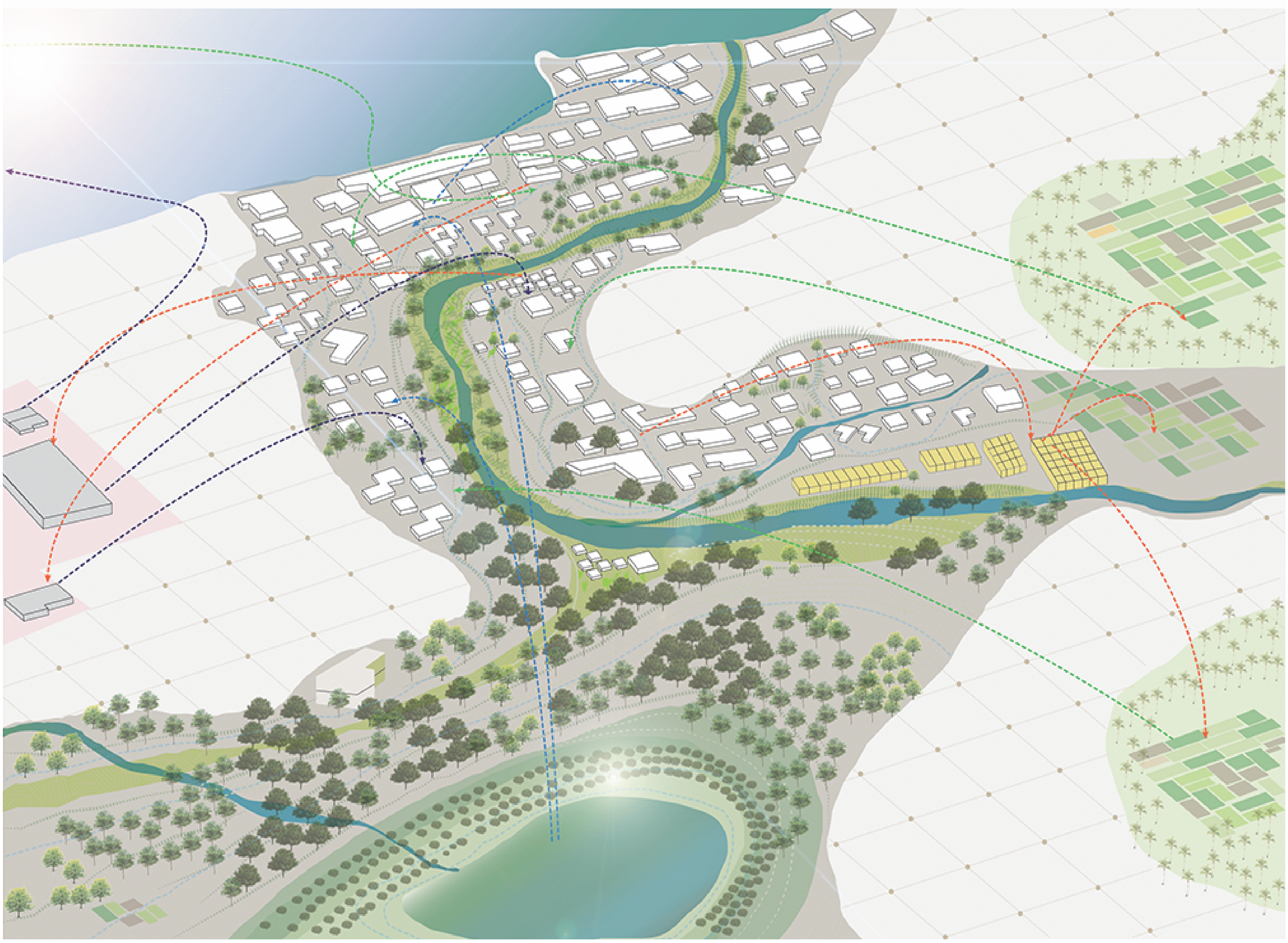
URBAN reSOURCES

Banking on cities for secondary resources to release the pressure on natural environment and progress towards Environmentally Sustainable urban integrated systems

Sai Sree Bhavya Bathena

Faculty of Architecture and the Built Environment | Delft University of Technology



URBAN RESOURCES

|Visakhapatnam|

Sai Sree Bhavya Bathena

Graduation Project Report

Delft University of Technology | Faculty of Architecture and the Built Environment

July, 2019 | Delft, Netherlands

COLOPHON

Title: Urban Resources
Sub-Title: - Banking on cities for secondary resources that can release the pressure on natural environment and progress towards Environmental Sustainable urban integrated systems

Graduation Thesis Report
Sai Sree Bhavya Bathena
4745205
M.Sc Urbanism
Faculty of Architecture and Built Environment

Research Group:
Urban Metabolism

First Mentor:
Dipl.ing Alexander Wandl (Environmental Technology and Design)

Second Mentor:
Dr. Diego Sepulveda Caramona (Spatial Planning and Strategies)

ABSTRACT

This thesis seeks to explore the concept of Circular Economy and its integration into urban planning as a tool of implementation. The goal of this thesis is to develop environmentally sustainable cities. To develop environmentally sustainable cities, the thesis focuses on two major resource flows in the city: food and water, whose waste streams and high demand are causing damage to the environment. The thesis has developed regional strategies for both the resource flows in decentralized systems and centralized systems. It has emphasized the integration of socio-ecological systems and socio-technical systems that are required in order to successfully implement a circular economy in developing countries. The strategies and the spatial design are elaborated in three pilot projects which have different challenges.


View of the city from the fishing harbour
Source: Author

ACKNOWLEDGEMENT

I take this opportunity to express my profound gratitude and deep regards to my mentors Dipl.ing. Alexander Wandl and Dr. Diego Sepulveda for their constant inspiration and continued support throughout the course of this thesis. I would like to thank Ir. Kristel Aalbers for being my mentor and helping me in my ups and downs. Discussions in the research group and the learning experience from the TiSD annotation courses have helped me progress in my thesis. I would also like to express my gratitude towards the Department of Urbanism TU Delft for their support and cooperation in the last two years.

Fieldwork in this thesis, has helped in the progression and validation of the research. I would like to thank the representatives of Greater Visakhapatnam Municipal Corporation for their support and guidance. And also the participants in the interviews during field visit for their cooperation and providing their views on the existing conditions and their interest in this field of research.

I am grateful to my parents and sister, who have always believed in my dreams and their encouragement has been of immense value and help to me. I am also thankful to Nimit, Dori and other friends in my research group for their support and critiques during the entire course of time.


Wastewater being discharged into the sea without prior treatment and there by polluting the water as well as eroding the shoreline

Source: Author

MOTIVATION

This thesis began with a desire to investigate the idea of adapting circular economy in the context of developing countries as a model of sustainable development. This thesis is focused on the rapidly growing city of Visakhapatnam. Due to the growing urban population coupled with the changing economy and lifestyle of citizens, the city is facing challenges of urban sprawl, social inequality, higher demand for resources and improper waste management practices. All the above conditions are degrading the environment resulting in a decline in quality of living. This condition acts as a motivation to adapt new principles and planning strategies for the sustainable development of the city

Glossary

E

Environmental Sustainability: meeting the resource and services needs of current and future generations without compromising the health of the ecosystems that provide them

R

Rythu Bazaar: farmers market

W

Wards: municipal area that is divided into territorial constituencies known as wards

Z

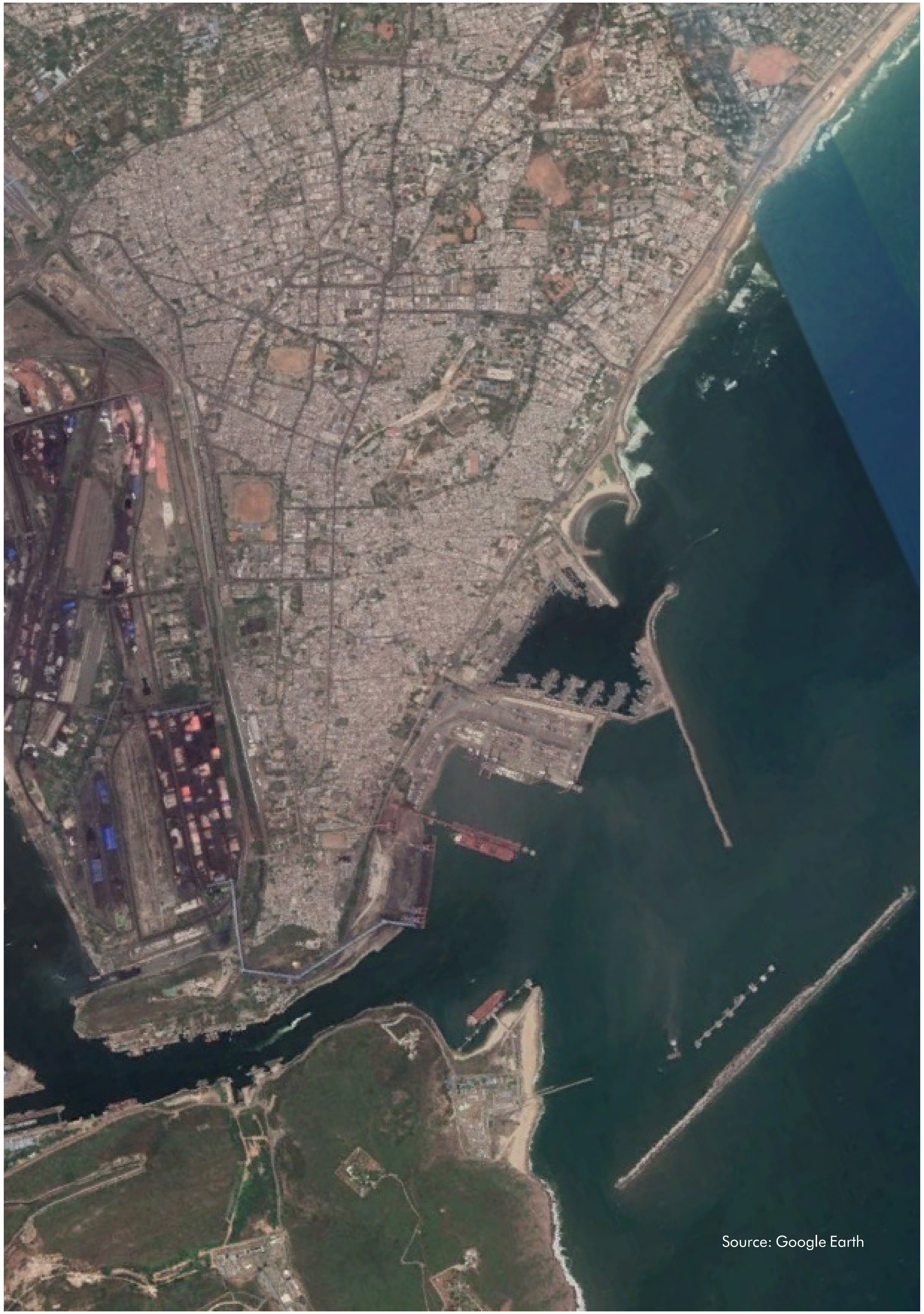
Zaid crops: the crops that do not require more irrigation and are grown during the seasons where there is no monsoon.

Acronyms:

A.D.B	Asian Development Bank
C.E	Circular Economy
C.I.M	Clean India Mission
CPCB	Central Pollution Control Board
CRZ	Coastal Regulation Zone
DAHDF	Department Of Animal Husbandry, Dairying and Fisheries
E.B.T.C	Enterprise Bancorp Inc
E.S	Environmetal Sustainability
FSSAI	Food safety and standards authority of India
G.I.Z	German Society for International Cooperation
MAFW	Ministry of Agriculture & Farmers' Welfare
MHUD	Ministry of Housing and Urban Development
MOEFC	Ministry of Environment, Forest and Climate Change
MOIWM	Ministry of Infrastructure and Water Management
M.S.W	Municipal Solid Waste
NGO	Non-Governmental Organisation
RWH	Rainwater Harvesting
S.T.P	Sewage Treatment Plant
S.S	Social Sustainability
U.M	Urban Metabolism
U.N	United Nations
UNICEF	United Nations International Children's Emergency Fund

List of figures:

Contents



VISAKHAPATNAM 1

Introduction to the city

Visakhapatnam is a growing metropolitan city in the pristine east coast. This chapter introduces the city, its growth and a brief insight to its challenges.

Project Introduction

Visakhapatnam is the ninth largest metropolitan city in India in the state of Andhra Pradesh (as shown in fig 1.1) with a population of 2.036 million (2011 census) living in the urban area. The city is the administrative headquarters of Visakhapatnam district and state headquarters of Indian Coast Guard.

In the year 2014, the state of Andhra Pradesh (India) was bifurcated into two states(The Andhra Pradesh state reorganization Act,2014) , making the city of Visakhapatnam, the financial capital of the newly formed state (Business Standard; 2015) and a GDP of 26 Billion$ (USD) (Population Of Visakhapatnam; 2018). In 2016, the Government of India has listed Visakhapatnam to be one of the 100 smart cities intended to develop under the scheme of Smart Cities Mission. Owing to the above factors, there has been high migration into the city from the neighbouring districts with a steady rise in population of 0.276 million per year (Population Of Visakhapatnam, 2018) resulting in informal settlements with more urban poverty, social and spatial inequalities (India, H. 2016, February 17). The growing affluence of the city has resulted in lifestyle changes, where there is an increase in the demand for resources followed by enormous amounts of waste generation as shown in fig 1.0. Along with the linear process of resource consumption, the city follows a linear system of disposal in handling the increasing waste streams. The city follows conventional systems of landfill for the municipal solid waste and releases both treated and untreated sewage into the sea or other natural water bodies (TNN.2016, July 28). In addition to these waste streams, the industrial waste from the port and industries is a major consideration with approximately 30% of it not being treated before disposal. All these practices have resulted in polluting the soil, air and especially water, as the pollution of the sea resulted in hydrographic and biotic changes (Raman, A.V. Helgolander Meeresunters (1995)). There is an urgent need for the city to develop more sustainable practices to cope with the increasing demand for resources and waste streams causing pollution. There is a potential to re-use the waste streams in the form of secondary resources by bringing circularity and contribute to the sustainable development of the region. Including circular economy in this growing economy might help boost its economic situation and be beneficial to the people by bringing more work opportunities and better living environment.

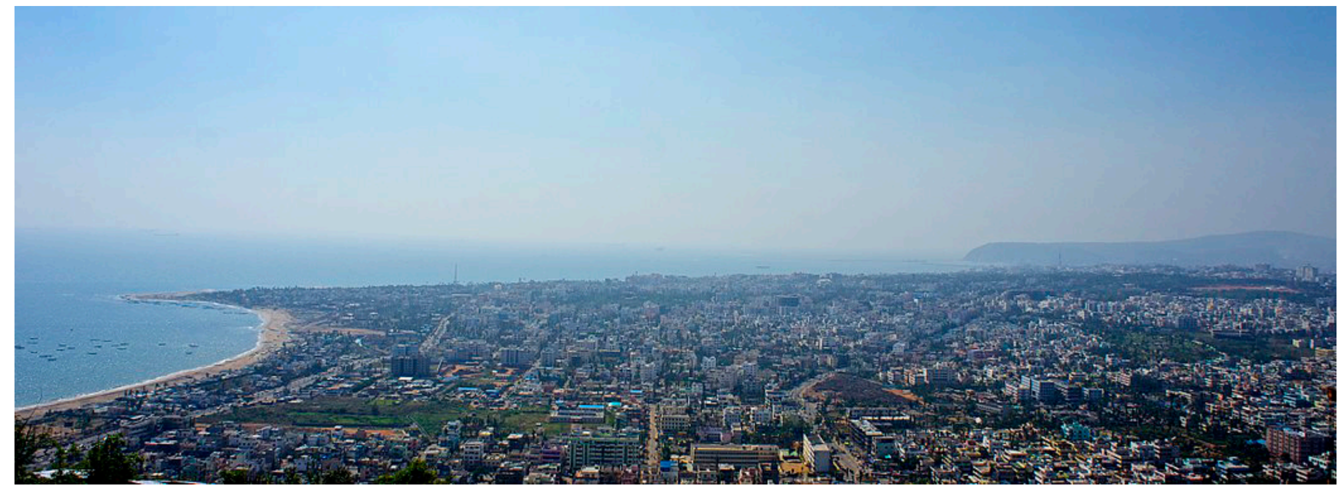
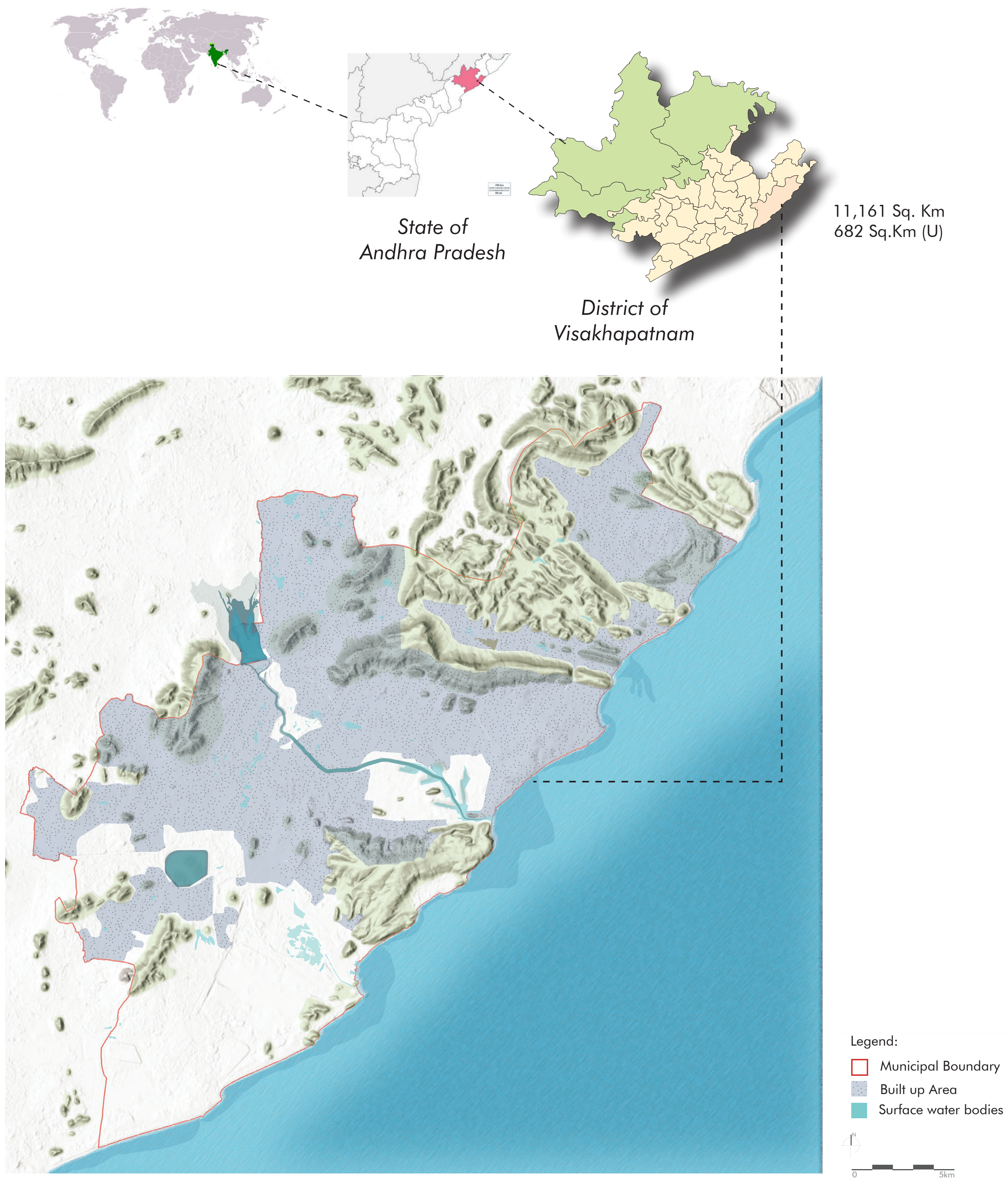


Fig 1.0: Aerial view of beach promenade and port in the city of Visakhapatnam (Top).
Pollution caused by solid waste and waste water (Bottom).

Source:
Image 1: https://en.wikipedia.org/wiki/Visakhapatnam

Introduction to the city



Visakhapatnam Urban

Fig 1.1 : Location of City of Visakhapatnam

Source:

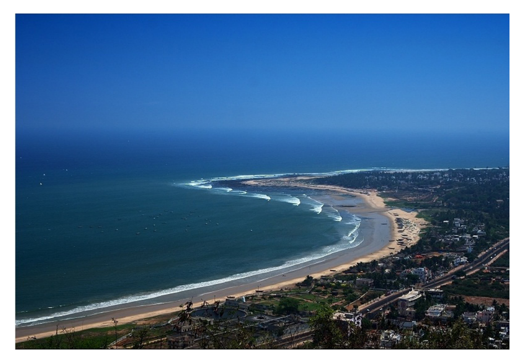
http://visakhapatnam.nic.in/

Port City

Industrial City

Naval Headquarters

Education center



Tourism

Pilgrimage City

Fig 1.2: Landmarks in the city

Source:

http://visakhapatnam.nic.in/

Morphogenesis of the city

History: The history of Visakhapatnam dates back to 6th Century BC, as a center for Buddhist pilgrimage during the Kalinga empire. In the 17th century, the Dutch had their port to trade spices in the Asian countries. It was one of the bases for The Dutch East India Company. By the end of the 18th century, The French had taken over the port.

1941

The British captured Visakhapatnam after the 1804 Battle of Vizagapatam and it remained under British colonial rule until India's independence in 1947. During this period, the city was a cluster of fishermen hamlet.

1975

Post Independence in 1947, the city was a Naval Base for the country. With the development of the National Highway, the city started to grow along the highway. During this period, the urban local body of the city was formed. Many industries developed in the city, which triggered growth.

1995

During this phase, the city started to expand with the development of new industries and port activities. It was growing as a tourist destination. More educational institutions were developed in the city. It started to grow as a destination for education and employment as well.

2005

Pharmaceutical companies, Thermal plants and chemical industries were developed in the city. The city started to expand to its nearby rural settlements.

2014

After being proposed as the new financial capital of the state, the city has been going through a rapid transformation. Within a decade, the city grew denser and there have been a lot of rural to urban migration for employment opportunities. This has resulted in more informal settlements in the city. According to 2011 statistics, the population of the city was 2.09 million and the population of people living in the slums was 0.8 million. The population of the city is expected to grow at the pace of 0.276 million per year (Population Of Visakhapatnam 2018). Hence, there shall be a lot more pressure on the city to provide resources, infrastructure and good quality of life to its citizens.

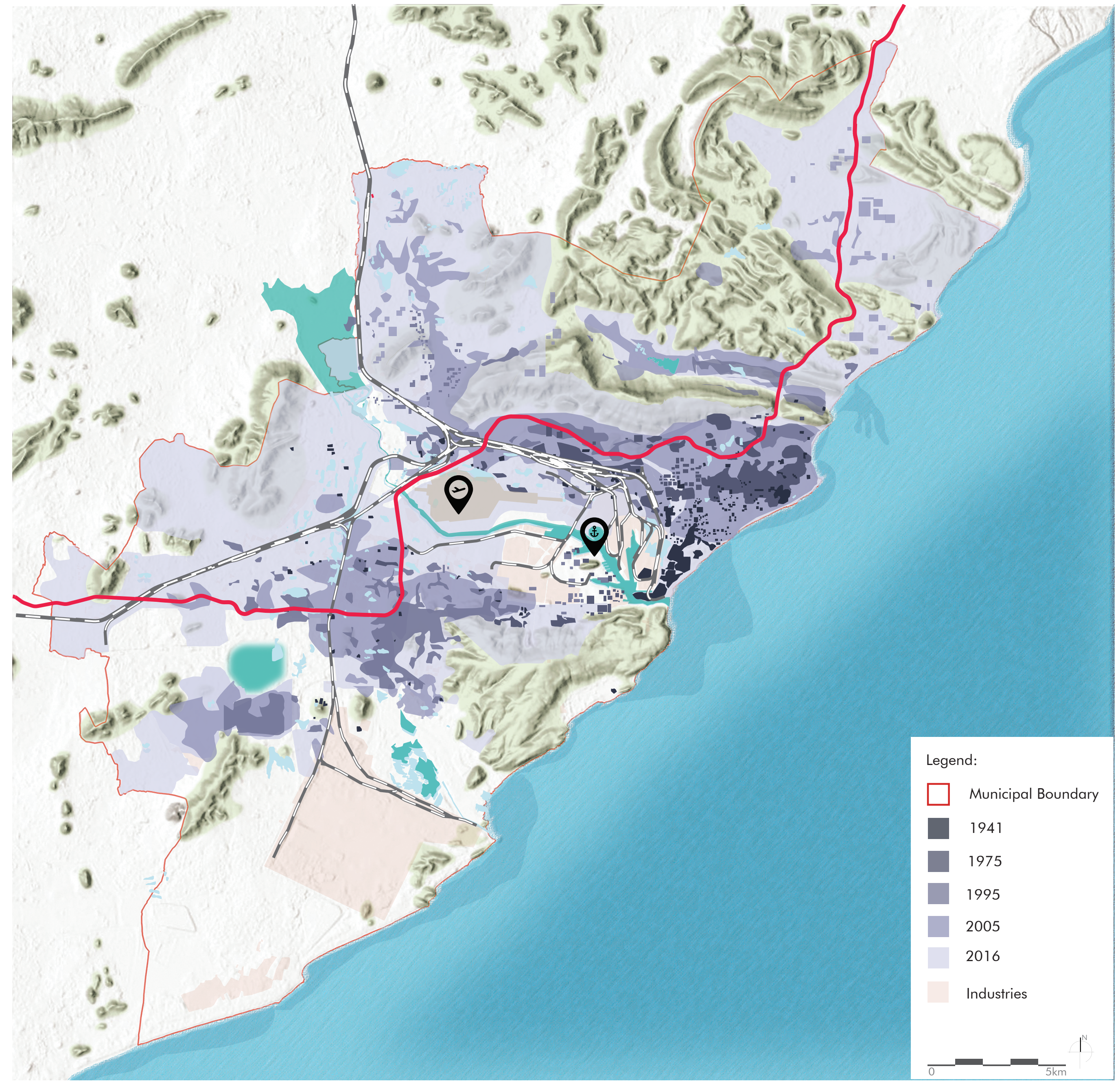


Fig 1.3: Growth of the city of Visakhapatnam

Source:

http://www.cibtech.org/J-GEOLOGY-EARTH-ENVIRONMENT/PUBLICATIONS/2012/Vol%202%20No%202/14-039%20Govindu...Spatio...GIS.pdf

If it cannot be reduced, reused, repaired, rebuilt, refurbished, refinished, resold, recycled, or composted, then it should be restricted, designed or removed from production

- Pete Seeger

Source: Author

2

VOLATILE RESOURCES

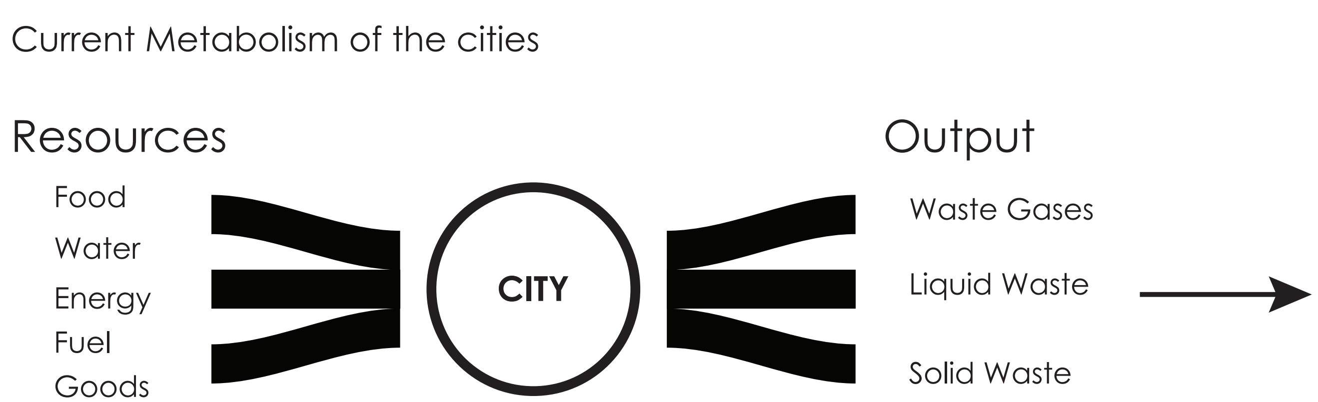
Understanding the problem context across different scales

This chapter discusses the challenges of the current linear metabolism of the cities and its detrimental impacts on the environment. The problem field is analysed in the city of Visakhapatnam.

