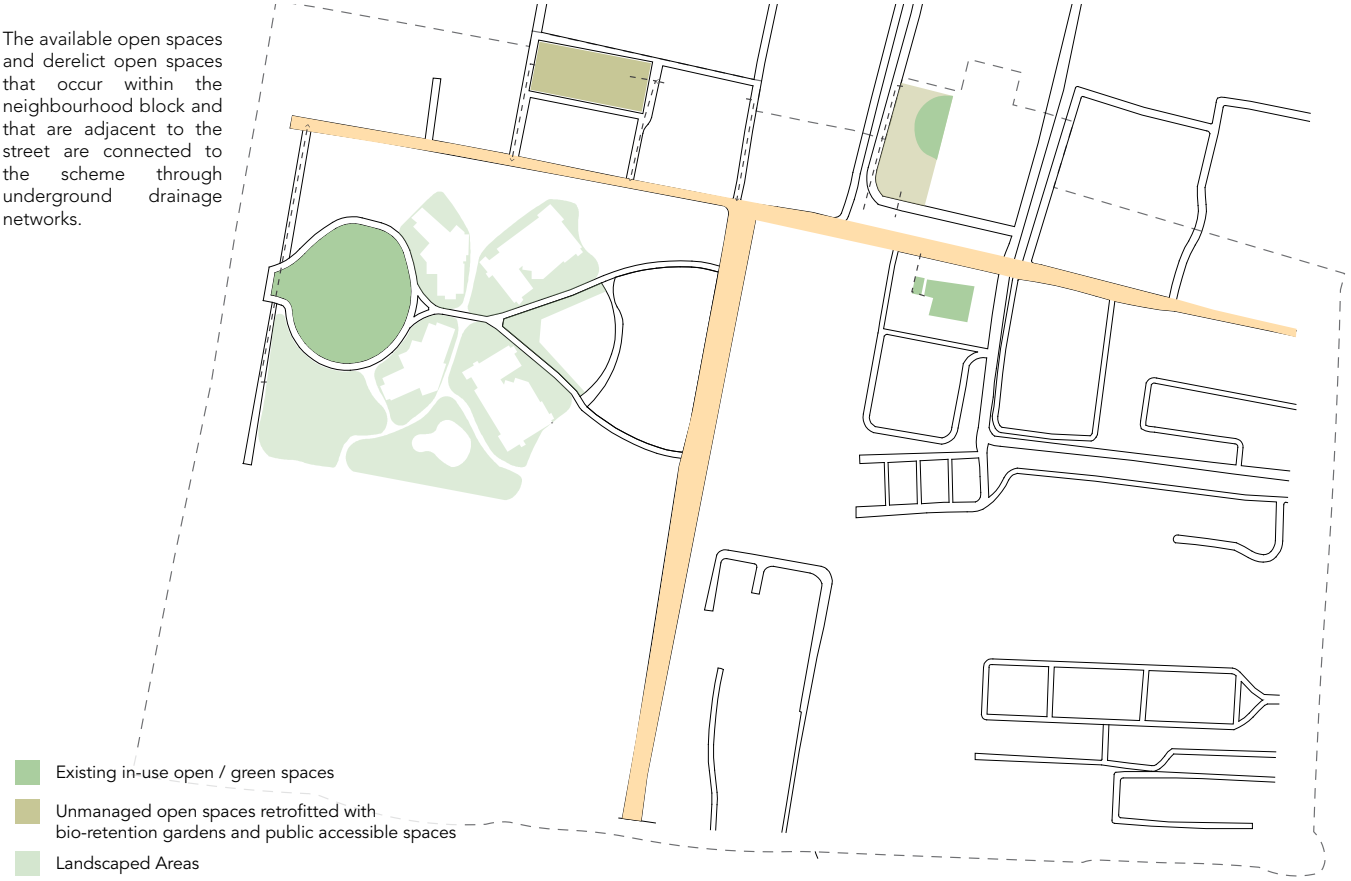


Figure 12.23


1
14
2
6
5
a
7
10
b
8
3
12
4
c
13
9
d
Proposed Connector Street retrofitted with SWD infrastructure
Built up
Industrial and Corporate
Existing Socio-cultural Community infrastructure
Residential
Commercial and Retail
Primary Green-Blue Corridor
Secondary Green-Blue Corridor
Tertiary Green-Blue Corridor
Existing Water bodies
Existing in-use open / green spaces
Unmanaged open spaces retrofitted with bio-retention gardens and public accessible spaces
Residential streets with trench to direct water to main corridor
Landscaped Areas

Figure 12.24


orts
mplex
16
15
20
19
17
18
11
21
e
Shared housing
22
B
B'
Temple
Mosque
0
60m
30m

AVAILABLE OPEN SPACE FOR USE

These spaces are those which can be programmed for public access and activity. These are mainly designed with a specific purpose and mandatorily accommodate soft surface landscape for infiltration.

DERELICT / UNMANAGED OPEN SPACE

These spaces are currently unmanaged and will be redesigned as community maintained bio-retention ponds. These are reclaimed from the existing urban fabric and reintegrated into the fabric for the purpose of bringing about water resilience. When this space occurs next to a water body, it functions as a public space.

	1	2	3	4	5	6
Sq. m Size	*11190.78*	*7348.62*	*9646.43*	*9145.37*	*2115.11*	*2270.58*
Shape	*Square*	*Irregular*	*Irregular*	*Irregular*	*Irregular*	*Irregular*
Activity	*Existing Parking space*	*Bio-retention garden with basic street furniture*	*Existing landscaped grounds of Wipro*	*Bio-retention garden with basic street furniture*	*Existing landscaped grounds of Wipro*	*Existing landscaped grounds of Wipro*
Hydrology	*Infiltration*	*Bio-retention + Infiltration*	*Infiltration*	*Bio-retention + Infiltration*	*Infiltration*	*Infiltration*
Quality	*Currently paved - redesigned with permeable landscape surfaces*	*Existing landscape redesigned with retention ponds*	*Existing landscape redesigned with retention ponds*	*Existing landscape redesigned with retention ponds*	*Currently landscaped with green surfaces*	*Currently landscaped with green surfaces*
Maintenance	*Maintained by Wipro Technologies*	*Maintained by Wipro Technologies*	*Maintained by Wipro Technologies*	*Maintained by Wipro Technologies*	*Maintained by Wipro Technologies*	*Maintained by Wipro Technologies*
Soil type	*Clayey*	*Clayey*	*Clayey*	*Clayey*	*Clayey*	*Clayey*

AVAILABLE OPEN SPACE FOR LNDSCAPE TREATMENT

These spaces are those which can be redesigned to suit surface run-off and better storm water management needs.

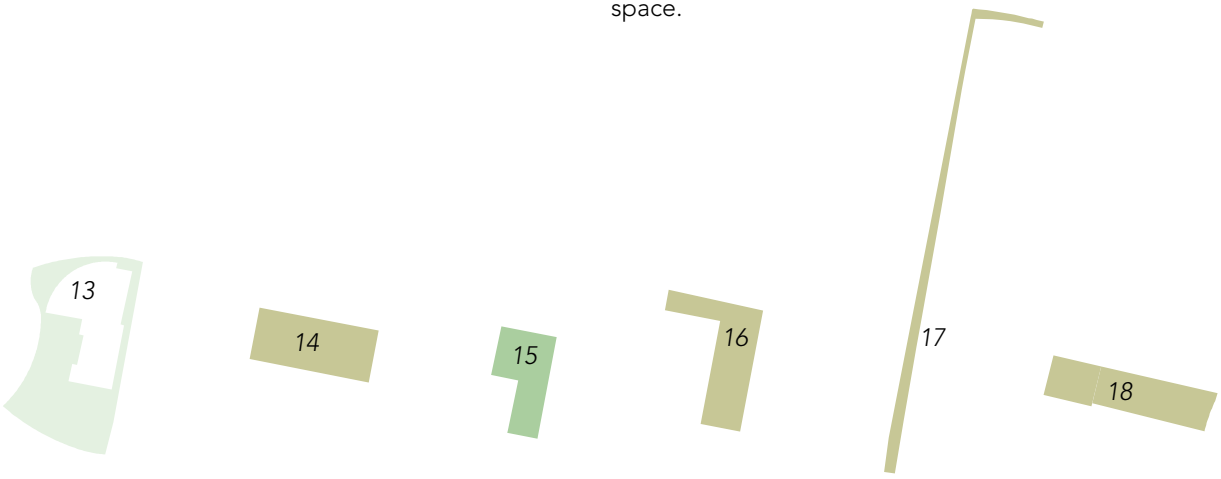
4195.50	*4126.16*	*4744.37*	*6269.20*	*1879.76*	*3255.35*
Irregular	*Irregular*	*Irregular*	*Irregular*	*Irregular*	*Irregular*
Existing landscaped grounds of Wipro	*Existing landscaped grounds of Wipro*	*Existing landscaped grounds of Wipro*	*Existing landscaped grounds of Wipro*	*Existing landscaped grounds of Wipro*	*Existing landscaped grounds of Wipro*
Infiltration	*Infiltration*	*Infiltration*	*Infiltration*	*Infiltration*	*Infiltration*
Currently landscaped with green surfaces	*Currently landscaped with green surfaces*	*Currently landscaped with green surfaces*	*Currently landscaped with green surfaces*	*Currently landscaped with green surfaces*	*Currently landscaped with green surfaces*
Maintained by Wipro Technologies	*Maintained by Wipro Technologies*	*Maintained by Wipro Technologies*	*Maintained by Wipro Technologies*	*Maintained by Wipro Technologies*	*Maintained by Wipro Technologies*
Clayey	*Clayey*	*Clayey*	*Clayey*	*Clayey*	*Clayey*

AVAILABLE OPEN SPACE FOR USE

These spaces are those which can be programmed for public access and activity. These are mainly designed with a specific purpose and mandatorily accommodate soft surface landscape for infiltration.

DERELICT / UNMANAGED OPEN SPACE

These spaces are currently unmanaged and will be redesigned as community maintained bio-retention ponds. These are reclaimed from the existing urban fabric and reintegrated into the fabric for the purpose of bringing about water resilience. When this space occurs next to a water body, it functions as a public space.



	13	14	15	16	17	18
Sq. m Size	*8324.60*	*4643.71*	*3236.70*	*4441.09*	*5533.44*	*149760.82*
Shape	*Irregular*	*Rectangular*	*Irregular*	*Irregular*	*Linear*	*Rectangular*
Activity	*Existing landscaped grounds of Wipro*	*Existing Parking space*	*Sports ground*	*Existing Parking space*	*Leftover space along the street redesigned with sit-outs and art installations*	*Central public park with small gardens*
Hydrology	*Infiltration*	*Infiltration*	*Infiltration*	*Infiltration*	*Infiltration*	*Infiltration*
Quality	*Existing landscape redesigned with retention ponds*	*Currently paved - redesigned with permeable landscape surfaces*	*Currently paved - redesigned with permeable landscape surfaces*	*Currently paved - redesigned with permeable landscape surfaces*	*Unmanaged - redesigned as landscape sit-outs and recreation*	*Unmanaged - redesigned as a public park*
Maintenance	*Maintained by Wipro Technologies*	*Maintained by Wipro Technologies*	*Maintained by Arena Gym*	*Maintained by Arena Gym*	*Maintained by ELCOT SEZ*	*Set up by Elcot SEZ and maintained by corporate companies*
	Clayey	*Clayey*	*Clayey*	*Clayey*	*Clayey*	*Clayey*

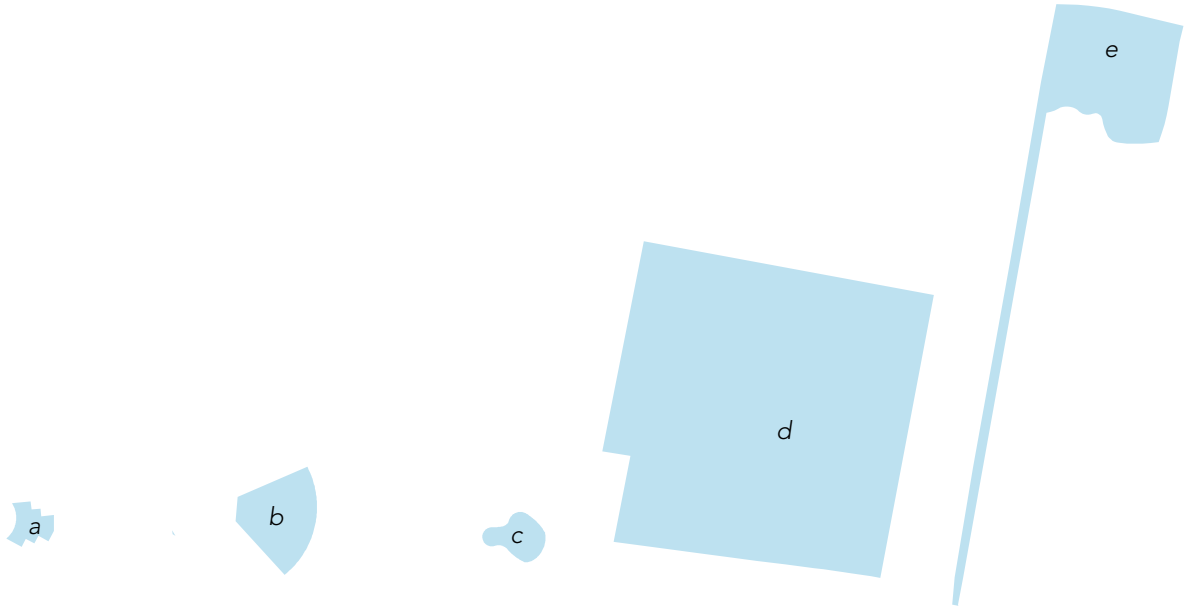
AVAILABLE OPEN SPACE FOR LNDSCAPE TREATMENT

These spaces are those which can be redesigned to suit surface run-off and better storm water management needs.

3032.15	*1207.75*	*1533.32*	*7289.51*
Irregular	*Irregular*	*Irregular*	*Rectangular*
Garden adjacent to the amphitheatre - leisure space	*Amphitheatre*	*Shared space for the apartment complex*	*Common space of the apartment complex*
Infiltration	*Infiltration*	*Infiltration*	*Infiltration*
Unmanaged currently - redesigned with bio-retention landscapes	*Existing permeable landscaping*	*Existing permeable landscaping*	*Currently paved - redesigned with permeable landscape surfaces*
Maintained by Wipro- CDC2	*Maintained by Wipro- CDC2*	*Maintained by residents*	*Maintained by residents*
Clayey	*Clayey*	*Clayey*	*Clayey*

WATER BODY

These waterbodies are designed to retain water and the edges are designed as an extension of the pedestrian spine



Sq. m	a	b	c	d	e
Size	*952.92*	*4047.14*	*1402.29*	*61722.37*	*17138.31*
Shape	*Irregular*	*Irregular*	*Irregular*	*Square*	*Linear*
Activity	*Recreation*	*Recreation*	*Recreation*	*Catchment*	*Catchment*
Hydrology	*Retain, Infiltrate*	*Retain, Infiltrate*	*Retain, Infiltrate*	*Retain, Infiltrate*	*Retain, Infiltrate*
Quality	*Needs to be strengthened - currently a swamp*	*Needs to be strengthened - currently a swamp*	*Needs to be strengthened - currently a swamp*	*Needs to be strengthened - currently a swamp*	*Needs to be strengthened - currently a swamp*
Maintenance	*Part of cemetery organization*	*Part of cemetery organization*	*Part of cemetery organization*	*Part of cemetery organization*	*Part of cemetery organization*
Soil type	*Clayey*	*Clayey*	*Clayey*	*Clayey*	*Clayey*

Proposed Civic engagement strategies and landscape surfaces connected to it , each with a specific purpose.

1. Collaborate

Maintenance and restoration of the environment and water network


CLEAN-UP ACTIVITY


CORPORATE SOCIAL RESPONSIBILITIES


PLANTATION ACTIVITY

2. Interact

Build feeling of community and social capital - crucial for community resilience


SIT-OUTS


PUBLIC SPACES


INTERACTIVE SPACES

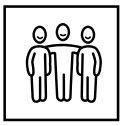

COMMUNITY ACTIVITIES


SPORTS

3. Participate

Take part in ongoing processes and decision making. Making the process more inclusive

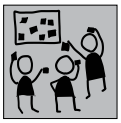

VOCATIONAL / SKILL TRAINING

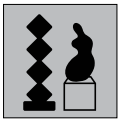

TEAM WORK

4. Educate

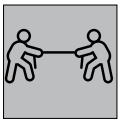
Spreading awareness about the environment and the importance of the different components of the water network


INFORMATION BOARDS


WORKSHOPS


ART INSTALLATIONS


PERFORMANCES


COMPETITIONS

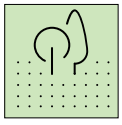

PERFORMANCE / FESTIVALS

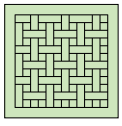

OPEN DAYS THAT INVITE OTHER GROUPS TO THE CAMPUS

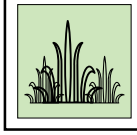

DRINKING WATER POINTS

Landscaping Surfaces


BIO-SWALES


PERMEABLE SURFACE


PERMEABLE PAVEMENT


BIO-RETENTION GARDENS

Proposed Civic engagement strategies

Figure 12.26

Proposed Civic engagement strategies and landscape surfaces connected to it

Figure 12.27

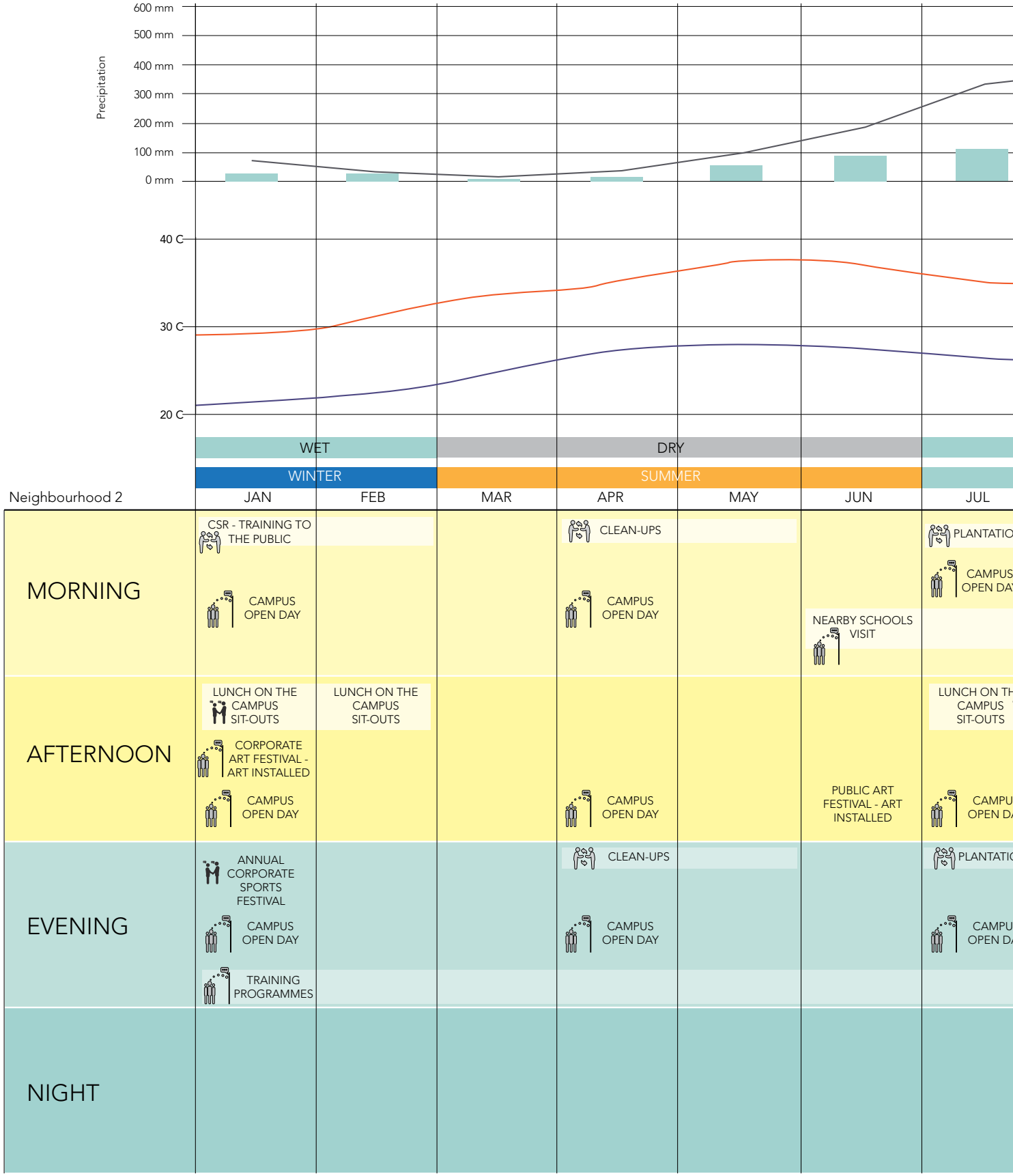
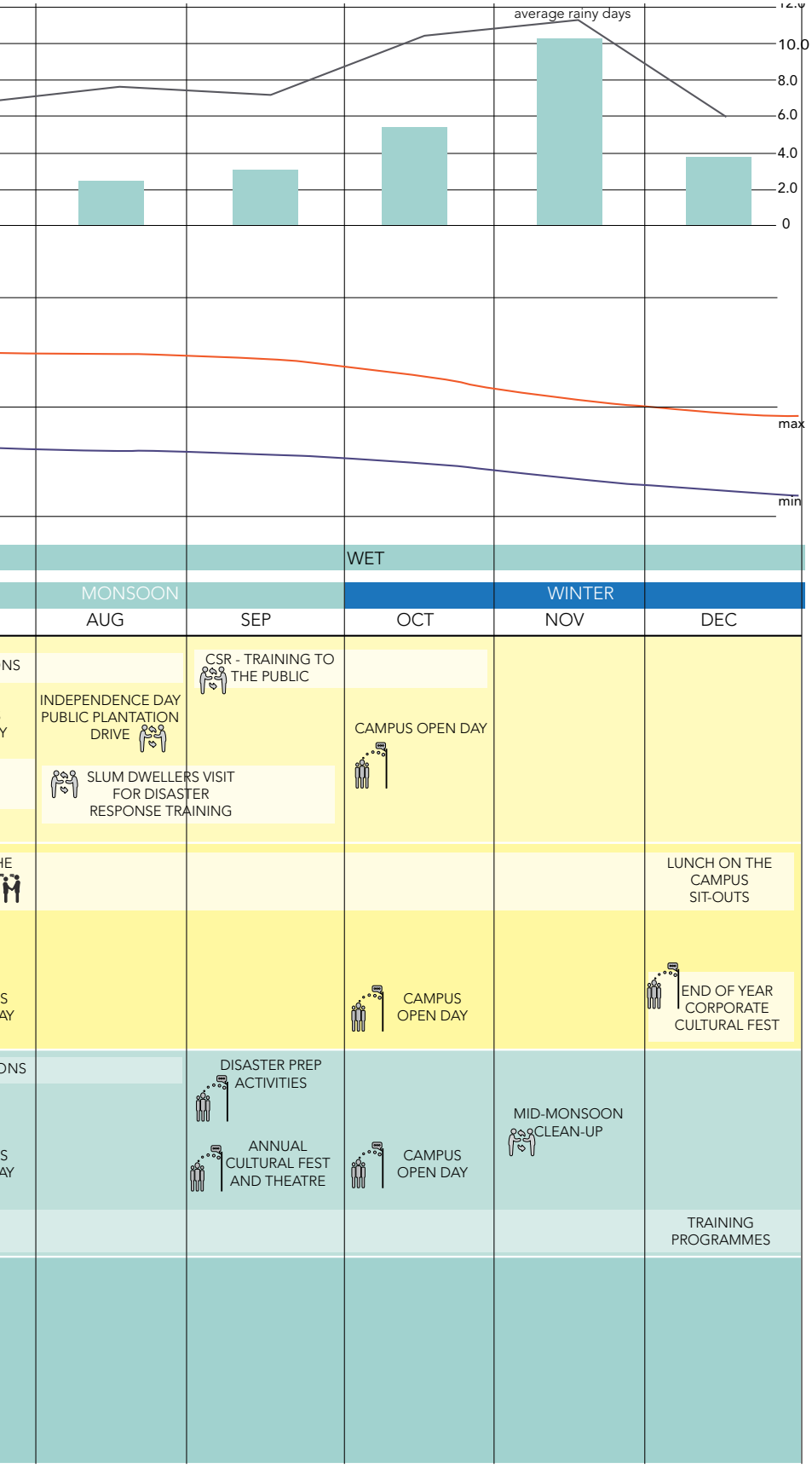

Precipitation
600 mm
500 mm
400 mm
300 mm
200 mm
100 mm
0 mm
40 C
30 C
20 C
WET
DRY
WINTER
SUMMER
Neighbourhood 2
JAN
FEB
MAR
APR
MAY
JUN
JUL
MORNING
CSR - TRAINING TO THE PUBLIC
CAMPUS OPEN DAY
CLEAN-UPS
CAMPUS OPEN DAY
NEARBY SCHOOLS VISIT
PLANTATIO
CAMPUS OPEN DA
AFTERNOON
LUNCH ON THE CAMPUS SIT-OUTS
LUNCH ON THE CAMPUS SIT-OUTS
CORPORATE ART FESTIVAL - ART INSTALLED
CAMPUS OPEN DAY
CAMPUS OPEN DAY
PUBLIC ART FESTIVAL - ART INSTALLED
LUNCH ON TH CAMPUS SIT-OUTS
CAMPU OPEN DA
EVENING
ANNUAL CORPORATE SPORTS FESTIVAL
CAMPUS OPEN DAY
TRAINING PROGRAMMES
CLEAN-UPS
CAMPUS OPEN DAY
PLANTATI
CAMPU OPEN DA
NIGHT

Figure 12.28

Event Programming based on climate data



Based on Climate data and seasonal variations, civic engagement activities are planned across the year to ensure maximum efficiency.

In contrast to the first neighbourhood, corporate social responsibilities can also be configured into this calendar such that people are more aware of the various activities taking place.

Activities such as open days, training programmes, volunteer days etc. are given importance in this scheme in order to mobilise the working class to participate and give back to society as much as possible.

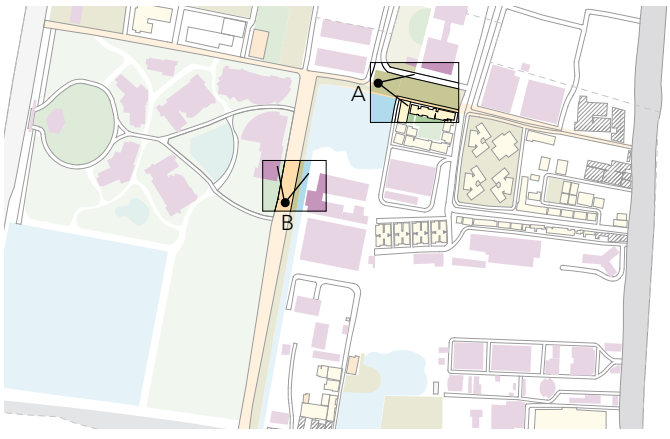
This activity planning can be used an effective tool to also educate the less aware, for example the socio-economically vulnerable. By using CSR, the companies can also extend their outreach to the slum dwellers and urban poor and educate them on the risks involved with flooding and further integrate them into the scheme. Hence, in this way, CSR used as a strategy to address varied vulnerabilities of certain groups and responds to it through awareness programmes and emergency training programmes.

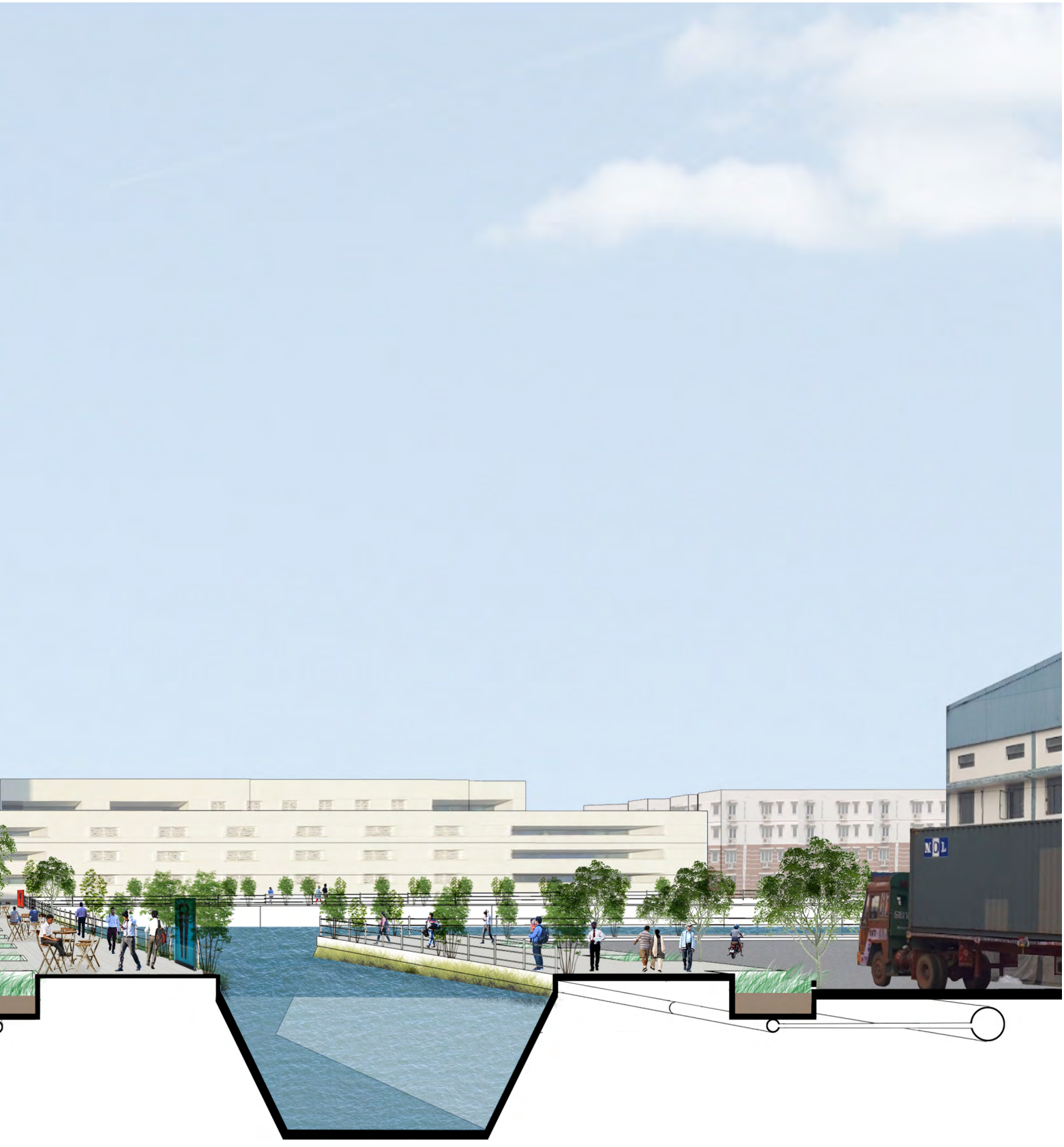

COGNIZANT TRAINING CENTRE
WIPRO TECHNOLOGIES
Wonderful to see all the young pople working together for our city!
This place is such a gift to the nearby residential areas!
I feel socially responsible!
Nice of the company to give us a place to express our work!