Problem Field

Urbanisation in the developing countries, especially in India is growing at an unprecedented rate. The metropolitan cities are expanding beyond their hinterlands with increasing urban population and affluence. Challenges faced due to this are; as shown in Fig 2.0, increase in the demand for resources, urban infrastructure and the amount of waste generated. Developing countries like India, face more complications such as social inequality and urban poor-who often settled down as informal settlements because of the migrating rural to the urban population.

The increasing demand for resources is creating pressure on the environment. The linear process of extraction of resources is affecting the environment. Due to India's sustained economic growth, increasing living standards and changing production and consumption patterns, there is an increase in the amount of waste that is being generated. This can be attributed to the linear approach towards resource consumption, usage and disposal. As shown in the Fig 2.1, the current metabolism of the cities comprises of feeding the resources into the cities and generating solid, liquid and gaseous waste as output. And the linear process of disposal of this waste such as landfilling and dumping is resulting in environmental degradation and affecting the public health. The linearity in both resource consumption and disposal is creating an unsustainable environment. The developed nations have started to acknowledge this issue and have started taking measures to reduce waste disposal and reuse them. But the developing countries are oblivious about the negative effects of the waste that they are generating. The map in Fig 2.1 shows the forecast of the amount of waste that might be generated. It can be observed that there is a sharp increase in waste generation in developing countries and a gradual rise in the developed nations. The reasons for this can be attributed to negligible measures being taken in order to address this issue, lack of knowledge and/or lack of funds and infrastructure.



People in the urban areas have no account of the amount of waste they generate and how it is being disposed of. It is estimated that on average, an urban resident generates 1.5kgs of solid waste per day. There is a lack of engagement of the local actors with their surrounding ecological systems. Compared to those in developed nations, residents in developing countries, especially the urban poor, are more severely affected by unsustainably managed waste. This is because the waste is often disposed of in unregulated dumps or openly burned in their surroundings. Such practices have detrimental impacts on the environment.

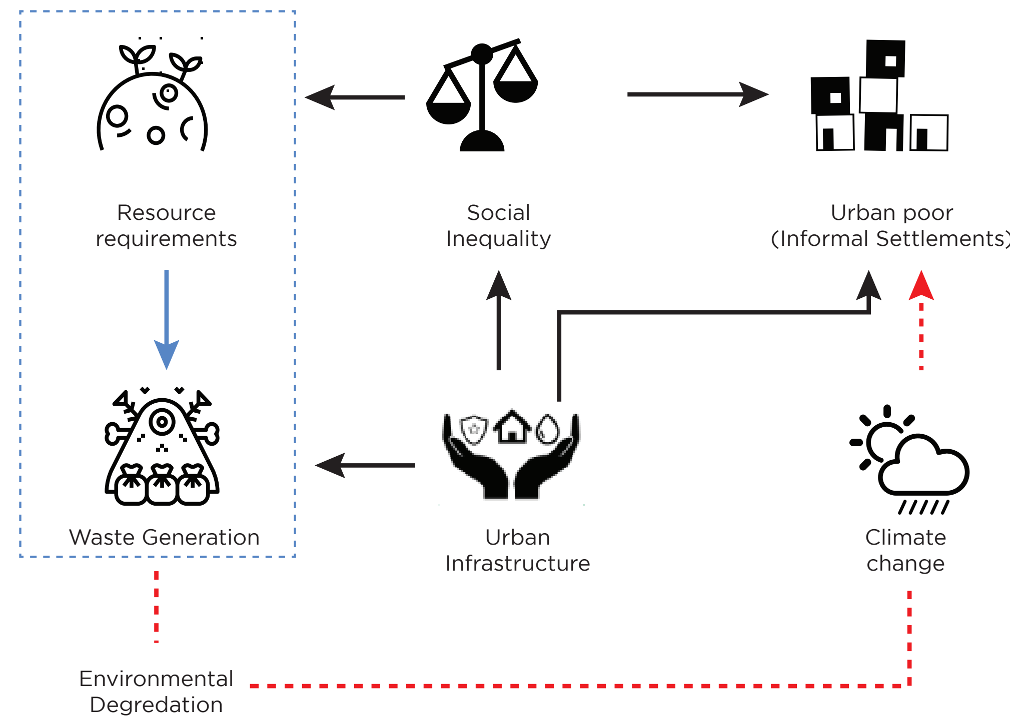


Fig 2.0: Challenges faced due to increasing urban population

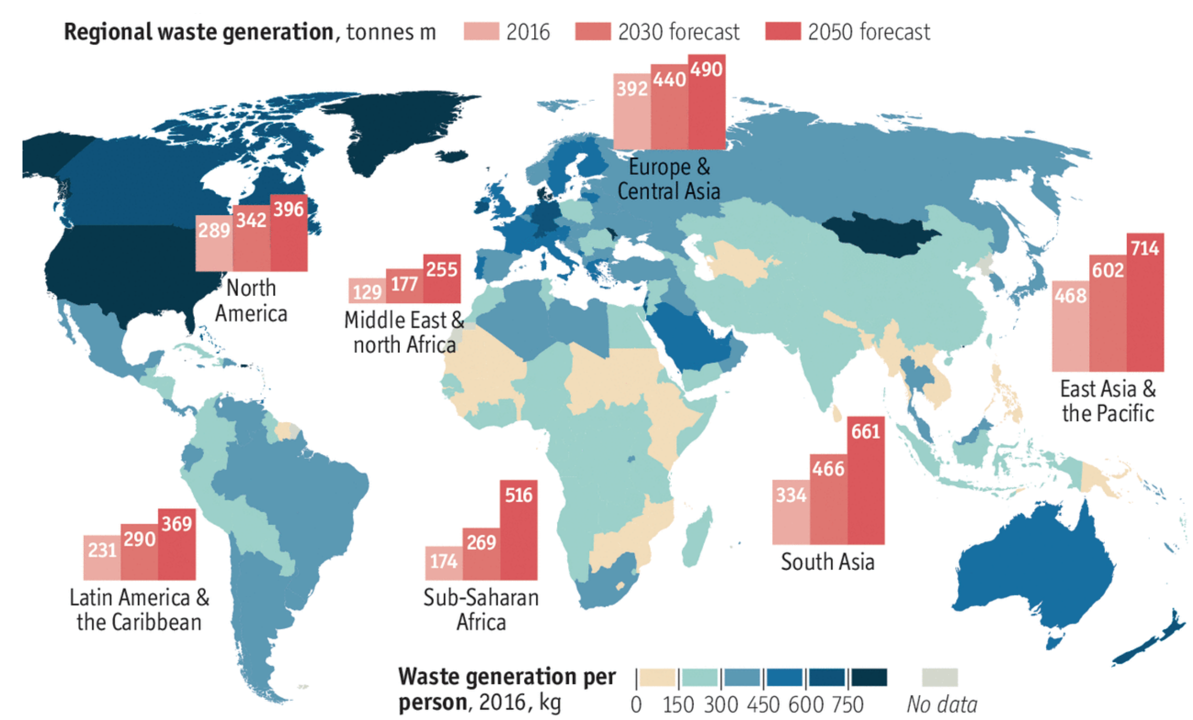


Fig 2.1: Increase in the amount of waste generated due to linear metabolism of cities

Problem Analysis: National Scale

In India, the types of waste are classified into Municipal Solid Waste (MSW), Sewage Waste, Industrial Waste and Agricultural Waste. Agriculture is the major occupation in the country while industries are the heart of its economic growth. The following sections discuss the current major streams of waste: Municipal solid waste and sewage treatment practices in the country and the measures that have been taken at the national scale.

a) Municipal Solid Waste:

In India, solid waste is classified into fourteen categories depending on the source, origin and type of waste. These include domestic waste, municipal waste, institutional waste, commercial waste, garbage, ashes, bulky waste, street sweepings, dead animals, construction and demolition waste, hazardous waste, sewage waste and industrial waste (Annepu,2012). The amount of waste generated across the country is approximately 19 million tonnes per day. Waste collected from the sources is dumped openly or in the landfills. These huge volumes cannot be dumped in the landfills anymore as the cities are growing beyond their hinterlands. The landfill sites are overflowing while dumping into water bodies might choke up the probability of access to clean water. Hence, it is important to change the attitude towards waste generation, considering the environmental impacts of linear methods of waste disposal and opt for more sustainable methods. In India, any municipal solid waste generated in a city or a town is managed and handled in accordance with the compliance criteria and the procedure laid down by the Central Pollution Control Board (CPCB) of India (mentioned in Notifications issued by Ministry of Environment and Forests, India). And it is executed by the urban local bodies (ULB) across the cities. (Annepu, 2012).

The approach of the ULBs, towards handling the waste is a linear process, as shown in the fig 2.4

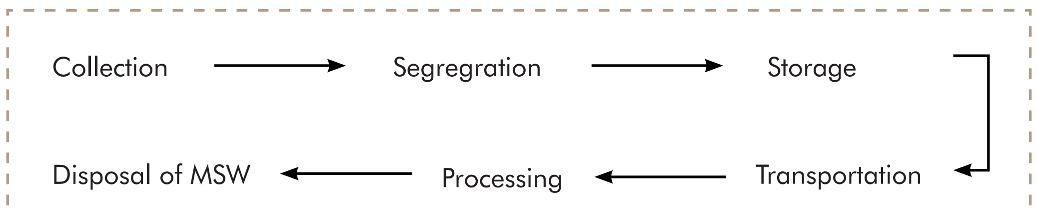


Fig 2.4 : Linear process of disposal of MSW

Most of the urban areas in India lack MSW storage facility at the source. Under these conditions, it has become a general practice of using the same bin for the collection of both decomposable and non-decomposable waste without any segregation and is disposed of at a community disposal centre. (Gupta S.). There has been no definite defined space for the community disposal centers. These are PVC or metal containers placed at the end of the street, often overfilled. For the years 2001 and 2005 (fig. 2.5), waste dumps or open burning continue to be the principal method of waste disposal. These methods cause several accidents and are a continuous source of emission of harmful gases and highly toxic liquid leachate (Kaushal, Varghese and Chabukdhara, 2012).

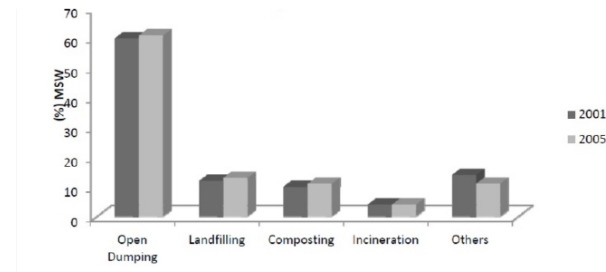


Fig 2.5 : Disposal Trends of MSW in India

The waste collected from the source is collected in a single bin and transported to open dumps or landfills at the outskirts of the city. Majority of the landfills are 70% filled (Annepu, 2012). If this practice continues, as shown in Fig 2.6, it is predicted that the entire nation would require 1600 Km2 of land to dump the waste being generated by 2050.

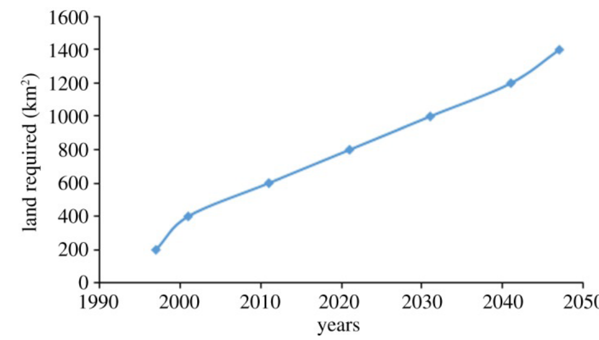


Fig 2.6: Graph showing the area required to landfill in the coming years

b) Sewage Water:

Treatment and disposal of sewage water is another challenge in urban India. Not all the regions in the city are facilitated with a proper sewage system and the existing STPs do not fulfill the required capacities that need to be treated. There is a huge gap between the amount of sewage generated and treated in urban India. The total treatment capacity gap between the wastewater generation and its treatment in the metropolitan cities combined is as high as 70% as shown in Fig 2.7. The cities on the coast release their untreated sewage water into the nearby sea, rivers or lakes. This practice is affecting marine life followed by the people who depend on it for income.

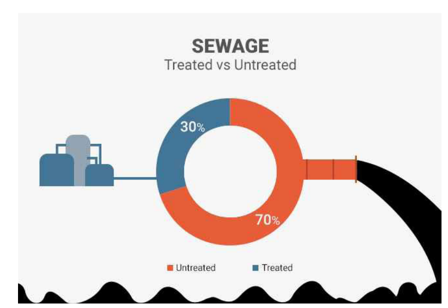


Fig 2.7 : The amount of sewage treated in the cities of India

Source:
https://swachhindia.ndtv.com/waste-management-india-drowning-garbage-2147/

Fig 2.8: Environmental degradation in the country due to improper waste management

Source:

1.https://www.insightsonindia.com/2016/12/01/insights-issues-waste-management/
2.https://www.thenewsminute.com/article/no-it-s-not-switzerland-bengalurus-bellandur-lake-spews-10-ft-high-toxic-foam-88917
3. https://www.eco-ventures.in/offshore.php
4.https://www.globalcitizen.org/en/content/urban-rural-two-sides-of-indias-sanitation-problem/
5.https://www.downtoearth.org.in/blog/waste/delhi-s-solid-waste-a-systemic-failure-56776
6.https://www.hindustantimes.com/india-news/swachh-bharat-in-jamshedpur-click-a-selfie-

Clean India Mission (SWACHH BHARATH ABHIYAN)

Clean India Mission(CIM) is a campaign developed by the government of India with an aim to develop open defecation free (ODF) cities and improved solid waste management and create public awareness in the country. It is supported by development partners such as USAID, ADB, UNICEF, GIZ, UN, World Bank and EBTC. This mission is categorised for rural and urban areas in the country. The objectives of CIM is to eliminate open defecation, improve sanitation in the city, behavioral changes towards sanitation practices, modern and scientific MSW management, create awareness about sanitation and its effects on public health and capacity augmentation of the ULB to implement the above (Swacch Bharath Mission guidelines, 2017). This mission encourages the participation of private sectors and NGOs, to implement the above-mentioned objectives. It has developed guidelines for the ULB to follow in order to achieve the goals. In relation to MSW, the guidelines state following the principles of 3Rs i.e., reduce, reuse and recycle. It has defined guidelines for disposal and reuse of different types of waste such as plastics, e-waste, C&D waste and hazardous waste. As an alternative to the existing practice of landfill, this program promotes Waste to Energy(WTE) plants. The WTE plants are right now under construction in few metropolitan cities of the country. However, their approach is more of an end-of-pipe solution as the resource value of waste streams is still underutilised.

This mission also discusses producer responsibilities and consumer awareness. Due to the hierarchy of the institutions, the responsibility of the implementation is majorly on the ULB. However, the program fails to provide a platform for sharing knowledge, bringing different actors together, especially at the level of ULB. The lack of sufficient funds and advanced knowledge at the level of ULB is causing a set back to this mission.

Though the objectives laid down by this board is a good step towards waste management, there are few shortcomings in this mission. The solutions proposed and current campaigns on creating awareness are only limited to the waste generated phase of the resource loop, end of pipe solutions and segregation of waste, rather than focusing on campaigns for responsible resource consumption, change in attitude towards waste and utilizing the streams of waste as secondary resources. The solutions proposed are also not being implemented in accordance with the guidelines developed at the National scale. The reason for this can be due to lack of knowledge and region-specific guidelines at the state and regional development authority level and not developing location specific guidelines at the scale of the urban local body. This is already mentioned in the guidelines but there is a gap at the lower scales.

This mission also targets on integrating private sectors for technology development and NGOs in implementing the guidelines or proposed solutions but it fails in integrating the citizens who are the main local actors in integration processes. The guidelines also do not discuss the spatial requirements to accommodate the waste flows or the proposed solutions on their agenda.

Problem Analysis: City Scale - Visakhapatnam

The city of Visakhapatnam is going through a rapid transformation. The city is growing with increasing economic opportunities. Being an industrial and port city, there are large streams of waste that have the potential to be reused but are disposed of in the landfill without any precautions.

a) Municipal Solid Waste:

The approach of the ULB to the increasing amount of MSW is optimising the existing linear practices. As shown in Fig 2.9, the waste across multiple sources is collected and transported to transfer station and later disposed of in the landfill site which spans over 100 acres (Fig 2.10). Except for the biowaste which is treated at the biomedical waste treatment plant, the waste is dumped into the land and burnt in the open after a few months (Annepu, 2012). This practice is resulting in the release of harmful gases. The leachate from the waste percolates into the soil and nearby water bodies. In the process of transportation of waste from one node to another, a lot of waste is left out in the surroundings of these nodes, degrading their quality of life. Recycling of waste is done on a small scale by the rag pickers.

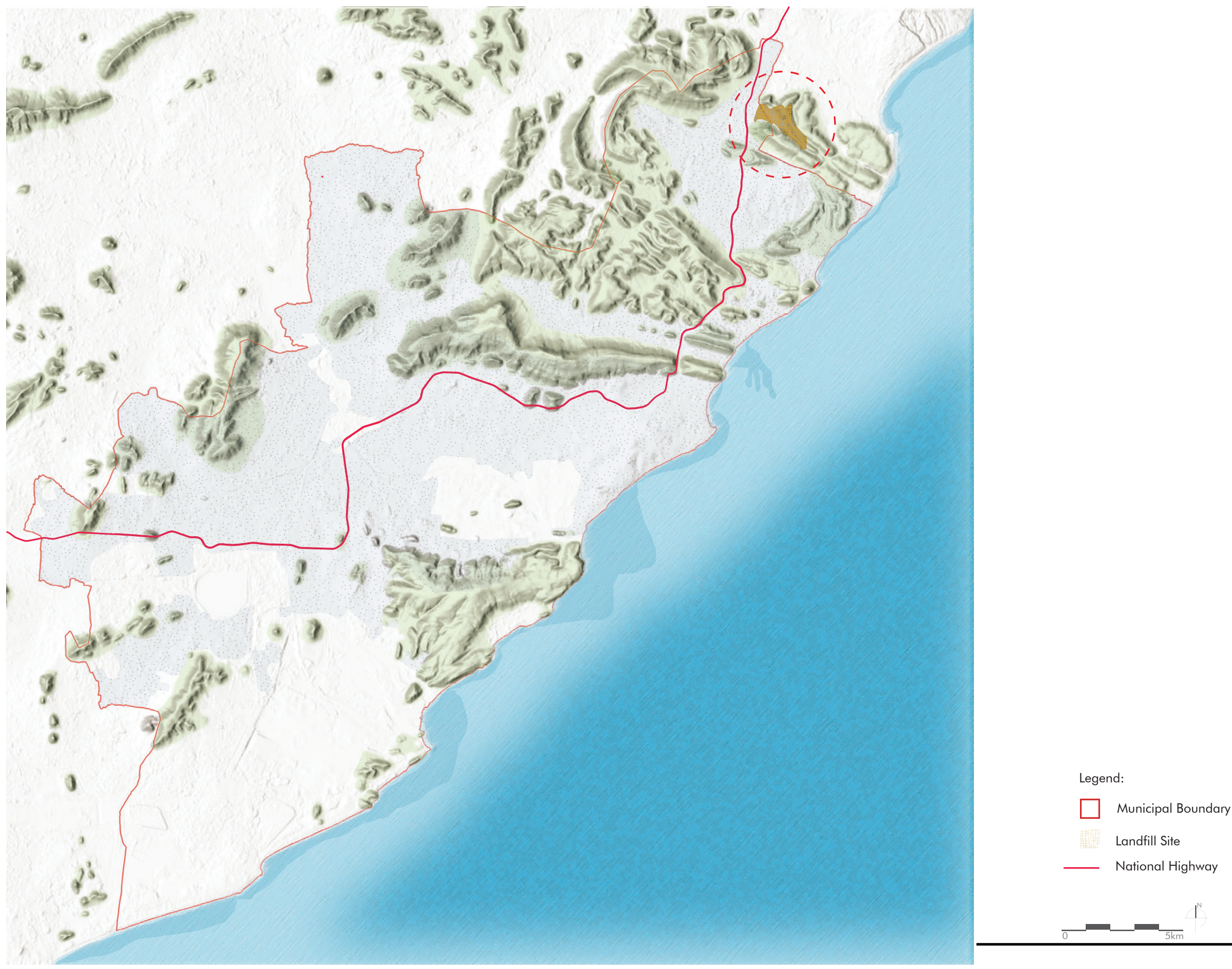


Fig 2.10 : Map showing the location of existing landfill site

Source:

https://www.gvmc.gov.in/wss/static_content/Sanitation%20Solid%20Waste%20Management.jsp

The above map shows the location of the temporary bulk storage sites and the landfill. The waste from all over the city is brought to the temporary storage site for segregation and later transported to the landfill which is located 32km away, located in the city hinterlands.

Fig 2.9 : Linear process of MSW disposal in Visakhapatnam and images of each step

Source:

https://www.deccanchronicle.com/151118/nation-current-affairs/article/shortage-dustbins-hits-clean-visakhapatnam-image

https://www.thehindu.com/news/cities/Visakhapatnam/overflowing-garbage-bins-raise-a-stink/article2860990.ece

https://www.thehindu.com/news/cities/Visakhapatnam/closed-garbage-transfer-stations-for-one-town-gajuwaka/article24542985.ece

https://www.thehindu.com/news/cities/Visakhapatnam/move-to-shift-dump-yard-makes-no-headway/article7254156.ece

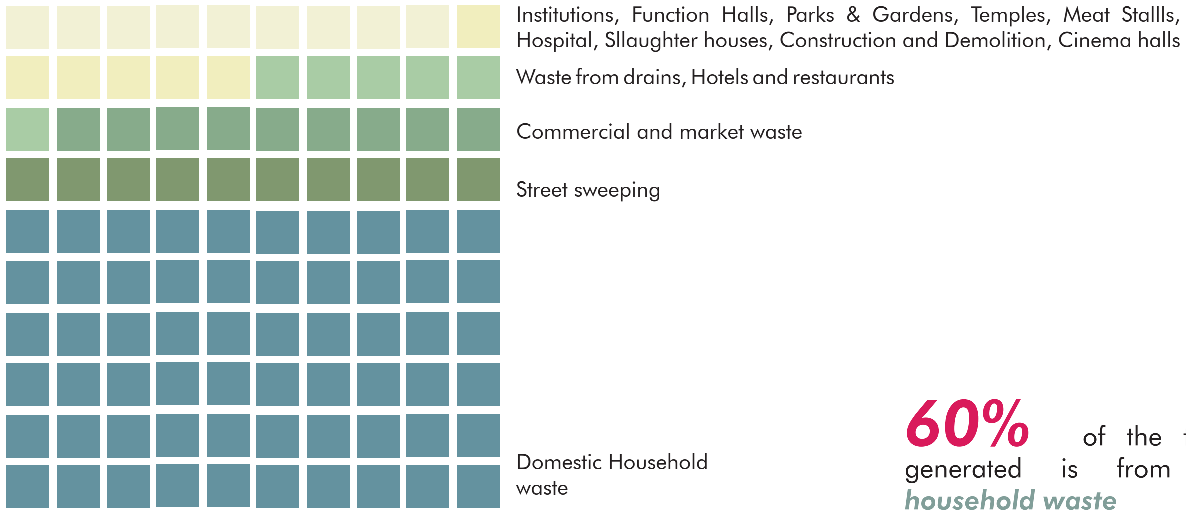


Fig 2.11: Amount of waste generated by different sources

60% of the total waste generated is from ***domestic household waste***

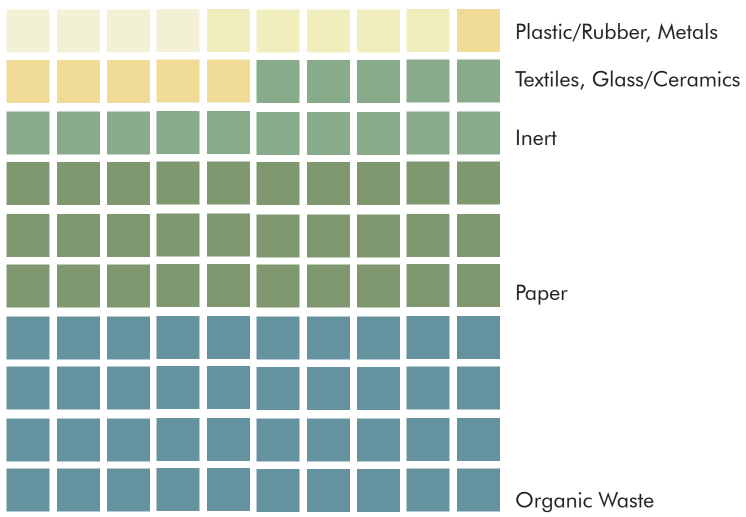


Fig 2.12: Characteristics of waste composition

40% of the total waste collected is ***organic waste***

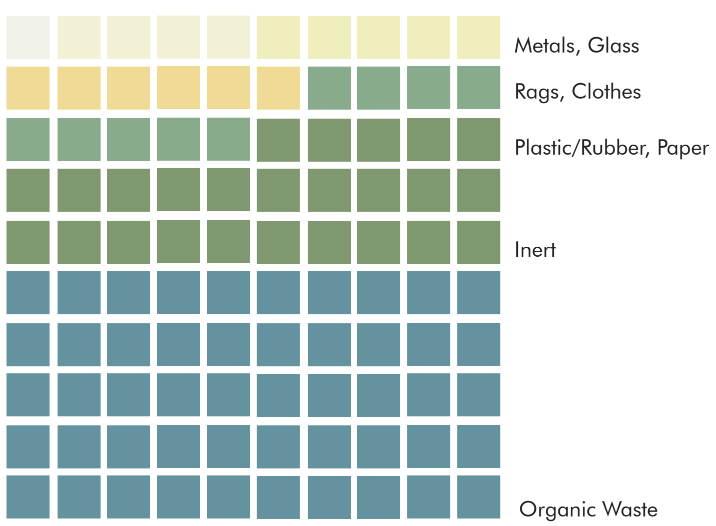


Fig 2.13 Characteristics of domestic household waste

50% of the domestic household waste comprises of ***organic waste***

Note: each pixel in the graph above denotes one percent

i) Different sources of MSW

Fig 2.11 shows the amount of waste that is generated at different sources. Domestic households generate the highest i.e.; 60% of the total MSW generated in the city. The waste collected from street sweeping, commercial spaces, markets have the next highest amount of waste generated. However, there is a remarkable difference in the quantity of waste that is generated in households compared to the other sources of waste.

ii) Characteristics of the MSW

Fig 2.12 displays the composition of waste in the collected MSW. Organic waste is the highest amount of waste generated followed by paper and inert materials. It is estimated that the amount of plastic waste generated in the country has increased to 25% (TERI IN, 2018).

iii) Characteristics of waste at domestic households:

It is important to analyse the characteristics of the domestic household waste as it is the highest source of MSW that is being generated in the city. In fig 2.13, it is shown that almost half of the waste that is being generated is an organic waste. Organic waste in households includes kitchen and garden waste. The second highest amount of waste is of inert materials followed by plastics/rubber.

From the statistics above it is observed that the majority of the MSW is produced in the domestic households and organic waste is the highest amount of waste that is being generated. Organic waste at the household scale is predominantly food waste. Hence, this project will focus on food flows

Source:
Source: Sharholy, Mufeed & Ahmad, Kafeel & Vaishya, Rakesh & Gupta, R.D.. (2007). Municipal solid waste characteristics and management in India. Waste management (New York, N.Y.). 27. 490-6. 10.1016/j.wasman.2006.03.001.

b) Sewage Water:

The linear method of disposal is followed in the case of sewage water as well. The STPs are also overloaded and often the waste is released into open water streams or ocean (Fig 2.11). Only 32% of the city has an underground sewage water collection system that could carry the sewage to the existing sewage treatment plants. The existing STPs do not have the capacity to treat these large volumes of sewage. Hence, they are often released untreated into the sea. The ULB is planning to construct more STPs. Around 60% of the city has individual soak pits. The ULB has developed a system to collect the sewage waste from them and transport it through tankers to the treatment plants and get treated. But most of the time, they are not disposed on time, creating a breeding environment for mosquitoes and insects, which transmit diseases. The collected sewage waste predominantly is released into open water streams or into the sea. This practice creates poor living quality around these water streams. The other 8% of the city does not have any sewage facilities and they follow open defecation. Due to this, the soil gets contaminated and there is an easy chance of spread of diseases due to an unhygienic environment.

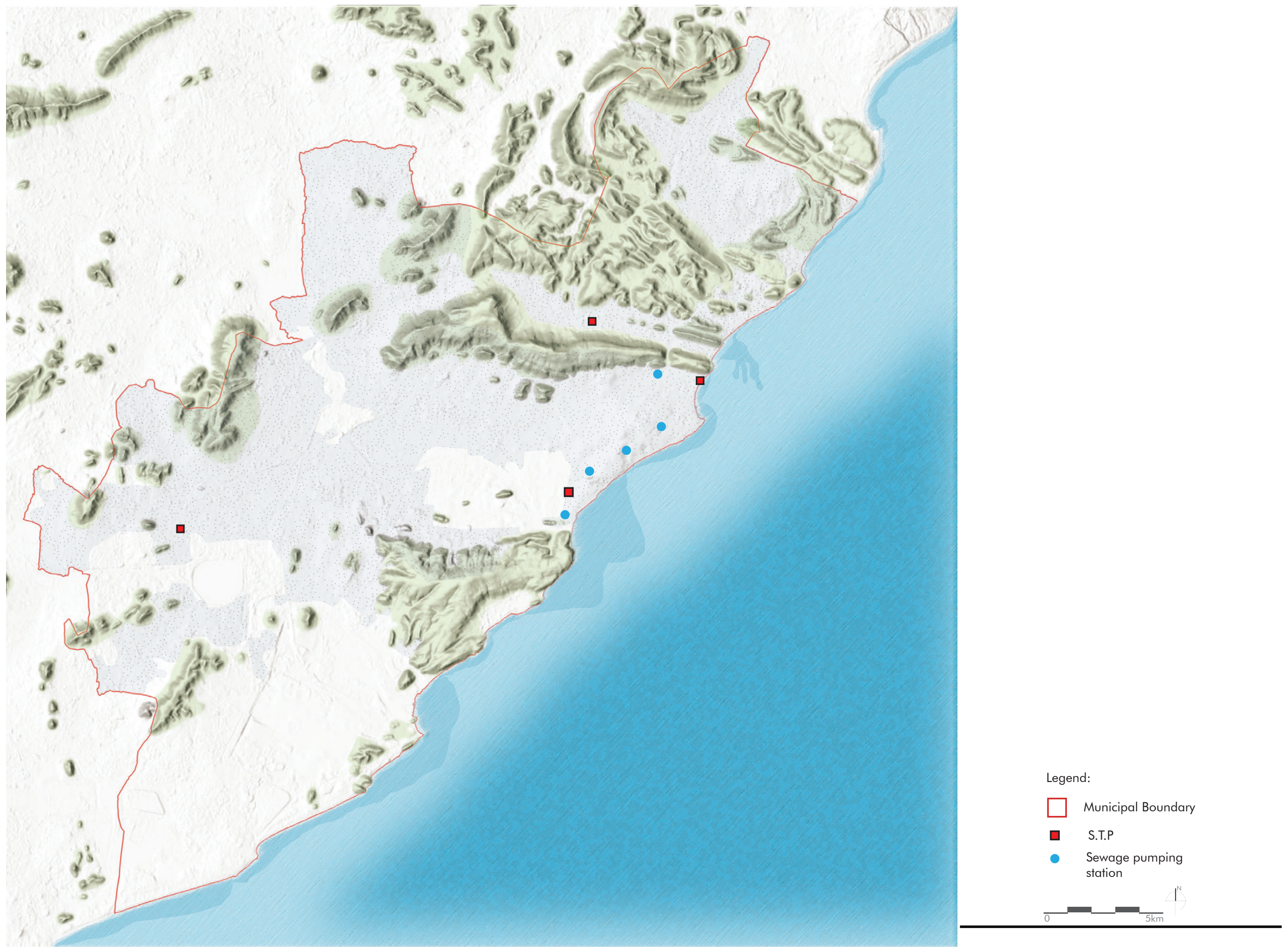


Fig 2.14 : Map showing the location of existing STP

Source:

https://www.gvmc.gov.in/wss/static_content/Sanitation%20Solid%20Waste%20Management.jsp

The above map shows the location of the existing STP in the city. Only 32% of the city has access to sewage drains, while the rest is released into open natural sources.

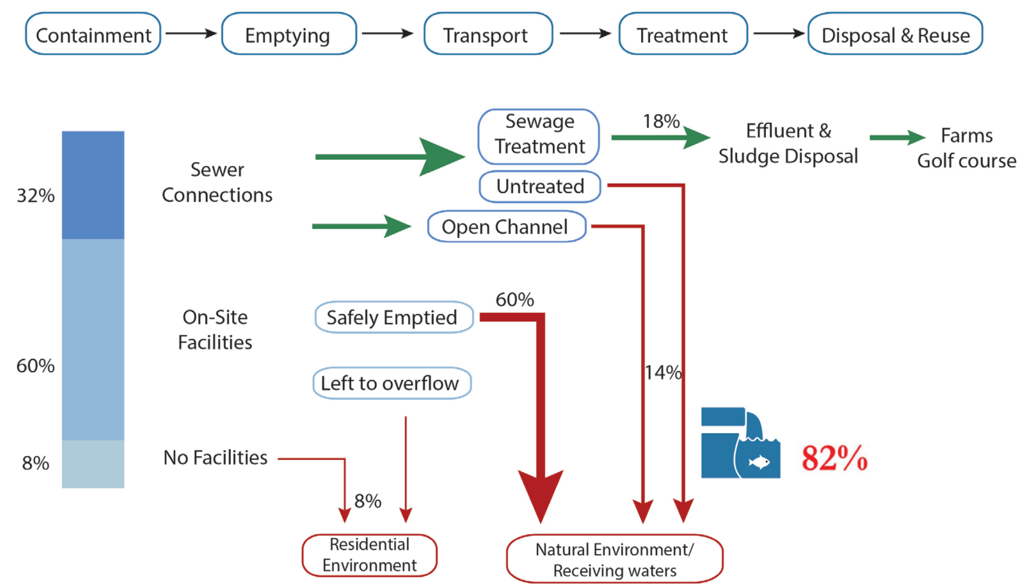


Fig 2.15: Linear process of sewage disposal in Visakhapatnam

Fig 2.16: The current condition of STP and sewage drains

Source:

Source: GVMC, INDIA CENSUS 2011

Images: (Clockwise)

Source: https://www.deccanchronicle.com/nation/current-affairs/270717/visakhapatnam-capacity-of-sewage-treatment-plants-to-be-increased.html

https://www.deccanchronicle.com/nation/current-affairs/200916/visakhapatnam-stps-can-treat-only-52-per-cent-of-citys-sewage.html

Fig 2.17: Environmental degragation in the country due to improper waste management

Clean India Mission - city scale

At the city scale, Clean India Mission functions as a part of the urban local body (GVMC) under the health and sanitation department. The current agendas at the urban local body scale are (i) segregation of wet waste and dry waste; (ii) establish vermicompost centers for the collected wet waste; (iii) proposal of waste to energy plant; (iv) authorising/merging the local actors, contractors involved in the waste management chain under the ULB; (v) importing waste for recycling. There are few gaps and lapse in the implementation of the agendas.

(i) Segregation of wet waste and dry waste: The segregation of waste at the household scale is promoted and campaigns are run through different media. However, there is less/ no participation of the citizens (consumers) in segregating the waste and only a few wards in the city have the facilities to collect segregated waste. While transferring to the tempory transfer station, the collected segregated waste is loaded into a single container. Thus, the activity of segregation is futile.

(ii) Vermi Compost centers: As a trial basis, two vermicompost centers are established in the city, where they are composting the collected segregated wet waste. In this initiative, the organic waste is recycled into manure and sold to local markets or import through other chemical fertilizer industries. However, this initiative is not well received by the residents of the neighborhoods surrounding these centers. The odor of compost is persistent and causing inconvenience to the residents. Thus, they are protesting against having a vermicompost center in the middle of neighborhoods.

(iii) Waste to Energy plant: Waste to Energy is a widely popular and used method of waste disposal. It is a common practice among western countries. However, in this process, all the waste that can be used judiciously is incinerated and energy is generated being an end of pipe solution. Secondly, the amount of waste required per day to generate electricity is 1200 tonnes/day and the amount of waste that is generated in the city is 920 tonnes per day. There is a gap in the amount of waste required and in order to maintain the calorific value, it is vital to have organic waste in the incineration. This is one of the major lapses in the agendas of the CIM.

(iv) The merger of local actors: The integration of local actors involved in the process of waste collection, transportation, informal sectors of waste collection under the purview of ULB will increase the load on the already sectoralised systems in place.

(v) Import of waste for recycle: Transboundary waste trade is a prevailing system in the developing countries. The driver for this is the economic benefits. Whenever recycling of waste has been used as an economic opportunity without taking into consideration socioeconomic impacts, there have been negative impacts on the environment, health and the living quality of the people ((Gayathri Iyer, 2018). Hence, it is important to take the socio-ecological systems into account in this aspect.

Environmental Impacts due to excess resource extraction and waste management:

Due to excessive pressure on resource extraction, there is a negative impact on the environment. The usage of fertilisers and deforestation is causing loss of nutrient levels of soils and soil erosion, as well as lower quality of underground water quality. The loss of minerals and mining also causing disruptions in the environment. In the linear process of resource consumption and disposal, the value of the resource is underutilized and lost. This excess waste also has negative impacts on the environment. Fig 2.14, outlines a few types of environmental impacts that are caused due to excess resource extraction and improper waste disposal.

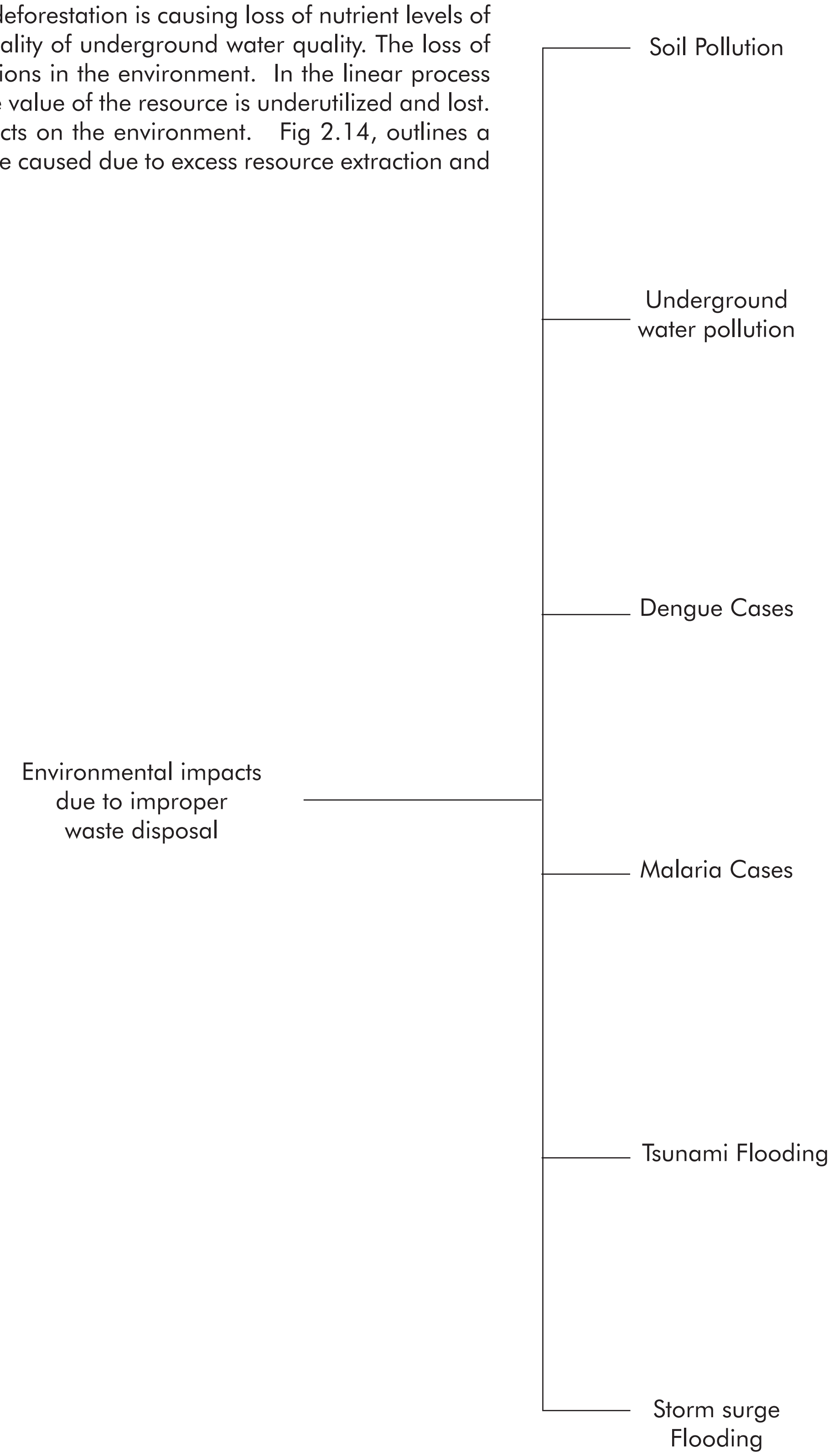
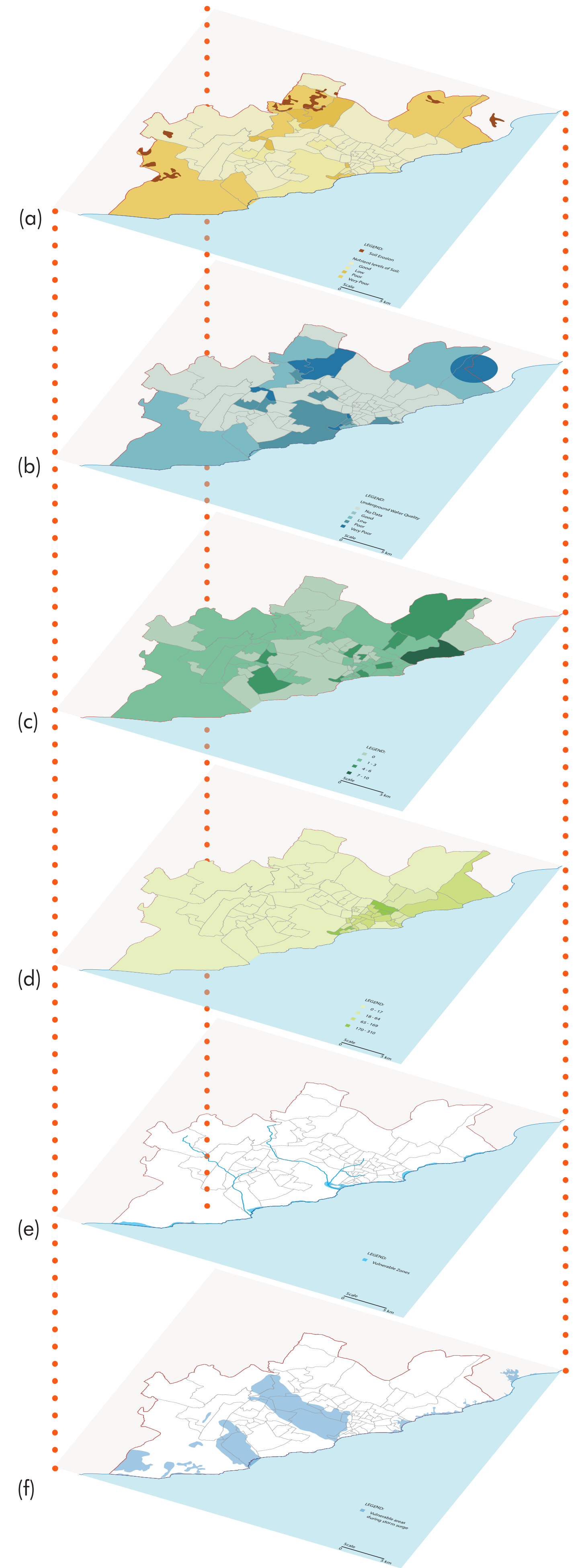


Fig 2.18 : Diagram showing environmental impacts due to resource extraction and improper waste management



The type of soil in Visakhapatnam is red soil. Crop of rice, corn and cashews are predominantly grown in this region. Map (a) indicates the zones of soil erosion due to the factors of deforestation, water and wind erosion. Due to heavy industrialisation and increase in the density of urban structures, excessive usage of fertilizers, the phosphorus levels in the soil are low, resulting in poor nutrient levels.

Map (b) shows the underground water quality in the city. The zones which have poor or very poor status are the zones surrounding industrial areas and areas of waste disposal. The circle represents the radius of 2500m from the landfill site which has been contaminated due to leachate formation.

Vector borne disease in tropical countries occur due to demographic, climate changes, poor and unhygienic environmental conditions. Map (c) shows the number of Malaria cases registered in the year 2011. In 2017, this number has increased to 1680 (New India Express, 2017)

The number of cases of people affected by dengue has been rising every year. Map (d) shows the number of dengue patients in the year 2011. According to 2017 statistics, the number raised to 710 (The Hans India, 2018).

Map (e) illustrates the zones of flooding that are vulnerable during storm surge.

Map (f) illustrates the zones of flooding that are vulnerable during storm surge.

Source: Multi-Hazard Risk and Vulnerability Analysis for the City of Visakhapatnam, Andhra Pradesh

Adapted : Author

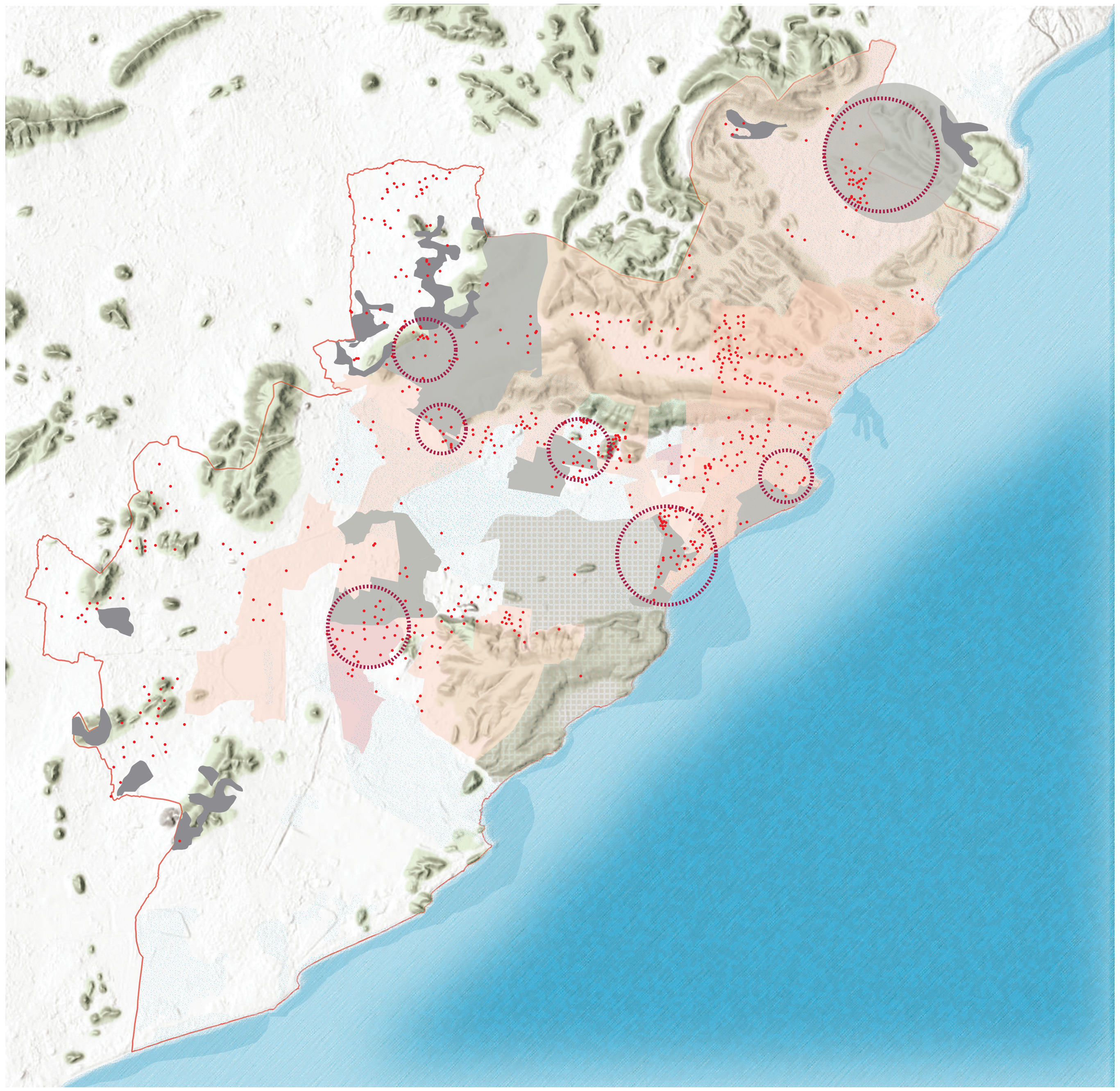


Fig 2.19: Overlapping all the layers of above listed problems

The map overlay of the regions affected by pollution and the vulnerable and risk zones of environmental hazards help in identifying the most problematic zones in the city. The highlighted regions in the map are the most problematic zones. These are the regions that are facing environmental disruptions. Most of the regions affected are the regions surrounded by regular deforestation, mountain mining, agricultural lands, industrial areas and port activities. Since the city is growing due to economic opportunities, there is a number of people migrating from the surrounding rural areas and settling down as informal settlements. These are more vulnerable due to environmental impacts because of the lack of proper infrastructure and awareness.