Figure 12.29

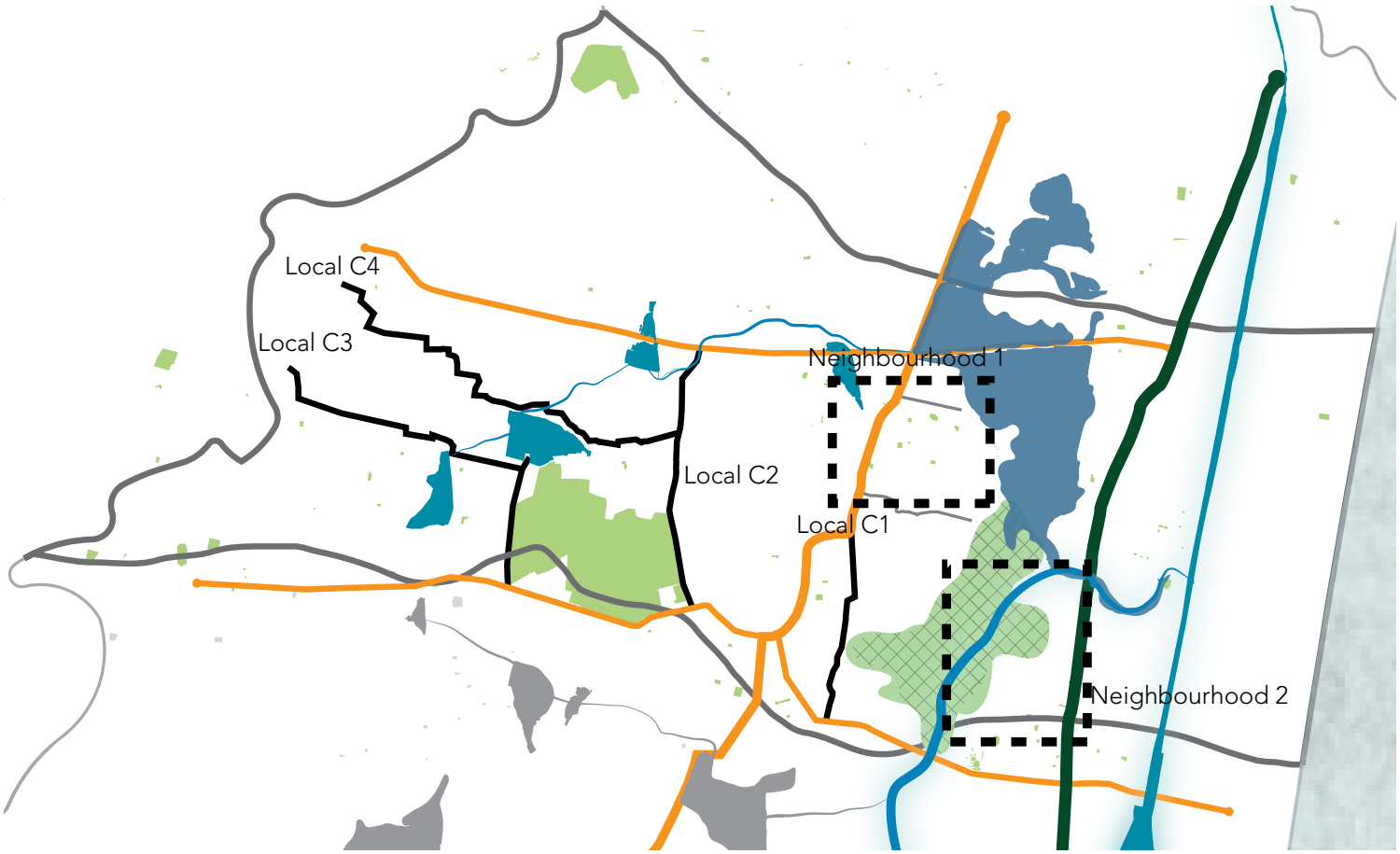
Industrial neighbourhood where a central recreation and bio-retention park is proposed. This becomes a hub for training and awareness activities that the companies carry out as part of Corporate Social Responsibilities.

Figure 12.30





Spatial impression showing connector street and leisure spaces planned for industrial neighbourhood. This becomes a spillover space from the offices as the employees interact with the spaces and nature, during lunch and coffee breaks and while walking around the neighbourhood. Ultimately the intention is to create a increased quality of the working environment.



City level biodiversity hotspot

Wetlands

Mid-catchment water bodies

Primary green-blue corridors

Secondary green-blue corridors

Tertiary green-blue corridors (Local C)

Figure 12.31

Proposed Blue-Green tertiary street

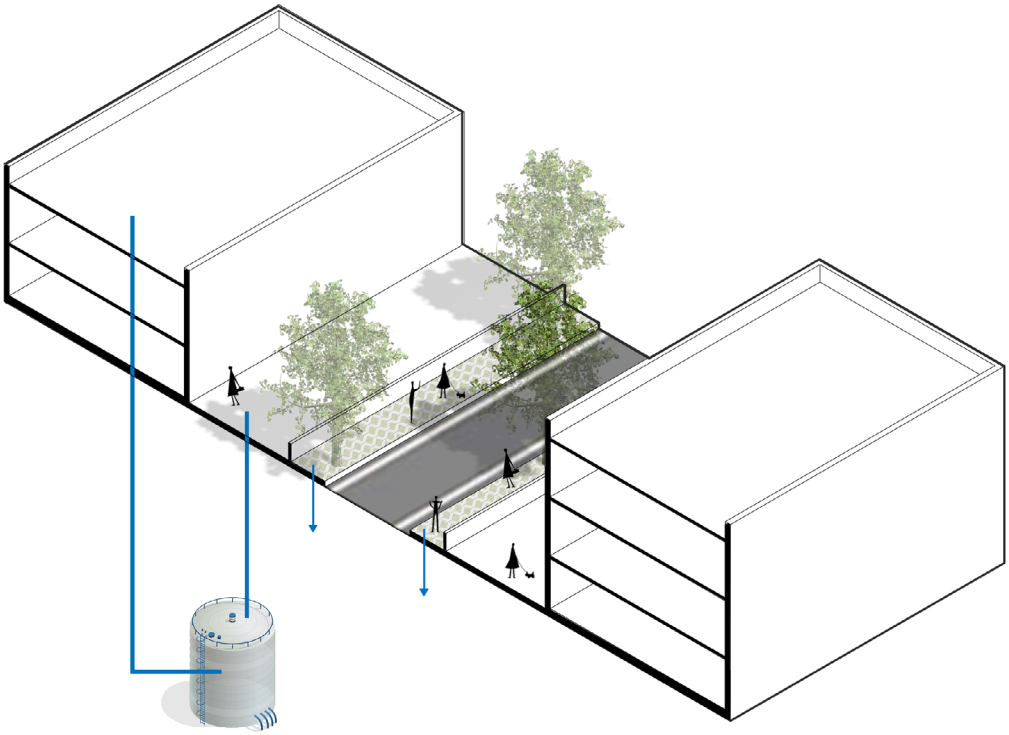


Figure 12.32

12.2. Sub - Watershed

While scaling up, the strategies are designed to make functional, the neighbourhood level strategies. Hence in the micro, meso and macro scales, integrated drainage design is given the main focus.

In the Micro scale of the sub-watershed:
i. All secondary infrastructure that occur along the natural flow of direction of water as designed as green-blue corridors.

ii. Two neighbourhoods of different characters, one mainly residential and one mainly industrial as chosen as test sites for local strategies

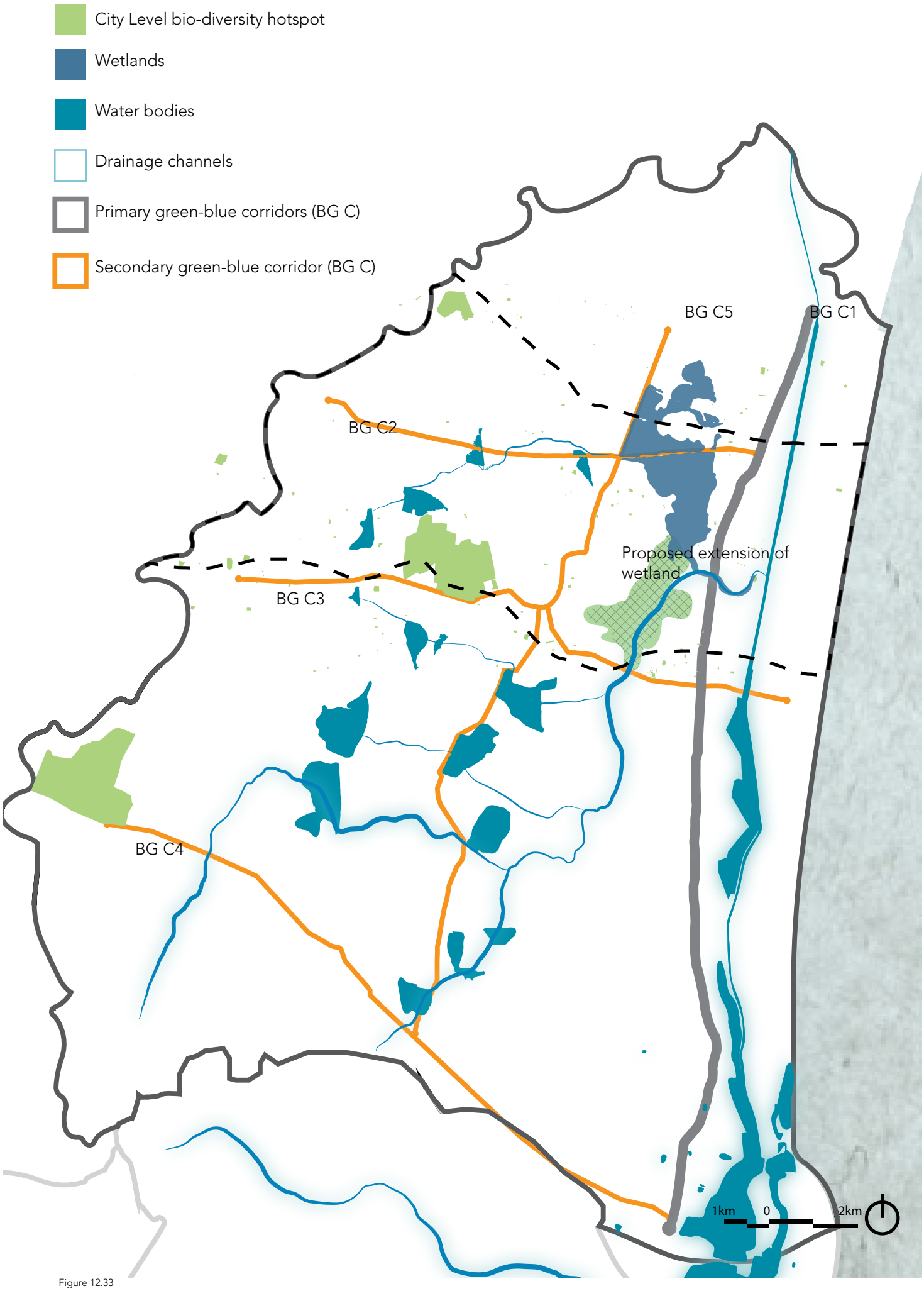

City Level bio-diversity hotspot
Wetlands
Water bodies
Drainage channels
Primary green-blue corridors (BG C)
Secondary green-blue corridor (BG C)
BG C5
BG C1
BG C2
Proposed extension of wetland
BG C3
BG C4
1km
0
2km

Figure 12.33

Wetland extension proposal
Figure 12.34

Proposed section for Blue-Green transit corridors

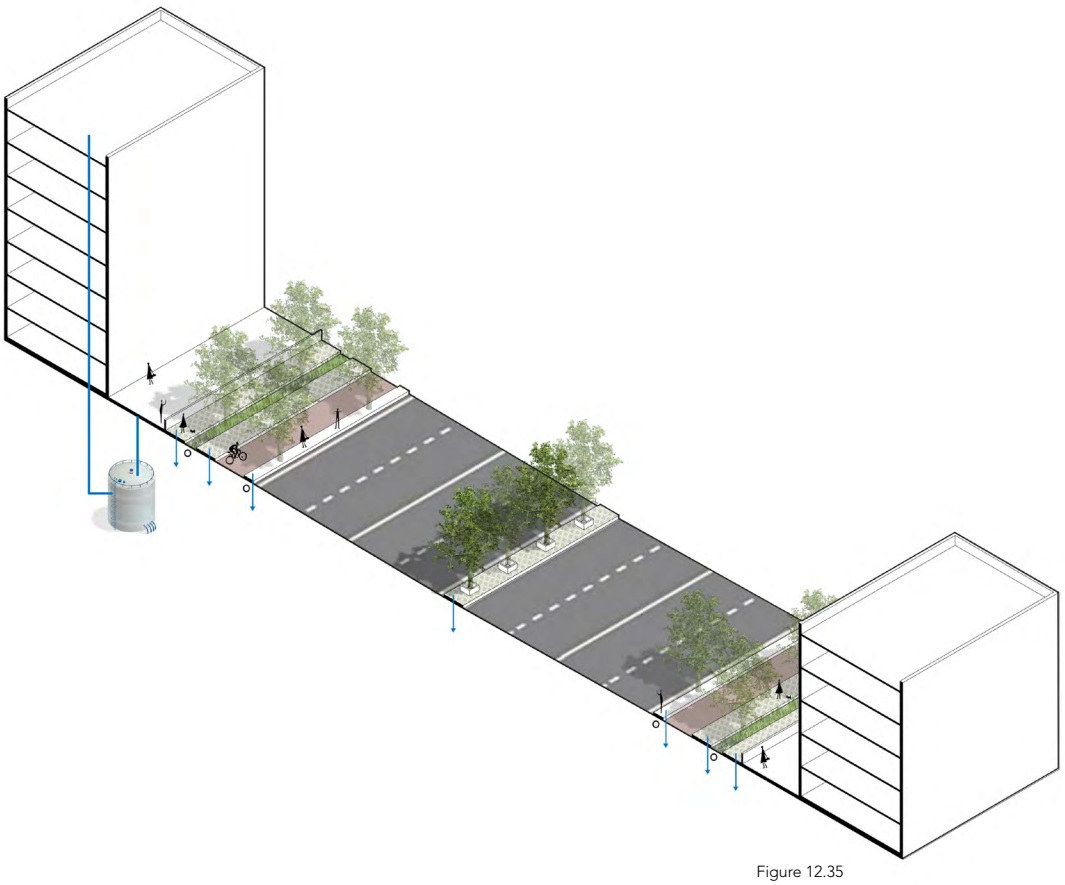


Figure 12.35

12.3. Pallikaranai Watershed

i. The natural drainage channels are designed as blue corridors

ii. All primary infrastructure that occur along the natural flow of water are designed as blue-green corridors to collect and convey storm water runoff. These are designed to support existing blue corridors. Road sections are designed accordingly.

iii. All buildings along these corridors must accommodate soft surface design and must offer front setbacks (6-15m) as soft surfaces.

iv. All buildings along these corridors must design their premises with maximum infiltration capacity.

v. A large drainage and infiltration basin is proposed between BGC2, BGC3 and BGC5 as an extension of the Pallikaranai wetlands. This is designed a large biodiversity hot-spot and also restores the wetlands.

vi. Second order drainage connections are designed smaller blue corridors. Water bodies that occur along these drainage channels are designed as sub-catchments

iv. The Pallikaranai wetlands is designed as the main catchment and leads to the outlet of the Buckingham canal.

Typical Section: Primary and Secondary Blue-Green Corridors

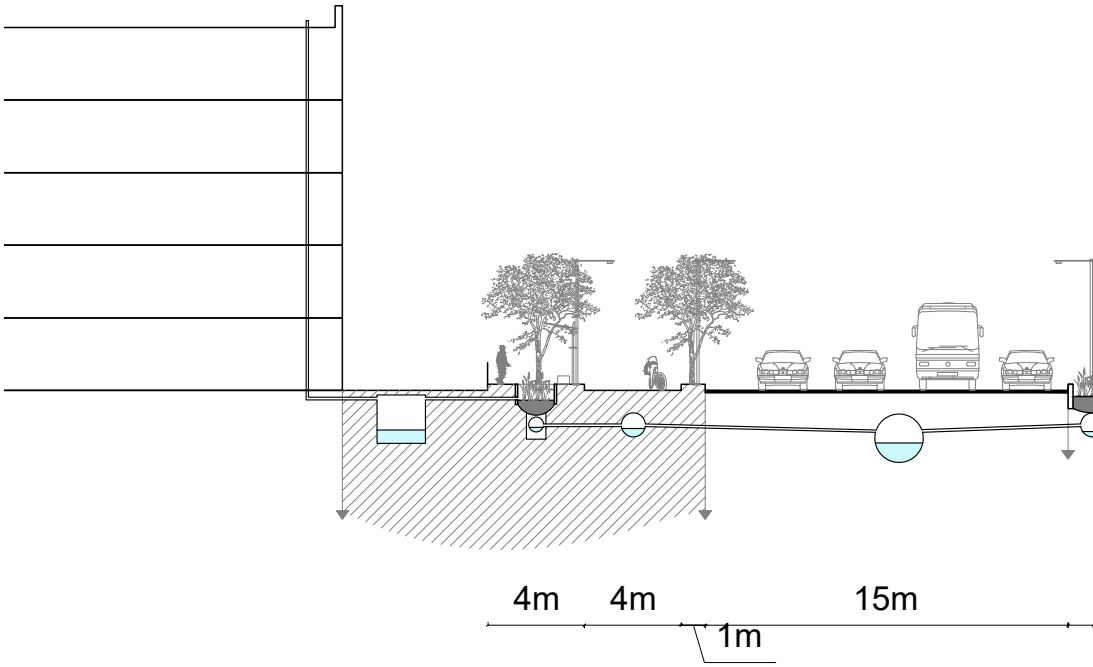


Figure 12.36

Typical Section: Tertiary Blue-Green Corridors

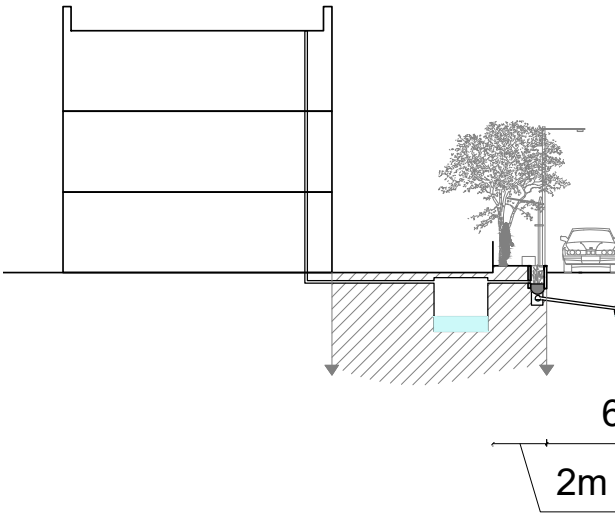
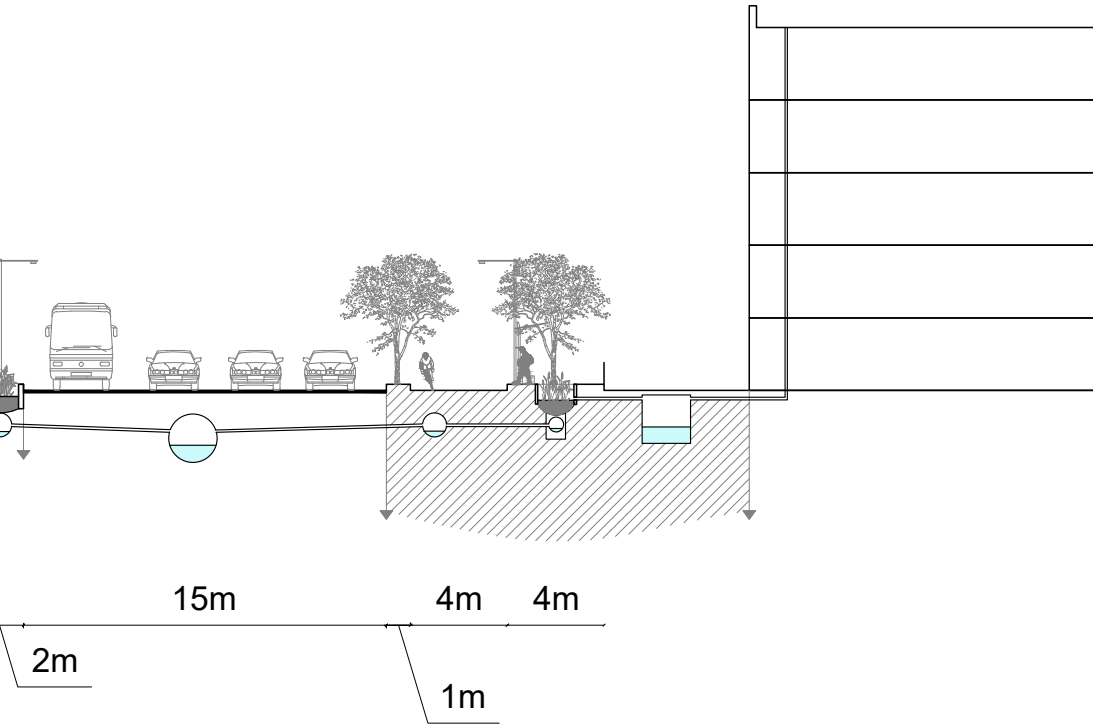
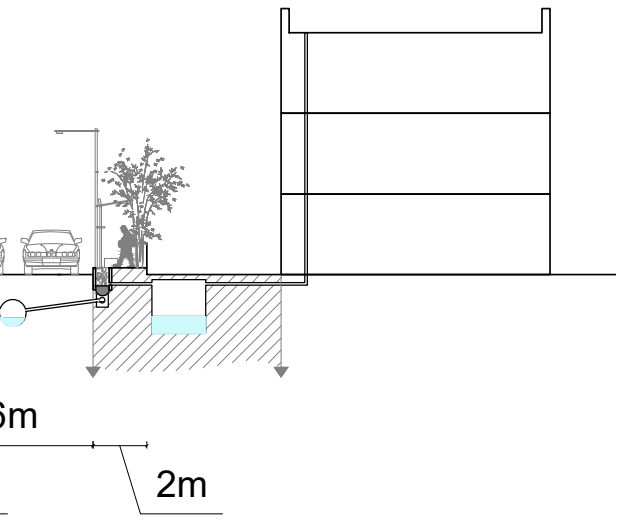


Figure 12.37


15m
4m
4m
2m
1m


6m
2m

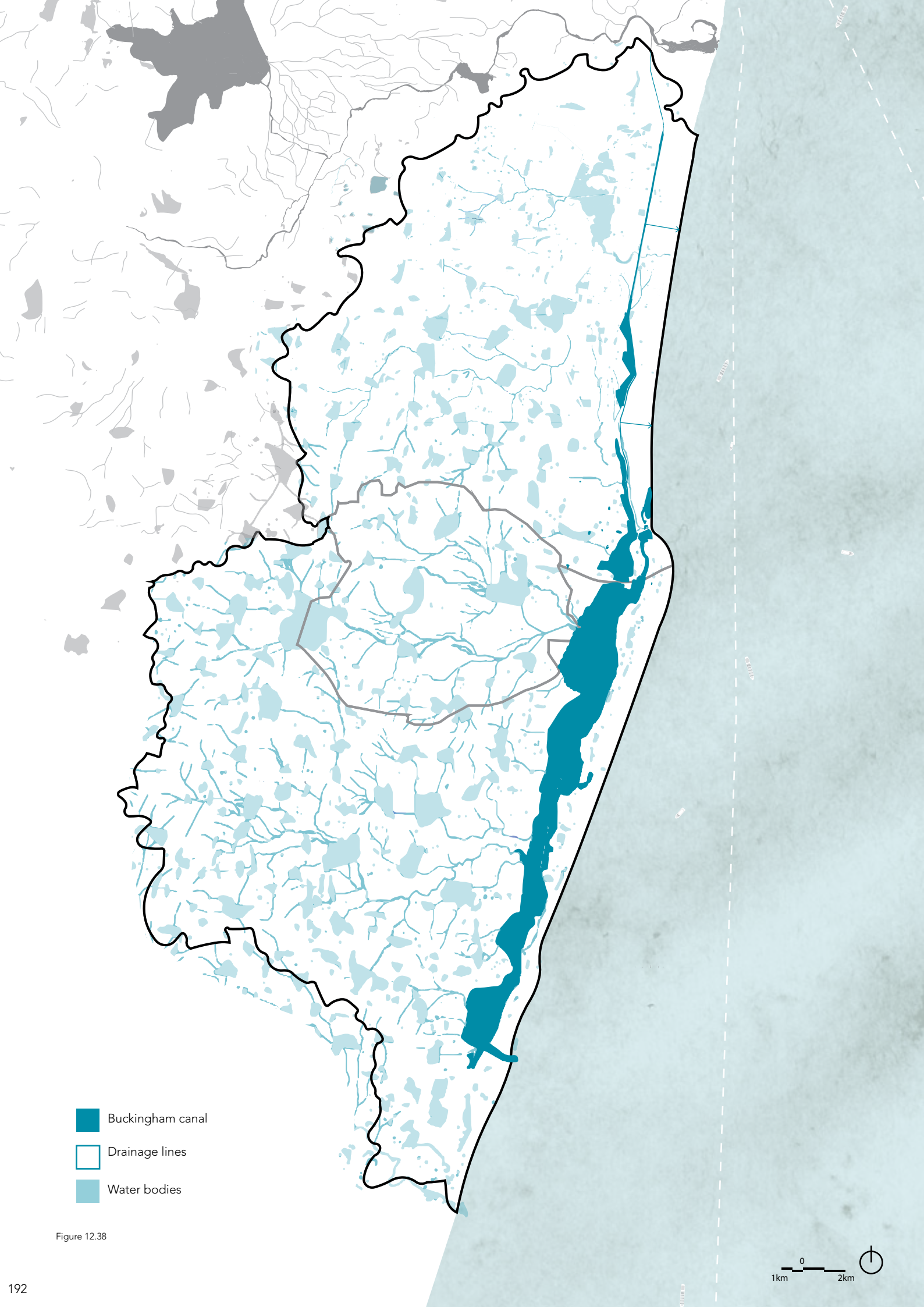


Figure 12.38

12.4. Pallikaranai Sub-basin

i. The outlet which is the Buckingham canal will be optimized to enhance carrying capacity

ii. This outlet is further designed to transition during floods. This extent is marked with a bund or a raised dike.

iii. Edges of the outlet and blue corridor must be permeable and accessible. Only public functions can take place in the edge zones.

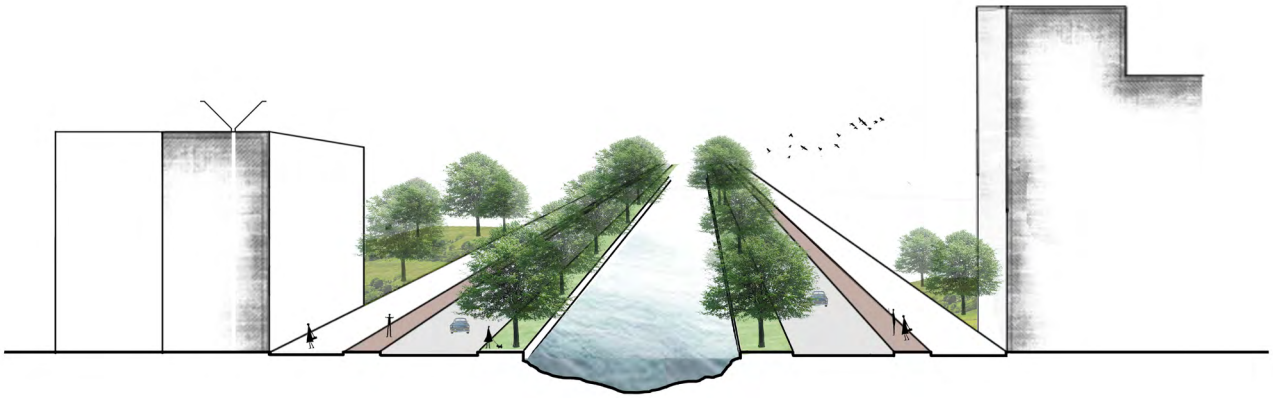
iv. If needed, the outlet will be connected to the sea to unload overflow at the time of disaster. These connections will be manned and controlled.

v. The watershed must drain into the Buckingham canal through the green-blue corridors

vi. The main drainage connections (1st order channels) form the blue corridors.

2 *Impression of the revitalised Buckingham Canal*

Figure 12.39



1 *Impression of the revitalised Buckingham Canal*

Figure 12.40

Figure 12.41

Typical Section: Revitalised Buckingham Canal in outer-city limits

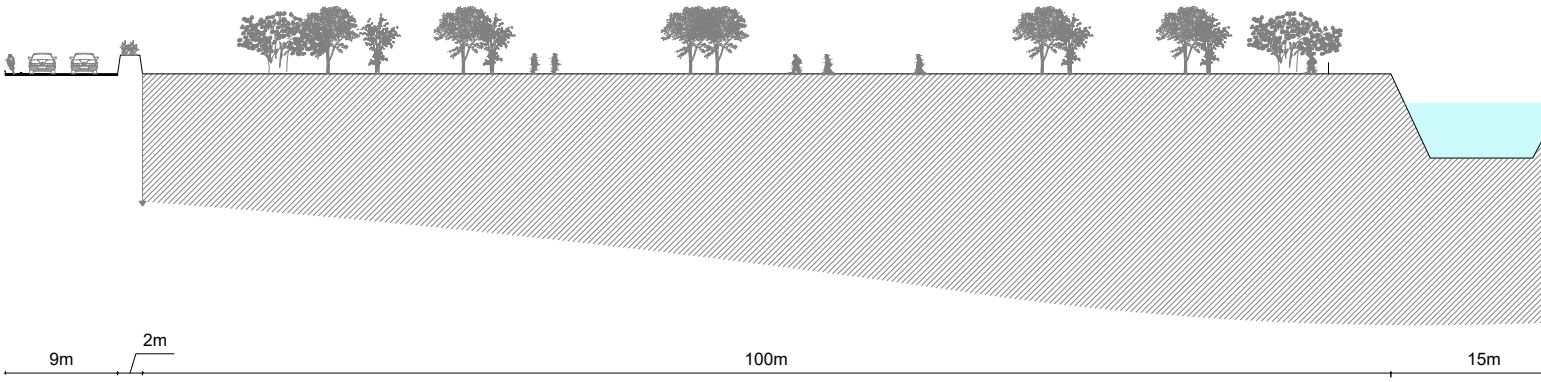


Figure 12.42

Typical Section: Revitalised Buckingham Canal within city limits

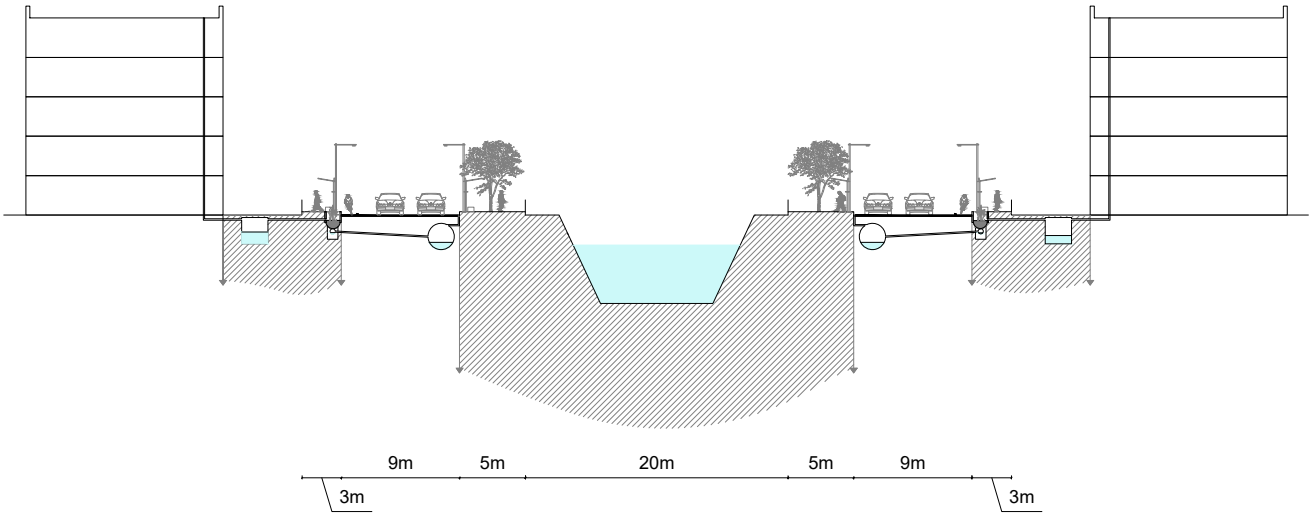
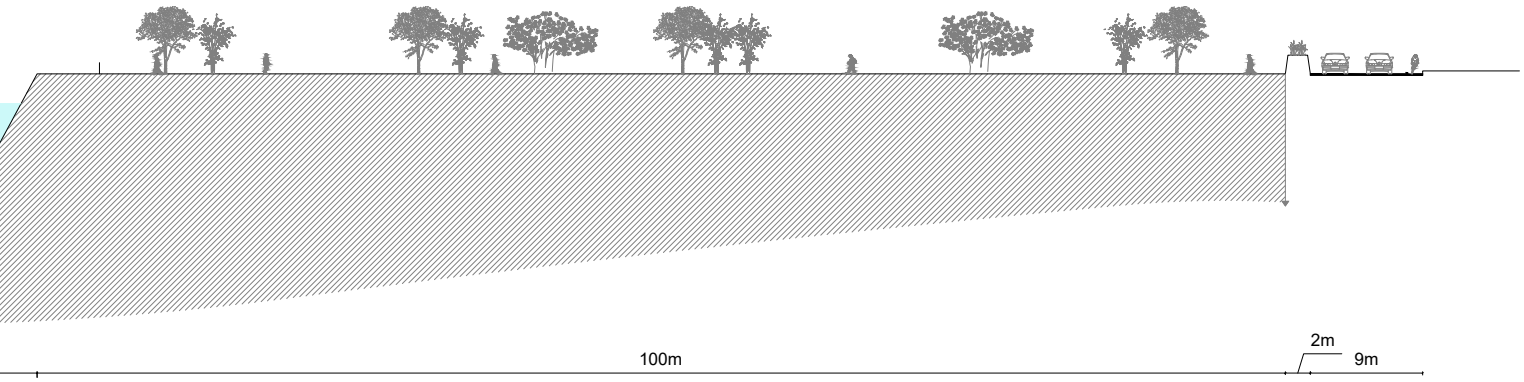


Figure 12.43



Typical Section: Blue corridors draining into Buckingham Canal

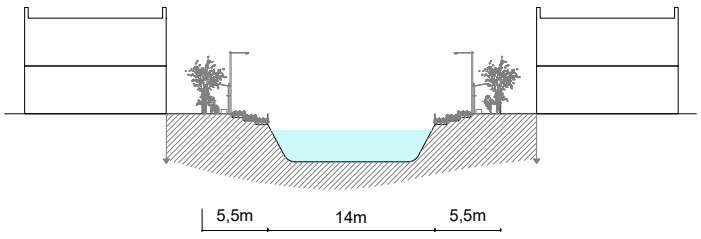


Figure 12.44

Part VI- Evaluation

Source: https://i.pinimg.com/originals/b5/3b/f6/b53bf66d5e8be3c83d227990d955f740.jpg

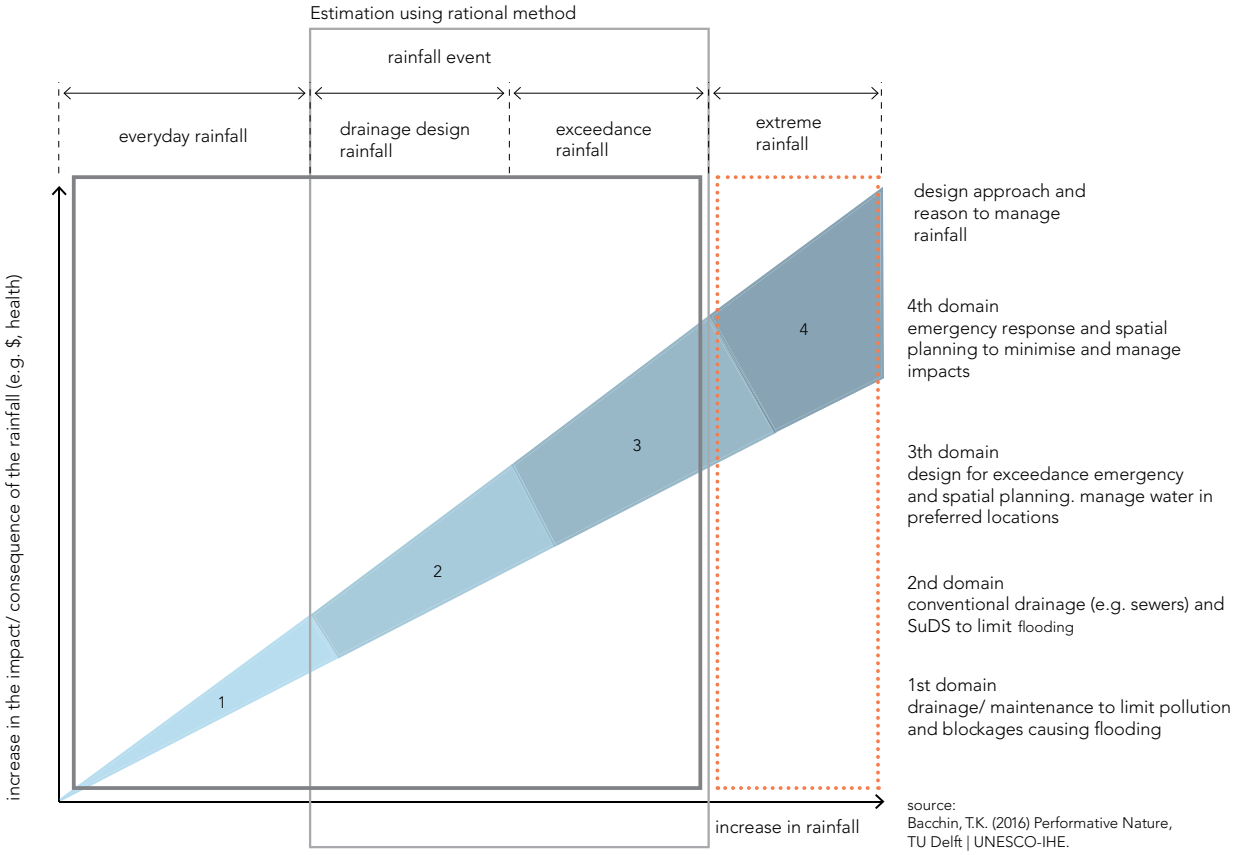

Estimation using rational method
rainfall event
everyday rainfall
drainage design rainfall
exceedance rainfall
extreme rainfall
design approach and reason to manage rainfall
4th domain
emergency response and spatial planning to minimise and manage impacts
3th domain
design for exceedance emergency and spatial planning. manage water in preferred locations
2nd domain
conventional drainage (e.g. sewers) and SuDS to limit flooding
1st domain
drainage/ maintenance to limit pollution and blockages causing flooding
source:
Bacchin, T.K. (2016) Performative Nature, TU Delft | UNESCO-IHE.
increase in the impact/ consequence of the rainfall (e.g. $, health)
increase in rainfall
1
2
3
4
on time > seasonal variation, continous/ disruptive changes

Figure 13.1

13. Performance

In this section, the performance of the neighbourhoods are evaluated using the four domain approach and run-off calculations are done using the Rational Method. The Run-off method is an effective way of estimating peak run-off flow during different rainfall intensities and hence is a simple yet effective way of estimating the technical requirement of storm-water drainage infrastructure. For this research, the Rational method is used to estimate the performance of the proposals for both the 10 year and 100 year return period and accordingly the minimum depth of the retention gardens and tanks are calculated. The coefficients from Table 1 are used for these calculations.