Legend:

- Municipal Boundary
- Informal Settlements
- Environmental damages
- Risks & Vulnerability

0 5km

Problem Statement

The growing affluence and linear model of resource consumption, production and disposal are causing environmental damage in the city of Visakhapatanam. However, the city's approach towards increasing volumes of waste is limited to optimizing the existing waste disposal systems and develop end of pipe solutions, though there is a potential in utilizing the waste streams as secondary resources and promote thoughtful consumption. This is due to the lack of awareness about the benefits of resource reuse for both the citizens and administrative sectors.

Hence, there is an urgent need to evolve this linear metabolic process into a circular process. Implementing the new system to an already existing system is the main challenge. It has to be implemented at multiple scales, with both top-down and bottom-up strategies.

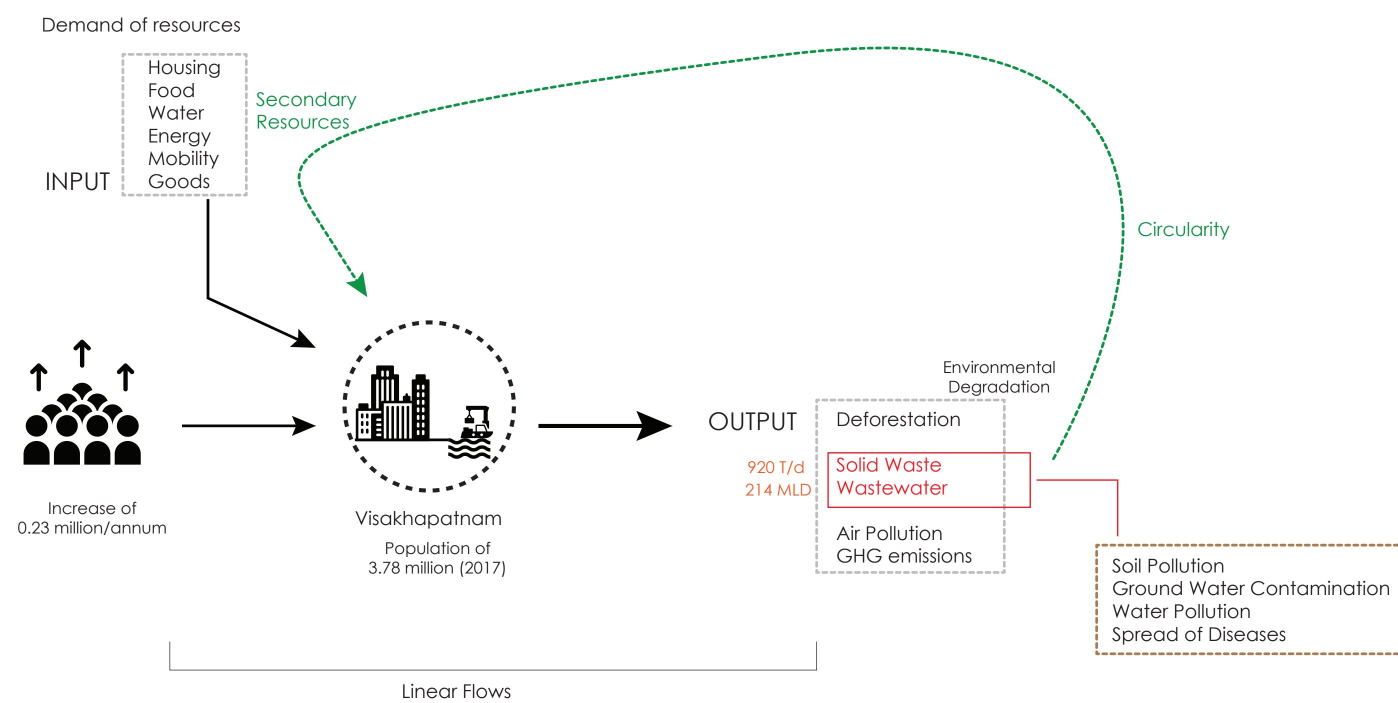


Fig 2.20: Problem Statement

Source: Author

THEORETICAL UNDERPINNING 3

This chapter gives a brief overview on the existing literature on principles of circular economy, urban planning as a method to implement it and the evolutionary resilience of the changing

Introduction

Based on the problem analysis explained in the previous chapter, it is understood that the linear metabolism of the resources is causing environmental degradation. Circular Economy (CE) has become a popular concept in the discussions to overcome the current linear process based on continuous growth and increasing resource demand. Economic growth and natural resource depletion are interrelated developments because the dominant process underlying growth is a linear one, which transforms resources into waste (van der Leer, J et al., 2018). The negative impacts of increasing waste cause environmental degradation and vulnerability. It is important for developing countries like India to adapt to sustainable measures as it is difficult to cope with the increasing challenges due to economic and social constraints.

The subject of Circular Economy (CE) is gaining interest all over the world as a way to curb the current linear system of wasteful production and consumption patterns in society and move towards sustainable development. CE has mostly been associated with waste management, many countries have adapted it as a tool to develop environmental and waste management policies. But the concept of CE is not limited to implementing waste management solutions, but it looks at the larger perspective of the resources extracted from the natural environment, throughput in the production of goods and the reuse potential of the resource. CE can be stated as a field favoring the resource management rather than only waste management which is only one subsector of the entire loop (Merli R. et al., 2018).

The transition towards CE is not a single step approach or just technological advances catalysing the change in the cycle, rather it is a complex process. It is challenging to shift from linear resource-oriented industries and mindset of the society (Leider and Rashid., 2016), it also requires changes in different subsystems on various scales (Van Buren et al, 2016). It is even more challenging to implement CE in Indian cities as it requires a long-term systemic behavior change for all the stakeholders across different scales and complexities. In order to implement CE in developing cities, it needs to be incorporated in urban planning which is an integrative discipline: it needs to integrate physical, socio-cultural infrastructure, the economy and the environment into its fabric and the planning and development process (Karvounis 2015; Rotmans, van Asselta, and Vellinga 2000; Van Der Leer J. et al., 2018).

There is extensive research being done in the field of CE, but its implementation is still in the early stage. This paper discusses the theories and principles of CE and reviews the current practices in the world with an urban planning framework to examine their integration in the built environment, both vertically and horizontally. The aim of this paper is to understand how the concept of CE can be integrated into urban planning practice with an idea to enable the urban planners to include CE into their work so that it can be implemented successfully. The following excerpts are the main important points discussed in the paper. (Refer to abstract for the entire paper)

> *"A CE accommodates resources flowing through man-made and natural systems in renewable ways, creating or retaining value through slowed, closed or narrowed loops, rather than rapidly destructing value through the creation of waste. This value can manifest itself in monetary principles as well as other social, ecological or economic principles, taking account of potential trade-offs." - Geldermans et al, 2017*

CE has been adopted as a guiding principle in many countries' policies, which have approached its implementation in different ways (George et al., 2015; R. Merli et al., 2018). Several CE definitions exist, evidence that this concept has undefined boundaries while changing the actors and point of view. Over the last years, CE has received great attention from scholars, both for its theoretical conceptualization and for its practical implementation strategies (Geissdoerfer et al., 2016). These studies are being done extensively across multiple fields. Kircherr, Reike, and Hekkert (2017) identified more than 114 definitions in 17 dimensions in their literature study.

Principles Of Circular Economy

Kircherr, Reike, and Hekkert (2017) distinguish between two types of core principles of CE. First one pertaining to "R" frameworks and the second being the systems perspective. Various formats of "R" frameworks have been used by academia as well as practitioners. The 3R framework [Reduce, Reuse and Recycle] is the most prominent framework. This framework is not a linear concept though arranged in that format, rather it is an order of preference where the first step is to reduce or prevention. While reuse and recycle play an important role in the decision making of resource management. It requires efficient and effective recycling methods in order to reuse as secondary material. In certain instances, the cost effect plays an important role in the decision making of recycling the product. The 9R framework by Potting et al (2017) (Fig 2) gives a holistic approach towards CE and prioritizes Refuse and Rethink over reduce. This hints towards a change on the global scale resource consumption, reducing the usage of natural resource dependencies and develop solutions which have revived value. In continuation with Reuse, it proposes multi reuse of the product in different loops with the steps of Repair, Refurbish, Remanufacture and Repurpose. And the final steps in his framework suggest recycle and recover.

Smarter product use and manufacture	R0 Refuse	Make product redundant by abandoning its function or by offering the same function with a radically different product
	R1 Rethink	Make product use more intensive
	R2 Reduce	Increase efficiency in product mahufacture or use by consuming fewer natural resources and materials
Extend lifespan of product and its parts	R3 Reuse	Reuse by another consumer of discarded product which is still in good condition and fulfils its function
	R4 Repair	Repair and maintenance of defective product so it can be used with its original function
	R5 Refurbish	Restore an old product and bring it up to date
	R6 Remanufacture	Use parts of discarded product in a new product with the same function
	R7 Repurpose	Use discarded productcts or its parts in a new product with a different function
Useful application of materials	R8 Recycle	Process materials to obtain the same (high grade) or low grade quality
	R9 Recover	Incineration of material with energy recovery

Systems Perspective

A systems perspective is the second core principle of CE. Zhijun and Nailing (2007). Jackson et al., (2014) discuss that the transition to CE should happen at three levels which can be interpreted as the three levels of the CE system: the micro level, meso level, and macro level.

Macro-systems perspective highlights the need to adjust industrial composition and structure of the entire economy,

Meso-systems perspective usually focuses on eco-industrial parks as systems (Heeres et al. (2004), Shi et al. (2010)).

Micro-systems perspective usually considers products, individual enterprises, and requirements to increase their circularity as well as consumer behavior (Jackson et al., 2014; Sakr et al., 2011).

Fang et al. (2007) and Lieder et al. (2017), mention that CE requires fundamental changes simultaneously at the micro, meso and macro system.

IMPLEMENTATION OF CIRCULAR ECONOMY BY INTEGRATING IT INTO URBAN PLANNING

The implementation of CE theory is challenging because of the current linear mindset and the structures in industry and society (Lieder and Rashid 2016) and because it requires changes in different subsystems on various scales (Van Buren et al. 2016; J Van Der Leer et al., 2018). It is important to find ways to incorporate a CE based approach in urban planning practice (Owen and Liddell 2016) in order to accommodate resources to flow through man-made and natural systems in renewable ways while creating or retaining value. (J Van Der Leer et al., 2018). According to He et al. (2011) urban planning can be defined as an interdisciplinary and comprehensive approach for balanced regional development and physical organization of space. In order to identify how to integrate a CE approach into urban planning, it is necessary to first understand the integrative dimensions of urban planning. Urban planning aims to change or manage spatial development by constructing new ideas, visions, actions, means for implementation, processes and other ways of understanding (Albrechts 2006a, 2006b).

It is an integrative discipline in which often two (organizational) dimensions are discerned: horizontal integration and vertical integration (Holden 2012; Stead and Meijers 2009). Horizontal integration has the aim to deepen specific knowledge (Albrechts 2006a) and emphasizes 'collaboration, coordination and the building of working relationships' (Albrechts 2006b, 1158) across policy domains, local agencies and departments (Hajer and Zonneveld 2000; Stead and Meijers 2009). Vertical integration is related to linkages between different scale levels (Albrechts 2006b), levels of government i.e.; national, provincial and municipal (Hajer and Zonneveld 2000) and different tiers of government (Stead and Meijers 2009) (J. Van Der Leer et al., 2018). Figure 3 illustrates the horizontal and vertical integration in urban planning.

Zhijun and Nailing (2017) describe that implementation of CE should first start at the level of enterprises, then in industrial parks, then in cities and regions, moving from micro to the macro level. Each of these levels serves as the basis for the next level above, and as a platform for the level immediately below. At the micro level (enterprise or an individual firm), the focus is on cleaner production, the economy of raw materials, reduce in toxicity and design/produce environmentally friendly products. At the meso level (industrial park/ network), material flow and energy flow level should be redesigned in principles of CE.

At the macro level (city or regional level) pollution prevention becomes paramount; this is characterized by material and energy circulation and has, as its ultimate objective, sustainable social, economic, and environmental development, including maximum energy and resource use and reduction of waste discharge.

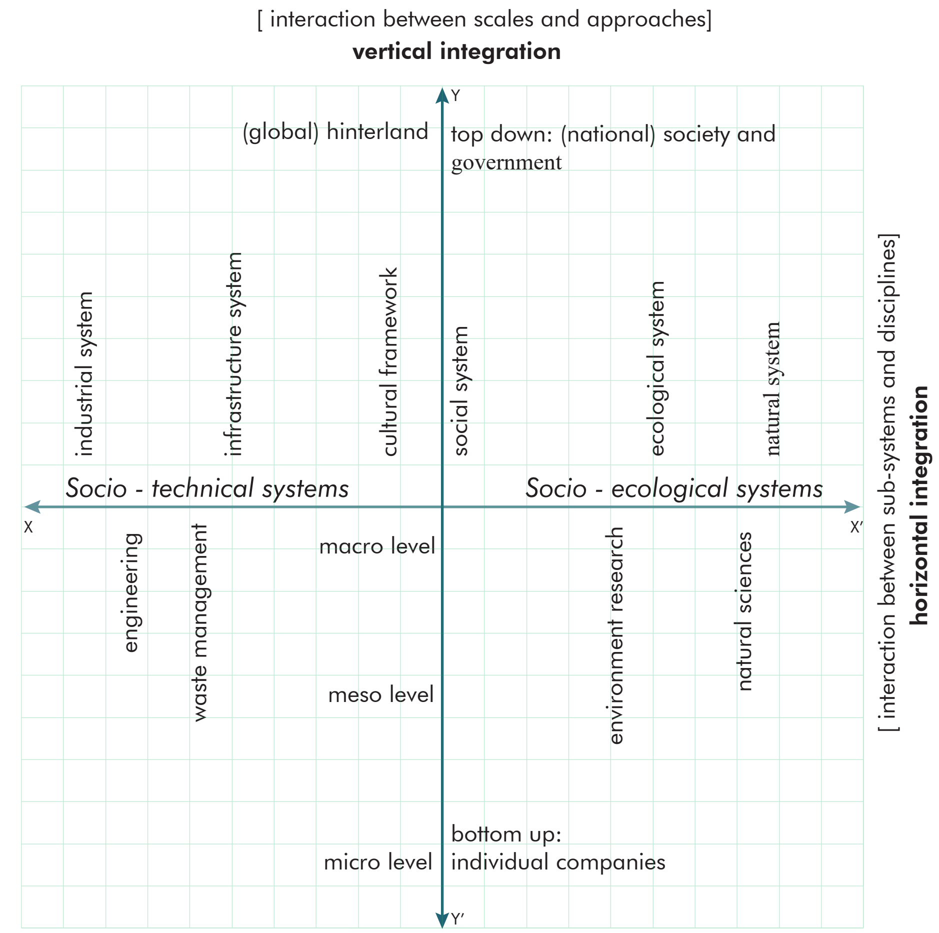


Fig 3.0 For the practical implementation of CE, Zhijun and Nailing (2017), emphasize that there should be integration of scales vertically and integration of subsystems horizontally.
Source: Van Der Leer J. et al., 2018

On the horizontal dimension, Zhijun and Nailing (2017) describe the industrial system, infrastructure, cultural setting and social consumption as interdependent large complex systems. The first step towards building a CE based industrial system is industrial and material symbiosis. The second step is the development of the required infrastructure. A CE oriented urban infrastructure is based on the circulation of materials, efficient use of energy and information sharing within the system, integration of clean production, eco-industry and eco-agriculture, and formulation of a holistic strategy. The third step is to build an eco-friendly human habitation environment that helps to restore the ecosystem in cities and boost the quality of life. In order to sustain the health of ecosystems resource use, production and waste disposal should be conducted below the ecological threshold. The final step elaborates on balanced consumption patterns. Consumer preferences, behavior, and patterns should be oriented toward environmental protection, ecological balance, and sustainable social development, with governments adopting policy measures to ensure the formation of a circular consumption mechanism.

J. Van Der Leer et al (2018), narrate that research into such large complex systems is often divided into socio-ecological systems and socio-technical systems. At the core of a socio-technical approach lie the interactions between technologies, material artifacts and human activities and actors (Mylan, Holmes, and Paddock 2016, J. Van 2018). Socio-ecological systems aim to integrate ecological and social sciences with a view to studying coupled human and natural systems (Liu et al. 2007). Feedback and interaction between ecosystems and humans are key in socio-ecological systems. A better understanding of the processes of human-environment interactions that affect the resource flows of cities is essential for sustainable resource management (Pahl-Wostl 2007; VanTimmeren 2006; Voskamp et al. 2016).

By combining and integrating a socio-technical and a socio-ecological approach, a "SETS" (social-ecological-technical-systems) approach can be utilized; in which social, ecological and technological aspects of environmental phenomena are considered leading to a better understanding, support and management of urban ecosystems (Groffman et al. 2016; Ramaswami et al. 2012). The main challenge is the further development of this multidisciplinary approach, the integration of theories and methods of engineering and design disciplines with natural and social sciences (Groffman et al. 2016) and its implementation in urban planning practice. (J Van der Leer et al. 2018)

To implement CE in India, a holistic approach is needed. The existing 3R framework needs to be revised into a comprehensive 9R framework. Detailed flow analysis has to be made to understand and implement the framework. This has to be realized at all three levels: micro, meso, and macro. Since India is a vast country with diverse socioeconomic, cultural and ecological system, it is difficult to determine the same principles and policies in a top-down approach. It needs to be a collaboration between the top-down approach and the bottom-up approach by bringing in diverse actors. Hence there is a need for a platform to exchange the ideas and practices being developed in the field and there should be involvement of actors at multiple scales and all phases of the resource flow. Policies have to be developed as a top-down approach by the government by a collaboration of different sectors such as industries, environmental agencies, financial institutions, and more academic research should be encouraged. A symbiotic relationship among all the actors is important to achieve the goals of the circular economy. Circular Economy rests on cooperation and collaboration. Collaboration and sharing can result in the dissemination and wider adoption of CE goals. Circular transitions rest on several factors which call for strong and active collaboration among stakeholders. And such changes can be realized only through "technical, social, ecological and organizational innovations throughout the value chain while bridging production and consumption activities".

From the discussed case studies of China and Netherlands, the emphasis is made on integrating the socio-ecological systems along with the socio-technical systems. By combining the socio-ecological and technical systems (SETS approach), social, ecological and technological aspects of environmental phenomena are considered leading to a better understanding, support and management of urban ecosystems (Groffman et al. 2016; Ramaswami et al. 2012). Ramaswami et al. (2012) point out that 'complex, cross-scale interactions between the natural system, the transboundary engineered infrastructures, and the multiple social actors and institutions that govern these infrastructures' are necessary for the sustainability of city systems. While CE planning might not solve climate change and resource scarcity, it offers opportunities for planning and design of new and existing areas based on the principle of decentralized, interconnected, polycentric circular urban systems (J. Van Der Leer et al). Along with the research towards transforming into CE, research on integrating the SETS into the current system of urban planning in the country should be made.

The sub chapter of theoretical framework breifly explains the theories applied in building the conceptual framework.

Environmental Sustainability

The term sustainability implies indefinite continuance. Achieving sustainability is the preset goal for both developed and developing countries. The triple bottom line model notes that there are three pillars of sustainability - environmental, economic and social. These three pillars of sustainability are interconnected, interdependent and influence each other.

Environmental sustainability: Our Common Future (WCED, 1987) defines (environmental) sustainability as "meeting the needs of the present without compromising the ability of future generations to meet their own needs."

Social sustainability: McKenzie (2004) defines social sustainability as occurring when "the formal and informal processes, systems, structures and relationships actively support the capacity of current and future generations to create healthy and liveable communities. Socially sustainable communities are equitable, diverse, connected and democratic and provide a good quality of life."

Meanwhile, the US President's Council on Sustainable Development captured, what is possibly, the best definition of Economic sustainability in its cognisance of humans and the environment: "Economic growth can and should occur without damaging the social fabric of a community or harming the environment" (Doane and MacGillivray, 2001: 3.1.1).

From the above definitions, it can be deducted that economic growth can instigate social sustainability by creating more employment opportunities, improve the standard of living in society and provide equal quality of life. Although environmental sustainability is needed by humans and originated because of social concerns, ES itself seeks to improve human welfare and SS by protecting the sources of raw materials used for human needs and ensuring that the sinks for human wastes are not exceeded, in order to prevent harm to humans. Humanity must learn to live within the limitations of the biological and physical environment, both as a provider of inputs (sources) and as a sink for wastes (Serageldin, 1993). This translates into holding the waste emissions within the assimilative capacity of the environment without impairing it. It also means keeping harvest rates of renewables within regeneration rates. (Serafy, 1991). In the economic forums, environmental assets are considered as the "Natural Capital", both limited and fragile. Any negative impacts on the environment will have a negative effect on the economy or affect the health and well being of society.

However, O'Conner (2006) alerts that the "triple bottom line" approach is insufficient.

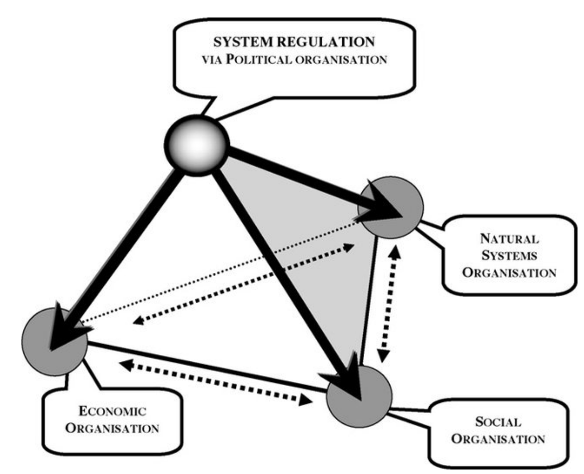


Fig 3.1: Four Spheres of Sustainability

He augments the triple bottom line with the "demarcation of a fourth fundamental category of the organisation". This fourth element of sustainability, the political sphere, is responsible for the regulation of the economic and social spheres and thus of relations with (and within) the environmental sphere. (S. Chitapi 2013). This concept of sustainability fits appropriately to this thesis of relating resource management and planning. This political sphere acts as the planning body aiming for environmental sustainability. As shown in figure 3.1, "it is meaningless to treat any sphere or interface in isolation from the others". Though this thesis has environmental sustainability as its priority but understands that it is pointless without social and economic sustainability which implies the need for organizational sustainability.

Literature: O'Connor, Martin. (2006). The "Four Spheres" framework for sustainability. Ecological Complexity

Urban Metabolism

Urban metabolism refers to "complexity of socio-technical and socio-ecological processes by which flows of materials, energy, people and information shape the city, service the needs of its populace and impact the surrounding hinterland" (Currie & Musango, 2016). It is a useful concept for understanding the relationship of resource flows with urban society and its environmental hinterland. UM is widely used to get a better understanding of the resource use and the waste generated. By examining the city as a system, the flows of energy, resources and even pollution can be traced. This information can help to manage these flows, reintegrate the flows with natural processes, increasing recycling rates, achieving higher efficiency in resources usage and production of renewable energy (Newman, 1999). Urban Metabolism was earlier limited to industrial ecology but now it has broadened its scope over time. Kennedy et al. (2007) describe urban metabolism as "the sum of all the technical and socioeconomic processes that occur in cities. These processes result in growth, the use of more natural resources, the need for producing renewable energy and eliminating waste". In this definition, the relation is being made with other systems within the urban system, like the social system and the economic system. So all systems interact with each other and do not operate separately. With the help of Material Flow Analyses (MFA) of a city, the level of performance of the city in sense of resource use can be analyzed (Ayres & Ayres, 2002). However, this theory is limited to the analyses and can show the potentials of the resource flows but it does not provide solutions.

Literature: Kennedy, C., Cuddihy, J. and Engel-Yan, J. (2007), The Changing Metabolism of Cities.

Kennedy, C., Pincetl, S., Bunje, P. (2010) The study of urban metabolism and its application to urban design and planning.

Zhang, Y., Yang, Z., & Yu, X. (2015). Urban Metabolism: A Review of Current Knowledge and Directions for Future Study

Evolutionary Resilience

Davoudi's (2012) evolutionary resilience is defined as "resilience is beyond a return to normalcy" (Pendall, Foster, & Cowell, 2010), It is interpreted 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 a panarchy diagram as shown in Fig 3.2. Gunderson and Holling (2002) use panarchy as a term to describe a concept that explains the evolving nature of complex adaptive systems. Panarchy accounts for the duality of stability and change in which complex systems of people and nature are dynamically organized and structured across scales of space and time (Allen et al. 2014). Through evolutionary resilience, the emphasis is laid on the need to not only address the issue but also improve existing socio-ecological conditions through strategies across spatial and temporal scales. The approach further emphasizes the relevance of local values and capacities and changes in societal conditions that impact the interactions between human and natural systems. Hence the focus is laid on the importance of local adaptation strategies that influence human-nature interactions through social changes.

Literature: Davoudi, S., Brooks, E., & Mehmood, A. (2013). Evolutionary resilience and strategies for climate adaptation. Planning Practice & Research

Gunderson, L. H., and C. S. Holling. 2002. Panarchy: Understanding Transfor- mations in Human andNatural Systems. Washington

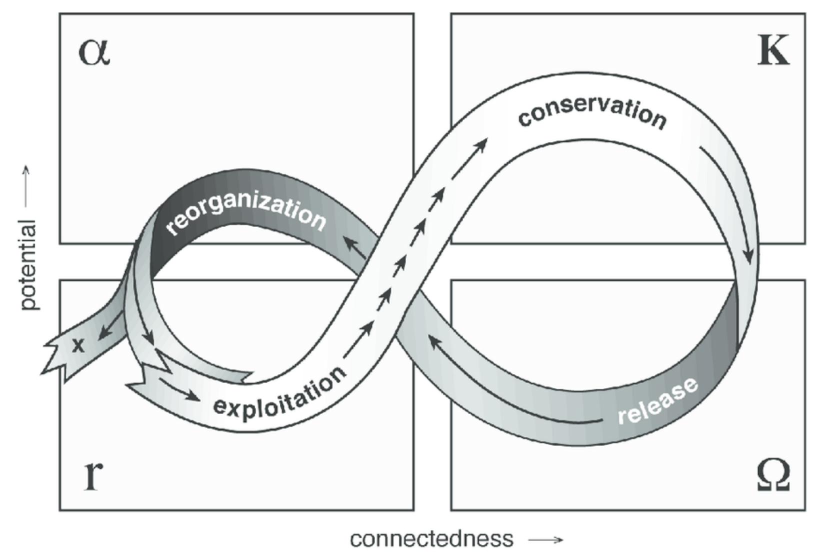


Fig 3.2 The adaptive cycle developed by Holling


Source: Author

METHODOLOGY 4

This chapter discusses the methodological approach of this graduation project. It has helped in structuring the research and to show how all the major parts of the research such as theoretical framework, methods, and measures work together to address the main research question. The research question is formulated from the problem analysis supported by the existing theories.

Research Question

using resources efficiently and reusing the waste streams as secondary resources by circular principles

integrative approach of governance, socio-ecological systems and socio technical sytems

How to integrate resource management into urban planning by developing *local scale spatial strategies* for an environmentally sustainable Visakhapatnam?

"meeting the resource and services needs of current and future generations without compromising the health of the ecosystems that provide them," (Morelli, John (2011))

Research Methods

"Mixed methods research is the type of research in which a researcher or team of researchers combines elements of qualitative and quantitative research approaches (e.g., use of qualitative and quantitative viewpoints, data collection, analysis, inference techniques) for the broad purposes of breadth and depth of understanding and corroboration." - Burke Johnson et al (2007: 123)

This project follows the mixed methods approach. This research has started in an inductive approach. The motivation of this project was from a city-specific context in which the increase in the population of the city and the improper waste management is damaging the environment. The first step to address the issue was to look at a broader scale of the Global South, where this is a common problem that all the countries are facing. This issue can be related to multiple fields such as social inequality, inefficient planning, lack of infrastructure and more. The study in a much broader scale has helped in deducing the relations and causes of the problem. This research follows the methods of descriptive study and predictive research. It addresses the issue in relation to two different fields i.e., Circular Economy and Urban Planning. It brings out the amalgamation of what seems to be two different fields and mixed methods approach make the research more rigorous. Notwithstanding this apt definition, the term integrative research is preferred because it better encapsulates this idea of integration (Burke Johnson and Onwuegbuzie, 2004). In resource management, material flow analysis is a key element where it focuses on quantitative methods, but it is equally important in a socio-cultural perspective which is a qualitative method. Thus, it is inevitable to adapt the mixing of methods and disciplines in this research.

Conceptual Framework

The conceptual framework is built from the literature of the existing theories in order to answer the research question. The aim of this thesis is to achieve Environmental Sustainability. The theory of Environmental Sustainability is based on O'Conner's (2006) four spheres of sustainability. He highlights that the three pillars of sustainability namely social, economic and environment are interdependent and influence each other. But the fourth pillar is the governance or administrative pillar that influences all the three. In this research, the fourth pillar is considered as the urban planning body. To achieve environmental sustainability it is important to understand the existing systems of flows in the city. In order to analyze these flows, the study of Urban Metabolism is adapted. Urban Metabolism gives the opportunity to recognize the potential of the resources. With the principle and concepts of circular economy, the potential flows can be made as secondary resources. Thereby, the pressure on the natural resources and the pollution from the waste streams can be reduced, with lesser damage to the environment. Hence, in order to bring these solutions into practice, it needs an integrative approach such as urban planning (in this case - governing sphere). According to Zhijun and Nailing (2007), integrative methods should be both top-down and bottom-up strategies. The outcomes of this thesis reflect many changes in the current system, for the citizens to adapt. Evolutionary resilience discusses the panarchy of the complex adaptive systems of the cities, with the changing dynamics of people - nature relationships organised across multiple scales. The conceptual framework in Fig 4.1, explains the relationship between the theories with the concepts that are followed across three different scales - micro, meso and macro. This framework is further elaborated in Fig 4.2, listing out the variables - aspects and sub-aspects of the variables focused on this research.

Conceptual Framework

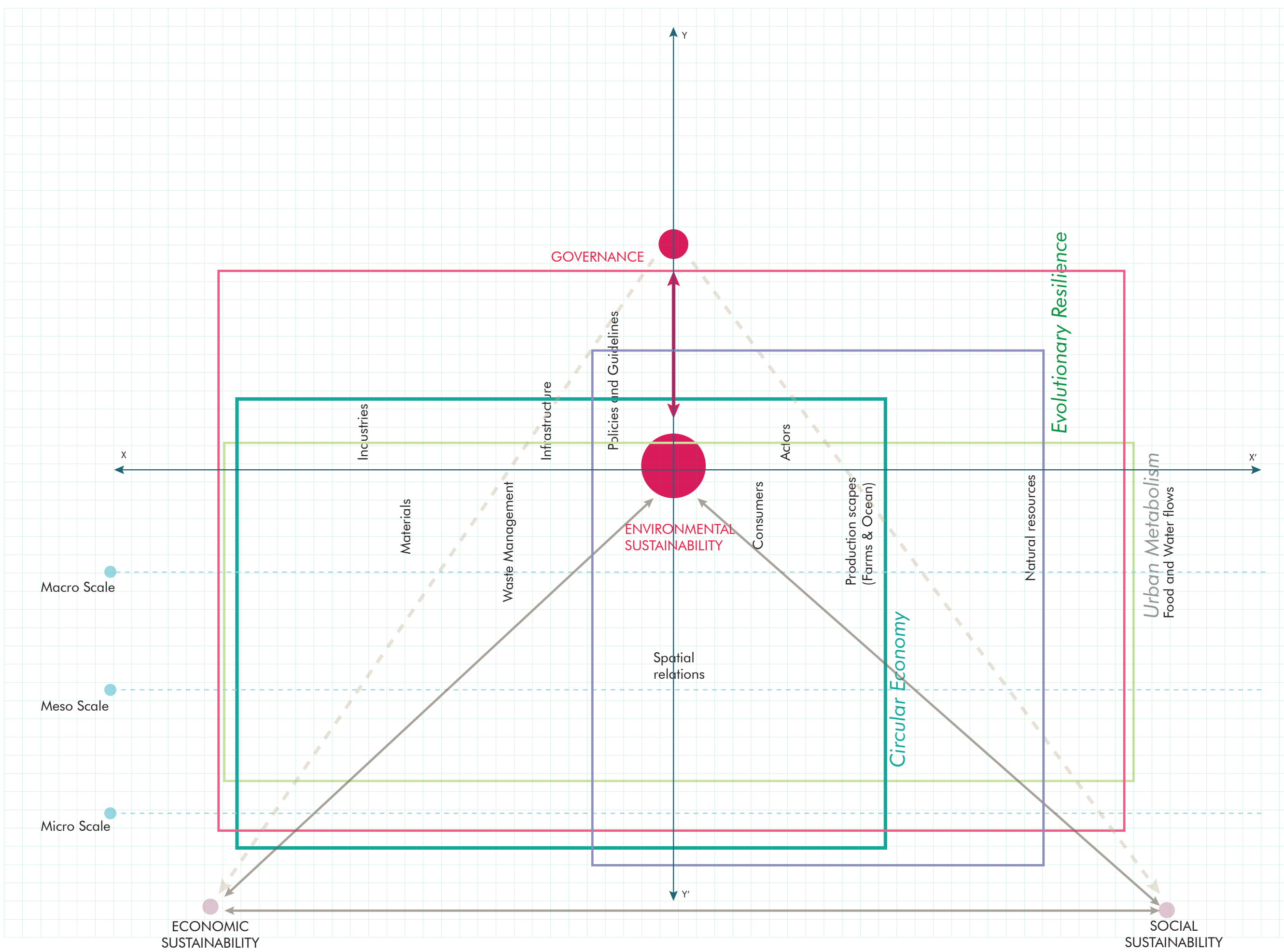


Fig 4.1: Conceptual Framework

Variables	Aspects	Sub - Aspects
Spatial relation	Spatial Requirement Functional requirement	Public/Open Spaces
Socio Ecological Systems	Actors	Governmental Institutions like MOEFC, MHUD, CPCB, MAFW NGOs Citizens
	Bio-physical systems	Source - Sink
Socio Technical Systems	Actors	Governmental Institutions like MOEFC, MHUD, CPCB, MAFW Labour socio-economic conditions
	Industries	Food processing Industries Packaging Industries Wholesale & Retails market
	Transportation	Road, Rail and Port Network
	Civic and utilities	Water and waste system facilities
Resources	Spatial aspects of food and water resources	Source Industries Wholesalers Retailers Consumers Sink
	Land Use	Agriculture Industrial Mixed Use
Environmental Pressure	Soil Pollution	Soil Erosion Salination Fertilizers
	Underground water contamination	Industrial sectors Fertilizers Leachate
	Surface water Pollution	Leachate Clogging
	Risks & Vulnerability	Storm Surge Tsunami Cyclone
Economic & Social Infrastructure	Finance	Banks Government Funds
	Technology	Research and educational Institutes

Fig 4.2: Variables, Aspects and Sub - Aspects of the conceptual framework

Sub Questions

The sub-questions for this research are categorised into three sets - analysis, intervention and impact. The type of research adapted to answer each set of questions is explained below:

Descriptive Research

Descriptive research focuses on investigating and mapping (describing) problems, processes, relationships and other existing phenomena. The first set of sub-questions are structured in a way to analyse the current status of the problem and factors that are influencing them. These questions try to find the interlinks between the flows and the urban form, and how they are influenced by other external factors. These questions help us in zooming into problematic zones which need immediate attention.

Predictive Research

The next set of questions are the intervention set. These questions try to find solutions for the problems prioritized in the first set of questions. This phase follows paths of both predictive research and exploratory research. The questions seek answers from the existing proven scientific methods that can be applied. While answering sub questions 6 and 7, the research method adopted will be an exploratory method. There is limited availability of studies in the case of implementation of CE strategies into practice. This phase seeks for exploration of studies and deducting ideas from them.

Impact

In order to finalise and justify the proposed design solutions, it is important to assess its impacts. The impacts are assessed on the basis of indicators. They are assessed on the literature available.

SQ 1	What is the current approach towards waste flows and what are the main challenges that are causing environmental degredation?	Problem Analysis
SQ 2	How are the major flows of resources in the city (food and water) causing environmental degradation?	
SQ 3	What are the socio-economic and spatial characteristics of the problematic zones and what are the socio technical systems and actors involved?	Zoom-in Analysis
SQ 4	How can these resource flows be made circular and be utilized as secondary resources at a local scale?	Technical Solutions
SQ 5	How can these solutions be developed across the region and involve multiple actors?	Design Strategy
SQ 6	What are the policy recommendations at different scales (bottom up and top down) inorder to initiate/ facilitate towards the proposed local based solutions?	Policy Review
SQ 7	What are the possible solutions to be implemented and what are the spatial requirements?	Spatial design
SQ 8	What are the impacts of the proposed solution?	Impact

Research Framework

The research framework in Fig 4.3, gives an overview of the research approach. It describes how the research question is deducted from motivation and problem field. It shows the interlinks between the applied theoretical framework and analytical framework to each of the sub-questions. It highlights the iterations and interdependencies of the sub-questions in order to achieve the outcome. The research aim and outcome, methods followed to answer the sub-questions and brief of the theories that this study is based on are explained in the next subchapters.

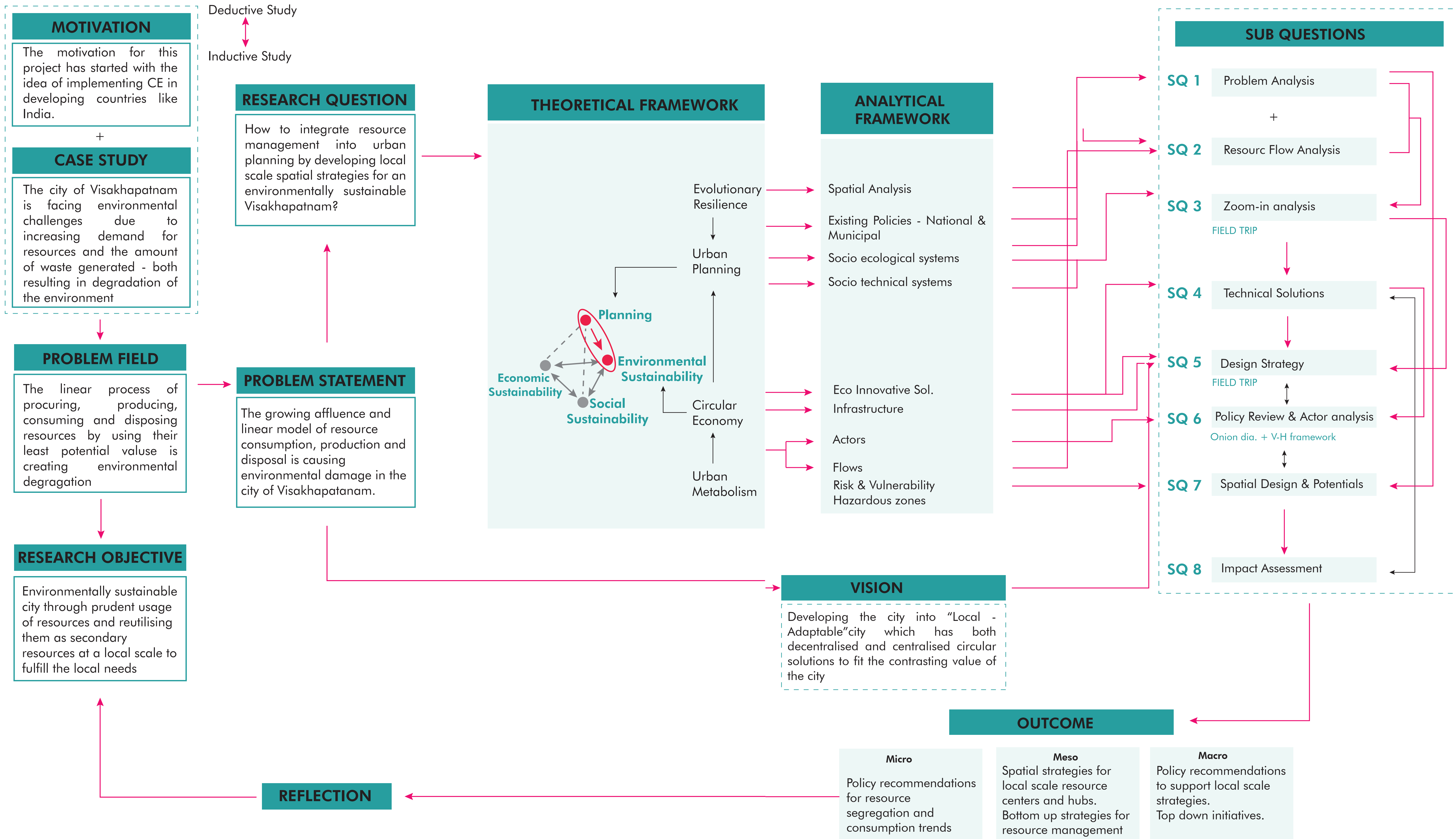


Fig 4.3: Research Framework

Research Aim

This thesis aims to develop environmentally sustainable city through integrated resource management. As shown in Fig 4.4, it intends to develop local scale spatial strategies which aid in enabling the local scale reuse and recycle strategies for secondary resources. It uses urban planning as a tool to implement these new strategies in the existing system. On a National and Global scale, this research aims to contribute to the sustainable development goals (Refer Appendix Pg no).

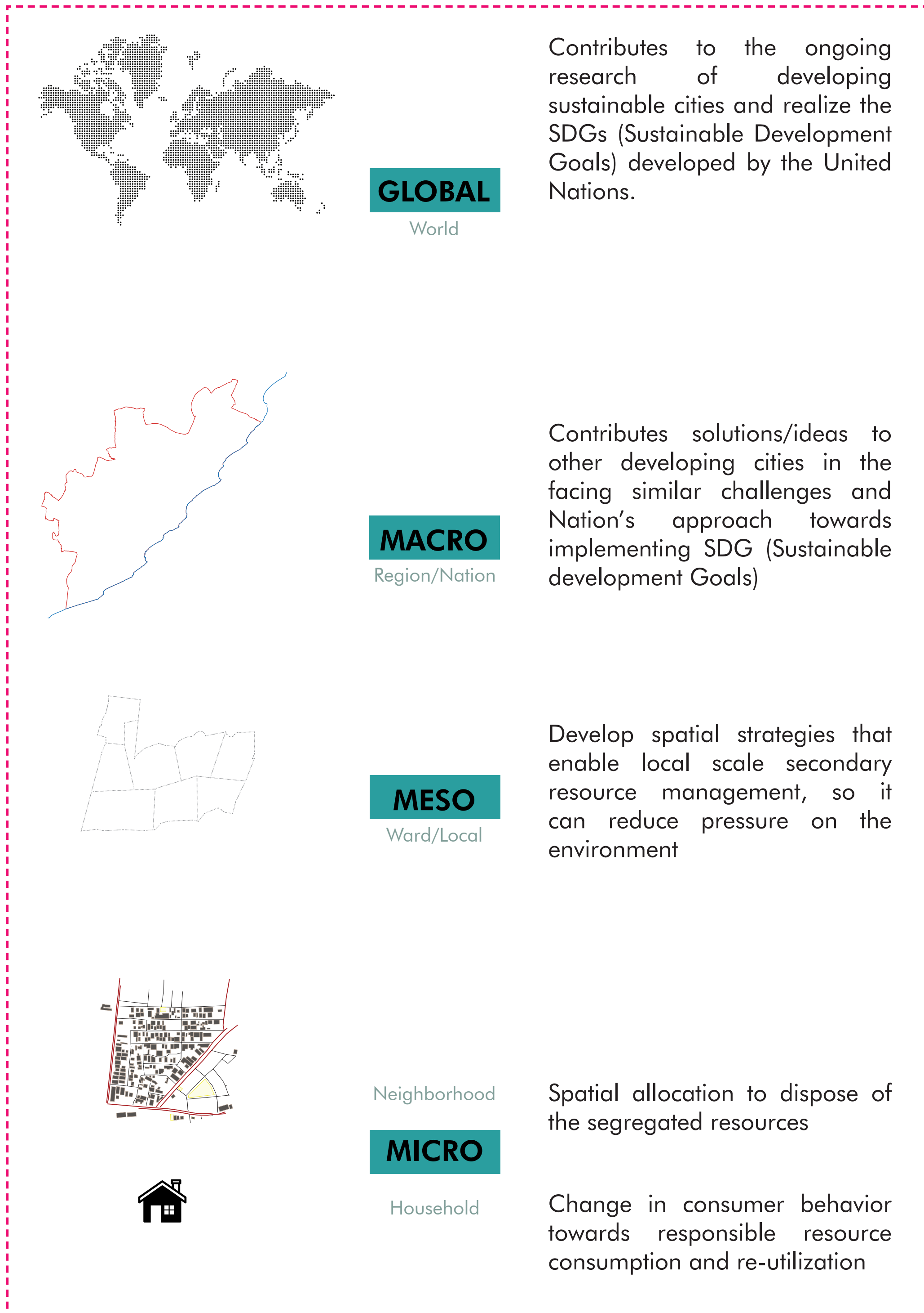


Fig 4.4: Research Aims

NOTE: The list of SDGs this thesis aims to contribute to is listed in the appendix along with the National indictaors and institutional actors involved in it.

Research Outcomes

In order to develop resource management through circular solutions, changes need to take place across multiple scales. According to Zhijun and Nailing (2007), the changes have to be in practice from consumer behavior (microscale) to usage of resources in the production of goods (macro scale). However, due to constraints in the duration of the graduation project, the design solutions are therefore focused on the meso (local) scale. On the mesoscale, local scale pilot projects are proposed which primarily focus on the spatial requirements to enable reuse and recycle of the waste streams to develop them into secondary resources. Followed by developing them into a regional strategy. However, these solutions cannot be implemented in isolation with micro and macro scales. As shown in fig 4.5, changes on each scale influence the other scale. Thus, in this project, the outcomes are designed based on their effects on the mesoscale. Policy recommendations are made on a micro and macro scale that help in realizing the design solutions made on the mesoscales. In order to implement the solutions, it is necessary to identify and integrate the actors involved in it.

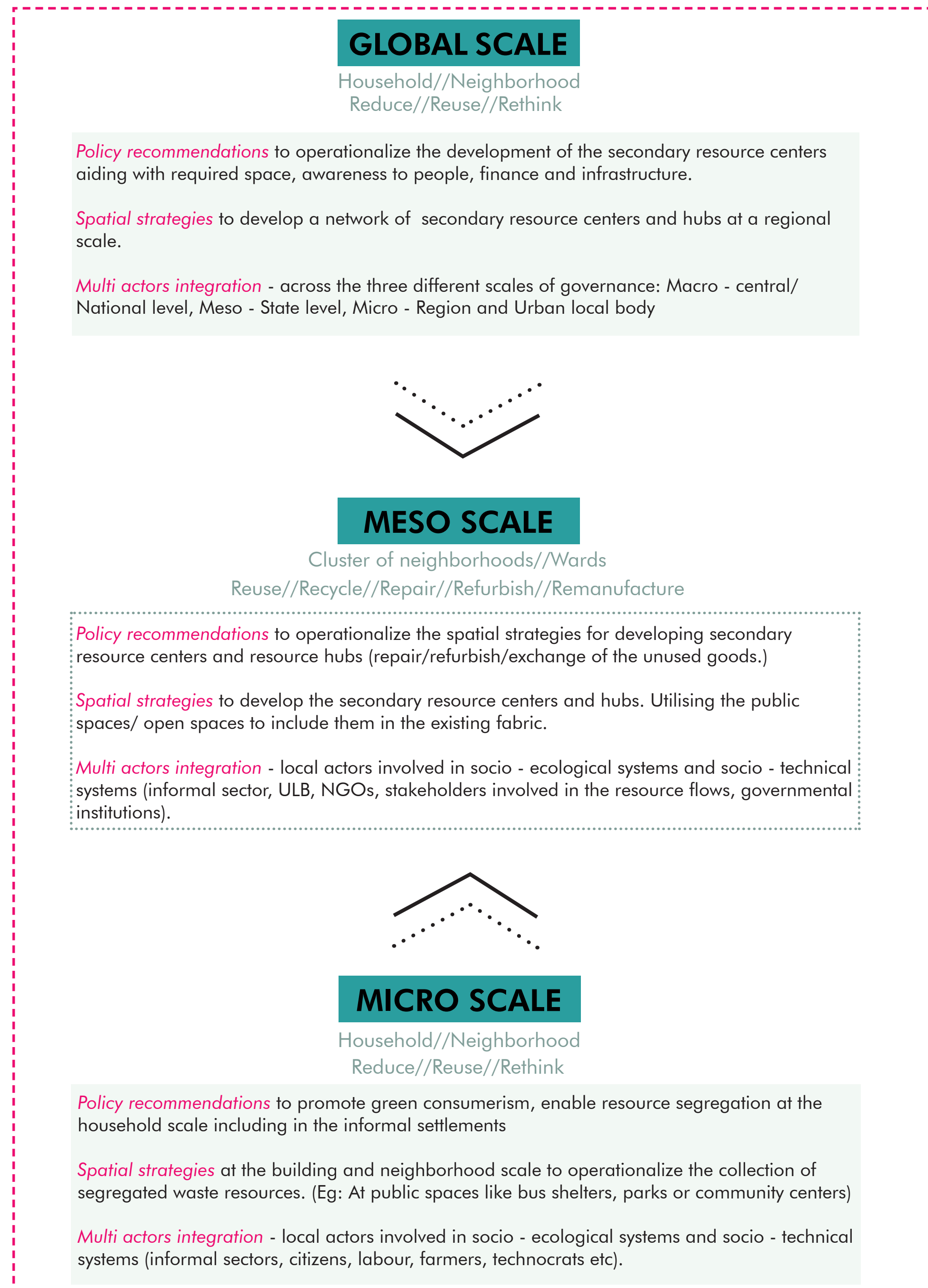


Fig 4.5: Research Outcomes

Methods and Outcomes

This chapter of methods and outcomes explains the methods, analytical framework and expected outcomes for each sub-question in detail (fig 4.6). The sub-questions are divided into two sets and a final step of impact assessment. The first set of questions are the analysis of the current situation. Along with the flows, the analysis also focuses on the major actors involved in the process. Each question is answered by a combination of qualitative and quantitative research methods. The outcomes of this set form a foundation for the further developments of the thesis. The second set of questions are the intervention phase. It focuses on developing new design solutions and spatial requirements. It also discusses the concepts that act as a catalyst for the development of the proposed solutions; such as policy recommendations and multi-actor integration. This framework also shows the interdependency of each question on another. Lastly, the impacts of the proposed solutions are discussed.

	Sub-Question	Method	Analytical Framework	Outcome
Current Analysis	What is the current approach towards waste flows and what are the main challenges that are causing environmental degradation?	- Mapping of waste flows and the linear process - Assessing env. degradation in the city - Analysis of C.I.M	-Waste Flows -Hazardous zones - pollution of soil, surface water, UGW, vector borne diseases -Risk & Vulnerability	-Maps showing the current - waste flow system - environmental degradation - Vulnerable & Risk zones - Highest amount of waste generated - Food and water - Gaps in Clean India Mission
	How are the major flows of resources in the city (food and water) causing environmental degradation?	-M.F.A. of water & Food -Mapping of resource flows - Overlapping with the maps of env. degradation	-Flows across different scales → Source to sink on all scales -Infrastructure	- Systemic Diagram of the M.F.A -Maps showing the current resource flows of food & water from source to sink -Map showing the problematic zones
	What are the socio-economic and spatial characteristics of the problematised zones and what are the existing systems in place and who are the actors involved?	Field trip -Site Visit -Interviews -Image documentation - Sketches	-Demographics - Land Use -Socio-economic conditions -Open/Public Spaces -Formal & Informal sector - actors involved - Gaps in knowledge & implementation	-Zoom - in Analysis of the zones - current issues, conflicts in the system and among actors, conclusion - Synthesis of the problem and determination of focus areas
Intervention	How can these resource flows be made circular and utilized as secondary resources at a local scale?	- Reference studies of existing practices	- Eco Innovative Solutions: (SETS approach)	-Catalogue of successful practices - integration of governance, socio-technical systems and socio-ecological systems
	How can these solutions be scaled up to the regional level and involve multilple actors?	-Mapping of existing systems -IntegratedActorAnalysis (Onion dia.+ VH framework)	- Infrastructure Analysis -IntegratedActorAnalysis	-Vision and goals - Local and Looping city strategy for food and water - Integration of actors - Timeline for the strategy
	What are the policy recommendations at different scales (bottom up and top down) inorder to reallize the developed circlular local solutions?	-Existing Policy Analysis -Reference studies on policies developed	-Existing policies	- Systemic goals diagram showcasing the actors initiating the policies across scales
	What are the possible solutions to be implemented and what are the spatial requirements?	- Zoom in analysis - SETS approach - Identifying the strategy and propose solutions	- Knowledge Transfer	-3 pilot projects and their challenges - proposal of probable solutions
Impact	What are the impacts of the proposed solutions?	-Comparitive Analysis	- Soil Quality - Nature Conservation - Noise	-Evaluation essay

Fig 4.6: Methods & Outcomes

Research Limitations

Redesigning or altering the resource flows in the city is a challenge in itself. It is difficult to address all the resource flows in the city and develop solutions for each of it. Keeping the span of graduation project in mind, this project has focussed on the major resource flows in the city; i.e., water and food. Within the chain of water and food, the scope of research at each section of the chain is huge. Thus, this thesis focuses on developing a holistic framework across different scales.