13.1. Performance under the four domains

The domain approach is adopted as a means to assess and evaluate the proposal with respect to the hydrological performance. In the first domain which consists of everyday rainfall intensity, surface drainage is achieved, by ensuring that the streets are clean and devoid of any blockages. In the second domain which consists of a 10 year return period rainfall intensity, the storm-water drainage infrastructure which has been retrofitted in the neighbourhood are fully functional and sufficient. In the third domain which consists of a 100 year return period rainfall intensity, the run-off is directed to preferred flooding locations for better water management. In this proposal, the retention gardens, water tanks and reservoirs act as the preferred location and help delay flooding. In the fourth domain which consists of an extreme rainfall events, emergency and evacuation services are activated. Lack of data on emergency services limited the evaluation to three domains only. This also highlights the need for Chennai to urgently address disaster preparedness and emergency and evacuation planning.

Performance in first domain

Figure 13.2

Performance in third domain

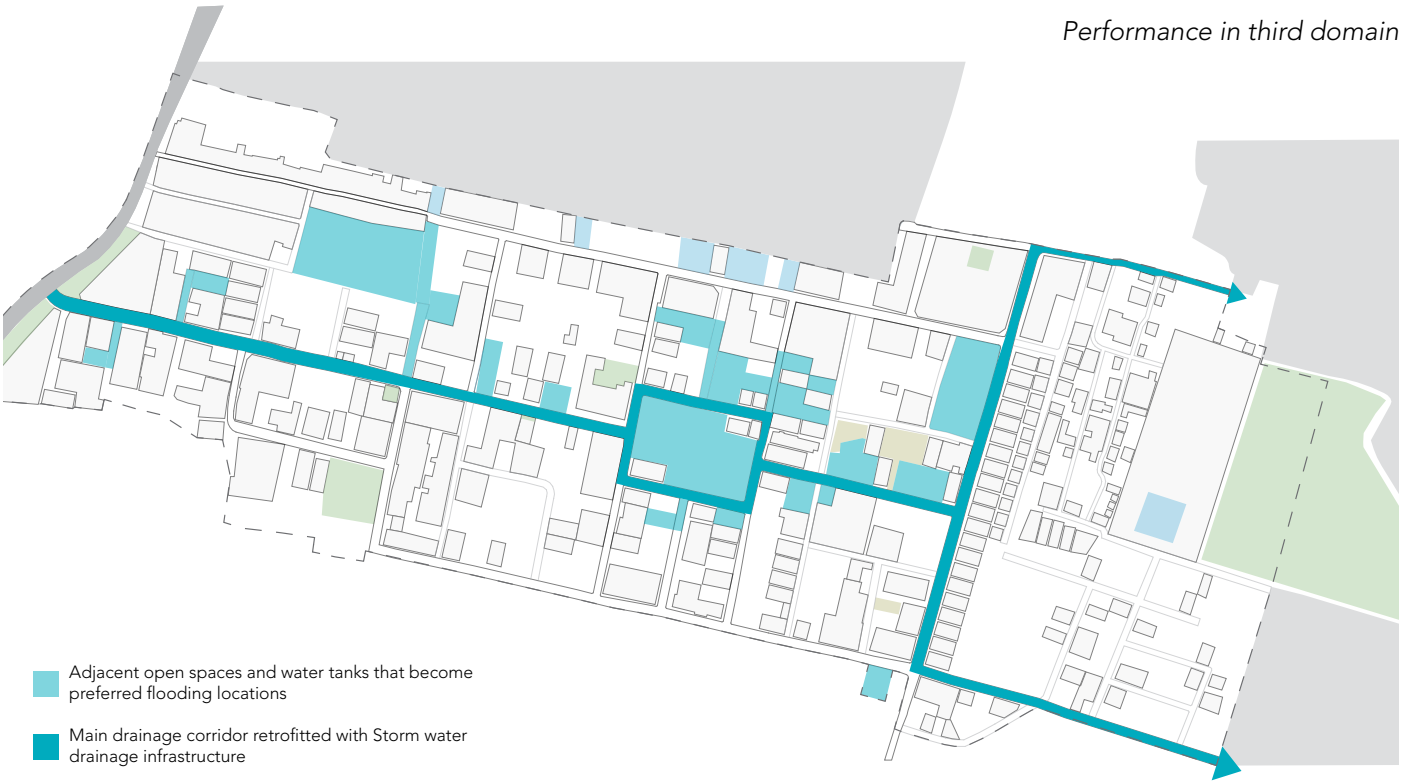


Figure 13.3

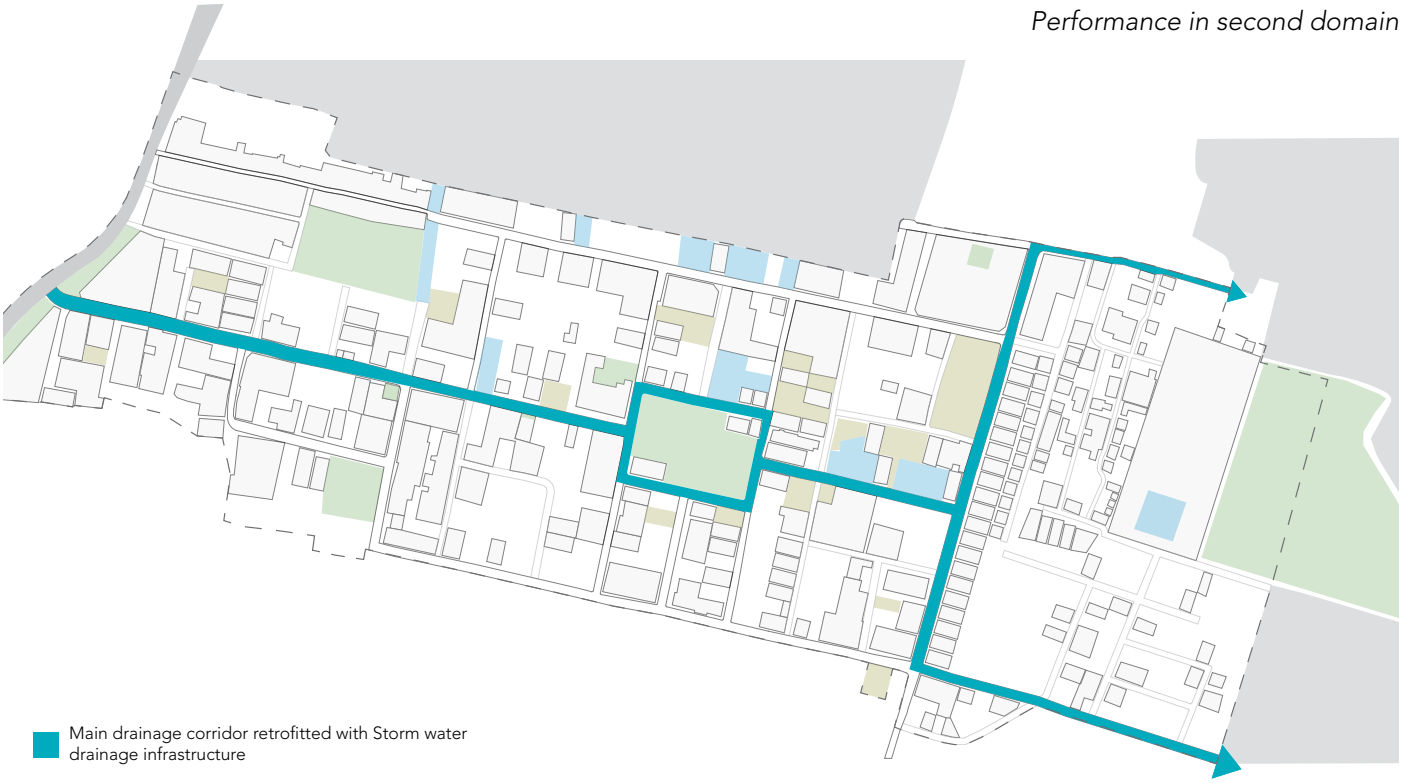


Figure 13.4

Neighbourhood 1 : Kamkotti Nagar

In this neighbourhood:

Domain 1: Surface drainage can be achieved by simply keeping the street clean and free of blockages.

Domain 2: Drainage is achieved by the storm-water drainage infrastructure retrofitted in the main corridor. The run-off from the adjacent streets is directed to this main corridor through surface trenches.

Domain 3: Water is managed in combination with the desired flooding locations and the drainage corridor. The open spaces, water tanks and retention gardens together collect, convey, retain and delay flooding.

Performance in first domain

Figure 13.5

Performance in third domain

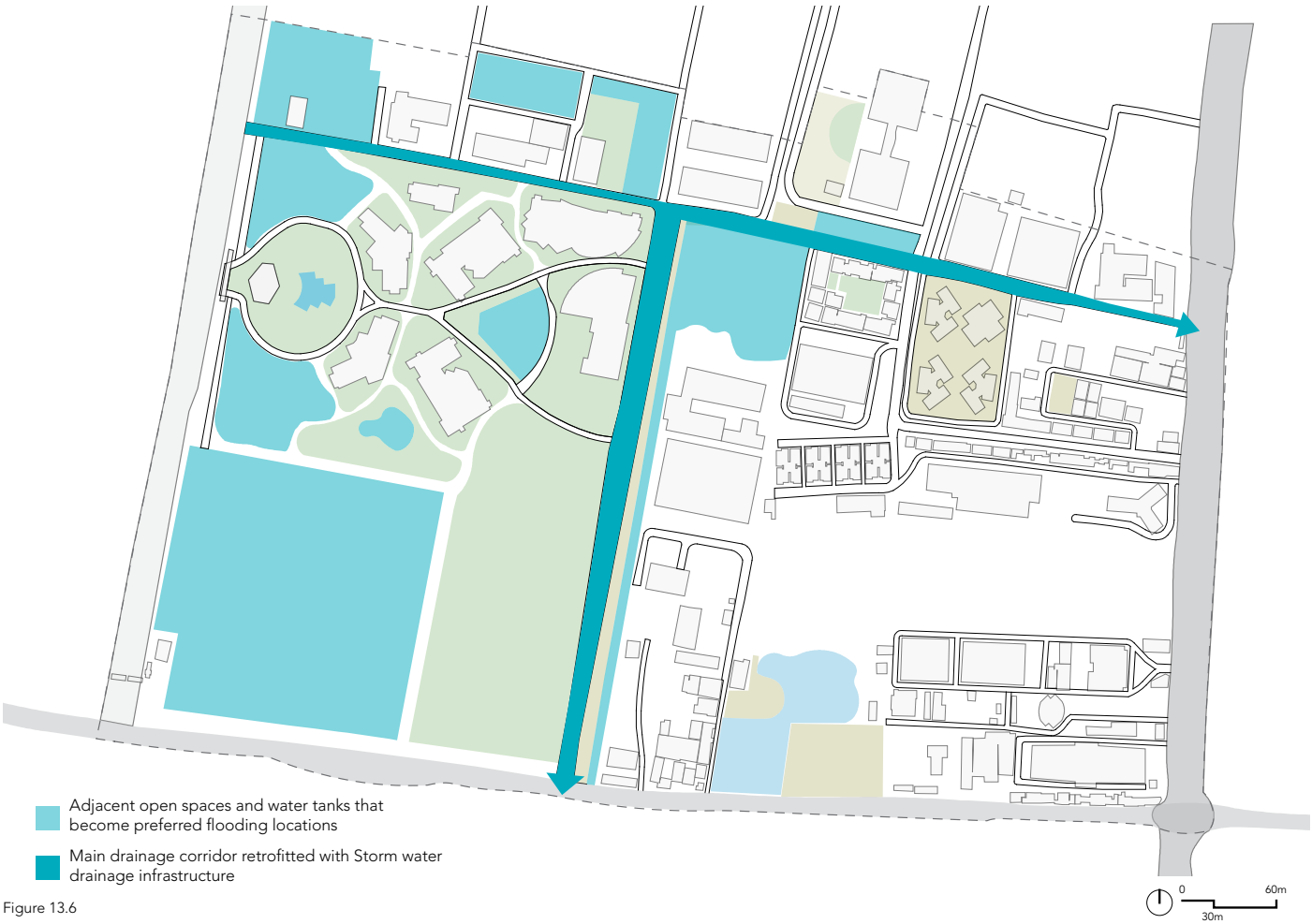


Figure 13.6

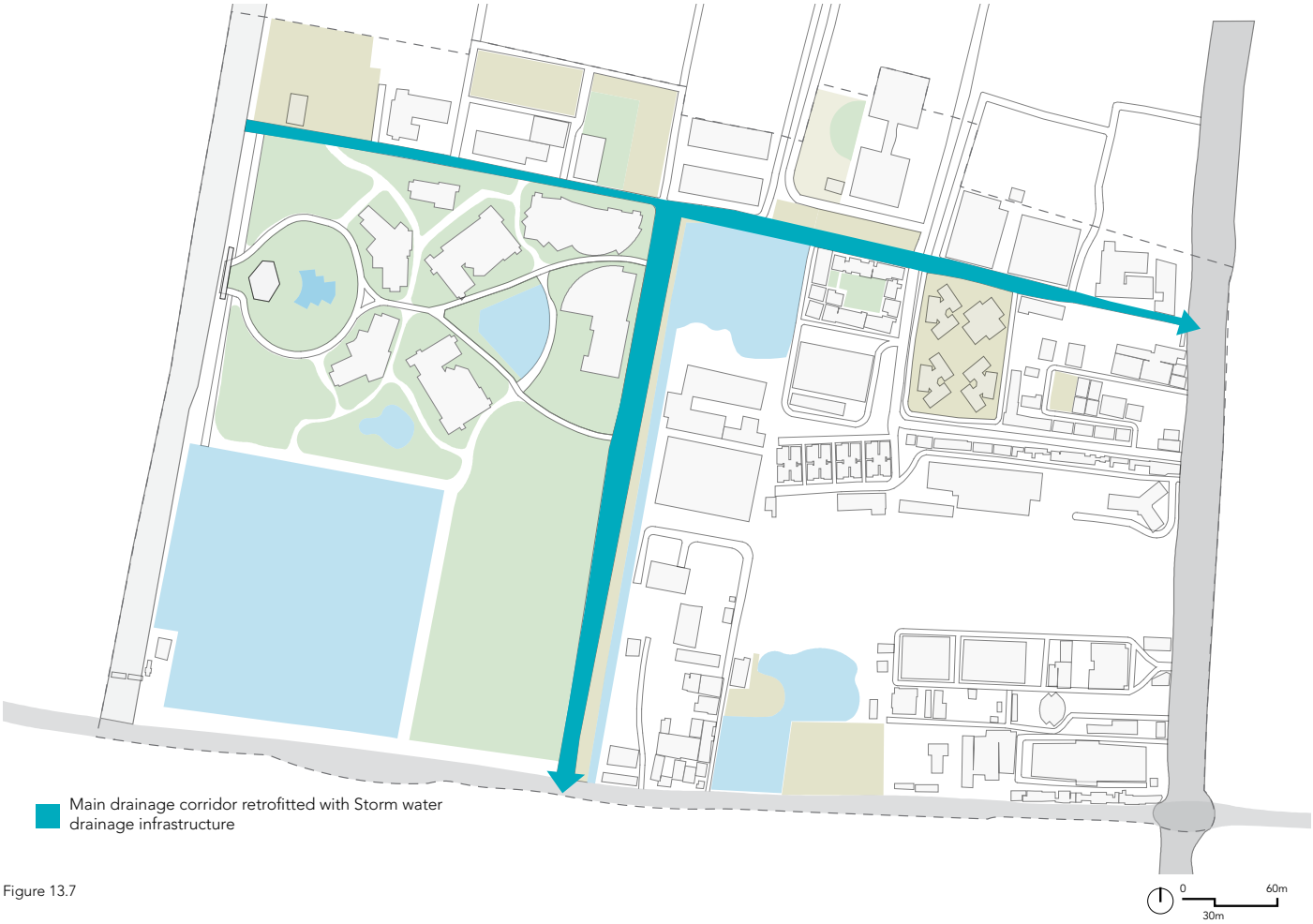


Figure 13.7

Neighbourhood 2 : Elcot SEZ

In this neighbourhood:

Domain 1: Surface drainage can be achieved by simply keeping the street clean and free of blockages.

Domain 2: Drainage is achieved by the storm-water drainage infrastructure retrofitted in the main corridor. The run-off from the adjacent streets is directed to this main corridor through surface trenches.

Domain 3: Water is managed in combination with the desired flooding locations and the drainage corridor. The open spaces, water bodies and retention gardens together collect, convey, retain and delay flooding.

13.2. Run-off Calculations - Rational Method

According to the ODOT Hydraulics Manual (April 2014),

The Rational Method (or Rational Formula) is
Q = C x i X A

Where:
Q = Peak flow in cubic metre per hour (m3 / hr)
C = Runoff coefficient adjustment factor to account for reduction of infiltration and other losses during high intensity storms
i = Rainfall intensity in inches per hour (mm/hr)
A = Drainage area in square metres (m^2)

Table 1 Runoff Coefficients for the Rational Method

	FLAT	ROLLING	HILLY
Pavement & Roofs	**0.90**	**0.90**	**0.90**
Earth Shoulders	0.50	0.50	0.50
Drives & Walks	0.75	0.80	**0.85**
Gravel Pavement	**0.85**	**0.85**	**0.85**
City Business Areas	0.80	**0.85**	**0.85**
Apartment Dwelling Areas	0.50	0.60	0.70
Light Residential: 1 to 3 units/acre	0.35	0.40	0.45
Normal Residential: 3 to 6 units/acre	0.50	0.55	0.60
Dense Residential: 6 to 15 units/acre	0.70	0.75	0.80
Lawns	0.17	0.22	0.35
Grass Shoulders	0.25	0.25	0.25
Side Slopes, Earth	0.60	0.60	0.60
Side Slopes, Turf	0.30	0.30	0.30
Median Areas, Turf	0.25	0.30	0.30
Cultivated Land, Clay & Loam	0.50	0.55	0.60
Cultivated Land, Sand & Gravel	0.25	0.30	0.35
Industrial Areas, Light	0.50	0.70	0.80
Industrial Areas, Heavy	0.60	0.80	**0.90**
Parks & Cemeteries	0.10	0.15	0.25
Playgrounds	0.20	0.25	0.30
Woodland & Forests	0.10	0.15	0.20
Meadows & Pasture Land	0.25	0.30	0.35
Unimproved Areas	0.10	0.20	0.30

Note:

- ***Impervious surfaces in bold***
- *Rolling = ground slope between 2 percent to 10 percent*
- *Hilly = ground slope greater than 10 percent*

1. Rational Method – Peak Run-off discharge calculations:

Q = C x i X A

Intensity of rainfall for Chennai for a period of 10 hours

Intensity of Rainfall for Chennai (Julius & Reddy, 2018)

Duration (hrs)	Intensity values (in mm/hr) for Return Period of				
	2 Year	5 Year	10 Year	50 Year	100 Year
1H	47.1254	60.9373	70.0819	90.2078	98.7162
2H	30.8942	38.6489	43.7831	55.0828	59.8598
3H	23.8403	28.5165	31.6125	38.4263	41.3069
6H	14.1008	18.7334	21.8006	28.5511	31.4049
12H	8.2680	11.1010	12.9767	17.1049	18.8500
24H	5.0541	6.9114	8.1411	10.8474	11.9915

A duration of 1 hour and return period of 10 years is assumed in the first calculation. Also duration of 1 hour and return period of 100 years is calculated for the second calculation.

NEIGHBOURHOOD 1 : Kamkotti Nagar (Residential)

- Area considered: A = 409108.21 sq. m
- Rainfall Intensity: i = 70.08 mm/hr
- Coefficient = To be calculated
- The terrain is flat as average slope is between 0.8 to 1 percent
- Type of soil : Sandy Clay Loam with moderately fine to fine texture having moderate run-off potential and is fit for the design of parks with retention ponds and wet landscapes. This has been considered in the design of the open spaces in the neighbourhood.

Coefficient calculations:

1. Driveways and Walkways

$$C_{(d+w)} = A \times 0.75 = 63629.44 \times 0.75 = 4772.208\ m^2$$

2. Roofs and Pavement

$C_{(r+p)}$ = A x 0.90 = 149976.07 x 0.90 = 134978.46 m^2

3. Apartment dwelling areas

$C_{(ad)}$ = A x 0.50 = 24934.76 x 0.50 = 12467.38 m^2

4. Parks and Cemeteries

$C_{(p+c)}$ = A x 0.10 = 45216.21 x 0.10 = 4521.66 m^2

5. Playground

$C_{(p)}$ = A x 0.20 = 3482.92 x 0.20 = 696.58 m^2

6. Unimproved Areas

$C_{(ua)}$ = A x 0.10 = 107517.40 x 0.10 = 10751.74 m^2

$$C = C_{(d+w)} + C_{(r+p} + C_{(ad)} + C_{(p+c)} + C_{(p)} + C_{(ua)} = \frac{168188.03\ m^2}{409108.21\ m^2}$$

= 0.41

Q_{10} = C x i X A

= 0.41 x 70.08 mm/hr x 409108.21 m^2

= 3.24 m^3 / sec = 11664.00 m^3 / hr

Surface area proposed for storage using open space, retention and water bodies = 18686.23 m^2

Calculated minimum depth for the proposed storage areas = 0.62 m

Q_{100} = C x i X A

= 0.41 x 98.72 mm/hr x 409108.21 m^2

= 4.56 m^3 / sec = 16416.00 m^3 / hr

Surface area proposed for storage using open space, retention and water bodies = 18686.23 m^2

Calculated minimum depth for the proposed storage areas = 0.88 m

As per the calculations for run-off and required storage for the design for exceedance, the surface area provided for storage for a 10 year return period is that of 18686.23 m^2 with a minimum depth of 0.62m and for a 100 year return period the same surface area should be designed with a minimum depth of 0.88 m.

NEIGHBOURHOOD 2 : ELCOT (Industrial)

- Area considered: A = 692681.23 sq. m
- Rainfall Intensity: i = 70.08 mm/hr
- Coefficient = To be calculated
- The terrain is flat as average slope is between 0.8 to 1 percent
- Type of soil : Sandy Clay Loam with moderately fine to fine texture having moderate run-off potential and is fit for the design of parks with retention ponds and wet landscapes. This has been considered in the design of the open spaces in the neighbourhood.

Coefficient calculations:

1. Driveways and Walkways

$$C_{(d+w)} = A \times 0.75 = 149976.05 \times 0.75 = 4772.208\ m^2$$

2. Roofs and Pavement

$$C_{(r+p)} = A \times 0.90 = 101599.45 \times 0.90 = 134978.46\ m^2$$

3. Parking

$$C_{(prk)} = A \times 0.90 = 19907.10 \times 0.90 = 17916.39\ m^2$$

4. Lawn

$$C_{(l)} = A \times 0.17 = 53653.66 \times 0.17 = 9121.12\ m^2$$

5. Playground

$$C_{(p)} = A \times 0.20 = 3236.71 \times 0.20 = 647.34\ m^2$$

6. Unimproved Areas

$C_{(ua)} = A \times 0.10 = 117819.23 \times 0.10 = 11781.92\ m^2$

7. Apartment Dwelling surfaces

$C_{(ad)} = A \times 0.50 = 35489.65 \times 0.50 = 17744.83\ m^2$

8. Light Industrial Areas

$C_{(lia)} = A \times 0.50 = 90502.50 \times 0.50 = 45251.25\ m^2$

9. Parks

$C_{(p+c)} = A \times 0.10 = 11323.95 \times 0.10 = 1132.39\ m^2$

$$C = C_{(d+w)} + C_{(r+p} + C_{(ad)} + C_{(p+c)} + C_{(p)} + C_{(l)} + C_{(prk)} + C_{(ua)} + C_{(lia)} = \frac{317676.74\ m^2}{692681.23\ m^2}$$

$= 0.46$

$Q_{10} = C \times i \times A$

$= 0.46 \times 70.08\ mm/hr \times 692681.23\ m^2$

$= 6.15\ m^3 / sec = 22140.00\ m^3 / hr$

Surface area proposed for storage using open space, retention and water bodies = $105081.19\ m^2$

Calculated minimum depth for the proposed storage areas = 0.21 m

$Q_{100} = C \times i \times A$

$= 0.46 \times 98.72\ mm/hr \times 692681.23\ m^2$

$= 8.66\ m^3 / sec = 31176.00\ m^3 / hr$

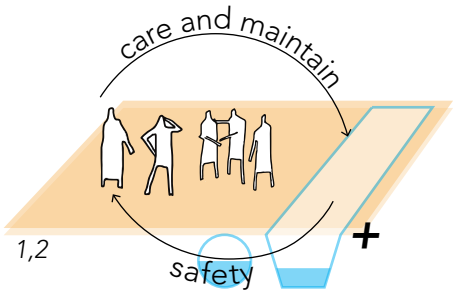
Surface area proposed for storage using open space, retention and water bodies = 105081.19 m^2

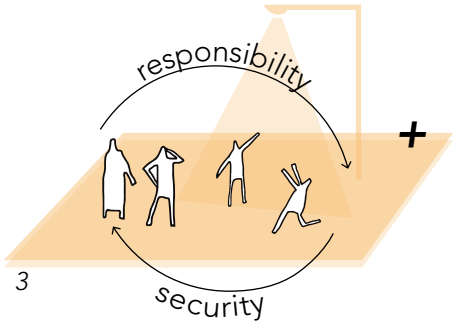
Calculated minimum depth for the proposed storage areas = 0. 30 m

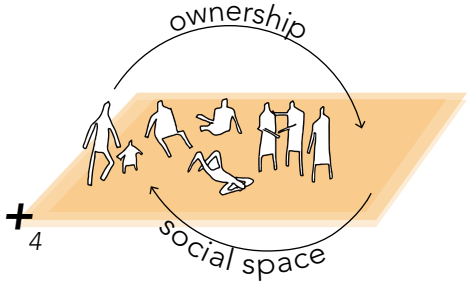
As per the calculations for run-off and required storage for the design for exceedance, the surface area provided for storage for a 10 year return period is that of 105081.19 m^2 with a minimum depth of 0.21m and for a 100 year return period the same surface area should be designed with a minimum depth of 0.30 m.

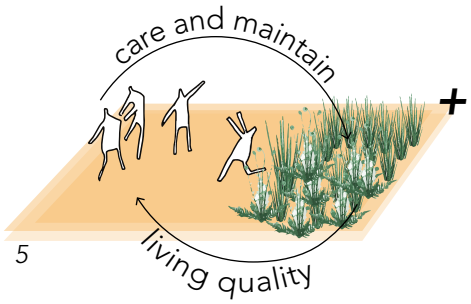
References:

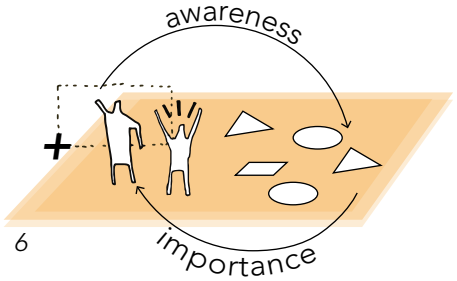
Julius, J. J., & Reddy, M. J. (2018). Intensity-Duration-Frequency Analysis of Rainfall for a Site in Chennai City.

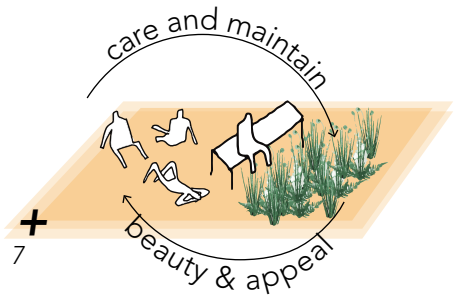

care and maintain
1,2
safety

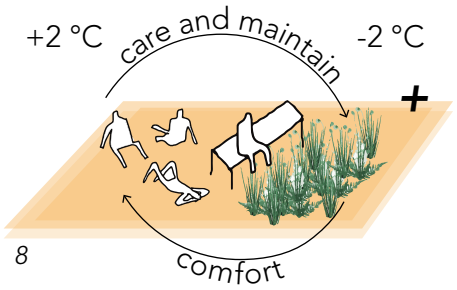

responsibility
3
security

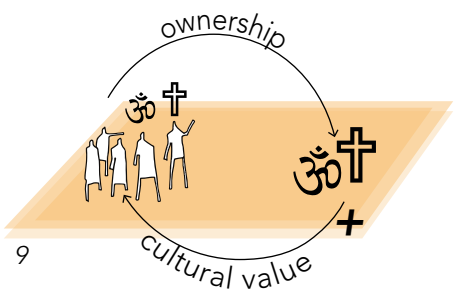

ownership
4
social space

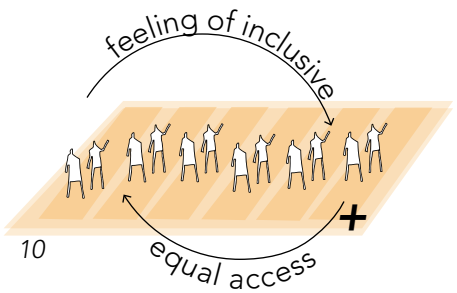

care and maintain
5
living quality


awareness
6
importance


care and maintain
7
beauty & appeal


+2 °C
care and maintain
-2 °C
8
comfort


ownership
9
cultural value


feeling of inclusive
10
equal access


responsibility
11
high activity
high business

Figure 14.1

14. Societal needs and encouraging behavioural changes

De Haan et al. (2014) elaborates on the how societies transition and the need to meet societal needs in order to increase liveability, appropriation and sense of belonging. Their work gives an interesting framework of the essential needs of society which in turn can be designed for in order to create a positive change, influence behaviour and make people act in a certain way. This framework which elaborates on the different existence, relatedness and societal growth needs, gives new insight on understanding sustainability and liveability all together.

In order to influence people's behaviour, sense of community and belonging and to influence their involvement, designing for these societal needs can be used as an effective tool to engage communities in return for the increased quality of life. Furthermore, these needs have also been linked to urban water management and hence using these standards as a method to evaluate the societal aspects of the design is highly relevant.

This sections, first lists down the different needs of the society and then elaborates on how these needs have been responded to in the proposal.

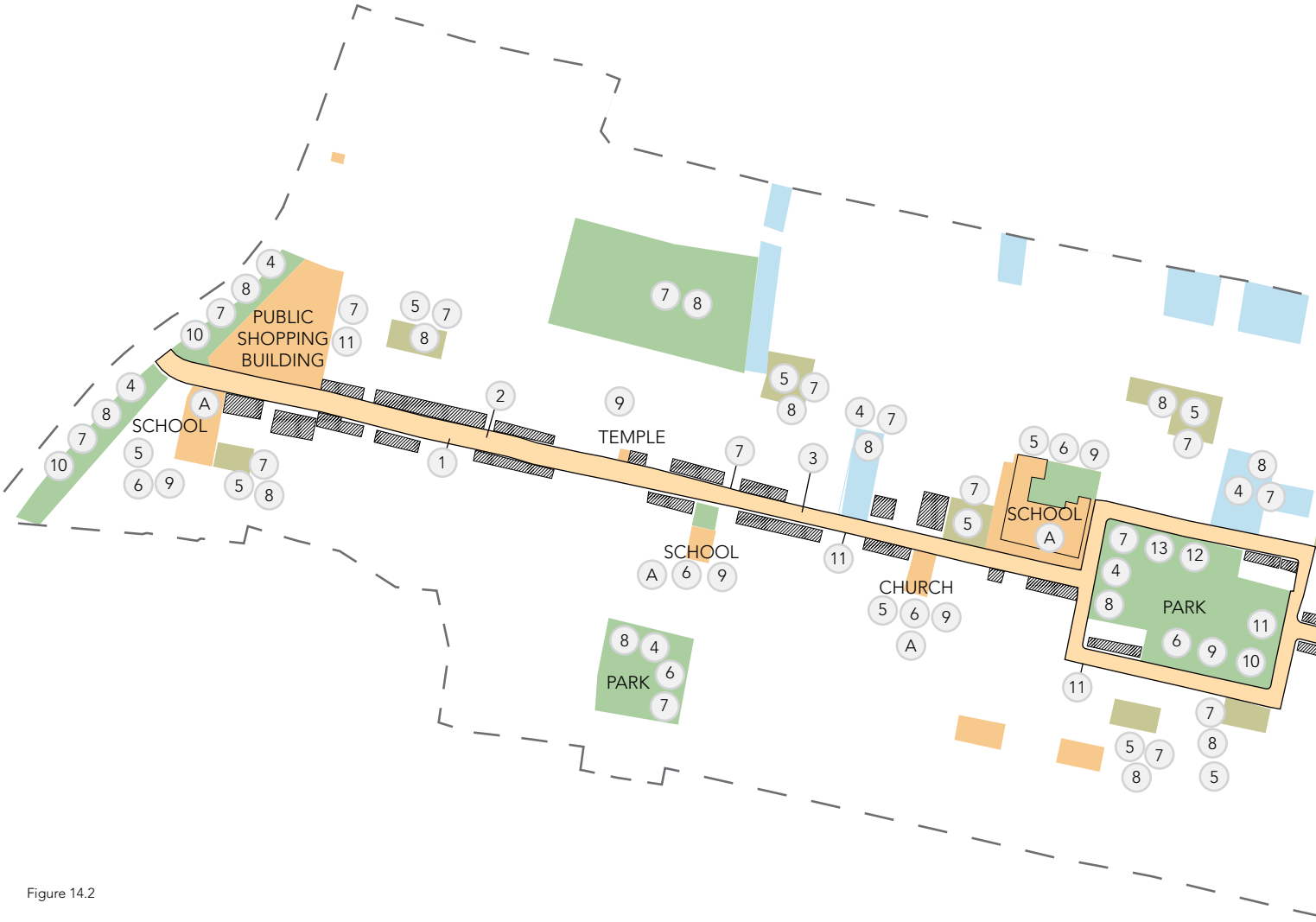


Figure 14.2

A Agencies of Social Change

Societal Need	*Proposed functions / activities*
1 Shelter	*Stormwater and green-blue infrastructure has been designed for performance under extreme rainfall events*
2 Safety	*Stormwater and green-blue infrastructure has been designed for performance under extreme rainfall events*
3 Security	*Street design to ensure and define safe pedestrian areas*
4 Interaction and Social Cohesion	*Family environment - Public spaces that integrate water retention and recreation, main spine caters to all daily needs and weekly markets etc.*
5 Ecological Health	*Community led clean-up and plantation activities*
6 Knowledge and Beliefs	*81.3% literacy within Chennai Corporation. Awareness and skill training programmes organised to educate people*
7 Beauty and Pleasure	*Aesthetic appeal of green and blue + graffiti and art Installations which are not only informative increase visual appeal*

S
8
9
10
11
12
13

Family environment

Part of Chennai district which has a literacy rate of 81.3%

Multiple schools in the area increased number of children visiting the area

Consists of an important temple which acts as a religious landmark

Neighbourhood 1: Kamkotti Nagar

Societal Need	*Proposed functions / activities*
Comfort and Convenience	*Under hot and humid weather conditions, presence of water tanks and retention gardens have a cooling effect on the micro-climate of the area*
Culture and Identity	*Water based festivals, cultural activities, religious expression, art and graffiti add to the essence of the place*
Equity and Justice	*All green-blue spaces are open to the public. Open space is treated as public property*
Purpose and Expression	*The edge which is designed as part of the proposal accommodates pedestrian activity. Small and informal businesses can benefit from the increased activity*
Influence and respect	*Community consultations and decentralisation empowers people to participate. Further RWAs,NGOs and Civic Bodies are also actively involved in decision making*
Freedom and Autonomy	*Citizens are encouraged to voice opinions and express their feedback through public consultations organised by the State*

Figure 14.3

A Agencies of Social Change

Societal Need	Proposed functions / activities
1 Shelter	Stormwater and green-blue infrastructure has been designed for performance under extreme rainfall events
2 Safety	Stormwater and green-blue infrastructure has been designed for performance under extreme rainfall events
3 Security	Street design to ensure and define safe pedestrian areas
4 Interaction and Social Cohesion	Working environment - Public spaces that integrate water retention and recreation, main spine caters to leisure and pleasant working environment
5 Ecological Health	CSR led clean-up and plantation activities
6 Knowledge and Beliefs	Awareness and skill training programmes organised to educate people through CSR as well as employees
7 Beauty and Pleasure	Aesthetic appeal of green and blue + graffiti and art Installations which are not only informative increase visual appeal

Working environment

Part of Chennai district which has a literacy rate of 81.3%

Consists of working groups and families

Located within a Special Economic Zone, hence has regional importance

Consists of large corporate Stakeholders who excercise Corporate Social Responsibilities

Neighbourhood 2: Elcot SEZ

Societal Need	*Proposed functions / activities*
Comfort and Convenience	*Under hot and humid weather conditions, presence of water tanks and retention gardens have a cooling effect on the micro-climate of the area*
Culture and Identity	*Water based festivals, cultural activities, religious expression, art and graffiti add to the essence of the place*
Equity and Justice	*All green-blue spaces are open to the public. Open space is treated as public property*
Purpose and Expression	*The edge which is designed as part of the proposal accommodates pedestrian activity and could attract other citizens to visit the many activities organised within*
Influence and respect	*Community consultations and decentralisation empowers people to participate. NGOs, RWAs and Civic Bodies are also actively involved in decision making*
Freedom and Autonomy	*Citizens are encouraged to voice opinions and express their feedback through public consultations organised by the State*

Part VII- Implementation

*Source: https://cdn-images-1.medium.com/max/1200/1*9S0cX7NBSufd-797UwFQPQ.jpeg*

Students learning about waste management
Source: http://www.pinsdaddy.com/arsha-vidya-mandir_wxt%7CbgGGHfzEQsagnfSAAHEU19btg3bAJ7r%7CQ3fwL7s/

15. Stakeholder Analysis

15.1. Stakeholder Matrices

A stakeholder analysis for the strategies on a regional scale and neighbourhood scale has been conducted below.

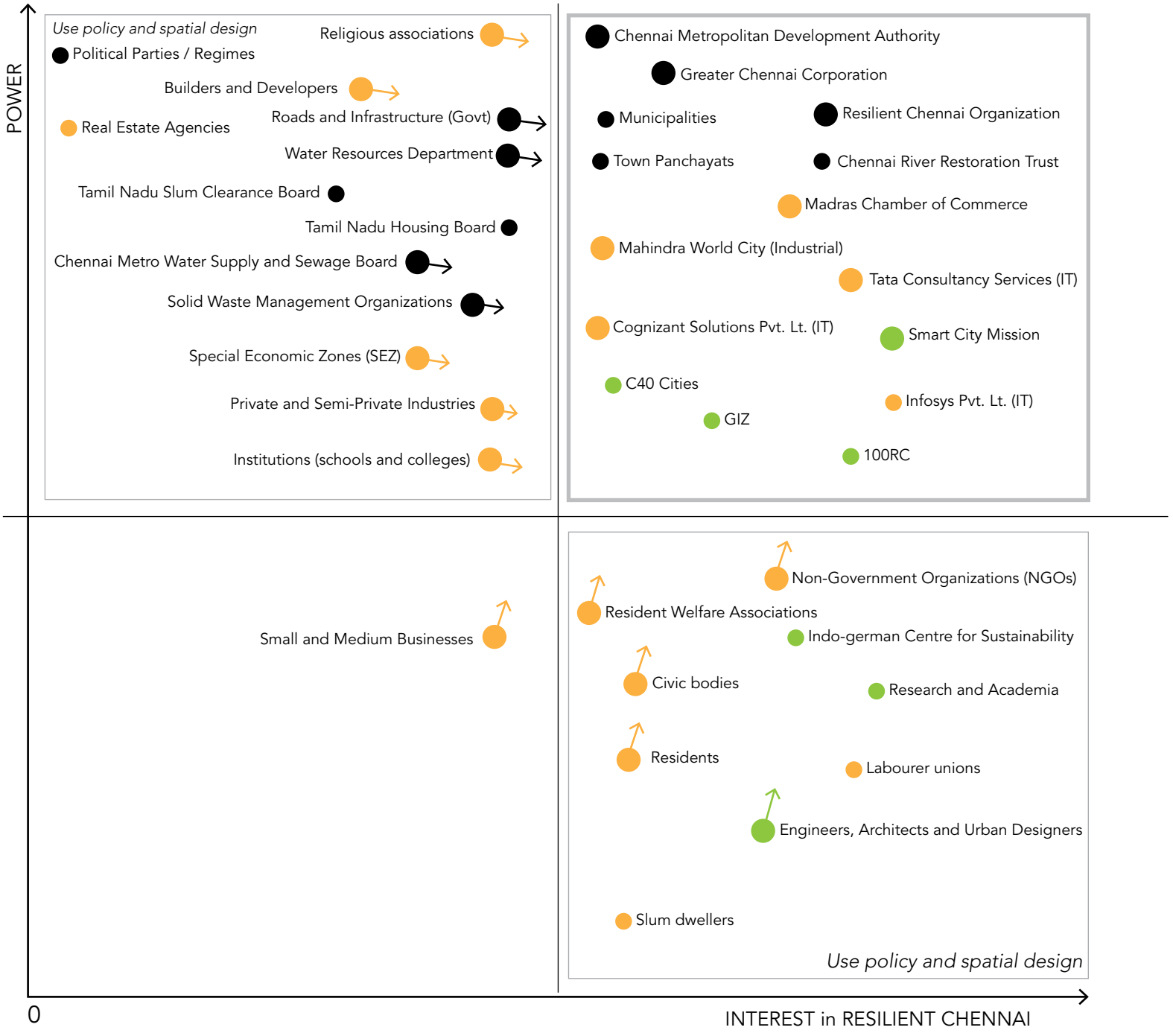
The strategies which have been explored for various scales need actors and participants at various hierarchies, social and economical. Thus, the following analysis helps to bring out which parties are instrumental at each scale and so as to make tangible connections between them through coherent policy design.

Based on the stakeholder analysis, key actors are identified across the various scales. Based on the type of stakeholder, different policies may be designed in order maintain their interest, convince them to get on board and to work around those who may be potential threats. A detailed analysis of the type of stakeholder involved can be found in Appendix 3.

The main actors crucial for realising the proposed vision are listed in the table. The government stakeholders listed as the 'transformers' of the context, are seen as those with power and the ability to implement the projects. However, since there are multiple actors within the government itself, the Chennai Metropolitan Development Authority and the State Government itself can play a crucial role in convincing its own departments to get on board. In addition to this, a statutory body which is the Resilient Chennai Organisation (RCO) is proposed in order to maintain the interests of those already on board and to convince those who can be brought into the equation. This RCO could become the mediating body between the different departments such that the vision of flood resilience can be achieved in addition to other parallel urban processes in Chennai.

In the case of the Preservers, the State government can provide incentives in order to persuade the stakeholders to adopt the proposed vision. In the case of the Business sector, the Madras Chamber of Commerce and Industry which has already shown high interest and influence, can play a pivotal role in persuading its member organisations to adopt the vision and cooperate with the State government. In addition to this, the residents who are also preservers can be convinced through spatial design and awareness programmes that highlight the benefits of the vision in terms of coping with flood risk. Not only are the residents persuaded on the grounds of safety against floods, but the vision also takes into consideration better living environment and increased quality of the public realm. Furthermore, in the case of the Civic Bodies and Residential Welfare Associations, the State Government can empower them by giving them decision-making powers and direct representation at the neighbourhood level. This will ensure better governance, awareness,inclusive decision making and participation.

Finally, in the case of the sustainer, spatial design which incorporates interdisciplinary involvement can play an important role in getting the stakeholders on board. For example, architects and urban designers can be commissioned for the detailed design and implementation of the proposed projects across the various scales, hence including them in the process as well.



Sustainer (Those who have the ideas and are Capable of upholding the vision)

Transformers (Those who have the power To implement through policy and intervention)

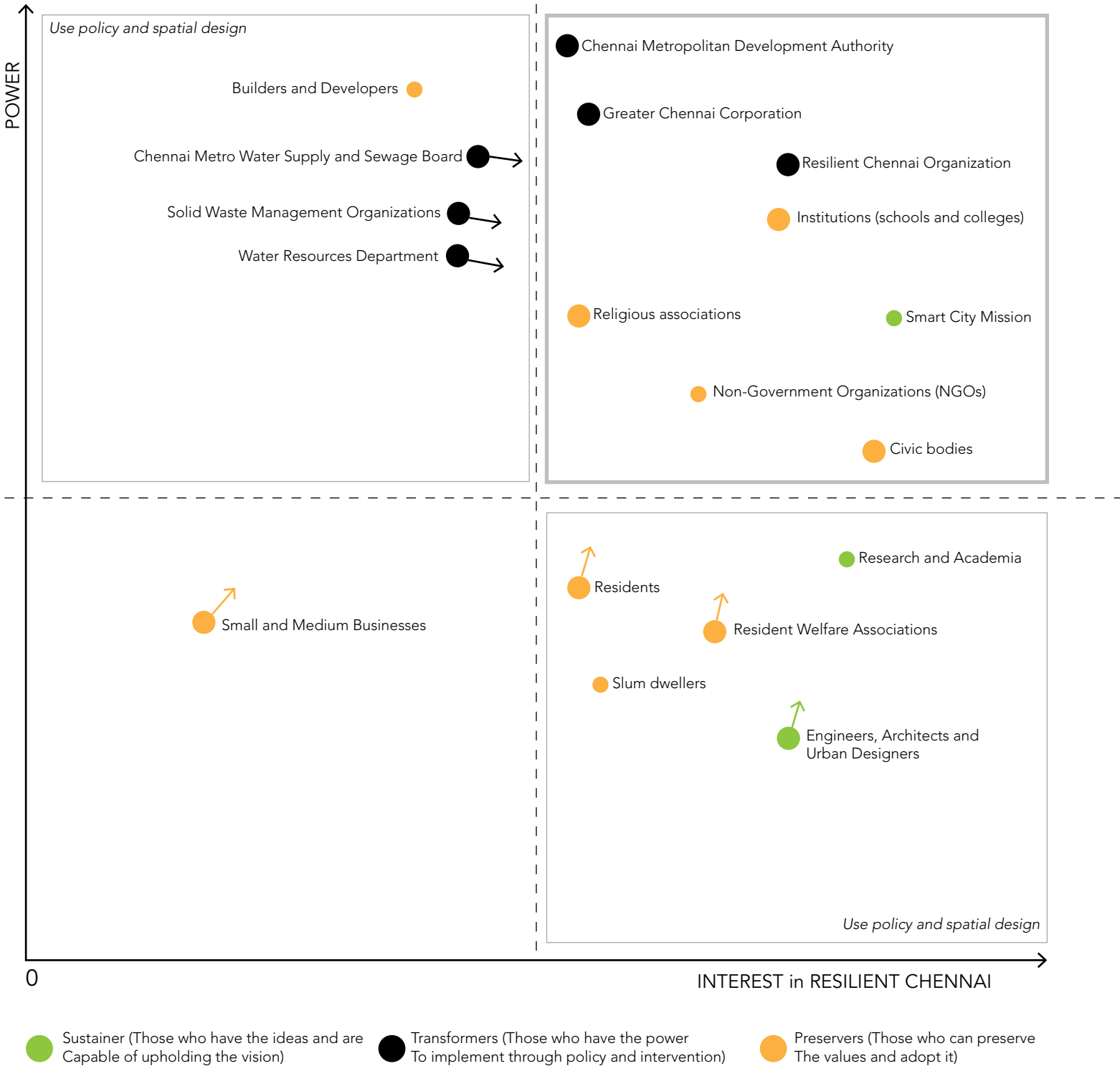
Preservers (Those who can preserve The values and adopt it)

Overall strategy - All Scales - Regional Level

On the regional scale, various actors are identified as crucial ones in order to achieve the vision. The idea is to keep satisfied the ones with high power and high interest, for example, Mahindra World City. This actor which is highly interested in sustainability and has immense economic power can play an important role in the implementation of the stormwater infrastructure by investing in it. Hence, policy design can be formulated such that it recognises the efforts and gives incentives to these actors to keep them satisfied.

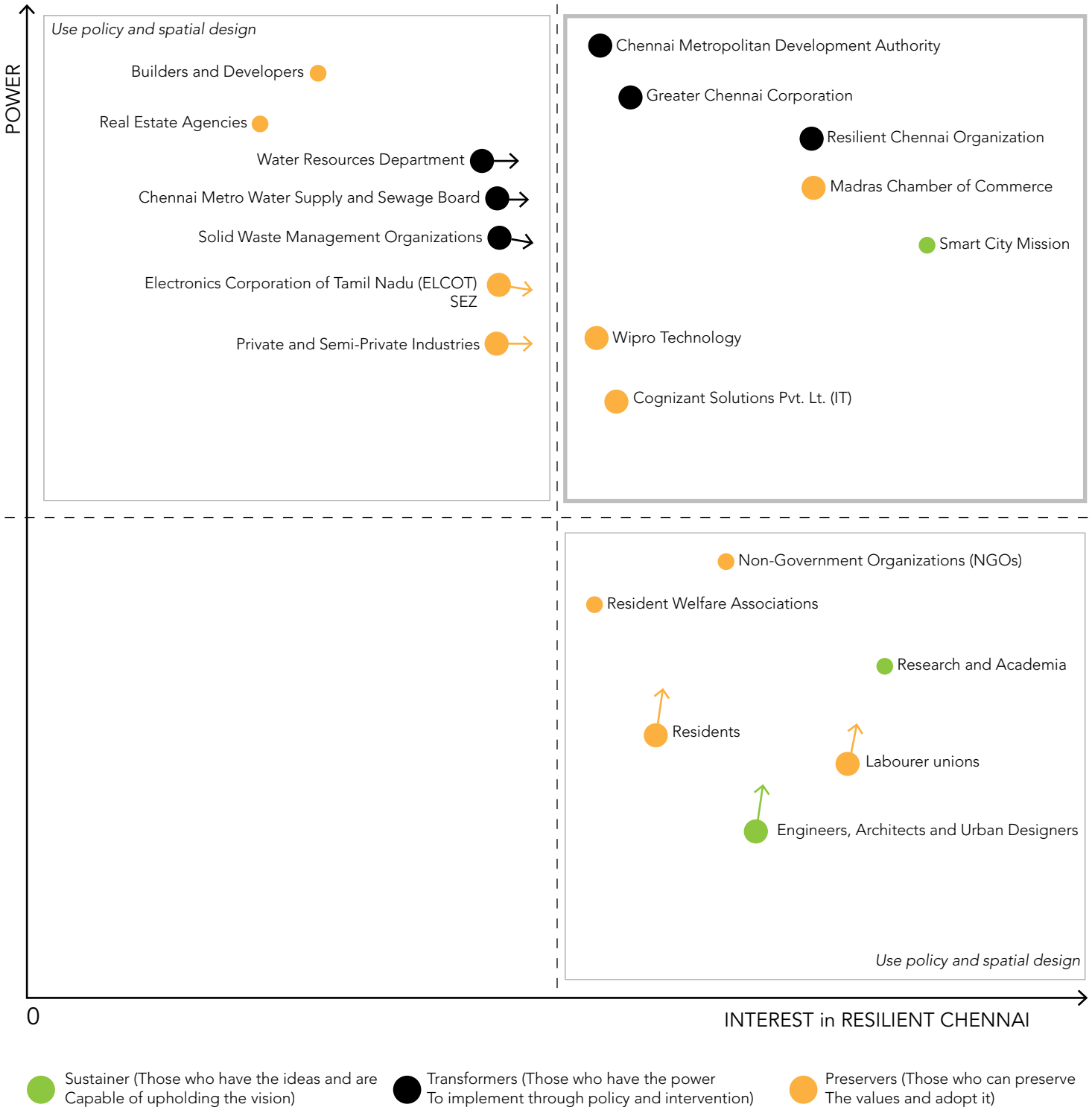
In the case of the high interest and low power actors such as the residents, NGOs and the research and design groups, these actors may be engaged through policy design and spatial design. More decision making powers and decentralisation can be strategies to convince and integrate these actors into the proposal.

Finally, in the case of the high power and low interest actors, it is important to convince these actors to get on board and they have high influence on implementations and investments. While the governmental actors such as the Housing Board can be directly persuaded by the State authorities, the Private and Semi-Private industries, Institutions and Builders may be persuaded using incentives and other engagement strategies. These are discussed in detail blow.



Neighbourhood 1 - Kamkotti Nagar (Residential)

On the neighbourhood scale, few of the main actors identified are the residents, RWAs, Civic Bodies, Designers, Small and Medium businesses and the Water and Services agencies such as Chennai Metro Water Supply and Sewerage Board. These actors may be convinced through awareness initiatives, spatial design and incentives. These engagement strategies and incentives are discussed below.



Neighbourhood 2 - Elcot Special Economic Zone

On the neighbourhood scale, few of the main actors identified are the Corporate Sector actors such as WIPRO technologies, Cognizant and the ELCOT SEZ organisation. These actors can be convinced and engaged through incentives, awareness programmes and spatial design which ensure better safety and security.

The Madras Chamber of Commerce which is a forum for all corporate and industrial actors can play an important role in persuading other private sector actors to get on-board the vision. Since the MCCI is high interested in the field of sustainability and also has its own initiatives in place, it is highly important to engage the MCCI, use their convincing power and keep them satisfied through support and recognition.

Incentives

Public Sector

Makes Vision attractive for private and community sector by:

Providing incentives for New and Existing Developments such as:

Tax Abatements in return for investing in the refurbishment of existing community infrastructure and for investing in stormwater infrastructure

Additional Floor Area Ratio (FAR) in return for investing in new community infrastructure

TDR - Transferrable Development Rights which allows increased floor space elsewhere while preserving available open spaces in congested settlements

Development Rights and Permits in return for a mandatory assessment of impact of the project on the drainage and water quality in the neighbourhood

Recognising efforts and contribution to society through awards and publicity

Providing subsidies to citizens for the implementation of rainwater harvesting systems

Providing Monetary support to community infrastructure in order to carry out the civic engagement activities and spread awareness - Giving the civic bodies and associations, decision making powers.

Maximimising participation and interest on the regional scale while still responding to:

Seven-Fold Regional Expansion

Economic development goals

New trends set to influence regional economic development

Expected Outcomes

Private and Corporate Sector

In return for creating social and environmental impacts

Incoporating the recommended soft landscape design

Investing in the vision and trends proposed in the project

Giving back to the community by investing in community infrastructure

Investing in the implementation of Stormwater Drainage Infrastructure in different parts of the city

Training its employees and mandating community services

Volunteering in restoration efforts

Taking up social responsibilities of educating different sections of the society through skill training programmes

Expected Outcomes

Community

Regularly engages with the environment, cares for it and maintains

Empowerment and voice at regional level

Community building and participation

Increased ownership and feeling of belonging

Societal needs fulfilled by the proposal

Recognition of efforts

Quality of living

Safety from floods

Following Open Space Reservation at residential level and to integate soft surface design

Abiding by plot coverage maximum of 60% and integrating soft surface design for the remaining 40% of site area

15.2. Planning incentives

The Public-Private-Community relationships are explored through incentives and expected outcomes. The Public sector is responsible for convincing private and community actors to engage and participate in the vision. These incentives are of different kinds: Building rights and regulations, awards and recognition, quality of life and community building.

As an outcome, participation of the Private sector is envisioned such that they directly invest and engage in the proposal and CSR related activities and responsibilities.

As the community sector outcome, increased awareness, engagement and community building is envisioned. Further building regulations can also support the proposal and ensure that the drainage infrastructure is implemented without any violations.

Actor	Engagement strategy	Description
Water Resources Department	Policy	Convince: proposed strategy to ensure efficient water management - support from State
Chennai Metro Water Supply and Sewage Board	Policy	Convince: proposed strategy to ensure efficient water management - support from State
Solid Waste Management Organizations	Policy	Convince: proposed strategy to ensure efficient water management - support from State
Roads and Infrastructure (Govt)	Spatial Design and policy	Convince: proposed road sections will ensure better flood managemment and increase efficiency - Support from State
Special Economic Zones (SEZ)	Spatial Design and policy	Incentives, Increase in floor area, spatial design to increase living quality
Private and Semi-Private Industries	Spatial Design and policy	Incentives, Increase in floor area, spatial design to increase living quality
Builders and Developers	Policy	Incentives for environmental performance, Increase in buildable floor area, spatial design to increase living quality
Institutions (schools and colleges)	Policy	Monetary support from State to carry out training and restoration activities
Religious associations	Policy	Monetary support from State to carry out training and restoration activities
Non-Government Organizations (NGOs)	Policy	Empowered and represented in the institution
Residents	Spatial Design	The proposed spatial design ensure better flood protection and safety
Resident Welfare Associations	Spatial design and Policy	Empower and give decision-making powers with respect to neighbourhood flood protection
Civic bodies	Policy	Empowered and given representation in the institution
Small and Medium Businesses	Spatial Design and policy	Design proposals accommodate informal economy and provide a space for them to function on a neighbourhood level
Engineers, Architects and Urban Designers	Spatial Design and policy	Multiple design competitions announced to carry out strategies

15.3. Engagement Strategies

While these engagement strategies are aimed mainly at those who do not share high interest and influence, the other actors which do occupy this strong position must be kept satisfied in order to truly realise the vision. The State government in this case can play an important role in giving incentives to private and semi-private stakeholders in order to 'keep up the good work' . These incentives could be awards for recognition, incentives for increased build-able area and by also including them equally in the decision-making process. The State Government and the CMDA here play a crucial role in facilitating collaborations between different powerful stakeholders by not only suggesting policies that help achieve the vision but also promote a profitable environment for the larger stakeholders to function within the region. For example, in return for the State government reducing real estate taxes for the IT Company Cognizant, the Corporate Giant engages more actively in Corporate Social Responsibilities and ensures carrying out specific social and environmental contributions.


ARE YOU HARVESTING RAIN WATER? YOU
CAN DO MORE!
OPT FOR SOFT SURFACES!
LET US RECHARGE THE
GROUND TOGETHER
URBAN DESIGN COMPETITION!
REIMAGINING THE
BUCKINGHAM
CANAL
URBAN DESIGN COMPETITION!
LET CHENNAI BREATHE
THROUGH
PALLIKARANAI!
URBAN DESIGN COMPETITION!
MAKE OUR CATCHMENTS
L(EDGE)GIBLE!
THE KICKSTARTER
MARATHON!
GRAND OPENING
NAMMA
BUCKINGHAM
CANAL
2025

Figure 16.1

16. Phasing

This section consists of the phasing of the vision such that it works out the overall time-line of the project as well as the detailed time-lines of the specific scales.

Self-learning, iteration and milestone mapping has been done to emphasize on the possible changes and modifications in the implementation along the course of the project.

To increase participation and engagement of different groups along the time-line, posters and inauguration events are also planned. Every two years, a progress review is planned as a way to document progress, evaluate and make the process efficient.

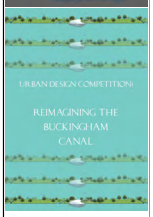
PHASE I

PHASE II

2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027

MACRO SCALE - Sub-Basin

Rain Water Harvesting Policy



Mapping and documentation

Land preparation

Implementation begins

Design Competition

Progress and Planning Review

MESO SCALE - Watershed

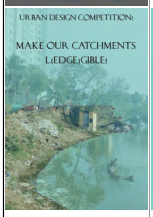
Rain Water Harvesting Policy

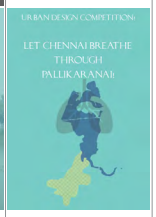
Mapping and documentation

Extension of Pallikaranai wetland

Optimisation of mid-catchments capacity

Macro level Green-blue corridors implementation begins





Design Competition

Pallikarnai wetland Implementation begins

Completion

Mid-catchment Implementation begins

Progress and Planning Review

MICRO SCALE - Sub-Watershed

Rain Water Harvesting Policy

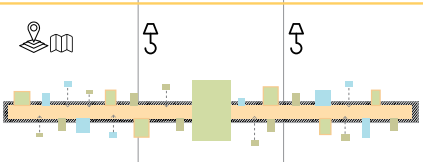
Mapping and documentation

Micro level Green-blue corridors implementation begins

Progress and Planning Review

NANO SCALE - Neighbourhood

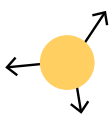
Rain Water Harvesting Policy



Mapping and documentation

Nano level projects implemented

Completion



Extension to other neighbourhoods planned

Progress years as optimise implem

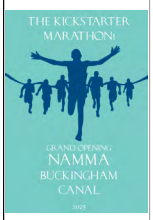
Progress and Planning Review

PHASE III

PHASE IV

2028 2029 2030 2031 2032 2033 2034 2035

Completion



Inauguration

Progress Review takes place every two years as a process to evaluate, revise and optimise the planning and implementation process.