The availability of data for the quantitative analysis was a challenge due to the unavailability of the data. Hence, the calculations are based on the data available at the country scale and reflected into the specific case in few circumstances. It is difficult to propose solutions specific to each problem zone in the city. Hence, three pilot projects are selected based on the intensity of the environmental damage and solutions are proposed.

Societal Relevance

The thesis aims at improving the environmental sustainability of the city. In regards to the growing urbanisation and its challenges, it is important for the city to adapt to sustainable systems. As discussed in the conceptual framework, the three pillars of sustainability are interdependent and influence each other. Environmental sustainability has an impact on both social and economic sustainability. With improved resource production and consumption patterns, there is the scope of improvement in the economy and social structure. Another aspect with reusing the wastewater or effective treatment of the wastewater results in lesser pollution of the water streams and sea; hence, the marine life is protected. This, in turn, reflects on the economy of fishermen who are dependent on the sea for their income. Involving the current informal sector of waste management in adapting the local resource management strategies improves the economic sustainability of the informal sector. Resource management provides the potential to develop new economic opportunities showcasing the potential for new developments and improved quality of life. Thus, Societal Relevance of this thesis reflects on the improved economy and living quality. The solutions and strategies developed can be further modified and implemented in other developing cities in the country, facing similar challenges. These solutions can also contribute or inspire other developing nations to develop environmentally sustainable cities.

Scientific Relevance

The objective of this thesis is to attain Environmental Sustainability by integrating the circular principles and concepts of resource management into planning. The main challenge to attain environmental sustainability is minimising the usage of natural resources and utilise the waste streams at a local scale to fulfill the local needs. In order to minimise natural resource consumption and adapt to the local scale of resource management, one needs to understand the existing system of flows. This research will contribute to the ongoing discussion of the implementation of resource management and circular economy in the urban regions in developing countries. It focuses on developing a holistic approach by integrating the V-H integration of urban planning. It also contributes to the ongoing research of spatial requirements/changes in the field of urban metabolism and circular economy.

Ethical Considerations

This project aims at utilising resources prudently and reuses the waste as a secondary resource. Generally, waste is described as any substance which is discarded after primary use or is worthless, defective and of no use. Urban population is ignorant about the potential of reuse of the waste they discard. Waste is often associated with a stigma in the civic society, especially in the developing (tropical) countries, where waste is often regarded as a reason for the outbreak of diseases. Hence, it is important to consider the inhibitions associated with waste and create awareness about the benefits of waste reuse. This thesis aims to reuse waste as a form of secondary resource that could satisfy the local needs. This implies changes in resource at three different scales - micro, meso and macro. The changes expand from individual lifestyle habits to city scale usage of resource flows and on the global scale of minimising the usage of natural resources. Change is not an overnight transition. It requires time to adapt to the new system of resource flows. On the other hand, proposing a completely new system gives opportunities for economic developments. There is already an existing system of stakeholders and employees having their livelihood dependent on the current process. There are possibilities of altering them to the proposed system. The probable design interventions might create a new spatial quality which the citizens need to adjust. All the above are sensitive issues which the government, planners or designers must pay heed to while proposing new solutions. It requires time to adapt to the changes and shouldn't come as an obligation to the people. Hence, care is taken while proposing new developments and they should involve people in the process by creating awareness and encourage them.

RESOURCES ANALYSIS 5

Analysing the current linear processes that are causing environmental damage

This chapter analyses the resource flows of food and water as they are the highest amount of waste generated. It identifies the locations that are already facing environmental degradation in the linear process of the flows. The identified locations are further analysed in the field trip and presented in the form of photographs and interviews.

Resource Analysis

The chapter of resource analysis is elaborated in two phases. The first phase focuses on studying the current linear metabolism of food and water flows in the city and its negative impacts. Further, it identifies the regions which are effected by the negative impacts of both the production of the resources and their disposal. An in-depth analysis of the problematic zones is carried out in the second phase in a field visit. The process of this analysis, though represented in a linear format, it is complex and reiterative.

Material Flow Analysis

Brunner et al (2004), has defined MFA as a systemic assessment of flows and stocks of materials within a spatially and temporally defined system connecting sources, pathways, and sinks of materials in order to analyse the transformation, transportation or storage of materials. Fig 5.0, elaborates on all the steps involved from source to sink, the spatial requirements, scale, transportation and storage. With the help of this schematic diagram, it is easy to identify the waste produced at each stage until consumption and post-consumption the waste being collected to the sink.

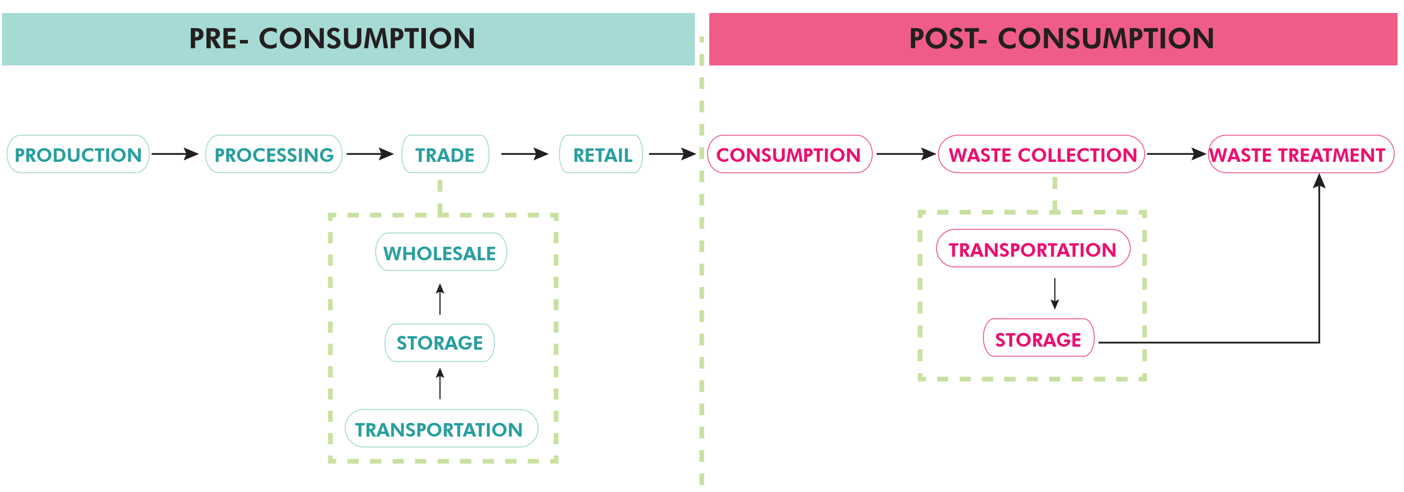


Fig 5.0 Resource Flow Analysis

Food Flow Analysis

Food is a difficult flow to track, given that it is sourced, transported, processed and delivered in a decentralized manner by multiple actors, including local farmers, multinationals, local companies and informal vendors (Currie P et al., 2018). The main occupation in India is agriculture, with two-thirds of the total population dependent on it as a source of income (Umamageswari Kumaresan). Agriculture includes cultivation of crops, livestock, dairy farming, fishing, and forestry. The contribution of agriculture to national income is 27% (Umamageswari Kumaresan). As shown in Fig 1.4, the city of Visakhapatnam is surrounded by regions that are dependant on agriculture as their main source of income. The port of the city also plays a crucial role in the food flows. The fishing harbour produces a major share of seafood that is being exported to the western countries. The state in which the city is located in the major producer of poultry in the country. 81% of the total poultry exports of the country is from the state of Andhra Pradesh (Poultry Sector Report India - RVO.nl). And these exports are carried out through the seaport of Visakhapatnam. The city is a hub for the trade activities of the food that is produced in the surrounding regions. However, the import of other food materials like fruits, vegetables, and processed foods are conducted through other ports and brought to the city through roadways.

Before starting to map the food flows in the city, it is important to understand the food consumption habits. The type of food consumed on a daily basis includes rice, sugar, wheat, pulses, cereals, vegetables and fruits as shown in fig 5.1. Due to class structure and culture, the consumption of meat, poultry, and seafood on a daily basis is less compared to the western countries (Gandhi and Koshy, 2006). However, dependence on dairy products in daily usage is significantly higher (Thakrar, 2007). Fig 5.2 shows the schematic diagram for the food flows in the city across different scales.

Fig 5.1: (Left to right) Typical breakfast meal and lunch/dinner

Source:

https://homegrown.co.in/article/802778/the-very-best-south-indian-thalis-across-mumbai-eat-your-heart-out

https://www.plattershare.com/recipe/south-indian-breakfast-thali

Food Flows

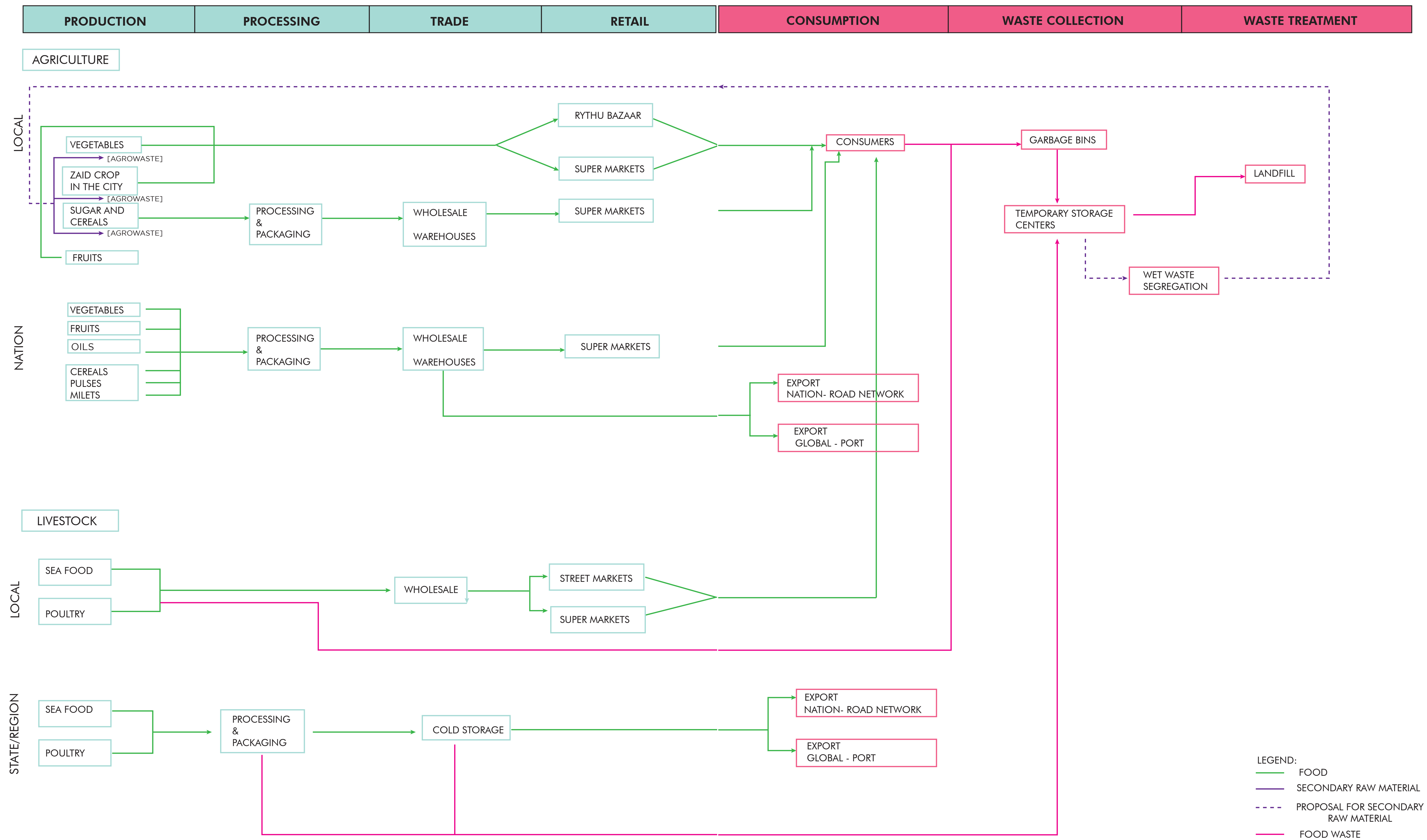


Fig 5.2 Systemic diagram of food flow analysis

Source of food (Production of food in the city and its peri-urban areas):

According to the Food and Agriculture Organisation (FAO), there is a difference between food 'loss' and food 'waste'. Food loss occurs in the production stage of pre-consumption while food waste is in the stages of processing, distribution and more during the consuming phase i.e., consumer behavior from purchasing in the markets to consumption. Food waste during the production phase is the organic waste post-production, or when the crop is left unharvested or rejected due to low nutritional value, species and quality of the product. Food loss is due to improper storage facilities, infrastructure for food distribution and lack of processing facilities close to the production sites (Gayathri Iyer, 2018). It is difficult to track the food loss compared to the food waste generated in the production chain. The waste generated post-harvest is often buried in the field to form natural manure or fed to the cattle or sold to industries that produce paper or burnt in open spaces causing air pollution. Fig 5.3, 5.4, 5.5, showcase the different types of food that were produced in the year 2016-2017 in the city and its peri-urban areas.

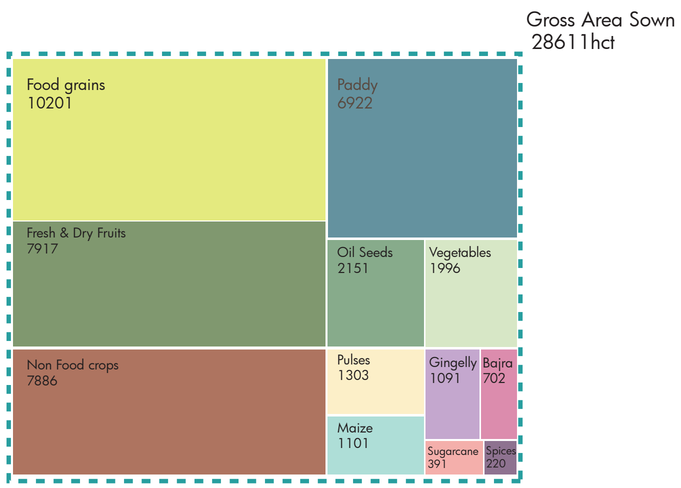


Fig 5.3; lists out the crops grown on the arable land in the city.
(Quantity in Quintals)

Fig 5.3 Crops grown on arable land

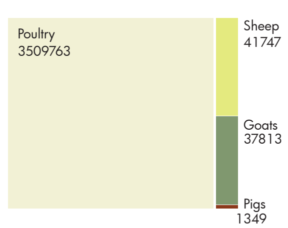


Fig 5.4 lists the livestock census in the year 2016 (in number)

Fig 5.4 Livestock census in 2016

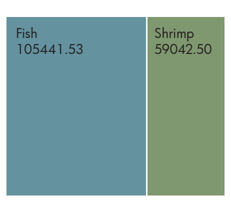


Fig 5.5 shows the amount of seafood produced in the year 2016-2017

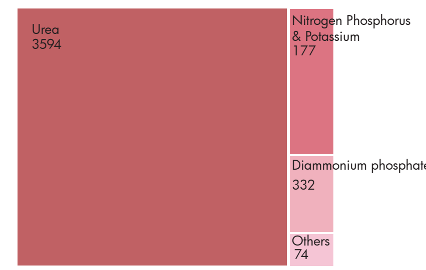
Fig 5.5 Sea food produced in the year 2016-2017

Fig 5.5 the amount of dairy products produced in the year 2016-2017

Fig 5.5 Dairy production 2016-2017

The milk for dairy industry is collected from 162 collection centers from the surrounding villages of the city.

The above figures have listed out the amount of food that has been produced in the city and its peri-urban areas. In order to cultivate food that can supply the increasing demands, the usage of fertilizer is increasing in the region. One of the alternate methods to track the food flows is to track the nutrient flows (Barles, 2007; Forkes, 2007; Metelerkamp, 2016). This highlights two impact points, namely: (i) the use of fertilizers, which are imported nutrients, on agricultural land, and (ii) the loss of nutrients through wastewater discharge into the ocean (P.K. Currie et al, 2018). Fertilizers are energy intensive to make (Gellings & Paramenter, 2004) and play host to a number of issues surrounding food sovereignty and often result in poor soil quality. Fig 5.5, showcases the quantity of fertilizers that are consumed in the year 2016-2017.



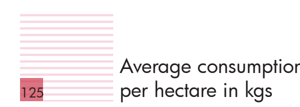


Fig 5.6 Consumption of fertilizers in the year 2016 - 2017

Waste from livestock & Sea food (at Source):

The waste from the livestock is collected at the meat shops and disposed of along with the MSW and the waste from the processing industries is dumped in the landfill as well.

It is estimated that 25% of the total production of marine capture fisheries is discarded as processing waste overs. The waste from shrimp accounts as 40-50% of its body weight. (Sudharani P, 2015). An average of 5150 tonnes of shrimp waste is generated in the Visakhapatnam fishing harbour (Sudharani P, 2015). Most of this waste is leftover at the site or is collected to be dumped at the landfill site of MSW.

The waste streams from the dairy industry predominantly include the packaging waste, followed by gaseous waste.

The analysis presented above has discussed only the quantities of food that are being produced per annum, and the fraction of waste that they are being produced in the production scale and the quantities of fertilizers that are being used to gain more yield, which is disrupting the environment.

The following maps spatially translate the flows shown in Fig 5.2. The household production of food, such as vegetables is not considered in the flow diagram, considering the changing building typologies and urban fabric. And the types of food that are being analysed is limited to food cultivated on the arable land i.e., fruits and vegetables, seafood and poultry.

Source:
https://www.plattershare.com/recipe/south-indian-breakfast-thali

Mapping the Food flows:

Production

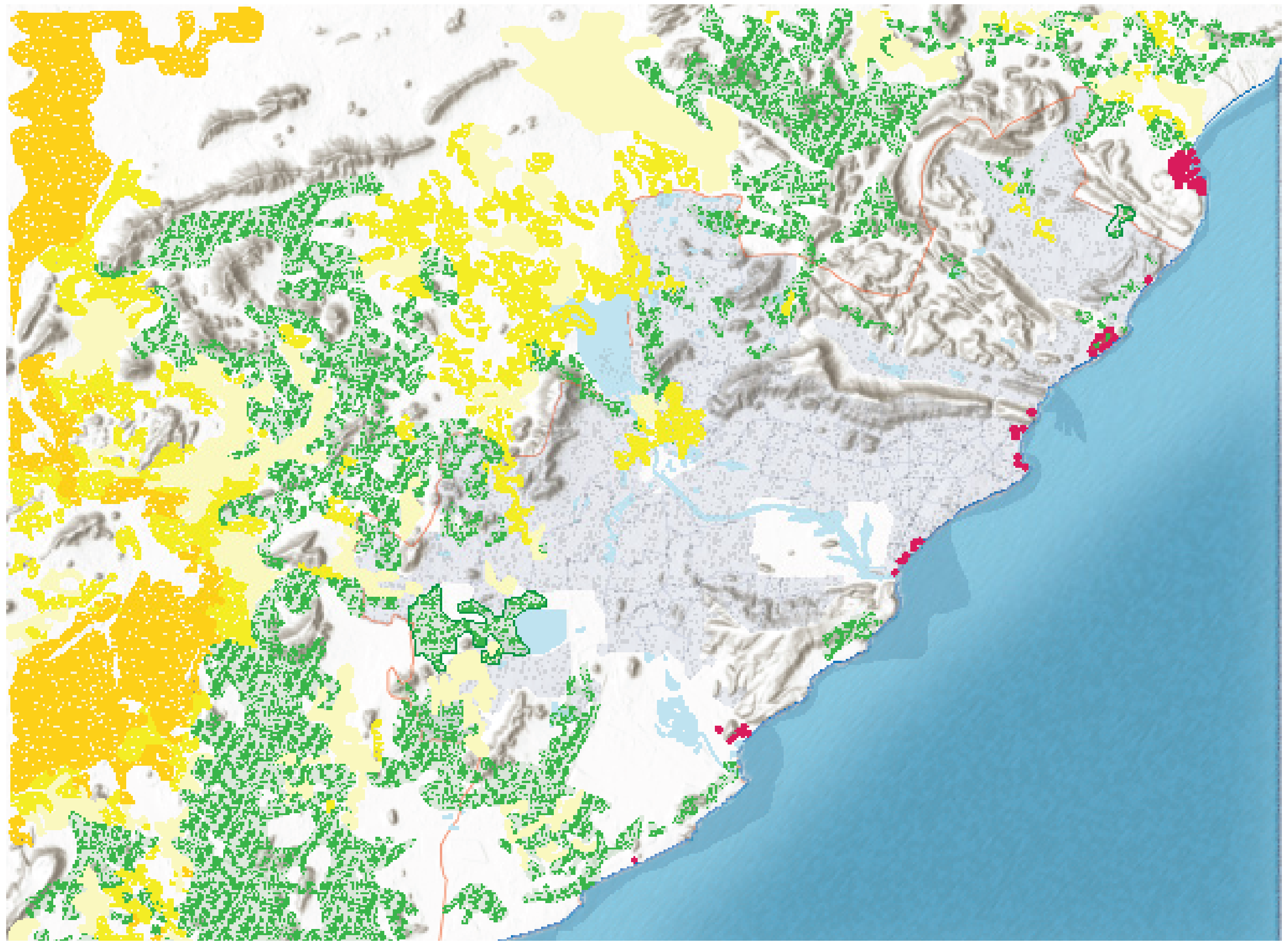


Fig 5.7 Food production on the arable land in and around the city

Fig 5.7, reveals the regions of production of food in the city. The different types of crops produced in this region are listed out in fig 5.2. Food is one of the major resource flow. To produce food it requires supporting resources such as land, water, electricity and economic infrastructure (P.K. Currie et al., 2018). This figure focuses on arable land use in the city. The agricultural plantations include cashew tree plants and other fresh and dry fruit tree plantations. While the zaid crop is vegetable production during the non-monsoon season, this type of crop requires less water. And in some regions, crops are cultivated for more than two seasons per annum due to the demand. In these regions, soil loses its nutrients and the usage of fertilizers is more. Excessive usage of fertilizers is resulting in poorer quality of soil as shown in Fig 2.15. Increasing activities of construction, industrialisation and deforestation are resulting in loss of natural cover and soil erosion. Fruits and vegetables are directed towards the wholesale markets and farmers markets to reach the customers, while the others go through the phase of processing. The waste produced in this phase is usually utilized within the farm or as feed for the livestock.

Source:

https://bhuvan-app1.nrsc.gov.in/state/AP

Processing, Trade and Retail

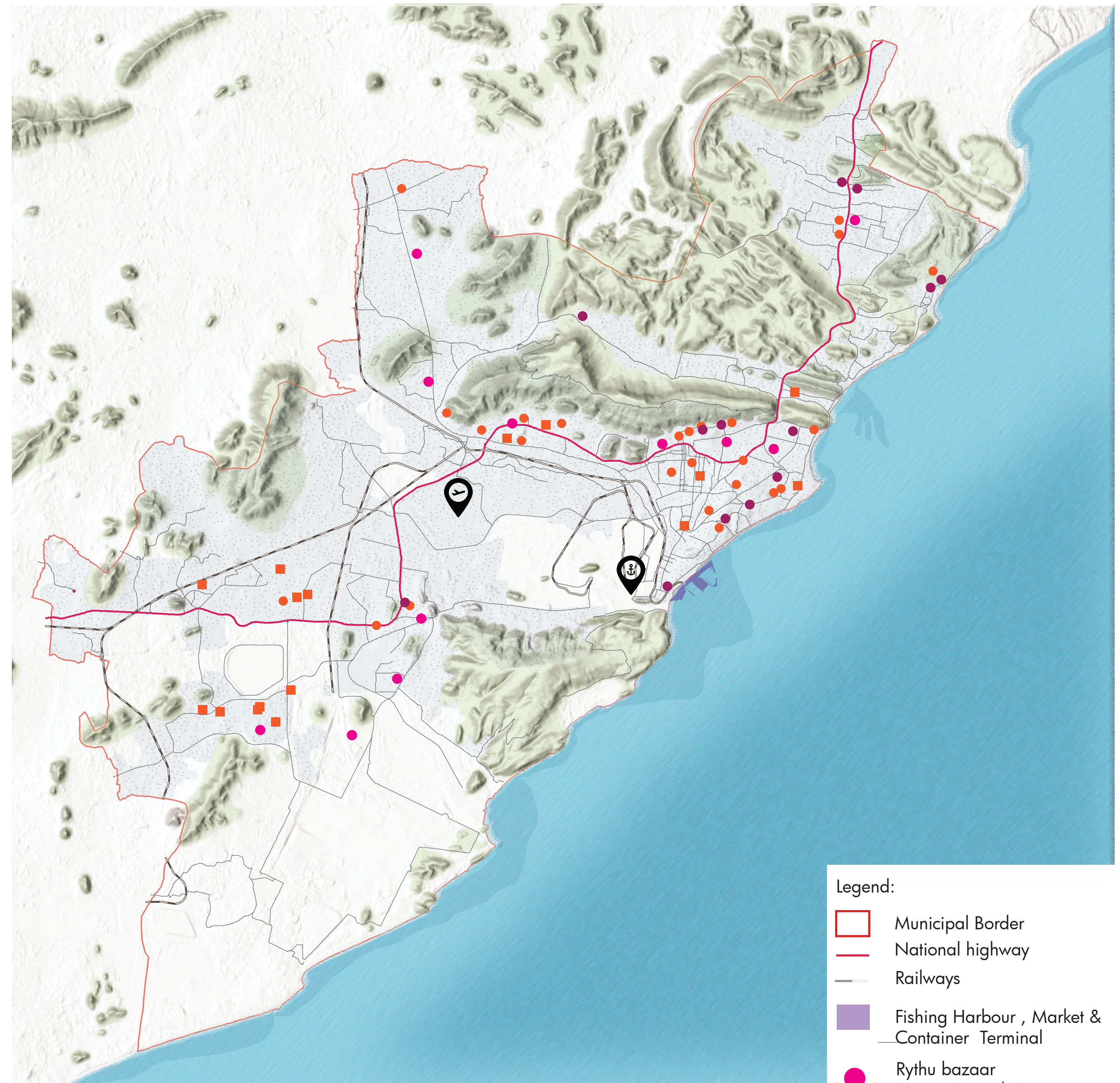


Fig 5.8 Map showing food processing industries, markets and the larger chains of retail outlets

Fig 5.8, shows the food processing centers and the Rythu bazaar (Farmer's market), wholesale dealers such as co-operative retail outlets and the major chains of food retail outlets. The waste produced in this phase is collected as MSW and disposed at the landfill site. The waste generated in the fishing harbour and seafood processing industries are collected as MSW as well.