Completion

Completion

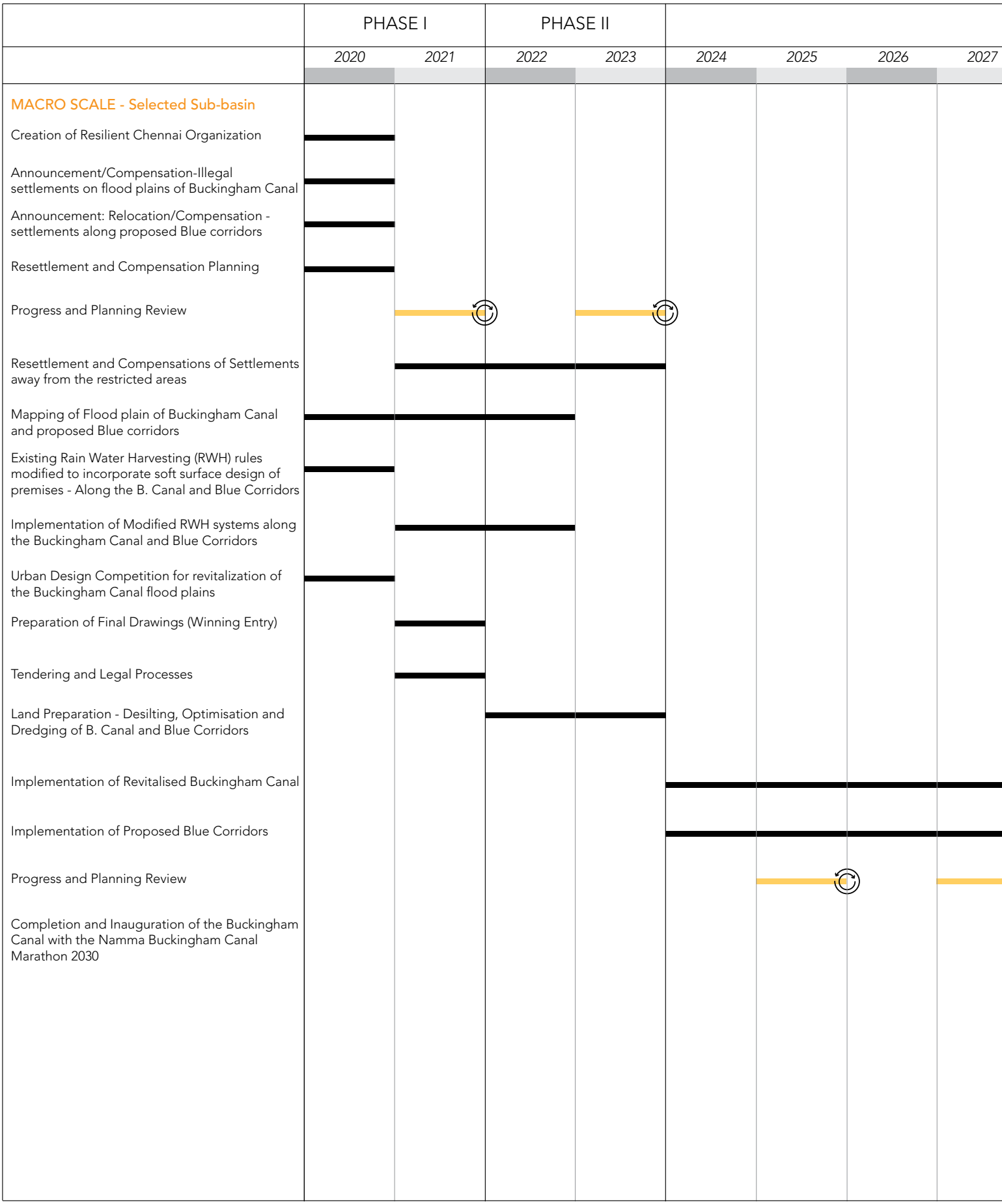
Progress Review takes place every two years as a process to evaluate, revise and optimise the planning and implementation process.

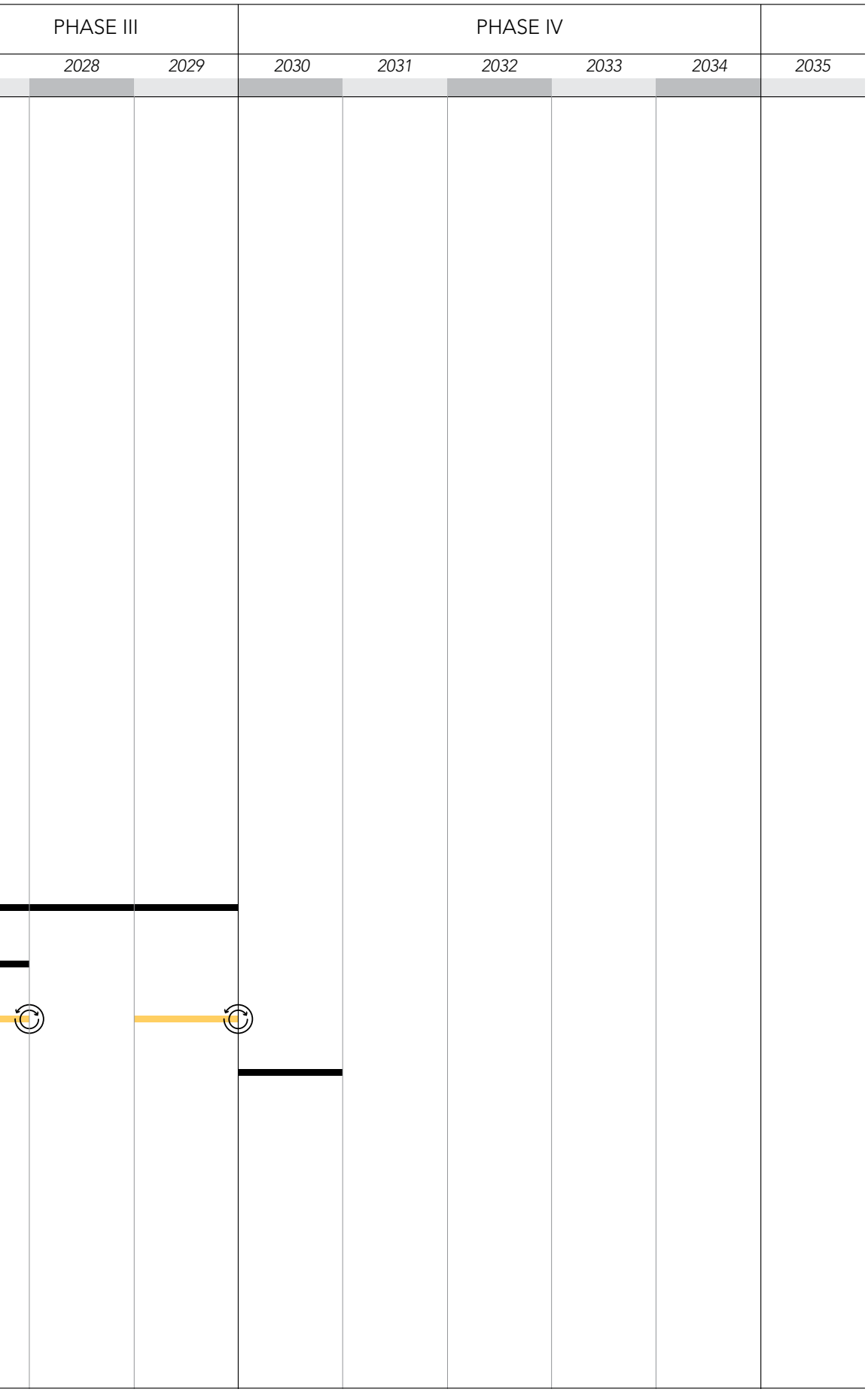
Completion

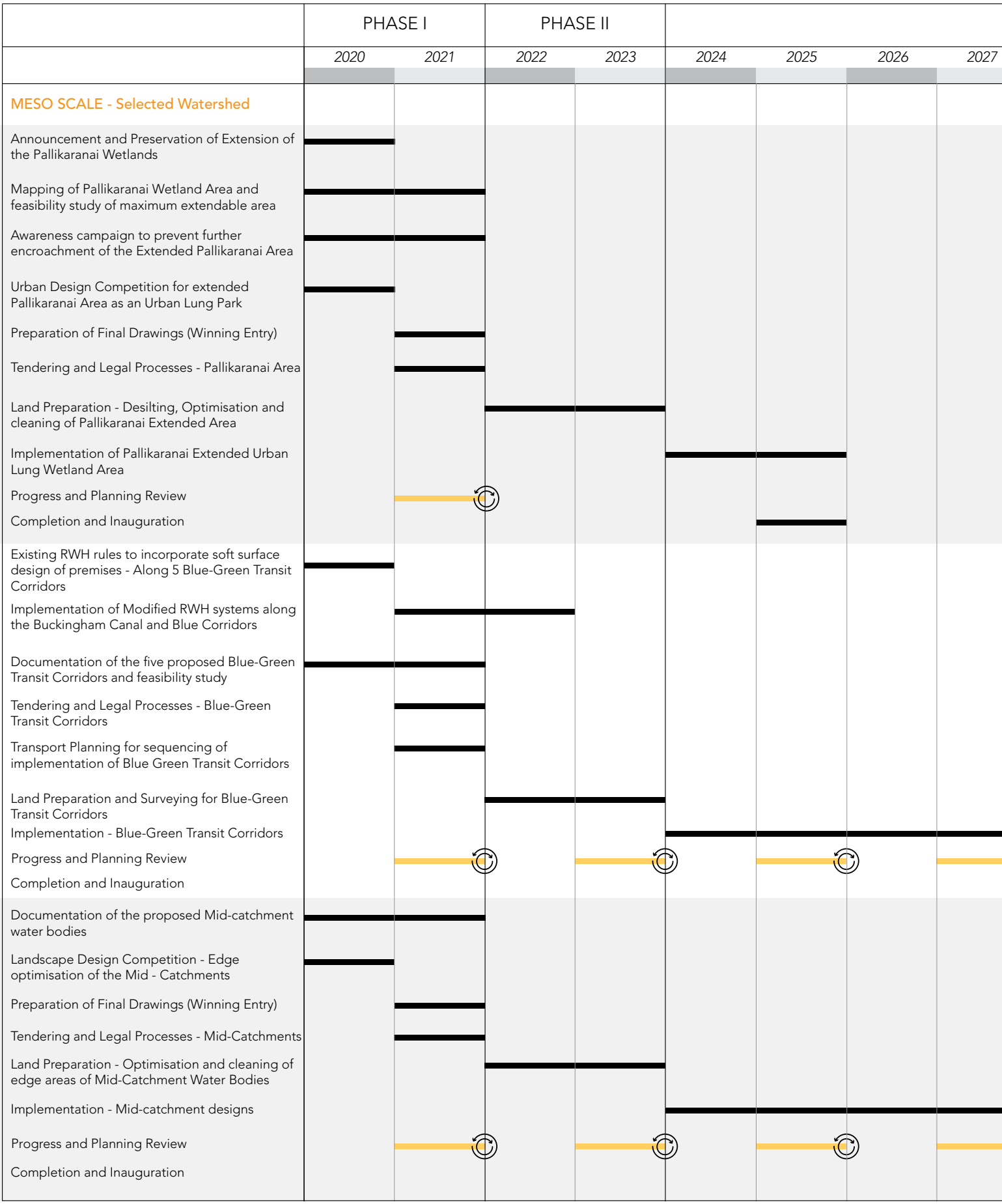
Progress Review takes place every two years as a process to evaluate, revise and optimise the planning and implementation process.

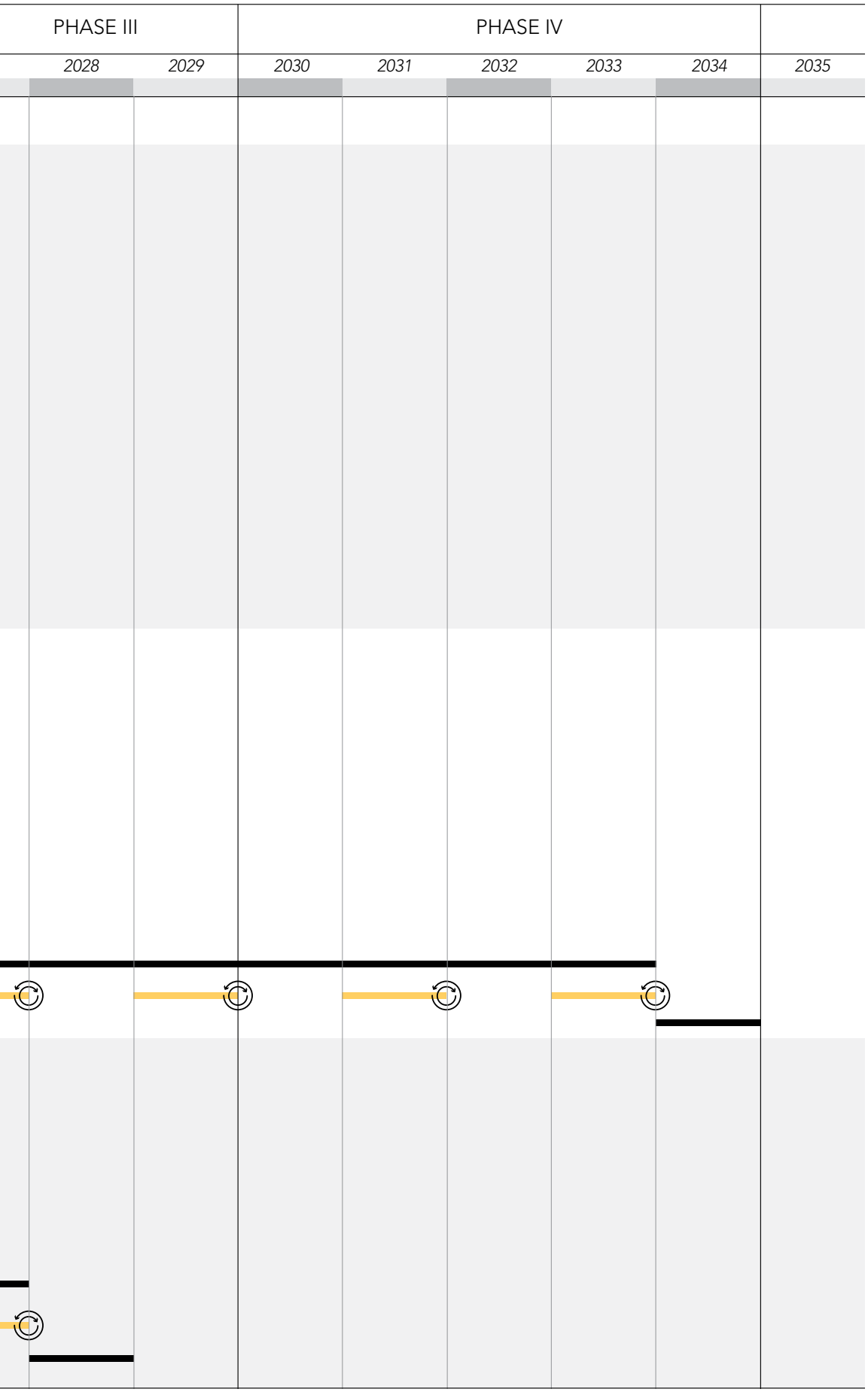
Community activities and programmes continue and spread to the rest of the region

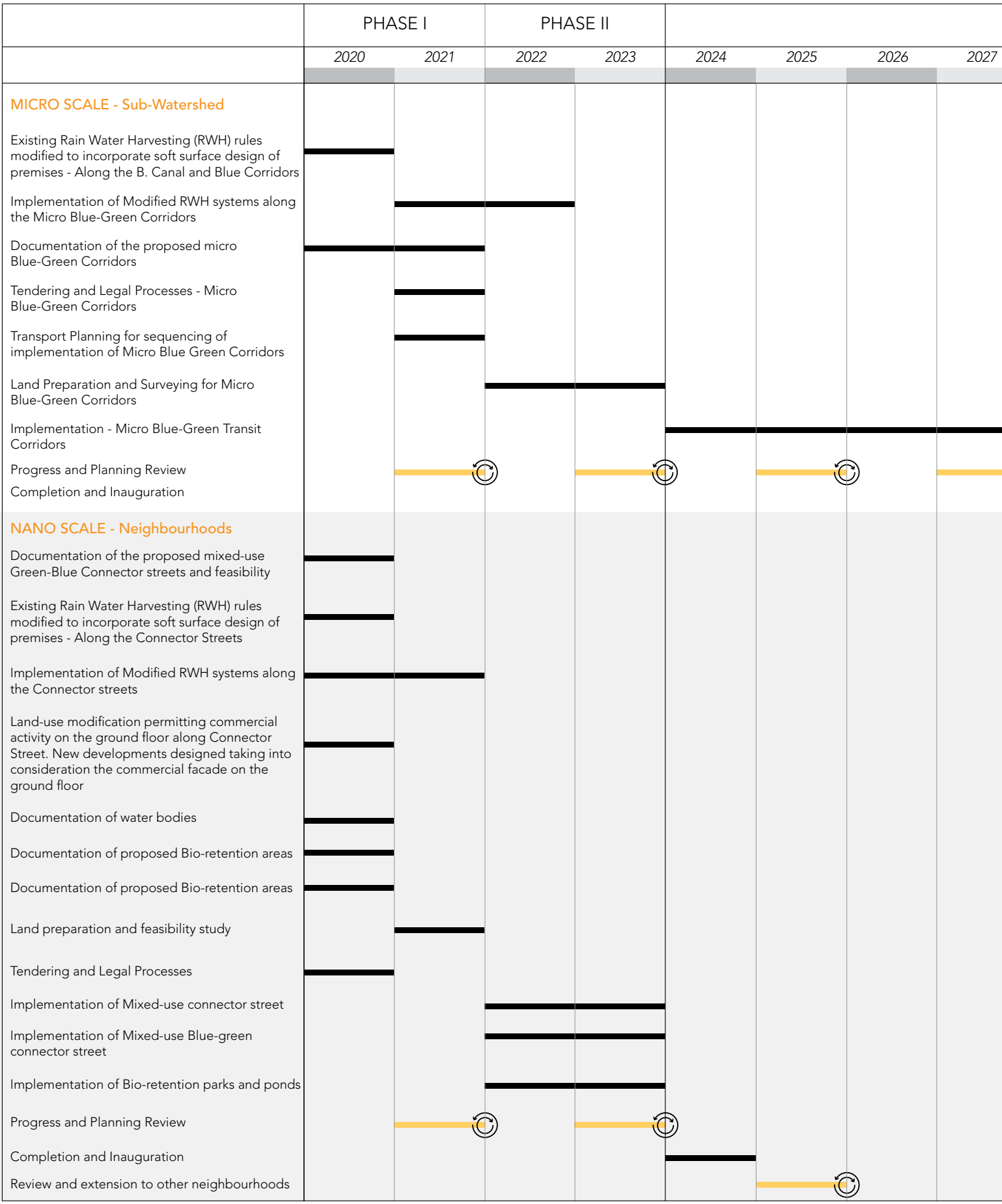
s Review takes place every two
a process to evaluate, revise and
e the planning and
entation process.

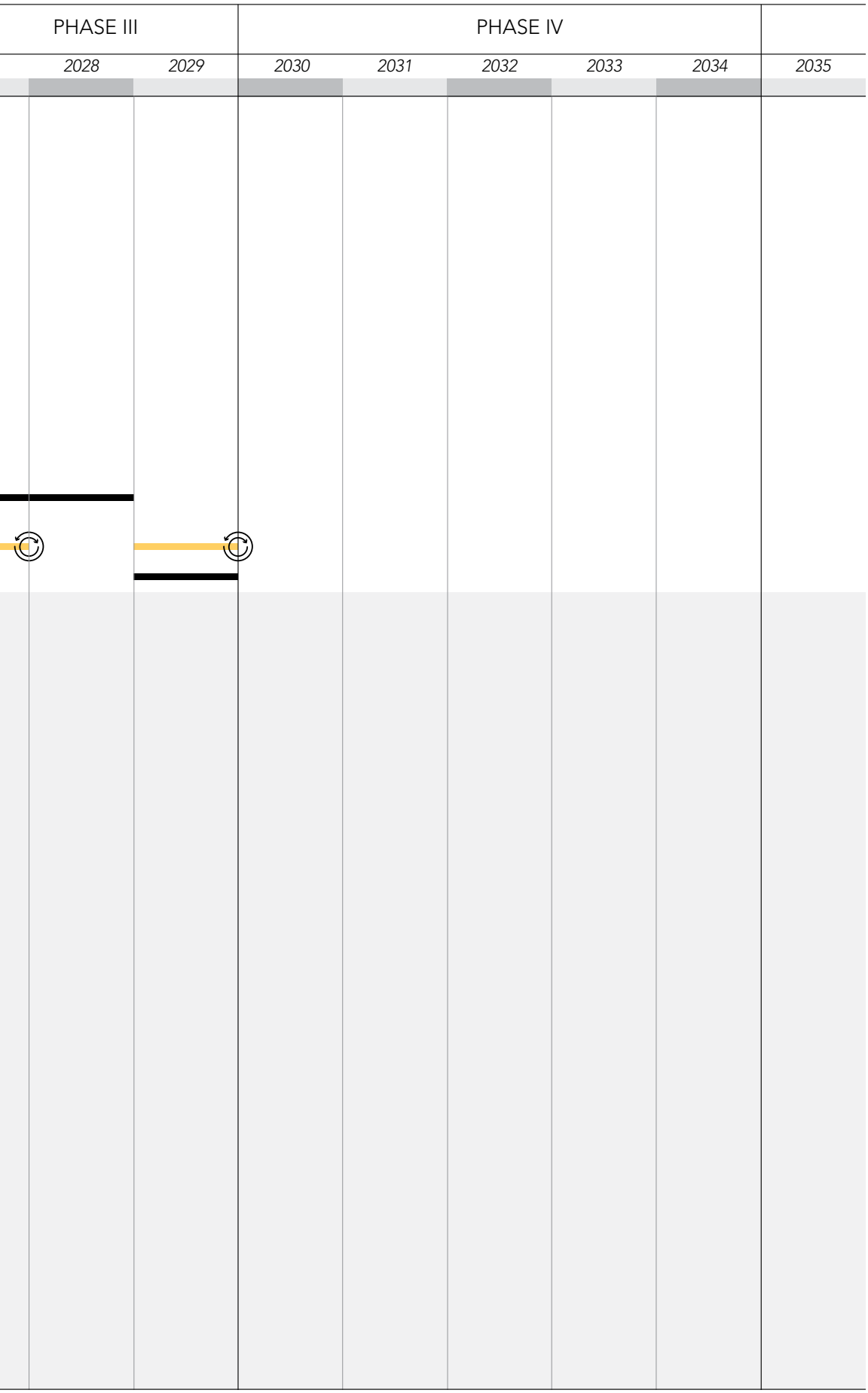

PHASE I
PHASE II
2020
2021
2022
2023
2024
2025
2026
2027
MACRO SCALE - Selected Sub-basin
Creation of Resilient Chennai Organization
Announcement/Compensation-Illegal settlements on flood plains of Buckingham Canal
Announcement: Relocation/Compensation - settlements along proposed Blue corridors
Resettlement and Compensation Planning
Progress and Planning Review
Resettlement and Compensations of Settlements away from the restricted areas
Mapping of Flood plain of Buckingham Canal and proposed Blue corridors
Existing Rain Water Harvesting (RWH) rules modified to incorporate soft surface design of premises - Along the B. Canal and Blue Corridors
Implementation of Modified RWH systems along the Buckingham Canal and Blue Corridors
Urban Design Competition for revitalization of the Buckingham Canal flood plains
Preparation of Final Drawings (Winning Entry)
Tendering and Legal Processes
Land Preparation - Desilting, Optimisation and Dredging of B. Canal and Blue Corridors
Implementation of Revitalised Buckingham Canal
Implementation of Proposed Blue Corridors
Progress and Planning Review
Completion and Inauguration of the Buckingham Canal with the Namma Buckingham Canal Marathon 2030

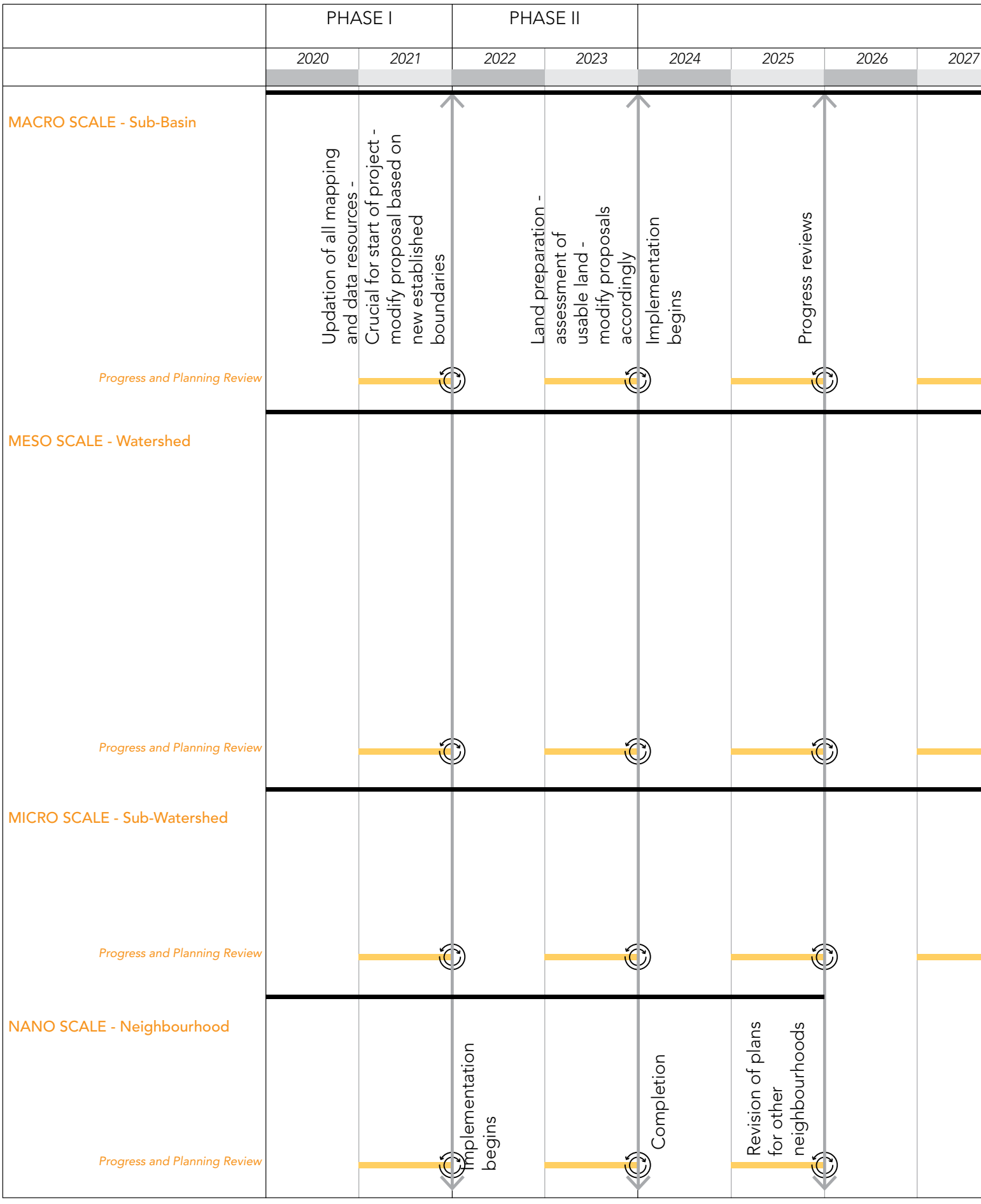

PHASE III
PHASE IV
2028
2029
2030
2031
2032
2033
2034
2035

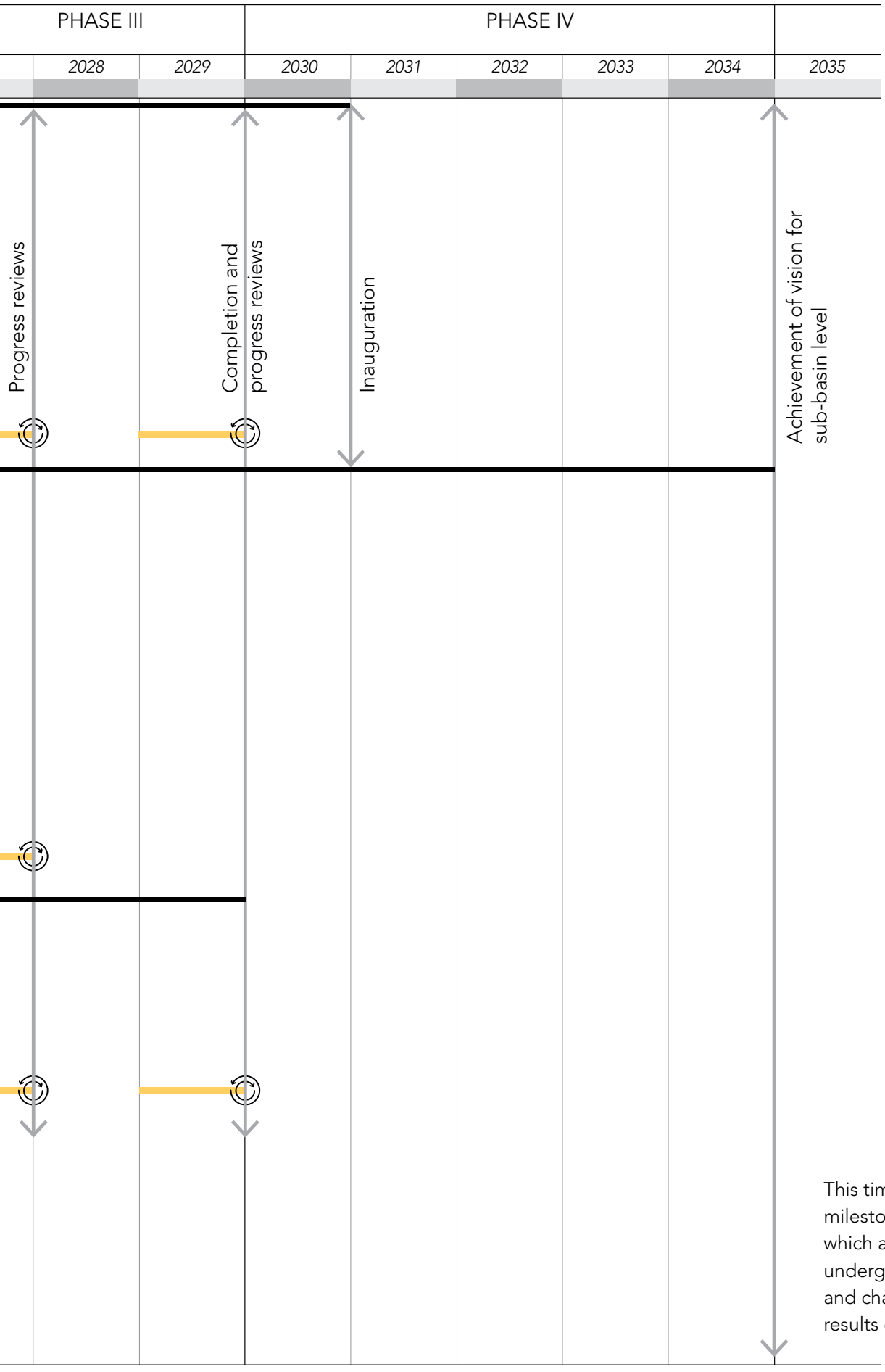

PHASE I
PHASE II
2020
2021
2022
2023
2024
2025
2026
2027
MESO SCALE - Selected Watershed
Announcement and Preservation of Extension of the Pallikaranai Wetlands
Mapping of Pallikaranai Wetland Area and feasibility study of maximum extendable area
Awareness campaign to prevent further encroachment of the Extended Pallikaranai Area
Urban Design Competition for extended Pallikaranai Area as an Urban Lung Park
Preparation of Final Drawings (Winning Entry)
Tendering and Legal Processes - Pallikaranai Area
Land Preparation - Desilting, Optimisation and cleaning of Pallikaranai Extended Area
Implementation of Pallikaranai Extended Urban Lung Wetland Area
Progress and Planning Review
Completion and Inauguration
Existing RWH rules to incorporate soft surface design of premises - Along 5 Blue-Green Transit Corridors
Implementation of Modified RWH systems along the Buckingham Canal and Blue Corridors
Documentation of the five proposed Blue-Green Transit Corridors and feasibility study
Tendering and Legal Processes - Blue-Green Transit Corridors
Transport Planning for sequencing of implementation of Blue Green Transit Corridors
Land Preparation and Surveying for Blue-Green Transit Corridors
Implementation - Blue-Green Transit Corridors
Progress and Planning Review
Completion and Inauguration
Documentation of the proposed Mid-catchment water bodies
Landscape Design Competition - Edge optimisation of the Mid - Catchments
Preparation of Final Drawings (Winning Entry)
Tendering and Legal Processes - Mid-Catchments
Land Preparation - Optimisation and cleaning of edge areas of Mid-Catchment Water Bodies
Implementation - Mid-catchment designs
Progress and Planning Review
Completion and Inauguration


PHASE III
PHASE IV
2028
2029
2030
2031
2032
2033
2034
2035


PHASE I
PHASE II
2020
2021
2022
2023
2024
2025
2026
2027
MICRO SCALE - Sub-Watershed
Existing Rain Water Harvesting (RWH) rules modified to incorporate soft surface design of premises - Along the B. Canal and Blue Corridors
Implementation of Modified RWH systems along the Micro Blue-Green Corridors
Documentation of the proposed micro Blue-Green Corridors
Tendering and Legal Processes - Micro Blue-Green Corridors
Transport Planning for sequencing of implementation of Micro Blue Green Corridors
Land Preparation and Surveying for Micro Blue-Green Corridors
Implementation - Micro Blue-Green Transit Corridors
Progress and Planning Review
Completion and Inauguration
NANO SCALE - Neighbourhoods
Documentation of the proposed mixed-use Green-Blue Connector streets and feasibility
Existing Rain Water Harvesting (RWH) rules modified to incorporate soft surface design of premises - Along the Connector Streets
Implementation of Modified RWH systems along the Connector streets
Land-use modification permitting commercial activity on the ground floor along Connector Street. New developments designed taking into consideration the commercial facade on the ground floor
Documentation of water bodies
Documentation of proposed Bio-retention areas
Documentation of proposed Bio-retention areas
Land preparation and feasibility study
Tendering and Legal Processes
Implementation of Mixed-use connector street
Implementation of Mixed-use Blue-green connector street
Implementation of Bio-retention parks and ponds
Progress and Planning Review
Completion and Inauguration
Review and extension to other neighbourhoods


PHASE III
PHASE IV
2028
2029
2030
2031
2032
2033
2034
2035


PHASE I
PHASE II
2020
2021
2022
2023
2024
2025
2026
2027
MACRO SCALE - Sub-Basin
Updation of all mapping and data resources -
Crucial for start of project - modify proposal based on new established boundaries
Land preparation - assessment of usable land - modify proposals accordingly
Implementation begins
Progress reviews
Progress and Planning Review
MESO SCALE - Watershed
Progress and Planning Review
MICRO SCALE - Sub-Watershed
Progress and Planning Review
NANO SCALE - Neighbourhood
Implementation begins
Completion
Revision of plans for other neighbourhoods
Progress and Planning Review



This time-line marks the milestones and the moments which are the most likely to undergo iteration, evaluation and change based on the results of the previous phase.