Source:

https://bhuvan-app1.nrsc.gov.in/state/AP

Consumption

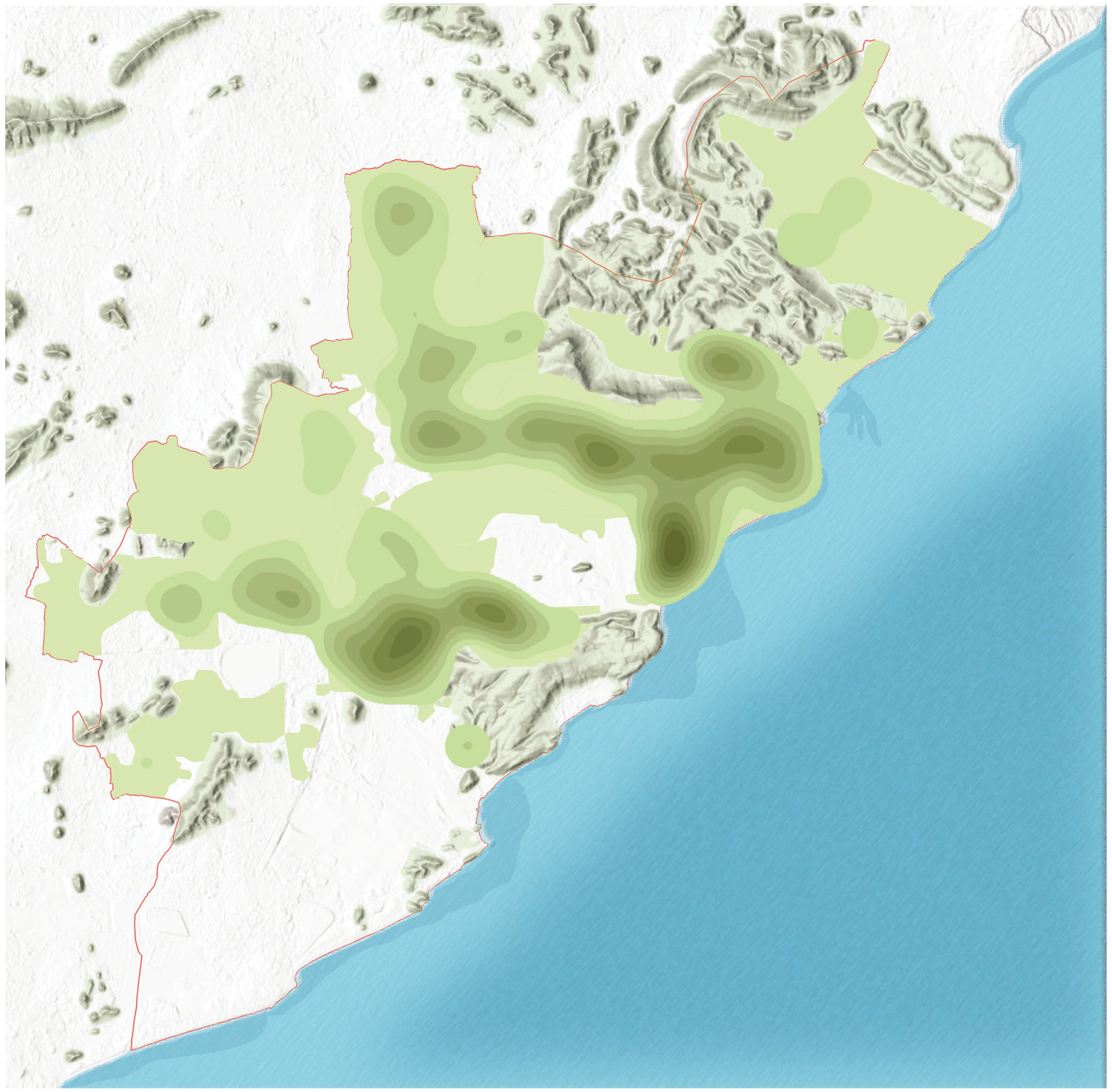


Fig 5.9 Map showing the number of consumers in each ward

Legend:

Municipal Boundary

High

Low

Fig 5.9 shows the number of consumers in each ward. Approximately, 0.9 - 1.2Kgs of waste is generated in each household/day (Interviewee 1). The organic waste produced by the consumers is collected along with other waste materials from door to door. There is no practice of segregating waste at the household scale in many wards. The waste collected from door to door is taken to collection points which are located at a distance of every 1.1 Km diameter (Interviewee 1). There are a total of 575 collection points in the city. The waste from the collection points is transferred to temporary storage sites.

0 5km

Source:
Urban observatory Data, 2016

Waste Collection

Fig 5.10 Map showing the current temporary storage sites and landfill site

Legend:

Landfill site

Temporary storage center

National Highway

Primary Roads

Arterial Roads

As shown in Fig 5.10, there is one temporary storage site for every two zones. Currently only one temporary storage site is functional. From these storage sites, the MSW is carried to the landfill site located 32km away, on the outskirts of the municipal boundaries. The waste from the hospitals is incinerated in a biomedical treatment plant. The waste is burnt once in few months. The breeding of musquitoes, the leachate from the waste is polluting the soil, drainages and the ocean and endangering the marine species.

0 5km

Source:
gvmc.gov.in

Water Flow Analysis

The main sources of drinking water in the city are the canals, reservoirs and rivers in the region feeding the reservoirs within the city. The water from these reservoirs is purified and distributed to the overhead tanks across the city and distributed through pipes or through tankers to the houses which do not have access through pipes. Many households in the city have their own underground water tube wells. Due to the pollution from industries, the increasing number of private borewells and climate changes there is increased pressure on both the quality and quantity of underground water in the city. The following Fig 5.11, shows the amount of water that is being supplied to the city from the sources in the region and the loss that occurs during the transfer from one reservoir to other.

Fig 5.12 gives an overview of the water flow from the regional scale, the sources within the city, consumption patterns of different sources of water and types of wastewater treatment in the city and the final step of discharging both treated and untreated wastewater. As mentioned in Fig 2.5, only 18% of the total wastewater is properly treated at the STP located in the city.

REGIONAL SOURCES OF WATER

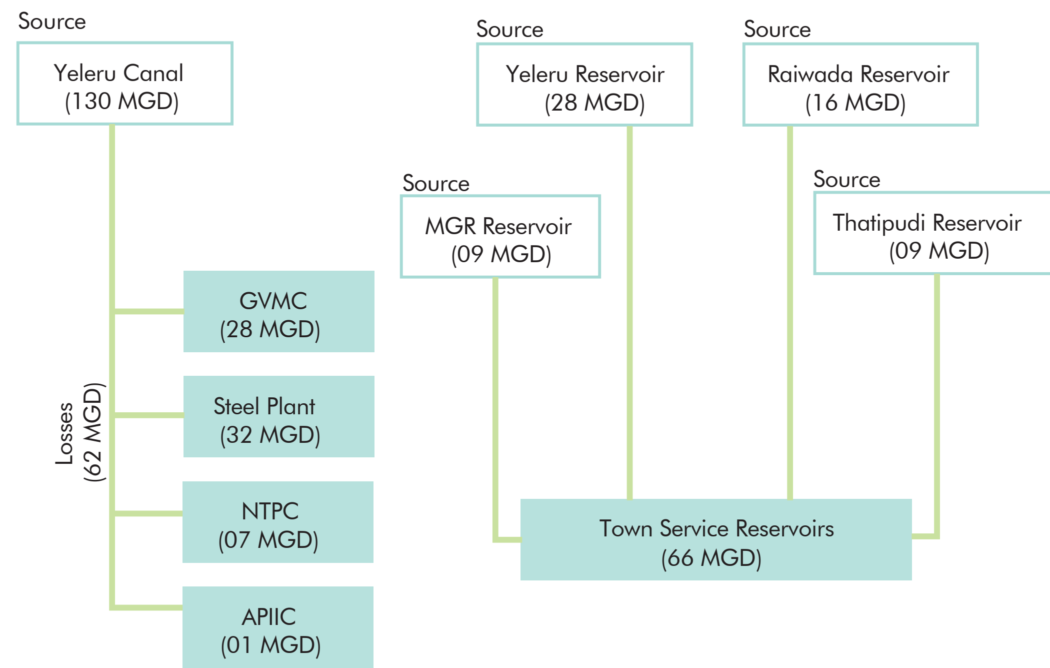


Fig 5.11 Sources of water feeding the reservoirs in the city

Water Flows

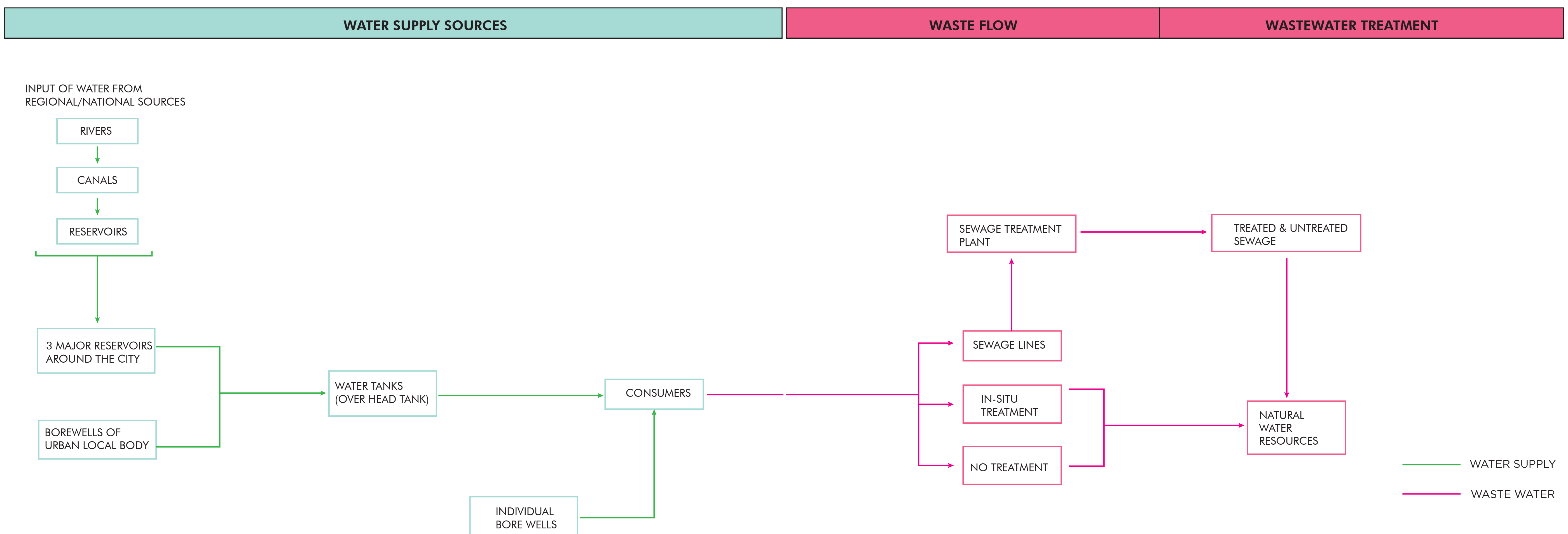


Fig 5.12 Systemic diagram of water flows

Mapping the Water flows:

Regional sources

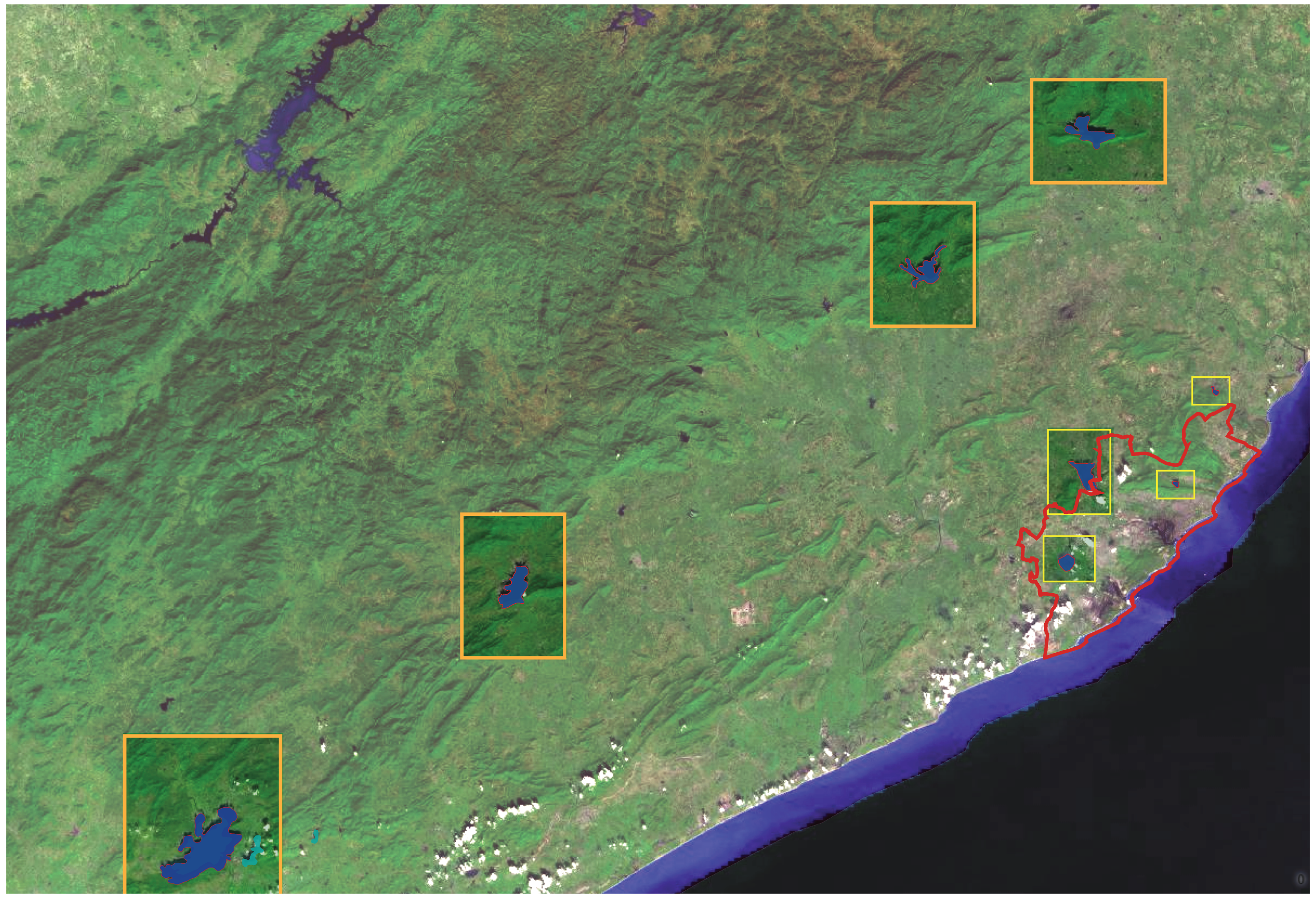


Fig 5.13 Map showing the sources of water in the region supplying to the city

The drinking water supply for the city is sourced from the major reservoirs which are fed from rivers and canals as shown in Fig 5.11. The map above (fig 5.13) shows the location of the major reservoirs that supply water to the reservoirs in the city. Currently there are four reservoirs in the city out of them only three are functional and a new reservoir is under construction in order to facilitate the increasing demand for drinking water.

Source:
https://bhuvan-app1.nrsc.gov.in/state/AP

Sources of water in the city

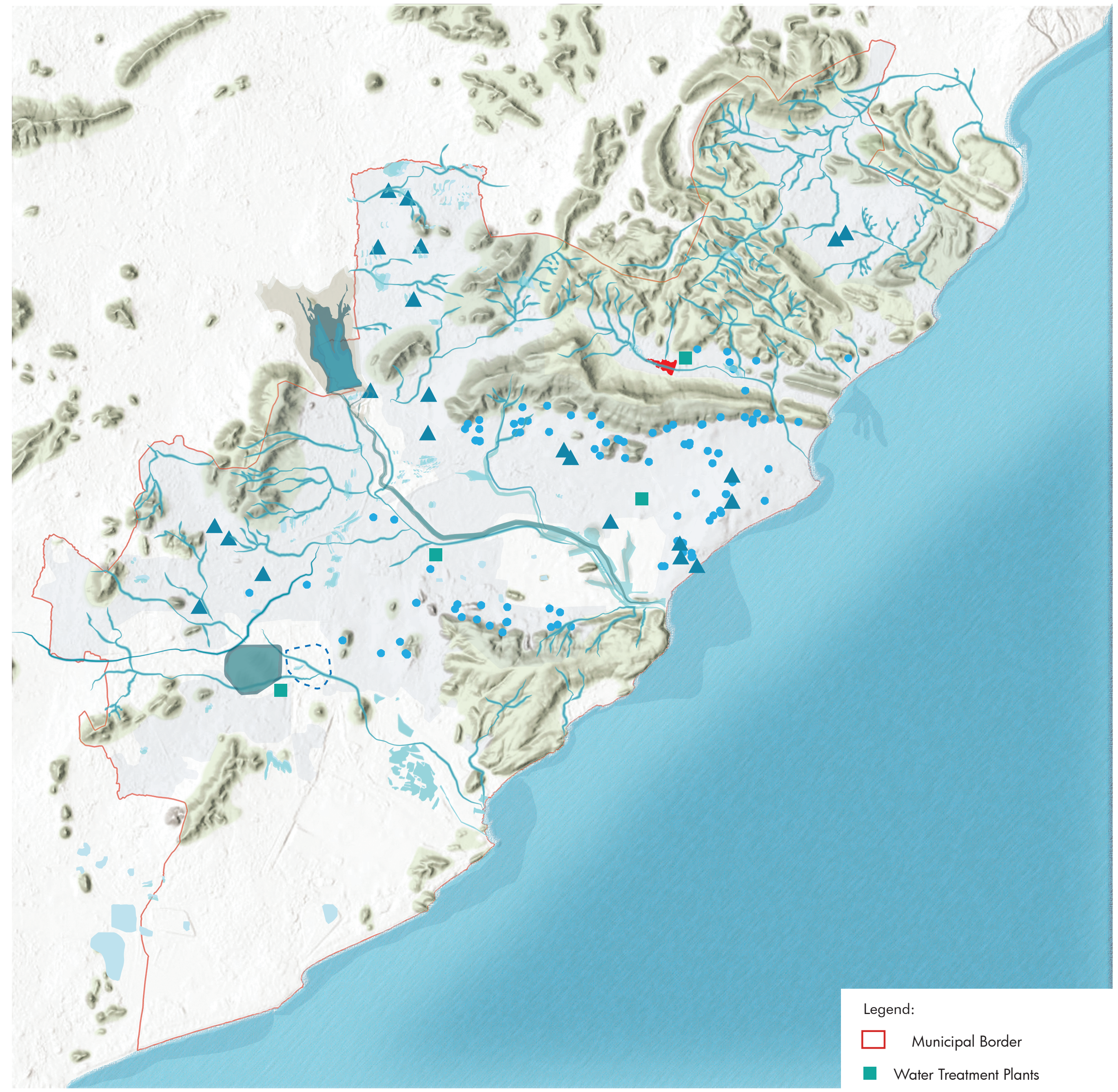


Fig 5.14 Map showing the overhead water tanks and drainages in the city

Water from these reservoirs is purified and pumped into the over head water tanks present across the city as shown in the fig 5.14. This water is distributed through pipes. Water is supplied through tankers to the households that do not have pipeline connection on every alternative day. Or they have depend on underground water through private borewells.
The natural streams of surface water were ewarlier the sources of water before the construction of reservoirs and now as shown in fig 2.3, are polluted.

Source:
Urban observatory Data, 2016

Dependence on underground water

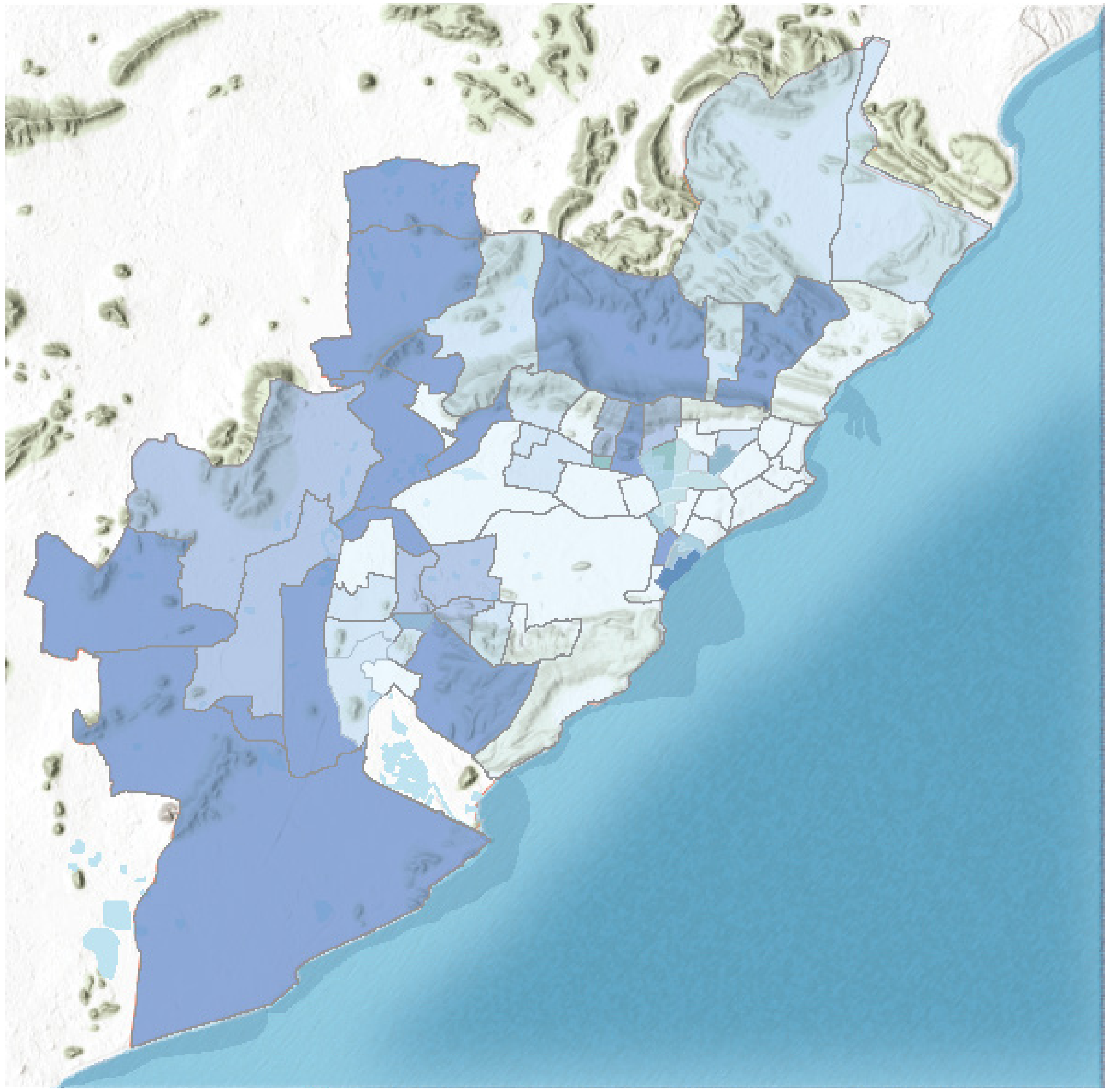


Fig 5.15 Map showing the number of households that are dependent on underground water borewells

Legend:
Municipal Border
0 - 1000
> 1000 - 1984
> 1984 - 2000
> 2000 - 7349

Fig 5.15, shows the number of housholds that depend on underground water. With the rising number of borewells, there is an increase in the pressure of underground water. The quality of underground water is diminishing in few regions as they are surrounded by industrial areas and the increasing number of construction activities as shown in the Fig 2.16.