17. Replicability and expansion to the region

The Strategies proposed in this project stay true to the immediate context while also being replicable to other parts of the region. The methodology and design principles used in the project can be applied to various neighbourhoods however based on the immediate nature, will retain place specificity. For example, the main central public space in the proposed neighbourhoods, took specific forms based on the residential or corporate nature of the surroundings.

Across the scales, the neighbourhood strategies can be replicated to other neighbourhoods within the sub-basin and accordingly sub-basin, watershed and sub-watershed strategies can be worked out. The proposal gradually spreads to all other neighbourhoods within the Pallikaranai sub-basin. Based on the lessons learnt and iterations made, similar processes can be conducted to implement the strategies for the other sub-basin and watersheds in the region. Gradually, the entire region is envisioned to be a network of neighbourhood scale strategies which together, restore the ruptured hydrological system and bring about community driven flood resilience.

The various engagement activities will continue even after implementation has completed, in order to keep people engaged and involved.

Opposite page:
Figure 17.1. Spreading to the rest of the region

Source: Author

Part VIII- Conclusions

Source: https://www.tumblr.com/search/streets%20of%20chennai

18. Conclusions

This project dealt with designing local adaptation strategies that focusses on community participation and resilience towards floods in the context of the Chennai Metropolitan Area. Through spatial planning and water management, this project addressed regional level visions that were made tangible through strategies across various scales, both spatial and temporal, and special emphasis had been put on the collective strength of local scale innovation and solutions.

The project conducted an in-depth problem analysis which recognised key conflicts within the region. This conflict was recognised as that of between humans and nature. This implied that regional growth and urban processes had occurred in conflict with the natural and hydrological processes hence resulting in the increase in risk of flooding in the region. To address this social and ecological conflict and make a shift towards socio-ecological resilience and harmony under the circumstances of increasing and inevitable risk of disaster, the theory of Evolutionary Resilience by Davoudi (2012) was used as a starting point.

Based on this initial approach, the main research question in this project was that of 'How can local adaptation strategies be planned to reinforce socio-ecological resilience towards floods in the Chennai Metropolitan Area?'. This was answered through a series of Sub-Research Questions and methodological steps such as Socio-spatial analysis, theoretical framework, analytical framework and fieldwork.

Local adaptation strategies can be planned in Chennai by using social and cultural networks as a leverage to being about environmental transformation. Socio-cultural networks are tapped into through community infrastructure, traditional water practices, civic engagement and ownership. Community building and the building of 'social capital' are used as a method to engage the local community and being about environmental restoration through direct involvement in the maintenance of the hydrological system. The project reconfigures the neighbourhood with a network of blue-green infrastructure which is then activated and maintained directly by the community. The edges of the green-blue elements are essentially transition zones and medium of interaction between human-nature and are activated through public space, landscape and programmes related to the community infrastructure adjacent to it. Together, the local community engages with the environment but also maintains it, hence, resolving directly, the current human-nature conflict. To ensure and maximise community participation, engagement strategies are proposed in detail and respond directly to societal needs, hence bringing about increased appropriation and ownership of the environment. These processes are planned over time, to iterate and learn from experience and become efficient with time. The project in this way, responds to the works of Davoudi (2012) and Wilson (2012), and their concepts of Evolutionary resilience and Social capital building respectively. Local scale action which are the most tangible as stated by Wilson (2012) forms the core of the project and the proposal makes a strong case for socio-ecological resilience in the context of Chennai.

The project takes a pragmatic approach, not only in terms of the search and design proposal but also gives insight into on-ground implementation. The project has developed detailed implementation methods such as community workshops and has taken into consideration actors and processes already in place in the region, hence making it highly realistic.

BRINGING SOCIO-ECOLOGICAL RESILIENCE TO CHENNAI:

The theoretical framework which formed the integral part of the approach adopted in the project, was based on different studies conducted in the field of socio-ecological resilience. Evolutionary Resilience was the starting point and further study pointed towards community-based resilience the concept of social capital. In a developing context such as India and especially in the less-explored terrain of Chennai, these concepts shed new light on the approach to planning flood resilience and community engagement. By understanding different theories, the project could create its own connections in the theoretical framework. This framework linked social capital, economic capital and environmental capital across various spatial scales and further recognised the institution as the facilitator between these capitals and scales.

One of the key products and findings in this project was the link between social capital and community infrastructure, which was made contextual through local examples such as places of worship, educational institutions, collective housing complexes, public spaces, parks, playgrounds etc. In this manner, the project not only learnt from the works of many researchers, but was also able to contribute to the ongoing discussion, especially in the case of Chennai.

In addition to this, the 'edges' which were recognised as a mis-managed element made the proposal more spatially relevant and rich. During the field visit, one of the key findings was that of the importance and potential of the edge as a transition space. The edges that are crucial to perception of the environment and are the spatial domains in which man and nature interact with each other. This domain is blurred or neglected in most cases and this project re-defines the edge through spatial design. This edge hence becomes the space in which the project approach and theory which largely focuses on social capital and community engagement for resilience are translated into design through community infrastructure, engagement strategies and green-blue infrastructure. This project hence redefines how blue-green infrastructure can be applied in the case of Chennai through the reconfiguring of the edges while responding to its social, economic and environmental aspirations.

This approach is relevant considering that the region is under high risk of flooding however this risk is yet to be fully addressed in its urban planning. In recent years, awareness of the problem and its link to urban planning has been highlighted and hence this project places itself in this ongoing discussion and pursues a less explored domain of flood resilience and urban planning in the case of Chennai.

Together, the community infrastructure and the edges became the most operational elements of the proposal. Through these elements, hydrological performance was enhanced across all spatial scales and socio-ecological resilience was designed for.

To take community participation and engagement a step farther, a co-evaluation workshop was conducted as part of the fieldwork on February 10th 2018. This workshop consisted of a participatory approach to strategy making and was attended by a total of 15 participants from different disciplines and walks of life. Together in three groups, the participants discussed and brainstormed different solutions in response to their perceptions of the problem of flooding. This workshop not only became a means of including the local citizens in the design process but also suggested future opportunities where local citizens must be

included as part of every step, from design to implementation. The above listed elements together make a strong case for inclusive development and participatory design in the context of Chennai. The fact that people are willing to be a part of urban development processes and actively participate in making the city more resilient is quite promising and opens new prospects for building social capital in Chennai.

MORE THAN JUST WATER! – LOOKING AT ECOSYSTEM RELATED SERVICES IN CHENNAI:

In a developing context like India, the urban planning strategies have over time responded to trends of economic development. In cases like Chennai, which is highly flood prone yet has undergone development with respect to its industrial growth, implementing flood resilience into the existing urban form is a daunting task. This could have been approached in two ways, first, as an idealistic project with large infrastructural projects, and the second, by retrofitting the different social, environmental and economic potentials into the existing fabric. This project followed the latter approach and the method of retrofitting strategies into the existing fabric to being about flood resilience.

While looking at flood management process, it is important to begin with the assessment of the traditional hydrological systems. The intention behind it was to look at how traditional systems used to work in a scenario where the intensity of the problem was not as rampant as today. What was unique about the case of Chennai, is that the study of traditional hydrological systems revealed that the water network in addition to serving drainage purposes also had inherent socio-economic values attached to it. For example, a temple tank which forms an important node in this network has a deep religious and sentimental value attached to it. This value becomes the primary means of interaction between the people and their environment.

Hence this network which once consisted of hierarchical water bodies also harboured a network of socio-cultural and recreational qualities, which makes water systems to be valued for more than just their hydrological performances. This ecosystem service based hydrological network is hence termed as value-adding green-blue networks.

While the research revealed the gradual disappearance of the traditional network due to urbanisation processes, it was also inferred that in addition to the loss of the hydrological performance, these inherent socio-economic values were also threatened. This further substantiated the theoretical framework which made a strong case for the need to consider the social dimension while responding to the design of drainage infrastructure. The project hence redefined this value-added traditional network by identifying community infrastructure as the inherent socio-economic layer, while ensuring efficient drainage.

In addition to this, a key finding during fieldwork was that water retention landscapes which responded to the water scarcity situation in addition to responding to flooding. Hence the storm water infrastructure should respond to these extremities, while incorporating retention landscapes as part of its drainage design.

CONTEXTUAL YET TRANSFERABLE:

Through research and design, a series of findings, concepts and solutions were explored in this project. Community infrastructure and the concept of the edges shape the local strategies in Chennai and this form the core of the project. There is a direct response to contextuality and local culture using cultural elements of the religious institutions, use of traditional water elements and typologies, use of cultural activities and festivals, use of locally seen placemaking strategies and the use of contemporary movements such as art installations and graffiti. Throughout this proposal, place specificity and contextuality has been maintained. Although the strategies are quite simplistic and straightforward, what truly makes it Chennai specific is that the use of locally inspired elements.

The strategic framework and the methodological process which was created as part pf the project have taken into account transferability to other neighbourhoods and contexts within India and also other developing contexts. While the theories and approaches used applies to other contexts, it also leaves room for contextuality and hence retains place-specificity. By using the framework suggested in the proposal and integrating local culture and practices, the project's approach and theoretical framework can be applied in other regions and could lead to different manifestations of social and community infrastructure. Hence, an extension of this work could also consider community infrastructure in other contexts which have similar problems.

RETHINKING THE ROLE OF THE INSTITUTIONS IN CHENNAI:

Through research and fieldwork, a fragmented institutional structure and exclusive governance model was recognised as a key problem and as a barrier to realising flood resilience. In response to this, a new body called the 'Resilient Chennai Organisation' was proposed as an autonomously functioning unit, overseeing urban processes through the lens of flood resilience. This unit was proposed to run by representatives from government stakeholders directly involved in the urban development processes. In addition to this, decentralised water management was also proposed to address bottom-up environmental restoration and to also address social and climate justice by directly involving different groups of the population into the proposal.

NEED FOR EMERGENCY PLANNING:

Due to the lack of data and resources with respect to emergency planning and critical infrastructure and services, the proposal was not able to devise a plan for the fourth domain being the extreme rainfall event. This lack of data with respect to disaster management sheds light on the need for the city and region to update its evacuation schemes and this could be one of the first steps that need to be implemented in future. In fact, the study of the existing Disaster Management plan revealed that, city level emergency plans are currently not fully developed and this could lead to further disaster if not dealt with at the earliest. Especially with the risk increasing and frequency unpredictable, emergency and evacuation planning is highly relevant for the case of Chennai.

RELATIONSHIP BETWEEN RESEARCH AND DESIGN:

The project initially looked at the main problem of flooding through a larger lens which investigated the contributing factors and trends influencing the increased flood risk in the region. The main problem was that urban planning and growth had taken place in complete conflict of climate adaptation and resilience. This conflict between human and nature paved the way for the initial project approach which was derived from Davoudi's (2012) concept of Evolutionary Resilience. To further understand this conflict, a socio-spatial analysis that investigated urban development processes was conducted. The findings from this study pointed towards an exclusive and fragmented institution, strong economic and infrastructural trends influencing urban form and a ruptured hydrological system influencing flood risk. These findings were then plugged into the theoretical framework which argued in favour of socio-ecological resilience in this case, where conflict is prevalent and risk is inevitable. These elements shaped the final project approach such that social infrastructure was the link between economic aspirations and environmental restoration.

In the phase of translating research findings into design, fieldwork was an important turning point in the process. This fieldwork was strategically placed between the research and design phase to first build a strong theoretical framework and then use observations, stakeholder interviews and site visits as a means to not only verify and corroborate the research but to also investigate the feasibility of the approach. As planned, the fieldwork yielded fruitful results and one of the key findings was that of the concept of the 'edge' which became the spatial medium in which the research was made tangible into a design proposal. In addition to this, the edge became the spatial link across the various scales that the project was working across. The design proposal hence was formulated as 'reconfiguration of the edge' such that by retrofitting social and cultural networks, it acts as a leverage for environmental restoration leading to the design of a new type of green-blue infrastructure.

LIMITATIONS:

In this graduation project set in the context of India, the biggest limitation was that of availability of data and documentation of the region. While in most cases the master plan documents did contain the basic information on the infrastructure at the regional level, data on water networks, services and neighbourhood functionality was scarce. This gap in the availability of data was the biggest challenge. As a result of these limitations, it was difficult to represent completely, the Chennai Metropolitan Area. This project has however attempted to overcome these limitations by carrying out a thorough system of triangulation where each piece of data was first sourced from various sources, was tabulated against each other before being used for the research and design processes.

FUTURE RESEARCH RECOMMENDATIONS:

•Considering the limitations mentioned above, a conscious decision was made in the process early on, to limit the design proposals at the Neighbourhood scale to only two neighbourhoods. This ensured in depth analysis and design applications for the selected neighbourhoods. For this purpose, place specific data was produced to yield tailor-made solutions which following a step-by-step methodological approach which was established as the benchmark for the design of neighbourhoods in this project. Hence, this approach

can be further applied to other neighbourhoods in the region, while responding to their place specificity.

•While on the one hand the project systematically designs the particularities and details of the social aspects of addressing water resilience through event programming, civic engagement strategies and stakeholder involvement strategies, on the other hand, the technical aspects of the project which have been less focussed on, could be a future research that could be pursued. Through an interdisciplinary design process consisting of fields such as architecture, civil engineering and water management, the technical performance can be further designed in detail. To already build a framework for this research and facilitate a sophisticated structural design of the storm water infrastructure, the peak run-off rate using the rational method has been determined as part of the project. This will further give a complete picture of the feasibility of the solutions proposed and the impact of the same on flood risk.

•During the research and fieldwork, a fragmented institutional structure was identified. As a result, there were several gaps in the functioning of the different departments engaged in urban development and water management process. In response to this, the project proposed an autonomous body that oversees the realisation of flood resilience by facilitating a common forum where there is representation from all departments influencing urban growth and services. Future research can explore the other potentials for the design of the institutional structure and its feasibility in the context of Chennai.

19. Reflections

The main research question of this project was to explore the ways of integrating local adaptation strategies for bringing about flood resilience in the Chennai Metropolitan Area. The project carves a strong case for the relevance of the social dimension to approaching urban planning and resilience. The process which spanned across 10 months was a highly lateral and iterative one, in which the project approach was first moulded by research and then further applied through design proposals.

CHOICE OF STUDIO: COMPLEX CITIES

The Complex Cities research studio places immense focus on the relationship between spatial planning, spatial design and policy recommendations while reflecting on the various socio-economic conditions of urban settings. This project although dealing with the core aspect of flood resilience, recognised flood vulnerability was fundamentally an implication of a gap between urban growth and environmental performance. This gap resulted in the adoption of a spatial planning approach to the project and being placed in the context of India, the sub group 'Inclusive cities in the Global South' was an obvious choice.

REFLECTIONS ON PROJECT APPROACH AND METHODOLOGY

Flood management from a socio-cultural perspective:

In the initial phase of the project, the problem analysis was carried out in order to understand the multiple aspects that contribute to increased risk in the region. This study was carried out from a flood management and infrastructural point of view. However further into the process, upon the analysis of the social and economic layers, a strong case was made for the social aspect of resilience. At this point, the project approach shifted towards making a strong case for building social capital and its influence over how cities urbanise and cope with risk. The project hence pursued civic engagement and placemaking strategies to address bottom-up solution that over time will make the region more adaptive.

Relationship between research and design:

The project initially looked at the main problem of flooding through a larger lens which investigated the contributing factors and trends influencing the increased flood risk in the region. The main problem was that urban planning and growth had taken place in complete conflict of climate adaptation and resilience. This conflict between human and nature paved the way for the initial project approach which was derived from Davoudi's (2012) concept of Evolutionary Resilience. In order to further understand this conflict, a socio-spatial analysis that investigated urban development processes was conducted. The findings from this study pointed towards an exclusive and fragmented institution, strong economic and infrastructural trends influencing urban form and a ruptured hydrological system influencing flood risk. These findings were then plugged into the theoretical framework which argued in favour of socio-ecological resilience in this case, where conflict is prevalent and risk is inevitable. These elements shaped the final project approach such that social infrastructure

was the link between economic aspirations and environmental restoration.

In the phase of translating research findings into design, fieldwork was an important turning point in the process. This fieldwork was strategically placed between the research and design phase in order to first build a strong theoretical framework and then use observations, stakeholder interviews and site visits as a means to not only verify and corroborate the research but to also investigate the feasibility of the approach. As planned, the fieldwork yielded fruitful results and one of the key findings was that of the concept of the 'edge' which became the spatial medium in which the research was made tangible into a design proposal. In addition to this, the edge became the spatial link across the various scales that the project was working across. The design intention proposal hence was formulated as the 'reconfiguring of the edge' such that by retrofitting social and cultural networks, it acts as a leverage for environmental restoration leading to the design of a new type of green-blue infrastructure.

RELEVANCE OF THE PROJECT:

The issue addressed through this thesis, which involves the disaster of flooding immediately has implication of the societal aspects of the region. The project recognised, early on in the process, the need for social and climate justice which was an important part of the theoretical framework. Arguments were made in favour of inclusive approach to planning and hence the concepts of community resilience, participatory design and civic engagement were given focus. This gave new insights into how flood management strategies may be planned and contributed to the sub-research group being 'Inclusive Cities of the Global South'. The research also attempted to make tangible, the concepts of social, economic and environmental capital and by testing these in the context of Chennai in India, new insights were given into working across scales in a developing context. Reflecting on the nature of the approach adopted, the public-private-community partnership is highly relevant in this case and the project has responded to this normative framework through its research and design proposals.

The project further was placed in a time when awareness about the risk of flooding was highest in Chennai, especially in the aftermath of the 2015 floods making it highly relevant. The project benefited immensely from the ongoing discussion and proactive participation of the various stakeholders making it well informed. This research also contributed to the on-ground discussion by the means of a community co-evaluation workshop which was organised by the author as part of fieldwork. Having used diverse methods of research, analysis, spatial design and planning, this research can now go on to contribute to further discussions which not only looks at flood management but also the development of social capital which is yet to be explored from a planning perspective in Chennai. Other neighbourhoods in the region, while responding to their place specificity.

The crowds
Source: https://i.pinimg.com/originals/1f/68/5b/1f685bad4944d7b048ee3c219e992bf9.jpg

20. References

ACCCRN. Asian Cities Climate Change Resilience Network. ACCCRN IN INDIA.

Adger, W. N. (2003). Social capital, collective action, and adaptation to climate change. Economic geography, 79(4), 387-404.

Adger, W. N., Huq, S., Brown, K., Conway, D., & Hulme, M. (2003). Adaptation to climate change in the developing world. Progress in development studies, 3(3), 179-195.

Albrechts, L. (2010). How to enhance creativity, diversity and sustainability in spatial planning: strategic planning revisited Making Strategies in Spatial Planning (pp. 3-25): Springer.

Arabindoo, P. (2009). Falling Apart at the Margins? Neighbourhood Transformations in Peri Urban Chennai. Development and Change, 40(5), 879-901.

Arabindoo, P. (2016). Unprecedented natures? An anatomy of the Chennai floods. City, 20(6), 800-821.

Arabindoo, P. G. (2008). Absent societies: Contouring urban citizenship in post colonial Chennai: London School of Economics and Political Science (United Kingdom).

Bernstein, L., Bosch, P., Canziani, O., Chen, Z., Christ, R., Davidson, O., . . . Kattsov, V. (2007). IPCC, 2007: climate change 2007: synthesis report. Contribution of working groups I. II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Intergovernmental Panel on Climate Change, Geneva.< http://www. ipcc. ch/ipccreports/ar4-syr. htm.

Bulkeley, H., Carmin, J., Broto, V. C., Edwards, G. A., & Fuller, S. (2013). Climate justice and global cities: mapping the emerging discourses. Global Environmental Change, 23(5), 914-925.

Bulkeley, H., Edwards, G. A., & Fuller, S. (2014). Contesting climate justice in the city: Examining politics and practice in urban climate change experiments. Global Environmental Change, 25, 31-40.

Burger, M., & Meijers, E. (2012). Form follows function? Linking morphological and functional polycentricity. Urban studies, 49(5), 1127-1149.

Chander, S. (2013). Modeling peri urban areas in Indian context a case study of Chennai metropolitan area CMA.

Chandrachud, S., & Gajalakshmi, N. A study on Special Economic Zones (SEZ) in Tamilnadu State.

Cities and Climate Change : An Urgent Agenda. (2010). Retrieved from Washington, DC https://openknowledge.worldbank.org/handle/10986/17381

Da Silva, J., & Morera, B. (2014). City resilience framework. Arup & Rockefeller Foundation. Online: http://publications. arup. com/Publications/C/City_Resilience_Framework. aspx [12/15/2015].

Davoudi, S., Brooks, E., & Mehmood, A. (2013). Evolutionary resilience and strategies for climate adaptation. Planning Practice & Research, 28(3), 307-322.

Davoudi, S., Shaw, K., Haider, L. J., Quinlan, A. E., Peterson, G. D., Wilkinson, C., . . . Davoudi, S. (2012). Resilience: a bridging concept or a dead end?"Reframing" resilience: challenges for planning theory and practice interacting traps: resilience assessment of a

pasture management system in Northern Afghanistan urban resilience: what does it mean in planning practice? Resilience as a useful concept for climate change adaptation? The politics of resilience for planning: a cautionary note: edited by Simin Davoudi and Libby Porter. Planning Theory & Practice, 13(2), 299-333.
de Haan, F. J., Ferguson, B. C., Adamowicz, R. C., Johnstone, P., Brown, R. R., & Wong, T. H. (2014). The needs of society: A new understanding of transitions, sustainability and liveability. Technological Forecasting and Social Change, 85, 121-132.
Earth, C. (2010). Adaptive Management Plan for the Conservation of Pallikaranai Marsh. Report prepared by Care Earth and City Connect, Chennai.
Ellis, R. (2012). "A World Class City of Your Own!": Civic Governmentality in Chennai, India. Antipode, 44(4), 1143-1160.
Geels, F. W., & Schot, J. (2007). Typology of sociotechnical transition pathways. Research policy, 36(3), 399-417.
Habitat, U. (2011). Cities and climate change: Global report on human settlements 2011. London: Earthscan.
Hallegatte, S., & Corfee-Morlot, J. (2011). Understanding climate change impacts, vulnerability and adaptation at city scale: an introduction. Climatic Change, 104(1), 1-12.
Heinrichs, D., Krellenberg, K., & Fragkias, M. (2013). Urban responses to climate change: Theories and governance practice in cities of the global South. International Journal of Urban and Regional Research, 37(6), 1865-1878.
INCCA. (2010). Climate change and India: a 4 × 4 assessment-a sectoral and regional analysis for
2030. Indian network for climate change assessment. Ministry of Environment and Forests, GoI.
Joerin, J., Shaw, R., Takeuchi, Y., & Krishnamurthy, R. (2012). Assessing community resilience to climate-related disasters in Chennai, India. International Journal of Disaster Risk Reduction, 1, 44-54.
Kennedy, L., Varrel, A., Denis, E., Dupont, V., Dhanalakshmi, R., Roumeau, S., . . . Vijayabaskar, M. (2014). Engaging with sustainability issues in metropolitan Chennai.
Kilpatrick, S., & Abbott-Chapman, J. (2007). Community efficacy and social capital. Social capital, lifelong learning and the management of place: an international perspective, 51.
Manohar, L., & KT, M. (2016). Towards Resilience in Chennai. In Carola Hein (ed.) International Planning History Society Proceedings, 17th IPHS
Conference, History-Urbanism-Resilience, TU Delft 17-21 July 2016, TU Delft Open, 2016., V.03 p.251. doi:http://dx.doi.org/10.7480/iphs.2016.3.1266
McGranahan, G., Balk, D., & Anderson, B. (2007). The rising tide: assessing the risks of climate change and human settlements in low elevation coastal zones. Environment and urbanization, 19(1), 17-37.
Narasimhan, B., Bhallamudi, S. M., Mondal, A., Ghosh, S., & Mujumdar, P. (2016). Chennai Floods 2015: A Rapid Assessment. Bangalore: Interdisciplinary Centre for Water Research, IISc. Retrieved from http://itra. medialabasia. in/img/Chennai% 20Floods-Rapid% 20Assessment% 20Report-May, 2023, 202016.
Parikh, J., Sandal, G., & Jindal, P. (2016). Climate resilient cities: vulnerability profiling of twenty Indian cities Development in India (pp. 351-365): Springer.
Parkinson, J., & Mark, O. (2005). Urban stormwater management in developing countries: IWA publishing.
Pendall, R., Foster, K. A., & Cowell, M. (2010). Resilience and regions: building understanding of the metaphor. Cambridge Journal of Regions, Economy and Society, 3(1), 71-84.
Robinson, G. M., & Carson, D. A. (2016). Resilient communities: transitions, pathways and resourcefulness. The Geographical Journal, 182(2), 114-122.
Statistics, E. (2017). Central statistics office, National statistical organization, Ministry of

statistics and programme implementation, Government of India.
Suriya, S., & Mudgal, B. (2012). Impact of urbanization on flooding: The Thirusoolam sub watershed–A case study. Journal of Hydrology, 412, 210-219.
Tanner, T., Mitchell, T., Polack, E., & Guenther, B. (2009). Urban Governance for Adaptation: Assessing Climate Change Resilience in Ten Asian Cities. IDS WORKING PAPER 315.
Tyler, S., & Moench, M. (2012). A framework for urban climate resilience. Climate and Development, 4(4), 311-326.
Vencatesan, J. (2007). Protecting wetlands. Current Science, 93(3), 288-290.
White, I., & O'Hare, P. (2014). From rhetoric to reality: which resilience, why resilience, and whose resilience in spatial planning? Environment and Planning C: Government and Policy, 32(5), 934-950.
Wilson, G. (2012). Community resilience and environmental transitions: Routledge.
Zevenbergen, C., Cashman, A., Evelpidou, N., Pasche, E., Garvin, S., & Ashley, R. (2010). Urban flood management: CRC Press.

21. Appendix

Appendix 1

Stakeholder Type Analysis

Stakeholder Name	Type of Support expected	Producing / Blocking Power	Typology of Interest
Small and Medium Businesses	Awareness and Implementation	Blocking	Acquaintance
Non-Governmental Organisations (NGOs)	Awareness and Implementation	Producing	Friend
Indo-German Centre for Sustainability (IGCS)	Proposals and recommendations	Producing	Friend
Slum dwellers	Awareness and Implementation	Producing	Friend
Civic Bodies (CB)	Awareness and Implementation	Producing	Friend
Resident Welfare Associations (RWA)	Awareness and Implementation	Producing	Friend
Residents / Citizens	Implementation	Producing	Friend
Architects	Proposals and recommendations	Producing	Friend
Urban Designers	Proposals and recommendations	Producing	Friend
Labour Unions	Awareness and Implementation	Producing	Friend
Research and Academia	Proposals and recommendations	Producing	Friend

Argument	Source
Small and Medium businesses tend to focus on individual interests and need support in order to collectively address sustainability as individual businesses may not be financially equipped or occupy a strong position in the economic context.	Fieldwork & Socio-Spatial Research and Analysis
Crucial as a link between the people and the institution	Fieldwork & Socio-Spatial Research and Analysis
Existing Research and Academia is a barely tapped into resource for new ideas for sustainability, adaptation and transformation. Can act as a support for a resilient future.	Fieldwork & Socio-Spatial Research and Analysis
This socio-economically weaker section needs to be persuaded in order to support restoration of the water resources in their surroundings. This needs to be addressed through policies, incentives and tapping into services that affect them directly such that they perceive water resources as a benefit to them.	Fieldwork & Socio-Spatial Research and Analysis
Civic bodies can play an important role in mobilising interest and supporting bottom-up initiatives.	Fieldwork & Socio-Spatial Research and Analysis
Resident Welfare Associations are effective leaders and agencies of change at the local level. They need to be empowered through policy and design in order to realise bottom-up decentralised water management and restoration.	Fieldwork & Socio-Spatial Research and Analysis
The ultimate users need to be mobilised and empowered to promote active participation. Design plays an important role.	Fieldwork & Socio-Spatial Research and Analysis
Design of buildings can play an important role in propagating the ideals of the resilient Chennai vision.	Fieldwork & Socio-Spatial Research and Analysis
Design of the urban realm can play an important role in propagating the ideals of the resilient Chennai vision.	Fieldwork & Socio-Spatial Research and Analysis
Labour unions are important stakeholders in order to address small and medium economies. Hence effective policy and incentives that support SMEs will help address different economic stakeholders.	Fieldwork & Socio-Spatial Research and Analysis
Floods in Chennai are a widely researched topic however, in many cases, this research is not publicly accessible and proposals may not see realisation. This knowledge base can be tapped into and can hold multiple potentials for addressing resilience, adaptation and transformations of the CMA.	Fieldwork & Socio-Spatial Research and Analysis

Political Stakeholders	Institutional support and rigour	Blocking	Saboteur
100 Resilient Cities	Policy and Design	Producing	Saviour
C40 Cities	Policy and Design	Producing	Saviour
GIZ	Policy and Design	Producing	Saviour
Municipalities	Policy and Implementation	Producing	Saviour
Town Panchayats	Policy and Implementation	Producing	Saviour
Chennai Metropolitan Development Authority (CMDA)	Policy and Implementation	Producing	Saviour
Greater Chennai Corporation (GCC)	Policy and Implementation	Producing	Saviour
Resilient Chennai Organisation (Proposal)	Policy and Implementation	Producing	Saviour
Chennai River Restoration (CRRT)	Design and Implementation	Producing	Saviour
Madras Chamber of Commerce and Industry (MCCI)	Policy	Producing	Saviour
Smart Cities Mission	Design and Implementation	Producing	Saviour

As political regimes expire after a period of 5 years, simultaneously, agendas for the region as well as the state might also differ. In this case, a new government may deem the resilient Chennai vision unnecessary and may pursue its own goals to satisfy its vote bank. Hence, the new overseeing body, which is the Resilient Chennai Organisation can play an important role in acting as the ultimate decision making body with respect to the resilient Chennai vision.	Fieldwork & Socio-Spatial Research and Analysis
Agency that can function as an advisory to the government as well as an implementer as it is backed up by third party organisations that function on a global scale	Fieldwork & Socio-Spatial Research and Analysis
Agency that can function as an advisory to the government.	Fieldwork & Socio-Spatial Research and Analysis
Agency that can function as an advisory to the government.	Fieldwork & Socio-Spatial Research and Analysis
These mainly govern peri-urban areas where their influence is considerable however interest may be low.	Socio-Spatial Research and Analysis
These mainly govern peri-urban areas where their influence is considerable however interest may be low.	Socio-Spatial Research and Analysis
The most powerful planning body. Their vision for Chennai is that of a 'The vision of Chennai Metropolitan Development Authority is to provide people-friendly administration in the process of ensuring better quality of life in Chennai Metropolitan Area through environmentally sustainable, economically progressive, technologically innovative management policies and programs'. The CMDA can play an important role in defining urban development in the existing as well as new extent. Also, as insufficient planning was also recognised as a major problem in the urban development of the region, the CMDA is also currently under heavy scrutiny while it prepares the new masterplan for the extended region. Hence this might play an important role and the CMDA is now responsible for delivering a resilient urban plan.	Socio-Spatial Research and Analysis
The second most powerful urban body in the region. This body deals with all kinds of implementation within the city area such as roads, health, census, demography, solid waste, water resources, policy, new projects and building licences etc.	Fieldwork & Socio-Spatial Research and Analysis
New proposal which oversees and integrates all urban development decisions as per human-nature balances.	Fieldwork & Socio-Spatial Research and Analysis
Existing efforts into the restoration of water bodies and water ways can be tapped into and used to the advantage	Fieldwork & Socio-Spatial Research and Analysis
Existing initiatives such as 'Sustainable Chennai Forum' reveal high interest within the organisation as well its members. MCCI is crucial for addressing corporate and industrial stakeholders.	Fieldwork
Existing initiatives and projects can be tapped into the support resilient vision	Fieldwork & Socio-Spatial Research and Analysis

Mahindra World City (SEZ)	Design and Implementation	Producing	Saviour
Cognizant Solutions Pvt. Ltd.	Design and Implementation	Producing	Saviour
Infosys Pvt. Ltd.	Design and Implementation	Producing	Saviour
Tata Consultancy Services (TCS)	Design and Implementation	Producing	Saviour
Religious Associations	Awareness and Implementation	Producing	Sleeping Giant
Roads and Infrastructure (Govt)	Design and Implementation	Producing	Sleeping Giant
Builders	Design and Implementation	Producing	Sleeping Giant
Real Estate Agencies	Policy	Producing	Sleeping Giant
Tamil Nadu Housing Board (TNHB)	Policy, Design and Implementation	Producing	Sleeping Giant
Tamil Nadu Slum Clearance Board (TNSCB)	Policy, Design and Implementation	Producing	Sleeping Giant
Water Resources Department / Public Works Department (PWD)	Policy, Design and Implementation	Producing	Sleeping Giant
Chennai Metro Water Supply and Sewerage Services	Policy and Implementation	Producing	Sleeping Giant

A global organisation, this company has shown immense interest in sustainable design. In addition to being an industrial stakeholder, they also set up residential projects which further address sustainable design. This stakeholder is a powerful as well as highly interested one.	Socio-Spatial Research and Analysis
A global organisation, this company takes interest in areas such as sustainability. It also openly supports Corporate Social Responsibility and this resource can be used to its maximum potential. As they are an important stakeholder with respect to economic contribution, their strong position can be used to promote resilient city visions.	Socio-Spatial Research and Analysis
A global organisation, this company takes interest in areas such as sustainability. It also openly supports Corporate Social Responsibility and this resource can be used to its maximum potential. As they are an important stakeholder with respect to economic contribution, their strong position can be used to promote resilient city visions.	Socio-Spatial Research and Analysis
A global organisation, this company takes interest in areas such as sustainability. Also they focus on citizen empowerment through digital governance. As they are an important stakeholder with respect to economic contribution, their strong position can be used to promote resilient city visions.	Socio-Spatial Research and Analysis
While addressing cultural networks, religious institutions have the enormous support of its followers and hence this valuable resource can be tapped into as an agency of change.	Fieldwork & Socio-Spatial Research and Analysis
Road design, planning and implementation can play an important role in realising effective drainage.	Fieldwork & Socio-Spatial Research and Analysis
Urban Sprawl has been recognised as a problem as it hinders with the human-nature balance in the form of encroachment of flood plains.	Socio-Spatial Research and Analysis
The housing market is large due to increased housing demands as well as to support the growing industrial nature and migration in the region.	Socio-Spatial Research and Analysis
Social Housing sector can be defined to support resilient vision	Socio-Spatial Research and Analysis
In addition to their built initiatives, TNSCB can play an important role in convincing slum dwellers about the new vision. For example, the TNSCB is currently working on an 'inclusive city' initiative.	Fieldwork & Socio-Spatial Research and Analysis
The existing set-up of the water resources sector can be tapped into to promote integrated water management.	Socio-Spatial Research and Analysis
The existing set-up of the water resources sector can be tapped into to promote integrated water management.	Socio-Spatial Research and Analysis

Solid Waste Management Organisations	Policy and Implementation	Producing	Sleeping Giant
State Industries Promotion Corporation of Tamil Nadu (SIPCOT)	Policy and Implementation	Producing	Sleeping Giant
Electronics Corporation of Tamil Nadu Limited (ELCOT)	Policy and Implementation	Producing	Sleeping Giant
Educational Institutions (Public)	Awareness and Implementation	Producing	Sleeping Giant
Educational Institutions (Private)	Awareness and Implementation	Producing	Sleeping Giant
Special Economic Zones (Public Ownership)	Policy and Implementation	Blocking	Time Bomb
Special Economic Zones (Private Ownership)	Policy, Design and Implementation	Blocking	Time Bomb
Tidel Park	Policy and Implementation	Producing	Time Bomb
IT Corridor Industries	Implementation	Blocking	Time Bomb
Industries along Development Corridors	Implementation	Blocking	Time Bomb

Waste management is recognised as an obstacle to integrated water management and hence needs to be addressed as a key agency of change. Also, the waste management sector consists of the largest work force.	Fieldwork & Socio-Spatial Research and Analysis
This SEZ consists of multiple industrial and powerful stakeholders that need to be satisfied in order to promote economic growth. As a State Set-up SEZ, policies can play an important role in also influencing its constituent industries to invest and promote the resilient city vision. The State can also capitalise on the 'novel sustainable image' of the SEZ and attract a new trend of industries that share similar interests.	Socio-Spatial Research and Analysis
This SEZ consists of multiple industrial and powerful stakeholders that need to be satisfied in order to promote economic growth. As a State Set-up SEZ, policies can play an important role in also influencing its constituent industries to invest and promote the resilient city vision. The State can also capitalise on the 'novel sustainable image' of the SEZ and attract a new trend of industries that share similar interests.	Socio-Spatial Research and Analysis
They are crucial in order to realise social resilience. Public owned education institutions can be motivated to become agencies of change through direct policies.	Socio-Spatial Research and Analysis
They are crucial in order to realise social resilience. Private owned educational institutions can be motivated to become agencies of change through policies as well as incentives. In addition they can also be persuaded to see a common gain and contribution to society.	Socio-Spatial Research and Analysis
As these are setup directly by the State Government, they may not necessarily change their goals to suit the environmental needs of the region and hence they might have low interest and can act as a blocking power.	Socio-Spatial Research and Analysis
Set up by State Government but managed by Private industries. This will be a tricky situation in especially cases where the stakeholder in question does not take interest in sustainability.	Socio-Spatial Research and Analysis
The Tidel Park is a powerful IT stakeholder, however does not necessarily share any interest with respect to sustainability. Hence policy can play a role in addressing and persuading this stakeholder.	Socio-Spatial Research and Analysis
This corridor consists of potential stakeholders that are powerful and need to be persuaded to address resilient design. Their critical position in flood prone zones can be a starting point to garner interest and support.	Socio-Spatial Research and Analysis
This corridor consists of potential stakeholders that are powerful and need to be persuaded to address resilient design. Their critical position in flood prone zones can be a starting point to garner interest and support.	Socio-Spatial Research and Analysis

Appendix 2

Fieldwork - Interviews and Workshop compilation

Source : Stakeholder Interviews	Details of Stakeholder	Perception of problem		Potentials / Opportunities	
		Urban Development(UD)	Water management (WM)	Socio-cultural (SC)	Water Management (WM)
Interviewee 1	Prithvi Mahadevan Agam Sei (NGO) and WeBe Design Lab (Architecture Firm)	Too many stakeholders within the government; Need for dedicated organisation for flood resilience and disaster management cell; need for policies that overrule any mismanagement of water resources	Infrastructure – management of waterways and the relationships between different hierarchies of water bodies	There exists a strong social cohesion and this resource can be tapped into	Strengthen water bodies
		Need for collective action from the citizens perspective		Tapping into daily activities and economies	Diverse hydrological and biodiversity resources
		It is unclear based on what the CMDA drafts its land-use maps. For example, ecologically sensitive areas such as the Ennore creek has been identified as waste land		Incentive based integration of socio-economically weaker sections	Need for integrated water management
		Commoditisation of ecologically sensitive areas is a major concern		Local culture and traditional values	Buckingham canal is a strong spatial element as it connects all three rivers and still has considerable flow
Interviewee 2	Jayshree Venketraman Care Earth Trust (NGO and ecological expert)	NGOs have replaced Local civic bodies and Community bodies in Chennai			
		There is no core or expert group that works in Chennai – this expert group should consist of urban planners, architects, sociologists, ecologists etc.			
		Local communities, Resident welfare associations etc have not been actively considered			
Interviewee 3	Daniel C40 Cities	Institutional disconnect	The biggest conflict is that of who owns the water and who manages it		
		Second master plan exists but it has not been revisited or revised since 2009	The agencies associated with water are so fragmented that when it comes to approaching water – how and who do you go to?	Institutionalise public input	
		Master plans needs to be revised more often due to the rapidly changing urban setting	We have all kinds of flooding – inland, coastal, river etc. We need to be able to plan ahead and foresee disaster and be prepared	Implementation through public input	
		Exploitation of misused land use terms such as mixed residential, next residential need to be controlled		Open platforms	
Interviewee 4	K.Saraswathi Secretary General Madras Chamber of Commerce and Industry	Floods were manmade as well as natural. However poor urban development has affected the city's ability to cope with floods.		Corporate social responsibility (CSR)	MCCI has facilitated an understanding with the governments such that corporate companies can take up particular water bodies and restore them as their initiative
		Unauthorised construction	Storm water drains are inefficient	Setting up skill training and development	Improving infrastructure through CSR and sustainable Chennai forum
		Economic and industrial development was unchecked	Waste and clogging of water bodies		
Interviewee 5	Dr. Abhilash Roul A. Ramachandran Akshaya Ayyangar Indo-German Centre for Sustainability (IGCS)	There is a gap between research and practice – multiple research conducted yet data availability is poor	Inefficient storm water drain system	Social resilience is more relevant in the case of the context of Chennai	We need to study our rainfall and flood zones and map them out
			Need for a new drainage mechanism	Going beyond disaster management and looking at resilience	
			The current approach to flood protection is that of disaster management rather than resilience		
Interviewee 6	Krishna Mohan Chief Resilience Officer, 100 Resilient Cities	Encroachment	How do we manage our waste and wastewater better	Citizens working together and creating awareness as a counter to existing process – especially in the present political scenario	Traditional water network – Kancheepuram has up to 300 tanks which are all integrated for instance; Restoration of lakes
		Manage urbanisation			Rethink our storm water drains and see how they can be reconnected back to the river
					Reviving the rivers – Coovum and Adayar are however almost dead

		Challenges			
Spatial Design (SD)	Institution and policy (IP)	Socio-cultural (SC)	Water Management (WM)	Spatial Design (SD)	Institution and policy (IP)
Public spaces to induce more activity	Involvement of local citizens and users	Need to break the perception of 'humans being disjoined from nature'	Prevention of droughts		Too many stakeholders
Place of engagement which functions as a public space as well as an urban drain		Gaining citizen interest and enrolment	Need to address extremities		No coordination between different disciplines
Increase ground water recharge – water from floods needs to be put back into the system		Data is available but not readily available for open usage – gap between past and ongoing research and practice.			
In fact we need to consider solutions from all aspects such as social, ecological, economic etc have to also be considered in addition to technological solutions.	Instead, we need an elected representative who is capable of mobilising strategies and actions and the government needs to be directly involved	Tendency to engage and plan for the future can depend on the age of the settlement			
		There is a 'temporary' mindset that prevails among the people of Chennai			
		Poor awareness of environment			
2500+ acres of water however there is not system that recognises the land value capture of water – lack of policy that protects water bodies	New guidelines for urban and building development				
Yes, in addition to manufacturing sector there is a new introduction of the defence corridor and new trend of aerospace industries	MCCI has facilitated an understanding with the governments such that corporate companies can take up particular water bodies and restore them as their initiative	Small and medium business (SME) were the worst affected and went into huge loses; They were unable to do anything individually and needed additional set up			
Segregation of waste	Merging CSR goals and government goals				
Increasing awareness and to strengthen rules	Investing in education, skill development				
Water retention landscapes	Institution playing an important role in creating awareness	Poor awareness at the local scale	We need to consider extreme situations with respect to water in Chennai		Lack of availability of data with respect to missing channels and canals
		How do local people know they are at risk? We need to address this		A design challenge will be that of managing both floods and drought as Chennai is not only flood prone but also water starved	
Concept of healthy urbanisation – with respect with water bodies	Tapping into CSR	Possibly amongst the lowest civic consciousness and awareness in the country (Also an inference of the survey)		Looking at both floods and drought – understanding why the city oscillates from extreme floods to extreme drought	No cross interaction between different departments and disciplines
	Decentralised water treatment methods – all natural and on site and such that water is let back into the rivers to revive them				Lack of the 'big picture' or the vision

Source : Stakeholder Interviews	Details of Stakeholder	Perception of problem		Potentials / Opportunities	
		Urban Development(UD)	Water management (WM)	Socio-cultural (SC)	Water Management (WM)
Interviewee 7	Mahesh Radhakrishnan Architect and Urban Designer Madras Office of Architecture and Design (MOAD)	Also there lacks long term visions which ensure that the risk is catered and responded to		Need to consider communities that live along water bodies	Design opportunity: Need to understand the purpose and role of each water body in the hierarchal system, recognise their values and set up typology
				How can community infrastructure become storage of water	
				Development and participation based on incentives	Tanks and water bodies should be designed as catchments
				Our traditional and cultural values are still intact and can play an important role in environmental restoration	Need for developmental guidelines
Interviewee 8	Balakrishnan Elangovan - Climate Change specialist Ex-CDIA - Cities Development Initiative Asia	Need for more systematic planning	No integrated water planning – micro and macro drainage is not integrated together		Integrated water management
		Instead of piecemeal projects, we need to bring a certain order into how we develop our cities and regions	Upstream management of water is poor		Waste water sector
		There seems to be no multi-tasking or any kind of cooperation; Reactive rather than preparatory in nature			
		Lack of urban vision			
Interviewee 9	Santhosh Chennai River Restoration Trust (Government stakeholder)	Encroachments – slums – however this was not that big a problem during the 2015 floods (this is probably because – temporary settlements tend to be washed away in the time of floods, hence the river course is eventually restored in one sense	During the British era, all the water bodies were classified as waste land. This has been carried forth as the same and has not been revised.	Community participation	Abundance of water bodies - up to 3000 water bodies in the CMA - 70-80% of which are interconnected
		Private stakeholder encroachment of concrete structures – this however is the biggest problem. These tend to be more than a floor high and are obstructions to water flow	Inundation – lack of drainage	Designing with the people	The biggest strength lies in the interconnectedness of the water bodies and that can be harvested
		Industrial encroachments – developing countries tends to concentrate more on development of the country and then concentrate – for example even though Sriperumbudhur is a flood prone zone, it creates more jobs. Hence it is a policy decision made by the government.			
Interviewee 10	Dr. Vishwanathan Chennai River Restoration Trust (Government stakeholder)	Unplanned growth – unorganised sector	Back flow of storm water drains	Traditional drainage networks exist in the form of the temple tanks, ponds and standalone water bodies.	
		Slums tend to dump solid waste in the river hence the river was choked up	Storm water drains are not for managing floods rather they are being used to manage rainwater. Its mainly to avoid stagnation rather than floods.	there is a potential for new industries to be brought in for using treated water so that they don't draw ground water.	
			Carrying capacity is reduced - clogging of rivers	Public consultations and integrating NGOs	
			Cloud burst – rainfall but the manmade aspect because of encroachments		
Interviewee 11	Mr. Nagaraju Arumugam Urban Infrastructure Expert Smart Cities India	Storm water drains inefficient	Carrying capacity of river compromised	Improving liveability	Area based water restoration
		Lack of flood modelling	Limited water supply	Promoting sustainable lifestyles	Improving water supply and distribution
		Lack of data on building document	Sewerage system has aged and become inefficient		
		Need to focus on public spaces			
Interviewee 12	K.S. Sudhakar GIZ	No coordination among the different departments - Separate departments for everything; Fragmented institution	Chennai is water starved as well flood prone	Civic Engagement - For the longest time, people have been excluded from ecology by conscious efforts in building barriers that do not enable interaction	Integrating resilience to the service sector such as waste, infrastructure slum clearance
		Lack of development vision	Pollution and clogging of water bodies	Ownership as a result of interaction with ecosystem	Peri Urban areas abundant with water resources
		Planning decision not taken by planners		Success stories from resident welfare associations successfully maintaining a neighbourhood park and lake (Tambaram)	Decentralised water management and restoration - People around a particular water body must have direct say in what it becomes through design

		Challenges			
Spatial Design (SD)	Institution and policy (IP)	Socio-cultural (SC)	Water Management (WM)	Spatial Design (SD)	Institution and policy (IP)
Quantifying community infrastructure with respect to density – using density analysis to make a typology set and assigning specific community infrastructure to it	Need for long term visions (20 years) which looks at planning, policy and design	This inability to recognise risk at the general masses comes from the absence of a dedicated and independent institution that thinks long term and educates and makes people aware of the risk		Each micro context is different from the other	There is hence a considerable gap between people and power
Looking at high density areas as a starting point		Gentrification and migration affects social cohesion		Age of neighbourhood plays an important role in feeling of community in each area	Weak institution
Roads as drains. If yes, what would be the way to design roads? How can roads be further connected to storage areas?				Laws need to be drafted such that they tap into day to day activities and can be implemented through incentives	
	Institutional development	Community feeling may be low due to high level of migrations		Solid waste needs to be dealt with	
				No catchments contributing to water storage	
				Address gap between water and waste sector	
				Peri-urban areas also lack infrastructure and need to be focussed on	
Abandoned quarries		Gaining interest and support of the people	Integrating drinking water with the various water bodies		
			Contamination of water bodies		
				Standalone water bodies exist in various forms in the context of Chennai.	Coordination among department – institution is scattered
				For example, a standalone tank with the use of irrigation was surrounded by agricultural land. However once the land use changes to residential, the water body still functions as the same and overflows into the built area. And the lack of canals and channels running to and from the water body makes the case worse.	
				However not all water bodies are connected or rather the connections have been lost over time.	
Retrofitting existing green areas	Integrated development	Availability of data	Aging of system in place		Integrating all departments and making them work together
Large focus on infrastructure and services		Awareness among citizens	Complex built fabric		
Waste as an opportunity - waste department has biggest man force	Tapping into real estate policies				
Designing with the people	Inclusive attitude		Suburbs are less monitored		
Pilot projects that motivate people			Peri-urban areas become dump zones of the city		

Source : Stakeholder Interviews	Details of Stakeholder	Awareness and perceptions of the water and risk	Perception of 'Safe' zones during floods	Social capital and community needs
		(AW)	(SZ)	(SC)
Interviewee 1	Prithvi Mahadevan Agam Sei (NGO) and WeBe Design Lab (Architecture Firm)	People in a neighbourhood need to know their own locality and their available infrastructure	Regional scale: Northern parts of the city	Public spaces to induce more activity
		Tapping into local knowledge is crucial in case of design of floods – it's a merger between the knowledge that local residents know and what we think could be done through design	Schools and parks	Place of engagement which functions as a public space as well as an urban drain
		Inability to think of larger problems ; Not aware of their placement in the context		
Interviewee 2	Jayshree Venketraman Care Earth Trust (NGO and ecological expert)	What influences our decision making is very different from what influences that of the local citizens		
		Most local communities don't see a planning horizon beyond 2-4 years which is the biggest shortfall when it comes to engagement – this might also be a shortfall of an urban area		
Interviewee 3	Daniel C40 Cities	Lack of awareness		Yes, situation is much better than 10 years ago. Local connect is crucial and community ownership can do wonders. Local interventions can be looked into an also the strength of art, public art, input and discussions can be explored
		Lack of actionable intelligence		
		Lack of data availability		
		Mis-information or rather acceptance that floods are a way of life – need to bring about change in mentality		
Interviewee 4	K.Saraswathi Secretary General Madras Chamber of Commerce and Industry	Awareness has increased due to the floods of 2015 and now everyone knows something should be done about it		Investing in education, skill development
		Large companies are able to judge their position and have developed some disaster management actions		Organised workshops and programmes that focus on human development through training
		However the SMEs need to be more aware and currently lack anything in place as they cannot function based on individual capacity		Workshops for slum dwellers – education and other inclusive developments
Interviewee 5	Dr. Abhilash Roul A. Ramachandran Akshaya Ayyangar Indo-German Centre for Sustainability (IGCS)			Parks
				Amma canteens – one of the best examples of contextual community infrastructure – all Amma canteens also played an important role during the floods of 2015
Interviewee 6	Krishna Mohan Chief Resilience Officer, 100 Resilient Cities			Citizen efforts and individual efforts which helps build resilience
				For example, individual people who create change
				Vegetable gardens and urban farms

Perceptions of public space	Interests and priorities vis-a-vis urban dev and water	Ongoing initiatives
(PS)		
Need to recognise breathing spaces – such as open spaces	Creating Awareness	Their project initiative looks at a civic engagement in order to achieve flood resilience.
Open spaces connected to biodiversity	Designing with people	Focus group discussion and Awareness programmes – street theatre, community workshops and exhibitions
Using specific type of flora in order to support flood risk through open spaces	Need to concentrate on water management	Engagement programmes and Training modules – origin management, water as a resource and economic factors, floods as water – awareness building and 'what you can do'
	Restoration of not just rivers but also water bodies	Collaborative design – creating small solutions
	Pallikaranai comprehensive management plan – detail analysis of the current state of the wetland and small scale design strategies	Greening strategies
	Chennai greening strategies that look into different kinds of plantations for different areas in Chennai	Biodiversity management
		Ecological planning and management
	Climate adaptation and advanced infrastructure	
	drainage and adaptation measures	
	millennium sustainable goals	
	Facilitate sustainable practices amongst their members	Representing companies
	Voice for sustainability between the government and corporate sector – for example – energy conservation building code	Setting up skill training and development
	Policy regulatory framework for industrial development which facilitated collaboration between architects and industries	Sustainable Chennai forum – Urban development is part of the ecosystem and hence we decided to make a business case for this
	Talk to different Stakeholder groups – interactions – online and offline citizen accounts, civil society groups, government departments, NGOS, Academia and private sector	Conducted five focus working group discussions – water, disaster management, informal settlements, unmanaged growth and civic engagement
		In the process of proposing a 'dashboard' that cuts across all stakeholder groups and gives anyone who comes into the city, a bird's eye view of what's happening in the city; Want to build a knowledge portal which bridges the gap between research and data
		Want to build a volunteer base – for example – cognizant has around 6000 employees and the company has agreed to spare an hour every week for volunteering – this is a good opportunity to channelize engagement in the right direction

Source : Stakeholder Interviews	Details of Stakeholder	Awareness and perceptions of the water and risk	Perception of 'Safe' zones during floods	Social capital and community needs
		(AW)	(SZ)	(SC)
Interviewee 7	Mahesh Radhakrishnan Architect and Urban Designer Madras Office of Architecture and Design (MOAD)	It varies from person to person	Safe zones are those where there are other people – both for rescue as well as support	Culture can play an important role in participatory planning
		Amongst the educated and securely employed people, the risk is fairly understood		Large number of NGOs can be used as critical facilitators of engagement and participation
		For those who fight for everyday survival, they do not feel the need to understand terms such as 'disaster' and flood risk		Despite being a mixed culture, instances from recent times show large scale public interest being steered into action – this is directly contradictory to the statement that the feeling of community in Chennai is on a decline due to increasing migration
				Cultural setup as an asset
Interviewee 8	Balakrishnan Elangovan - Climate Change specialist Ex-CDIA - Cities Development Initiative Asia	Lack of awareness on local level		Indirect benefits
		Migration may have a role to play		Local associations should be considered
				Focus on awareness
Interviewee 9	Santhosh Chennai River Restoration Trust (Government stakeholder)			NGOs
				Educations and awareness
Interviewee 10	Dr. Vishwanathan Chennai River Restoration Trust (Government stakeholder)			Giving river back to the people
				Heath and tourism opportunities
				indirect benefits – wellness and happiness to people through good environment
				Parks, public spaces
Interviewee 11	Mr. Nagaraju Arumugam Urban Infrastructure Expert Smart Cities India			
Interviewee 12	K.S. Sudhakar GIZ	Poor awareness among the local citizens has a direct relationship with lack of leadership		Need of open and green space - however community can play an important role in shaping these areas
		Inability of people to differentiate different components of ecology		
		Inability to differentiate sewage and drainage		

Perceptions of public space	Interests and priorities vis-a-vis urban dev and water	Ongoing initiatives
(PS)		
Make our open and community spaces accessible to people as well as rain		
	Multi-stakeholder involvement	Assisting the Chennai corporation and Identify focus areas
	Well developed institutional – need for overall structure that works together	Interact and facilitate urban infrastructural development
		Water and waste rehabilitation
		Strategy for flood risk management; Strategy for storm water management
		Reviving, restoration and rehabilitation – focussing on rivers and preparing an integrated plan for restoring rivers for all the urban local bodies and all stakeholders to follow. Integrated as in for all governmental and non-governmental stakeholders to follow and they collaborate with the PWD and water department.
		Considering existing scenario rather than restoring to its original state
		River restoration, cleaning river and stopping sewage flow, flood management and giving the river back to the people.
	Clean Energy	Public plazas and spaces
	Last mile and multi-modal transport	Pilot projects that focus on public services
	Information Technology driven services	Pedestrian friendly design
	Sustainable and liveability	Water supply and distribution
	Retrofitting existing green areas	Capacity Building - for decision makers - Top level and local level- building awareness and knowledge
	Solar power plants and clean energy	Governance structure - setting up climate action cell in institution
		Policy recommendations

Source : Workshop	Details of Stakeholder	Perception of problem		Potentials / Opportunities
		Urban Development(UD)	Water management (WM)	Socio-cultural (SC)
Workshop group 1		Relooking at building design and resilient typologies	Roads do not drain well	Power of social media
		Chennai city – more reactive and not preparatory by planning for future	Bylaws for flood resilience lacking	
		Laying of roads	How do we manage cut off areas during floods?	
		Lack of real time data - More creative and transparent depiction of data		
		Bridging the gap between different sectors		
Workshop group 2		Gap between research and decision makers	Environmental: Dumping waste	Community engagement in decision and policy making
		Socio-economic: Lack of community awareness	Misc: Poor flood plain management and Encroachments	Create local economic opportunities
		Administration: Lack of planning policies and long term visions	Environmental: High levels of BOD	Need for more responsibility to their surroundings
		Lack of connect between citizens and environments	Clogging of water bodies and Reduction in Carrying capacity	Direct connection of water bodies to usage – bringing it to their front yard
		Lack of strict policy - Government gets away through loopholes in the system		Incentive based initiatives
				Community meet-ups
Workshop Group 3		Lack of integrated development	Biodiversity depletion	Environmental revival connected to cultural revival (Perungudi lake festival) - Using culture and festivals to influence
		Unplanned development	Drought versus floods – inter seasonal distribution of water	Awareness programmes at schools
		No involvement of different age groups	Pollution	
		Encroachment		

Source: Workshop Survey	Details of Stakeholder	Awareness and perceptions of the water and risk	Perception of 'Safe' zones during floods	Feeling of community (10)
		(AW)	(SZ)	(FC)
Participant 1	21, F, Architecture Student			6
Participant 2	24, M, Urban Planner	Lack of community awareness and lack of constructive interactions	Elevated area – prevents further flooding and sense of security; Bund and public ; places on elevated area	3
Participant 3	21, M, Architecture Student		As per my knowledge, during the 2015 floods, a lot of people felt safe in spots like institutions and commercial spaces. Example – Loyola college and Phoenix mall	6
Participant 4	22, F, Architecture Student	Need to grow as a community	I would consider public spaces safe, that are higher levels and away from water bodies in Chennai. Proximity to healthcare and basic necessities	6
Participant 5	45, M, Development Professional	Driving factor : Media influence ; Obstacle : Sustaining the momentum	Definitely an elevated residential area closer to services and resource availability	5
Participant 6	28, F, Tech Start-up	Driving factor: people's love for the city ; Obstacle : Bureaucracy and lack of clarity and discussion	A hospitals first floor or rooftop of an apartment or any friends place that is accessible to food and supplies	10
Participant 7	23, F	Driving factor; to decentralise it community wise and work together as a community, re-establishing places for multi purposes	No I would never consider it safe. I would prefer to first check if it safe enough after some ground work. Safe place according to me can be an area or a part of a region wherein there are different facilities that can be incorporated so that people can rush out there in the time of emergency	8
Participant 8	24, F, Architect and Interior Designer	Sense of being a part of something bigger than you, following a person or group with gravitas are the main driving force. Obstacle would be the mind-set of the needs of one outweighs the needs of many.	A building that is on higher ground, with access to basic amenities and at a safe location with ease of access from me. Usage would be private most probably due to the prevalent nature of land use and their apparent proximity. Commercial buildings like shopping complexes create a sense of safety as they are designed on a platform to accommodate parking which in turn creates a dry ground during floods. They are also unobstructed in accessibility and are spacious enough to accommodate larger groups. Primarily the important resource to look at would be health care, followed by availability of food and water.	6

Water Management (WM)	Spatial Design (SD)	Institution and policy (IP)
Decentralised flood mapping	Spatial design - Multi-functional public spaces	Policy - Prioritising risk – life then economy
Ground water recharge	Designing roads as drains - Can we create a model road section for flood defence?	Policy – regarding open space reservations
Preserving natural resources	Water retaining landscape	Setting up crowd sourced flood data
Rain water harvesting – decentralised scale	Landscape design is made such that the surfaces become more succulent and water retaining Create a sponge city	Stronger building regulations
Using rainwater harvesting infrastructure to fight floods	Creating pilot projects and prototypes using the power of academia and research	Better infrastructural planning – example – the Airport
Open spaces (OSR) can be made into micro drainages in the city	Reimagining street design	Local bodies – vested with more powers
Ecosystem services	Solid waste management – effective implementation between community + government + private sector	Three main elements of urban planning – Public, private and Community work together
		Economic incentives for research
		Private sector - Handle by-products and waste more effectively
		Utilise public -private platform for knowledge sharing
		Corporate Social Responsibility
		Top down approach greater than bottom up approach, hence need for inclusivity and participation
Storage of rainwater – using public spaces	Penetrative public spaces	Increased taxation policies for water sensitive and disputed areas
Tokyo's underground drainage tunnel	Designing better human-nature relationships	Economic services - revival, economic incentives
	Bringing back indigenous species of flora	

Perceptions of public space	Where would you seek shelter	Ongoing initiatives
(PS)		
Accessible, sense of place and safe		
Any land except that under private ownership; Public parks – place with coverage	The location should be accessible by walk	
The roads, my apartment corridor	Public landmarks – within 4-5 km access. Also I should be able to believe that the place is going to be safe for me	
Parks and roads	Availability of food and water would rank first for people. We has travelled to areas that were non flooded for access to resources	
Open spaces /institutional spaces owned or under government control. Parks, water bodies and government schools.	Would seek help from friends and relatives in a radius of 5-10 kilometres in areas where I would be sure of my safety from natural hazards	
	Closest relatives or close circle of friends; maybe as far as 15 km depending on condition of roads	
Public place is something that connects a lot of people on a large scale. Designing public spaces or places is particularly what the people lack in Chennai.	If there are plug in places developed for the betterment of the people in terms of landscape areas or institutions designed for this purpose, the definitely I would rush out there. But there should be a system put to place so that people know where they can go.	
Any place or space that is obvious in its public identity and inclusivity to all user groups, with no psychological barrier of preventing entry, and one that does not have stringent and apparent supervision.	A place of familiarity is my first response, as being evicted from ones home during a calamity is quite unsettling in itself and a new place adds on to the psychological pressure. Due to my being a native in the city I have relatives in proximity to me, outside a zone prone to flooding. Their residences would be my first priority to go to in the case of a flooding. Also, I have access to vehicular transport that can travel through considerable depth of water allowing for evacuation during floods. Food and water would have to be rationed as the supply is minimal at outlets and the demand is much higher. Electricity too is scarce in these scenarios due to fear of electrocution and loss of life.	

Perception of problem		Potentials / Opportunities		
Urban Development(UD)	Water management (WM)	Socio-cultural (SC)	Water Management (WM)	Spatial Design (SD)
Lack of coordination among different sectors	Contamination of water bodies - High levels of pollution	Temples and places of worship can play an important role as a connect to people (Most water bodies have a temple or place of worship in the vicinity)	Need to manage waste and water	Water retention landscapes
Multiple agencies working on similar things	Edges poorly managed	Awareness among the locals	Floods versus drought extreme	Sponge city
Disaster management centres poor	No distinction between man and nature - lines undefined	Incentive based change	Systematic mapping of flood areas	Community infrastructure can play an important role in defining edges and their functions
High lying and low lying areas poorly managed	Poor nature-human relationships	Each community typology can have a purpose attached to it - can be made a strategy	Identifying aquifer and ground water recharge areas for the design of water retention landscapes	Locating higher ground is crucial for design of community infrastructure
Peri - urban areas poorly managed	How do we live with floods?	Amma Canteens - important community hubs		Soft landscape design
Poor condition of buildings	Poor local knowledge about immediate ecosystem			Polycentric urban development for the expansion (garden city concept) - each centre must have different laws and priorities based on where it is placed with respect to the river or water body - example - upstream downstream. For better water resource management
Poor spatial appropriation	Peri-urban flood plains relatively untouched			
Limited public spaces - few examples of nature-human coexistence	Dumping yards adjacent to water bodies and flood plains makes health and hygiene during floods a serious issues			
The entire IT corridor is planned on the low lying area between the East Coast and Pallikaranai area - resulting in the entire development corridor being completely submerged	Looks like it did not matter whether it was low or high lying area during the floods - urban flooding does not necessarily depend on slope - rather it is based on obstructions			

	Challenges			
Institution and policy (IP)	Socio-cultural (SC)	Water Management (WM)	Spatial Design (SD)	Institution and policy (IP)
Institutional development - How do we make the government setup function more efficiently	Existing Relief centres are not designed to handle emergencies	Waste segregation and management at the scale of the region	Designing for everyday life as well as disaster	Political mess
Building regulations custom made for flood resilience construction	People prefer seeking help with their kin than through public infrastructure	Coovum and Adayar are on the brink of complete death	Multi functionality of design strategies	Different government departments do not work together
Incentive based policies	Creating sense of safety within the community is crucial as they tend to rely on individual measures during floods		Context and built unbuilt grain will play an important role in spatial design	CMDA - plans, GCC implements - No city goals or vision
Decentralised water management	People on the outskirts and peri-urban areas tend to flee the city at times of disaster		The region is expanding seven-fold	
Accommodate local participation	Demographics and qualities of the resident population			
NGOs and Civic groups can play an important role	Inability of locals to differentiate sewage and drainage - VERY IMPORTANT			

Appendix 3

Precedent Study

Precedent study has been conducted to evaluate spatial underpinnings of the strategies formulated as part of the framework. Two precedents are articulated at different scales and both are based in India, to impart contextual coherence and similar socio-cultural and economic conditions.

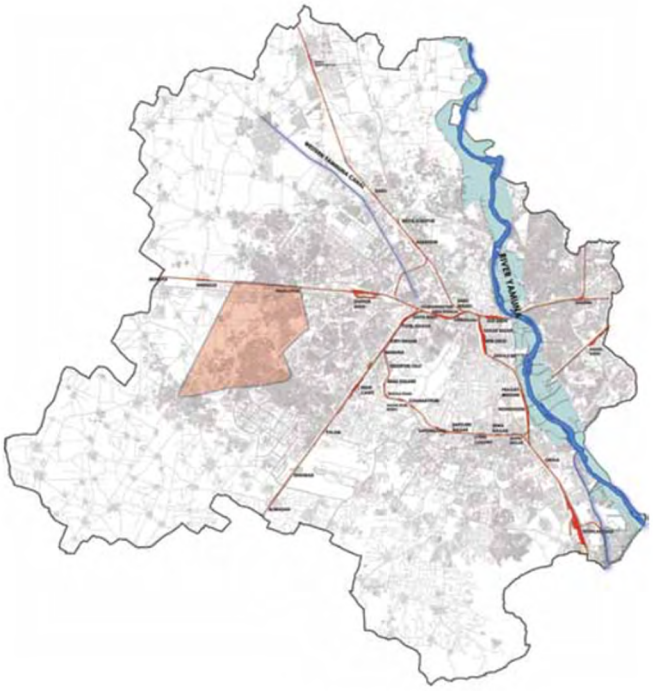
Regional water resilience system for Najafgarh Drain, New Delhi

The first is placed in an urban regional scale of New Delhi where a drainage system of Najafgarh was prone to annual flooding. In response to this risk, a regional strategy was designed which used infrastructural lines and programmatic edges as strategies. The precedent study gave an insight in how strategies of flood resilience can be integrated into various land-uses and at various scales from macro to nano.

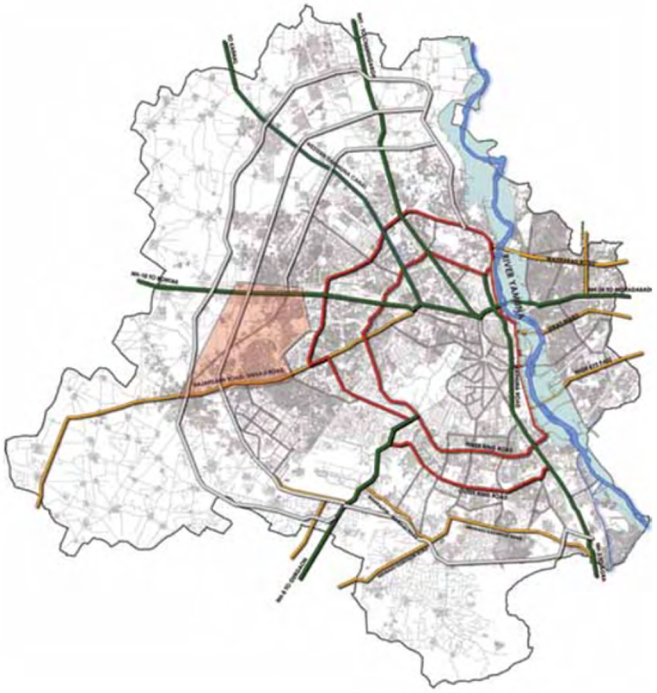
Water system and hydrological resilience in Village Jaunti, Haryana

The second precedent is a case evaluation of village Jaunti where three water bodies were superimposed with social, cultural and religious programmes so as to amass public participation in order to restore and maintain an active connection between various scales of hydrological systems. The precedent is a shining example of how public participation and shared ownership of resources can be activated using underlying social and religious structures.

City Scale layers

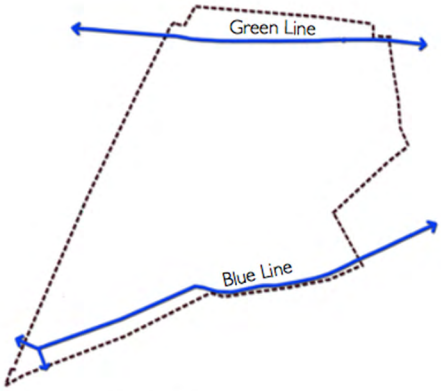


Infrastructure

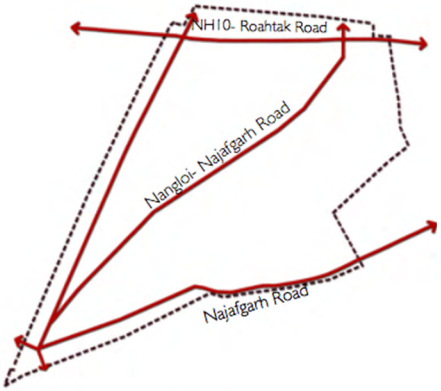


Secondary Infrastructure

Exisiting Fabric

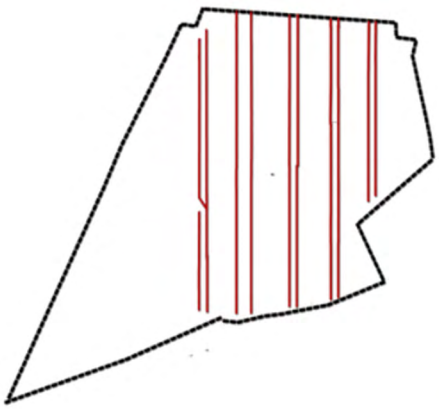


Inter city transit lines



Intra city transit lines

Regional Scale

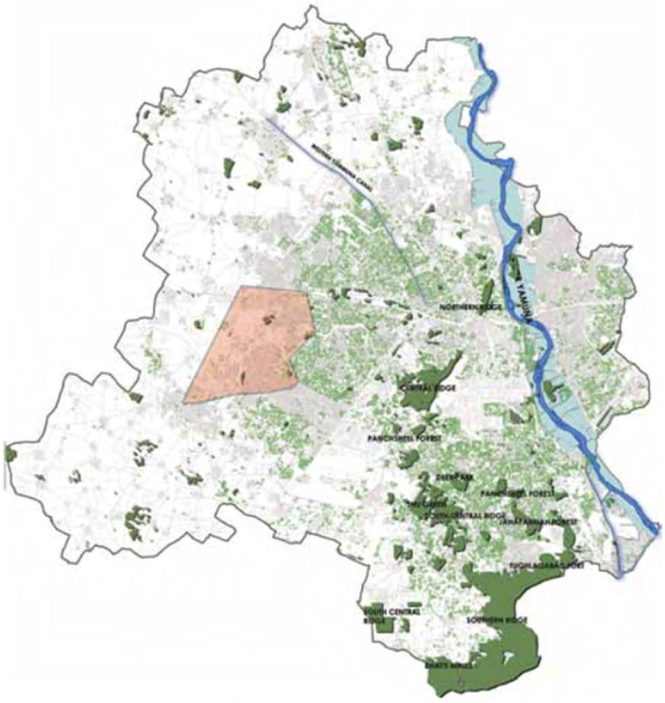


Horizontal connections to transit

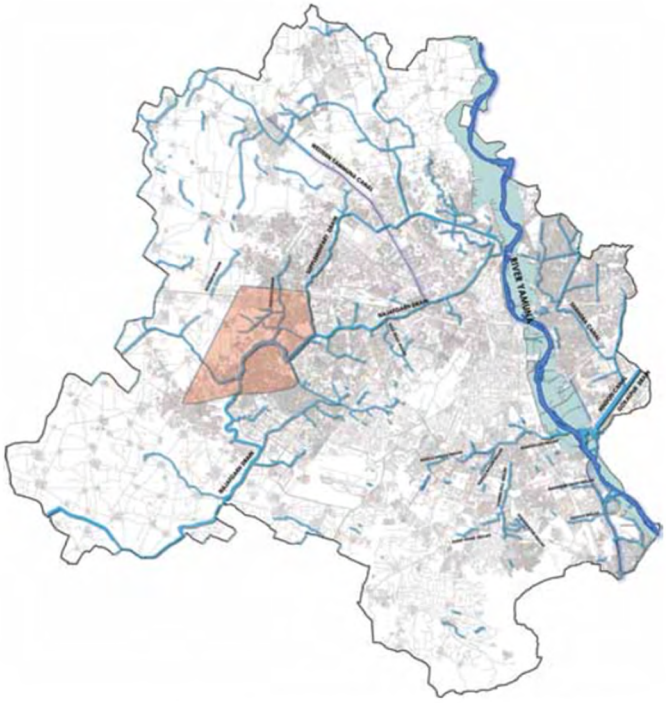
Residential Disposition

Built up

Source: DUAC Najafgarh



Green corridor superimposed infrastructure



Blue corridor superimposed infrastructure

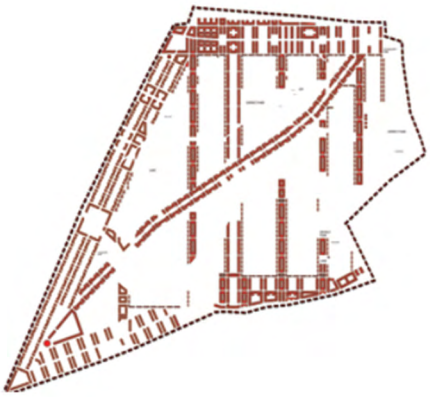
Blue corridors

Green corridorss

Green- Blue overlap

Institutional Periphery

Infill Residential Super Blocks



Commercial belts

Edge Condition A

Along the Regional Drain

Edge Condition B

Along the proposed and exisiting drains

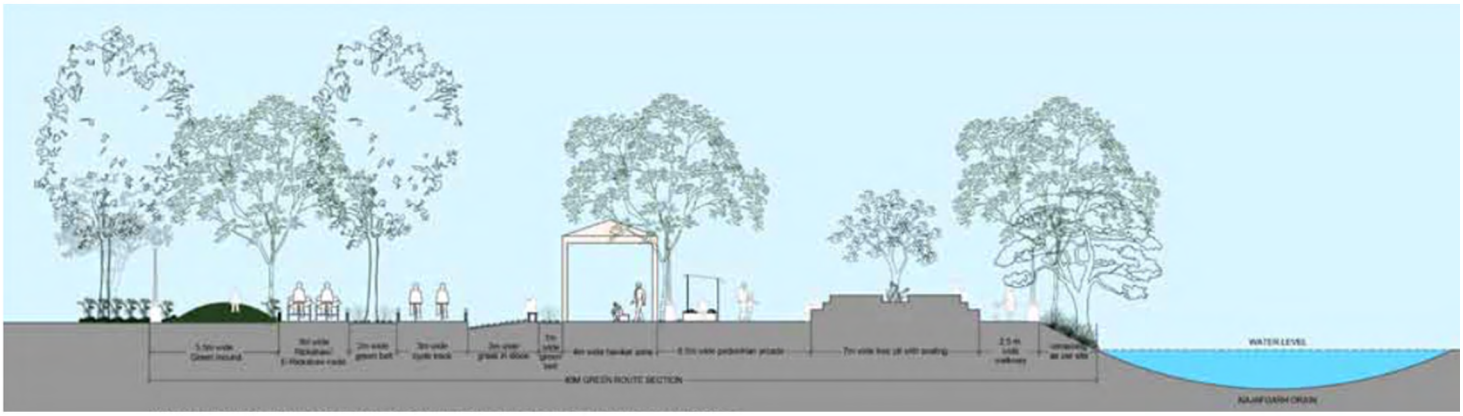
Edge Condition C

Along the transit corridors

Edge Condition D

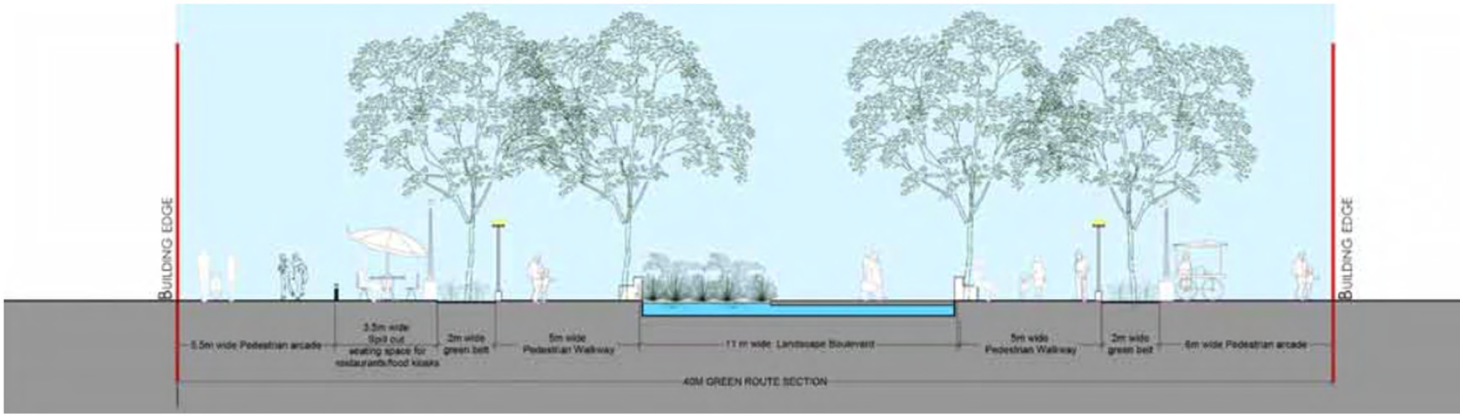
In between the buildings

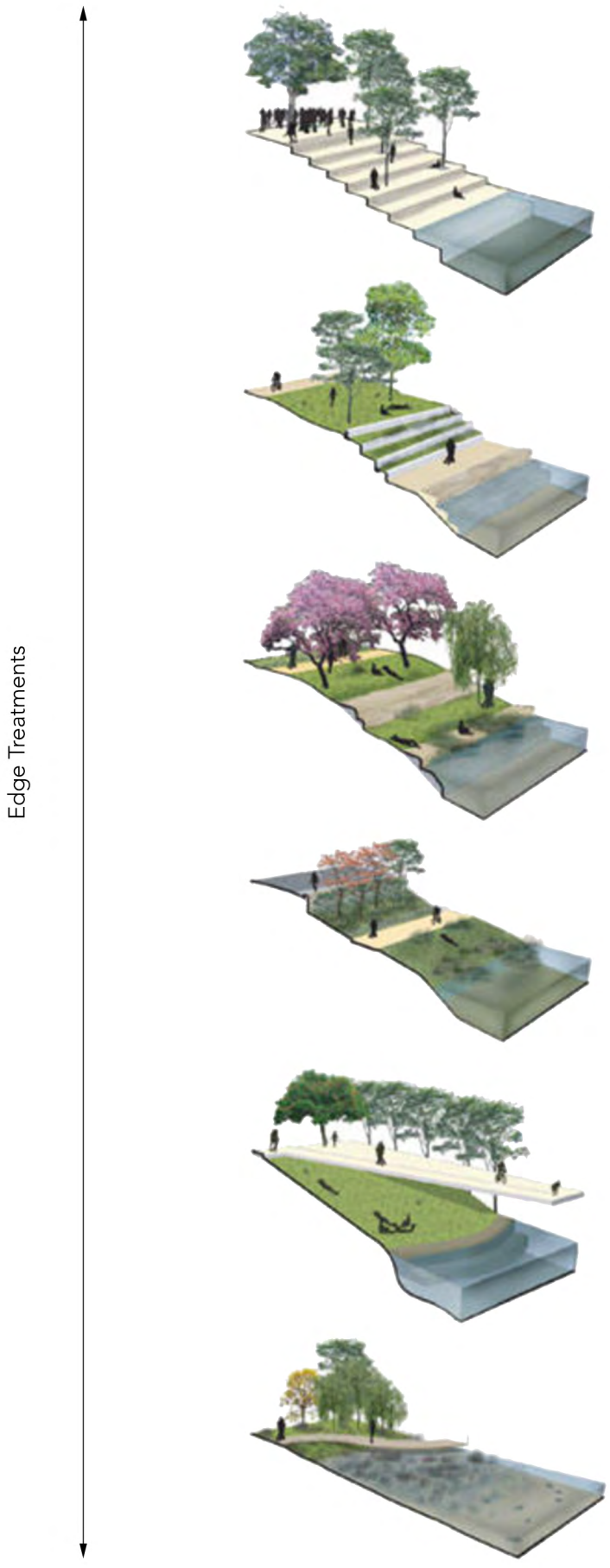
Source: DUAC Najafgarh


WATER LEVEL
40M GREEN ROUTE SECTION
NAJAFGARH DRAIN


EXISTING GREEN
EXISTING GREEN
8m wide
Green mound
3.5m wide
cycle track
2.5m wide
pedestrian
path
with greens
4m wide pedestrian
bridge
12m wide pedestrian plaza
4m wide pedestrian
bridge
2.5m wide
pedestrian
path
with greens
8m wide
Green mound
40M GREEN ROUTE SECTION


PROPOSED
40M WIDE ROAD
WATER LEVEL
40M GREEN ROUTE SECTION
NAJAFGARH DRAIN


BUILDING EDGE
BUILDING EDGE
5.5m wide Pedestrian arcade
3.5m wide
Spill out
seating space for
restaurants/food kiosks
2m wide
green belt
5m wide
Pedestrian Walkway
11 m wide Landscape Boulevard
5m wide
Pedestrian Walkway
2m wide
green belt
6m wide Pedestrian arcade
40M GREEN ROUTE SECTION



Source: DUAC Najafgarh

Programmatic Treatments

BOARDWALKS

A network of elevated trails will be proposed for pedestrian/cyclists to cross over from one edge of waterway to other.

EVENT SPACE

Public open spaces are provided along the river for spontaneous programs.

COMMERCIAL

Site becomes a district that creates job opportunities; money generating landscape where people can shop, play and relax.

BIODIVERSITY

Biodiversity parks provides habitat for various flora and fauna.These are depicted by dense plantation.

CONTROLLED FLOODING

Water is welcomed through engineered landform.It provides opportunities for programs and refuge for wild species

ARBORETUM

Plant communities are diversified,which creates opportunities for the public to learn more about plant species

URBAN AGRICULTURE

Urban agriculture in the neighbourhood brings healthy and sustainable food access to needed populations.

URBAN REFORESTATION

Green space will be maximized to promote walking and exercising along waterway to make it a healthier place

AQUATIC

A mature ecological matrix is formed with wetland plant species that improves overall water quality and stabilize banks

BALANCED CUT & FILL

Balanced earth work is the key.Cut and fill are limited on site to create green mounds as stormwater management tools

TERRACES

Terraced landform keeps soil on slope and it provides opportunity for urban agriculture and dynamic programs

BANK STABILIZATION

Bank is stabilized through sustainable way-planting trees.The root system of plants will keep soil from being washed away

HERITAGE

Heritage character is retained by awaring people by open spaces displaying about its significance

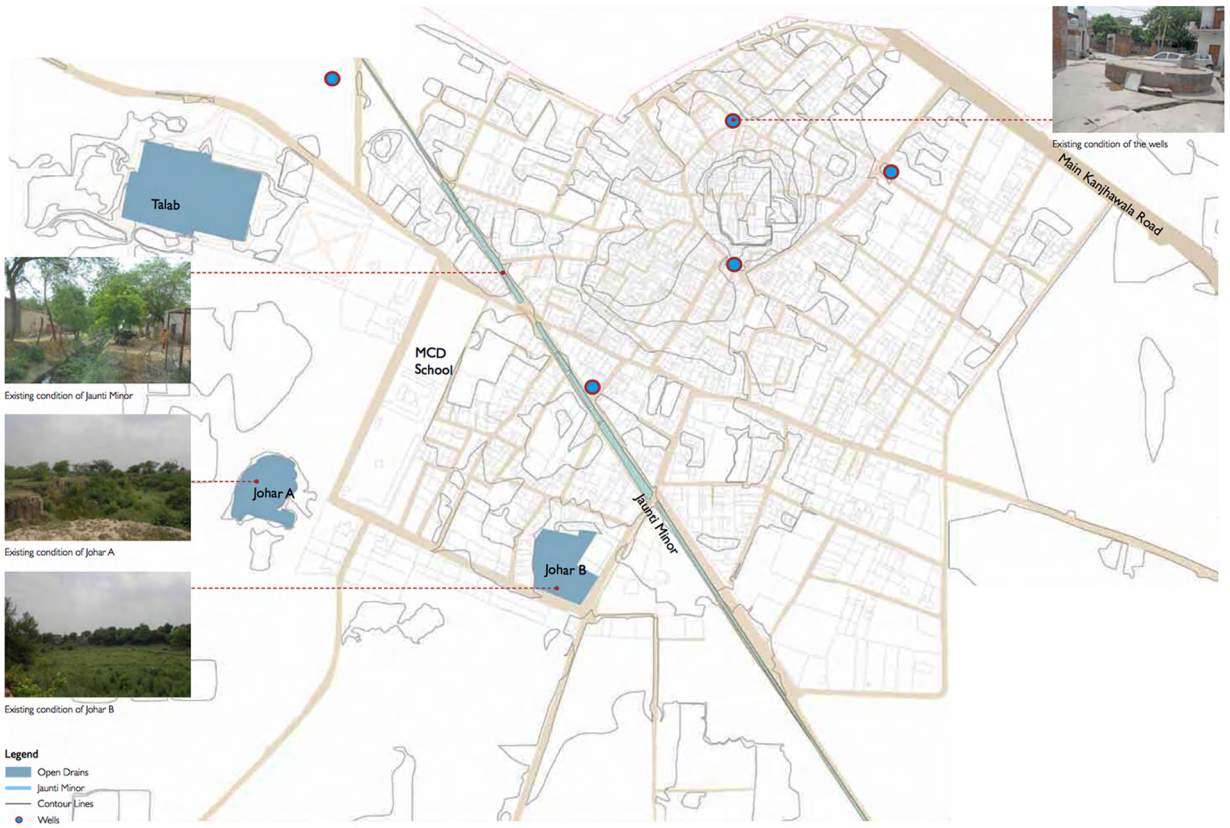
ENERGY EFFICIENCY

Water harvesting and solar energy can be used as sources of power as they are natural energy resources.

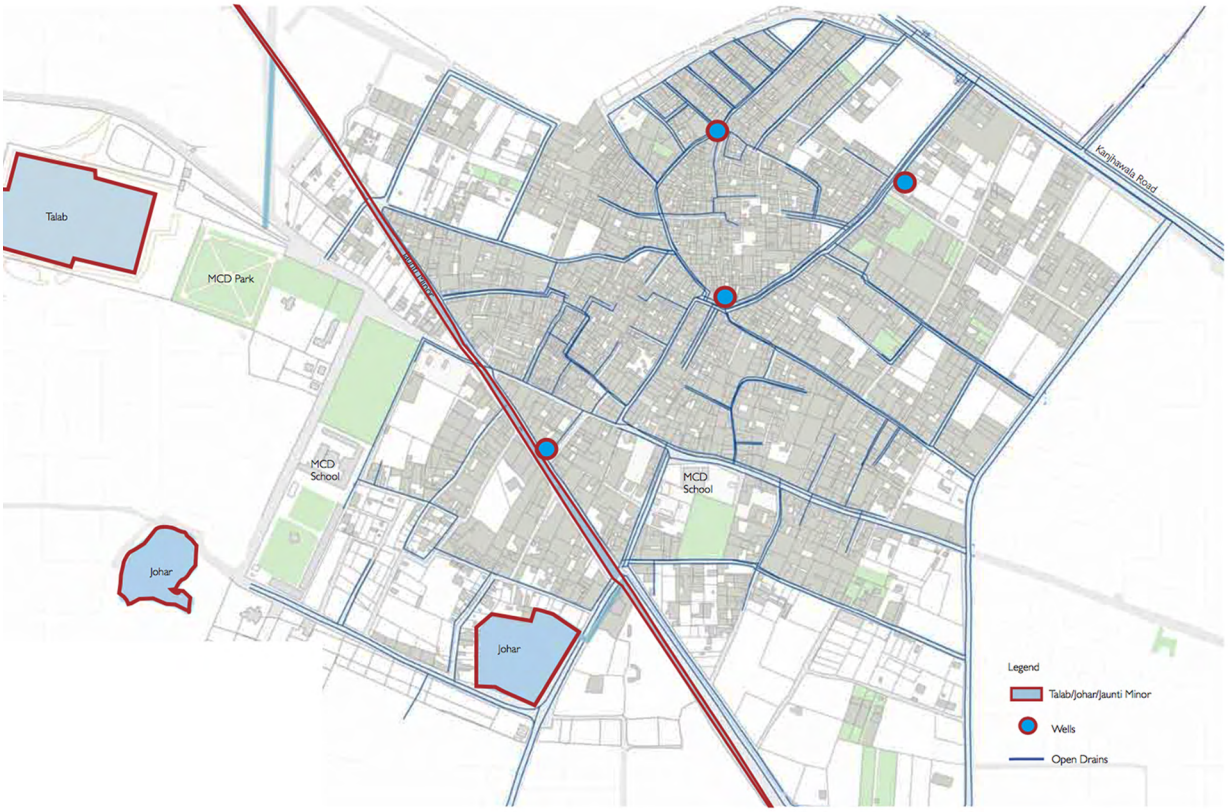
CULTURAL AND HISTORY

Cultural and natural history of the site is represented through design,which has the potential to increase public awareness about waterway

TYPOLOGY . Precedent study 2. Socio-cultural activators for stitching the hydrological systems in Village Jaunta, Haryana



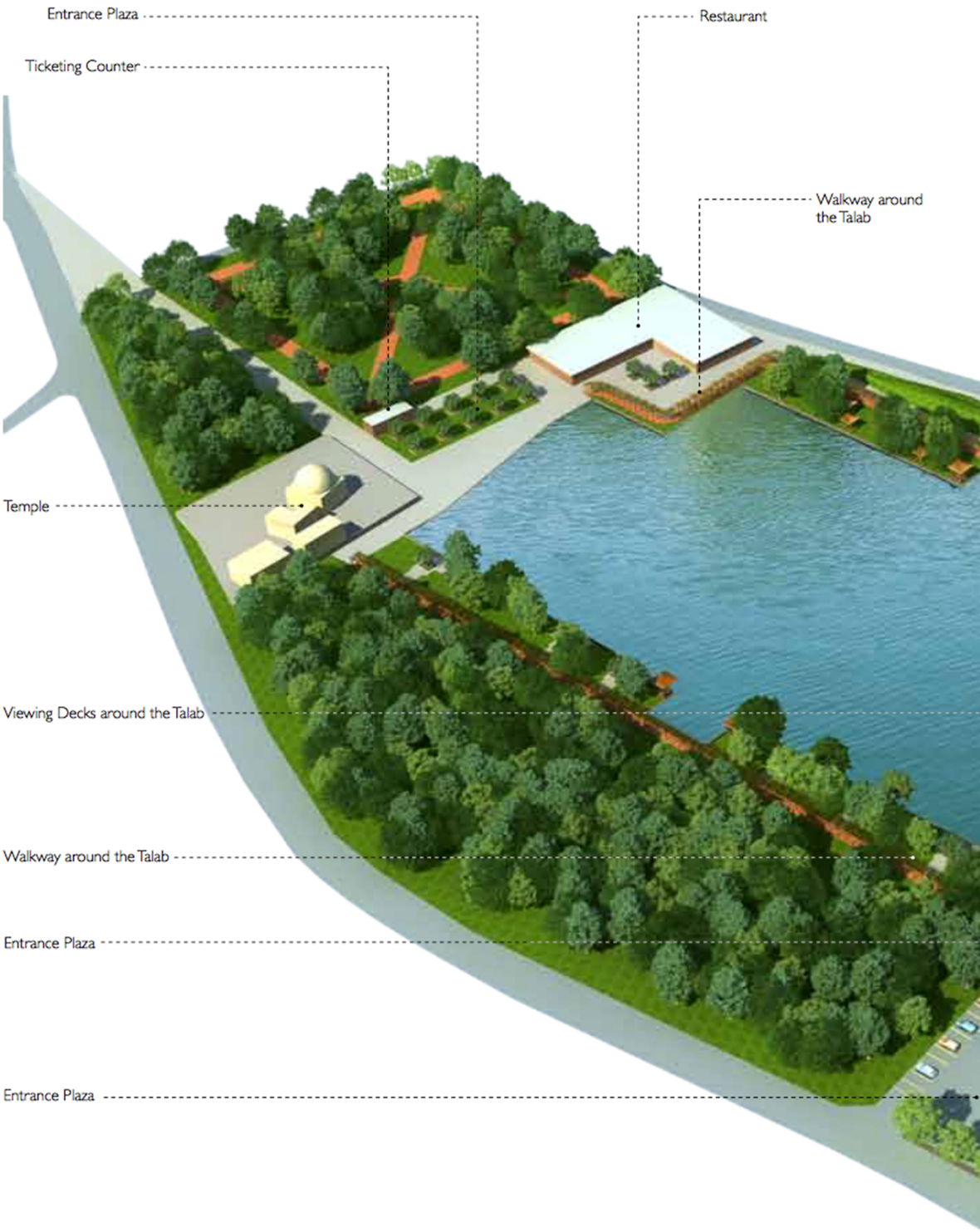
Source: INTACH archive, Municipality of Jaunti, Haryana



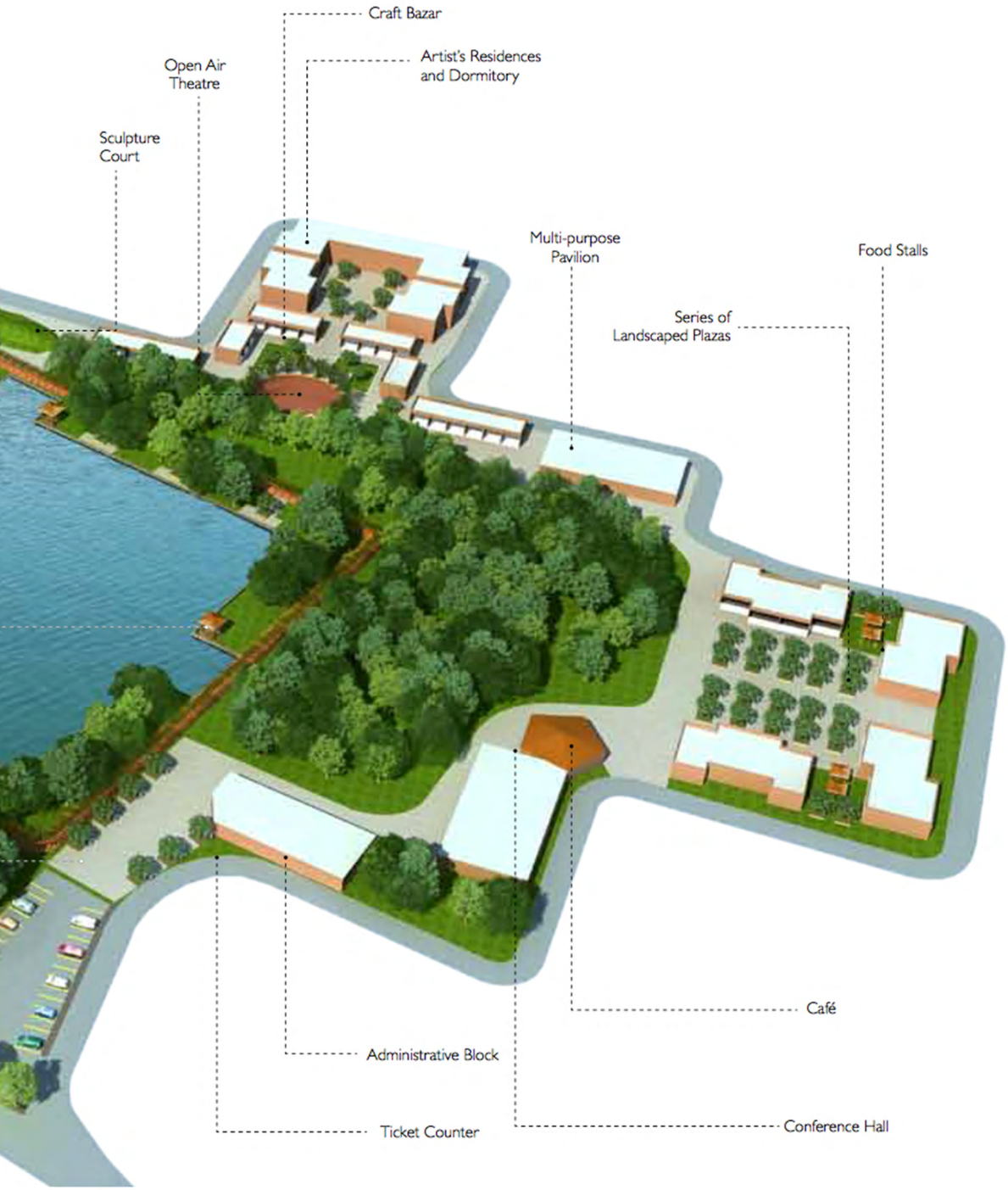
View of the existing condition around the talab

Walking trail around the talab

TYPOLOGY . Precedent study 2. Socio-cultural activators for stitching the hydrological systems in Village Jaunta, Hary



vana


Craft Bazar
Artist's Residences and Dormitory
Open Air Theatre
Sculpture Court
Multi-purpose Pavilion
Food Stalls
Series of Landscaped Plazas
Café
Administrative Block
Ticket Counter
Conference Hall