Source:
Urban observatory Data, 2016

Sewage connection availability

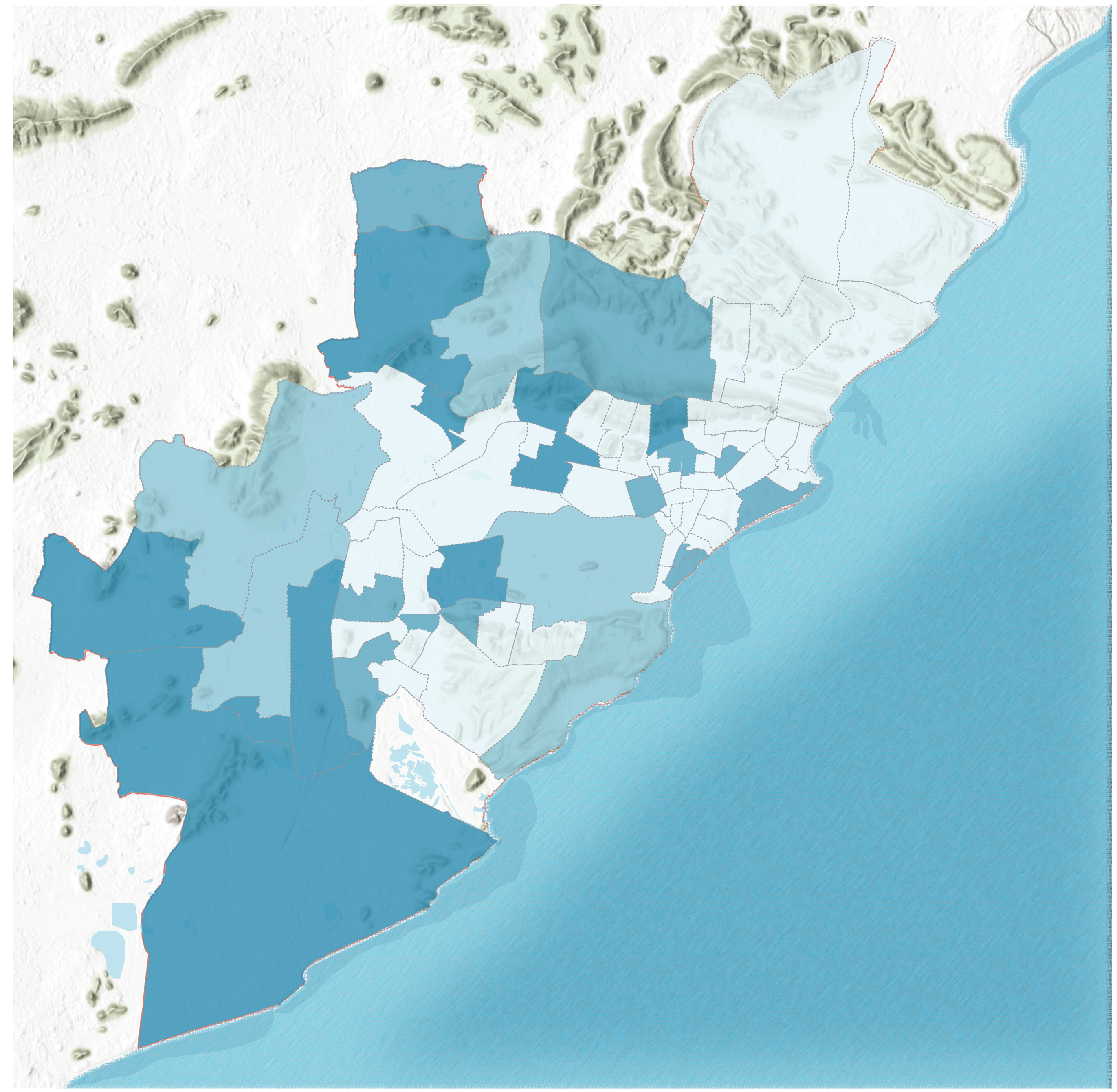


Fig 5.16 Map showing the number of houses that have connections to the sewage

Legend:
Municipal Border
less than 250
250-500
500-1000
1000 and above

Post consumption, the sewage water that is generated is sent to the STP. Fig 5.16, shows the number of households that have access to STP. As shown in the Fig 5.17, the current STPs in the city are of under capacity.

Source:
Urban observatory Data, 2016

Sewage Treatment Plant

Fig 5.17 Map showing the Sewage Treatment plants

Fig 5.17, shows the existing STP located in the city. Both the treated and untreated sewage water is released into the natural sources through the STP. The households that do not have access to STP, have their own individual soak pits. The waste from the soak pits is collected periodically and is being released into natural water sources without any treatment. This is causing pollution in the natural sources of water such as canals and ocean.

Legend:

- Municipal Border
- S.T.P
- Sewage Pumping station
- Polluted surface water

0 5km

Source:
www.gvmc.gov.in

Problematic locations:

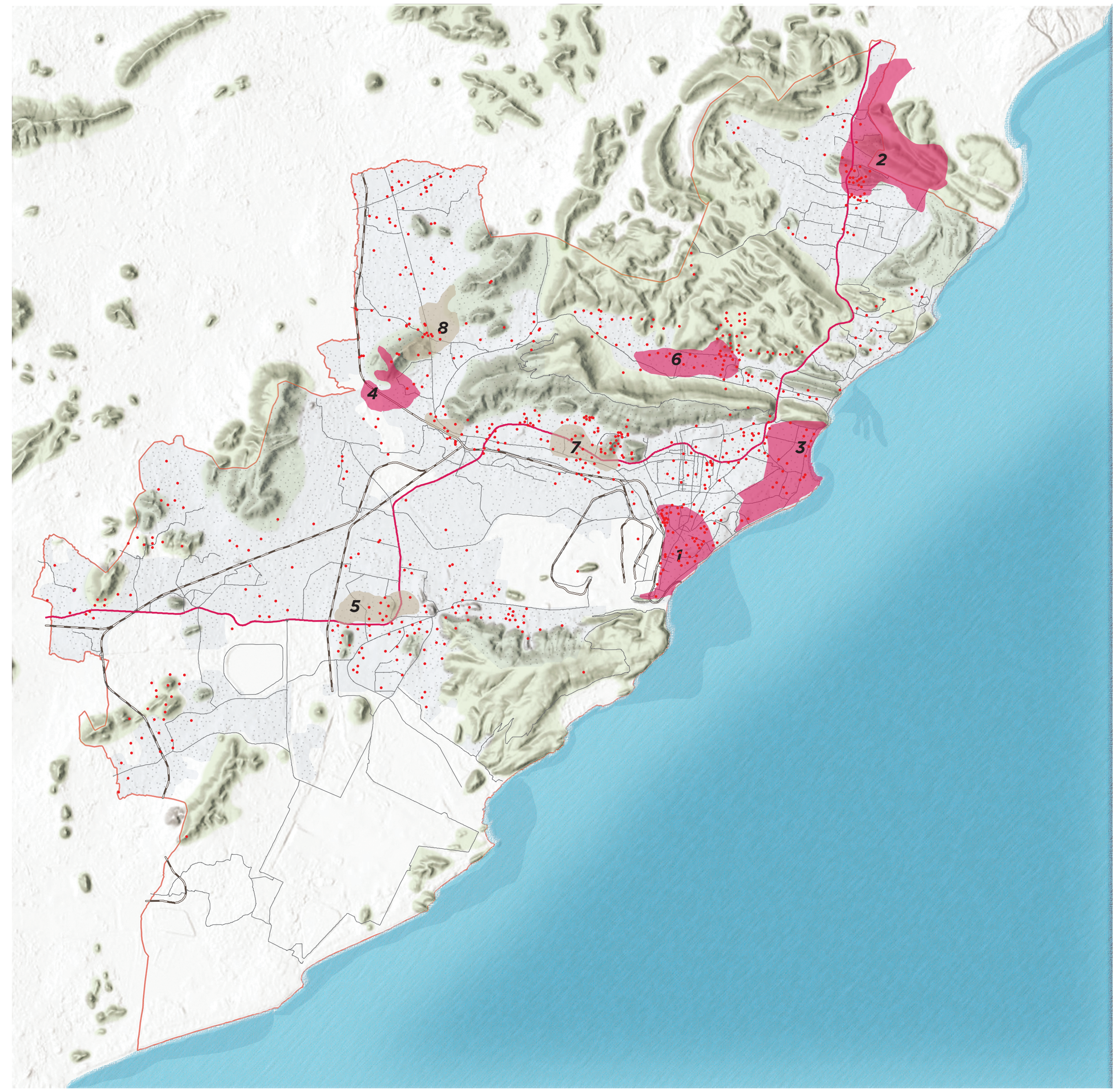


Figure 5.18: Map showing identified problem locations

Figure 5.18, shows the map of the identified locations in the earlier stages of problem analysis. The 8 locations identified were categorized into two i.e., problem zone I and problem zone II in relation to the severity of the problems in these locations. In the second phase of the analysis, the above 8 locations are analysed in a field visit and documented through photographs, sketches and interviews.

Legend:

- Municipal Border
- Problem Intense Zone I
- Problem Intense Zone II
- Vulnerbale Zones - Informal Settlements

0 5km

FIELD WORK | 5.a
Phase - II Analysis

This sub-chapter gives a detailed analysis of the issues faced in each of the eight locations and conclusions on the measures that have to be taken to address the problems. It also presents the statements given by the local actors in their interviews. And it draws conclusions from the overall analysis and determines the steps of focus for providing the proposals.

LOCATION 1:

Figure 5.19: Collage of images of location 1

Issues:

- The under capacited STP is releasing untreated water into the canal. And increasing the capacity of the STP is the next step on the agenda of ULB. Though the usage of water for port activities is carried out, often the pungent odour and inefficient recycling of the untreated water is limiting the re-use activity.

Conflicts:
- The untreated water from STP, port and industries and the dumping of solid waste is disturbing the marine life in the sea. Thus resulting in lesser yield of sea food.

Conclusion:
- The canal needs to be refurbished and stop the wastewater discharge into it. The fishing harbour needs waste segregation and reuse system in place.

LOCATION 2:

Figure 5.20: Collage of images of location 2

Issues:
- The drainages next to the site are polluted with leachate and later released into the ocean
- Toxic gases and waste seapage into the soil

Conflicts:
- Residents from the newer develpoments want the landfill site to be relocated.
- Loss of resources in the WTE plant. The current campaigns of wet waste and dry waste are subsided in the incinerator.
- No future vision for handling excess waste in the WTE plant

Conclusion:
- Measures have to be taken to address the issues of the existing damages.

- Informal settlements spreading over the hills along the National highway

LOCATION 3:

Figure 5.21: Collage of images of location 3

Issues:

- The negative affects on marine life can be visually seen and it requires immediate attention
- Excessive extraction of ground water through bore wells can be the major reason for saltwater infiltration aprt from the natural causes.

Conflicts:
- The neighborhoods which face these issues are under Coastal regulation Zones. Any proposal that is made should be in compliance with the Costal regulations.
- The difficulties of municipality to opt for advanced techniques and solutions

Conclusion:
- Residents and officials are oblivious to the damages caused by waste water. This location would be of first priority in choosing the pilot site locations to propose solutions.

LOCATION 4 & 8:

Figure 5.22: Collage of images of location 4 & 8

Issues:
- soil erosion, poor soil quality and underground water deterioration.
- But in contrast the actors are unaware of such situations and every thing is working well in their location
- Resources in the waste streams are left unutilized

Conflicts:
- Lack of facilities like MSW disposal and water availability that needs to be provided by the municipality
- Changing attitude of the consumers - deflecting from traditional methods of sustainable living

Conclusion:
- Although different studies have highlighted the vulnerability of this region there are no visual evidences that prove the sensitivity of the location. hills along the National highway

LOCATION 5 & 7:




Figure 5.23: Collage of images of location 5 & 7

Issues:
- Consumer Behaviour and attitude towards waste is the prime issue in these two locations.
- Adapting and changing to new treands and systems

Conflicts:
- The conflict between the municipality and citizens is one of the reasons in the gaps of implementation

Conclusion:
- Though there is constant publicity thrugh different media to segregate waste and adapt to sustainable practices there is lesser influence in the people. The reasons for this can be attributed to the lack of confidence in current governance system, negligence or the dilemma/taboos associated with waste.
- Hence the solutions proposed should enable them to practically see, motivate and adapt to sustainable practices.

LOCATION 6:

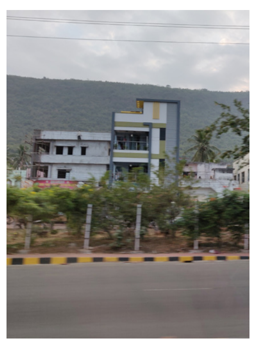



Figure 5.24: Collage of images of location 6

Issues:
- The major issue in this location is the primary source of water that has dried down.
- Loss of migrating birds habitat due to no water and less greenary.

Conflicts:
- Lack of control on the number of borewells
- Illegal construction activities in eco-sensitive zone
- Measures being taken are retorted into short term agendas rather than long term vision

Conclusion:
- The location requires long term vision in order to keep it revived and the natural streams of water needs to be refurbished. The capacity of the reservoir is 1.5MGD and measures have to be taken to revive and sustain the catchment area.

INTERVIEWS:

“ Name: Thatha Rao, Farmer

We are not aware of any environmental damage. We use fertilizers and pesticides in regulated amounts as said by our owner. Depending on the season the yield varies. Other than that we cannot say reasons for soil degradation and poor water quality. We receive water in pipeline for farming in early mornings. So we do not see any trouble. Our households depend on hand pumps for water or on drinking water tanks.

Waste from th crop is used as fodder for cattle. Waste from our houses is dumped in the open and we burn them once the pile is huge. Municipality does not provide us any facilities, they are not for us. ”

Name: Satish, Construction Manager ”

“ *1200 MTonnes/day is required to generate 15MW/hour. In order to maintain the required calorific value, all types of waste is used except C & D waste, e-waste and medical waste. WTE plants have started in few other cities in India. One of them is currently functioing, If this plant is successful more plants shall be developed in the state.*

“ Name: Kanaka Raju, Rag picker

We pick glass waste from the dumpyard. Earlier we collected electronic items as well. These days we find only pet bottles, bottle caps and glass. We sell them to the local shop vendors. Our next generation does not want to work in this field so the number is going down. ”

Name: Poliah, Informal rag picker ”

“ *Earlier we used to go to houses and collect waste like papers, metals, glass etc., these days no one has time to segregate them and sell. I've been working all my life in this, over the past few years there is drastic decline. Now the domestic maids help us in collecting the unused materials from households and we sell them to wholesale vendors or shopkeepers. Profit from this is very low, so everyone is migrating to other jobs.*

“ Name: Ramulamma, Fisherwoman

I've been fishing since the age of 14. We fish only 6-7 months in a year. My husband goes for fishing and I sell them. We throw the waste into the water as there is no other place to throw. Yes, we are aware that it harms the marine life, but eventually it will land up in the water even though we through it anywhere else. Over the last 3-4 years, the variety, quality and quantity of fish has reduced. The coast has changed a lot as you can see. Now we have to go deep into the sea for fishing. The bigger companies also go deep into ocean and catch in bulk. There is some loss over there as well. As per my knowledge there are more than 1500 fisherman who depend on this livelihood in this harbour. ”

Name: Lakshmi,waste collector

I collect waste from 350 houses per day in the morning and clean the same streets in afternoon. The waste collected from the houses should be segregated into wet waste and dry waste as per the new rules. But most of the houses do not follow, hence we collectors have to spend extra time in segregating the waste at the end of the day. The waste from street sweeping is burnt and the houses that leave waste on the streets is burnt as well.

Name: Pushpa, Housewife

It is smelly and unhygienic to store waste in bins at home. And it is also additional costs to pay for collecting the waste from the house. The streets are anyhow cleaned on a daily basis, so I throw it there and it is cleaned by the end of the day.

Name: Rajamani, Environmentalist at the United Nations Development Programme

Almost all the natural streams of water are damaged in the city. 80% of these streams are disturbed due to clogging by new urban developments and by the toxic liquids released by the industries. Under ground water pressure is also one of the rising issue in the city. The number of indivisual borewells has drastically increased in the past few years. The zone in which the reservoir belongs to has all the natural systems disturbed while the zones next to it are also getting disturbed due to construction activities.

Name: Appa Rao, Farmer

We use fertilizers in required amounts and spray pesticides twice a week. We did not experience any loss of yield and notice loss of soil quality.
Everyone in the village throw the garbage at the end of street and burn it once the pile is huge.

Yes, the previous generations have recycled waste into fuel or fodder or any other purpose. But now the time has changed, it is not the same type of waste and we do not have the time to invest in those activities.

Name: Prasad, Building Contractor

There is not much emphasis given on waste flows during construction of apartments or any buildings. There are building codes and regulations and norms for fire safety which we follow. Waste flows are carried out in an organic manner by the resident.
All the segregated waste is again dumped in the landfill site. No one knows if they are really doing anything useful with it. And these campaigns do not last long. So no one is interested to put their energy into it.

Location: Greater Visakhapatnam Municipal Corporation
Name: Rajamani, Environmentalist at the United Nations Development Programme

Coastal Erosion is one of the main environmental problems our city is facing. About 50 - 150m of the coastline is eroded and this is visibly seen in areas like R.K.Beach, Yarada, Rushikonda. It has made a flip from accretion to erosion. Fisherman are the most effected people as the marine life is in danger because of this. Reasons for this can be the increasing amounts of pollution or change in the currents due to construction of new dams in the port.

The next major issue in the city is decreasing amounts of underground water quality (& quanity as well) and pollution of it especially in the industrial bowl area. In few areas it is due to salt water intrusion, geological influence or increasing pressure on UG water. Reservoir in Mudasarlova has entirely dried up for more than a year now, this is due to blockage of natural streams of water due to illegal construction activities, dumping waste into it or releasing toxic liquids from the industries.

As for the degradation of food sources, soil erosion and poor soil quality have been documented by the soil and land use survey department. The impat of construction activities on this is more than the usage of their fertilizers or pesticides. The farming activities within the municipal borders are mostly limited to vegetable, fruits and sugarcane production. Hence, the damaged caused by chemicals is much lower than other regions in the district.

There are very few research documents discussing environmental degradation before any disaster. The focus has always been post disaster. Post disaster the attention is towards the social issues in comparision to the environmental issues.

Location: Greater Visakhapatnam Municipal Corporation
Name: Ramesh, City Planner in the Municipality

As you know, that our city is not a planned city. It was always organic growth. Earlier it was due to the increasing number of industries and the population rise is due to socio economic or tourist purposes. Post bifurcation of the two states, this is the only biggest city in the state. So all the business, industrial and other ventures are moving to this city. Thus we have this sporadic growth. Political decissions are instrumental in developing the city rather than the perspective of a city planner. As city planners both in the municipality and regional planning department our agenda is to develop master plans, identifying the potential zones within the available land etc. Even these activities are influenced by zoning regulations and various other departments.

The flows of waste and the steps to handle them have always been theoretical in developing the plans. These are set guidelines by the central governement departments and we implement them. At the scale of municipality it is carried out by the Chief Medical Office for Health. They decide the steps to be taken in relation to the improvememt of services for waste collection and disposal. Now they have a separate section within their department for Clean India Mission. The new proposals and advancements are made by this section.

Being a vast country, our system structure is more fragemented. Hence, at certain times there are some gaps in implementation. Whilst everything works smoothly and we are providing better services to the public.

Location: Greater Visakhapatnam Municipal Corporation
Name: Pavani, Clean India Mission section in department of CHief Medical office of Health

We are improving the door - door waste collection systems. And providing smart bins within a radius of every 5kms. The waste from different sources will be decentralised and solutions will be provided to dispose or reuse them. Currently we are operating one wet resource center for composting, there will be more in the future. Dry waste is sent to the WTE plant. We have workshops from the Central government departments on what are the steps that we need to take. Right now, the focus in the city is on eliminating open defecation system.

The steps we are taking right now are similar to circular economy, we are generating power from waste. Maybe in near future we have more solutions and you can give us suggestions as well. As for the informal sector in the waste flows, we are trying to identify them and regularise them as a part of the department in the municipality. All the steps taken are implemented through Public Private Partnerships.

Location: Andhra University
Name: S Bala Prasad, Professor of Environmental Engineering

Implementing Circular Economy in India is more complex compared to that of the European Nations. The entire system dynamics are different at different scales. It is not impossible but it requires more time for it to be established in India. Apart from the complexities of Population, density, governance, space and finances the attitude of people at different scales has to be changed. The power lies in the hands of consumer behaviour and the governance system. The advantages for the European or Western countries is that the consumption is less, imports and advanced technology. In the case of India, our industries belong to manufacturing and exports, so the changes are going to be complicated with immediate effect on the economics. Other than this, the composition of waste here is also different. 35% of MSW is silt, so the segregation is much harder. People would not like to make an effort to think and segregate the waste.

Even in the current system of collection and disposal which are implemented has many loop holes. The city is not planned and the form is organic. Developing a routing system for collection and precisely defining the waste and making it available for this population is also quite a challenge. The schemes and campaigns developed by governments are uncertain and are most of the time political propoganda rather than working for the benefit of the country.

There are many gaps in the current processes that are being taken place. On the macro scale the industries are trying to be circular in their production processes and produce minimum toxic waste. On the other hand, the attitude of people is refraining them to make a change. "Not in my Backyard"is the policy they believe in. No one wants to have a recycilng unit next to their house. This is due to the social taboo associated with waste for many years. And technocrats and their proposals are not considered during the stakeholder meetings. Any decission making lies in the hands of political bodies and their agenda has always been coveting the public praise through their welfare schemes. They still propose the technology that was proposed 10 years ago and ironically ten years later this might be the same and completely non-functional. So let us hope there might be changes one day.

Overall Synthesis

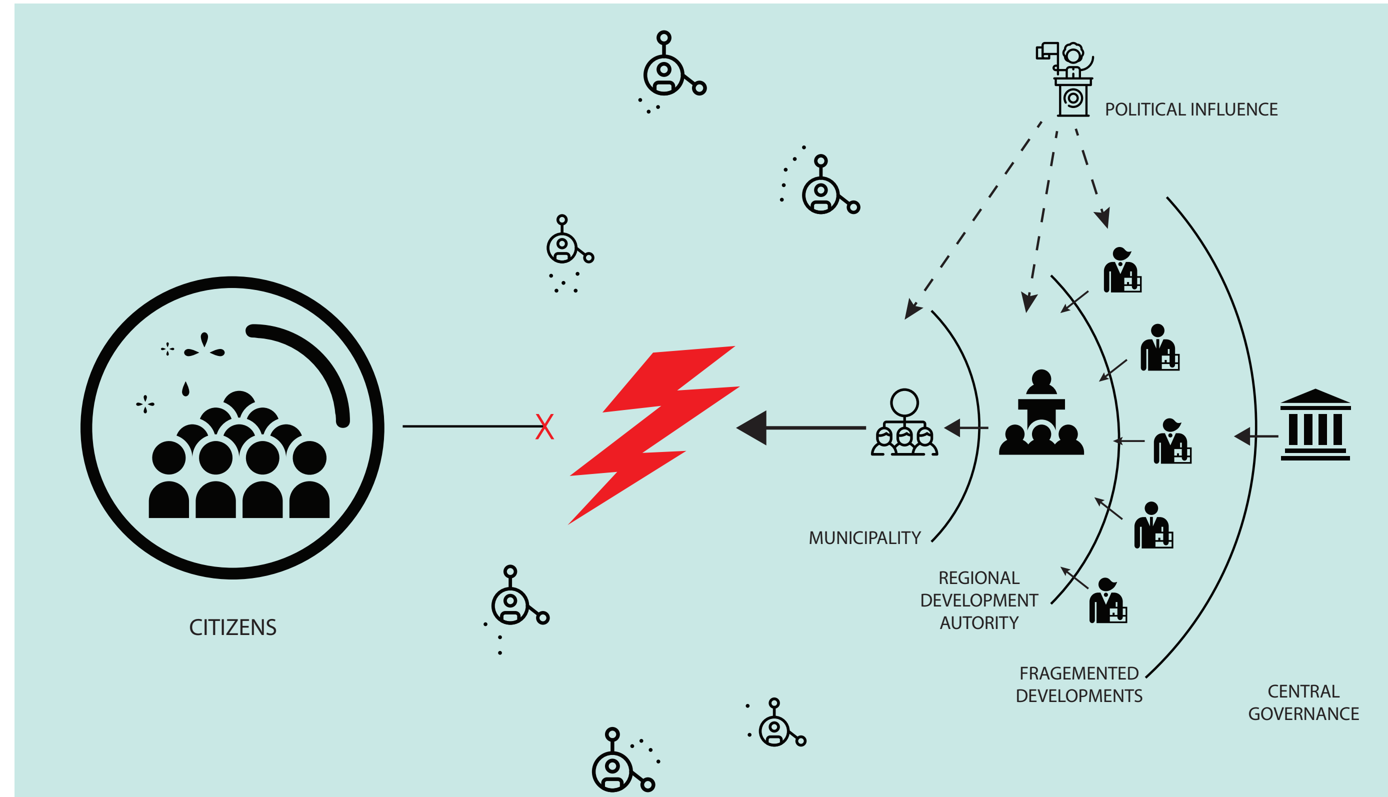


Fig 5.25 the conflict between the citizens and governance system

Fig 5.27 displays the current situation in the city of Visakhapatnam. The following points are observed during the field trip.

Conflict and resistance towards change from the citizens

Consumer behavior and people's attitude towards waste and governance system

Gaps in Knowledge

Gaps in Implementation

Environmental issues overlooked on social welfare

In the overall analysis of the field trip, the main issue which is largely prevalent in consumer behavior and attitude towards waste and change in the conventional waste management process. The second major problem is the negligence of environmental damages that have occurred especially in the eco-sensitive zones. And the third issue is the gap in knowledge and implementation of sustainable practices even though the primitive steps have been taken. Hence, the next phase of the thesis aims to develop a vision and road map for sustainable practices for the city and focus on proposing solutions to two of the problematic locations.

6

ENVISIONING RESOURCES

Developing a vision for environmentally sustainable Visakhapatnam

This chapter elaborates on the vision and goals for food and water flows. It further develops regional strategies for each resource flow and shows the levels of actor integration. Further, it elaborates on systemic goals for rainwater harvesting, wastewater reuse and policies required for reducing the food waste generated.

Vision

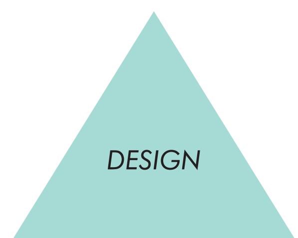
In 2050, The city of Visakhapatnam will be known as "Local - Adaptable City", owing to its long term vision of cohesive food and water resource management systems. The looping within existing infrastructure, mesoscale localised strategies for water management and the network of organic waste compost centers across the city are the key steps for the transformation. Reinforcing the blue and green infrastructure for regenerative purposes translates into the enhancement of the local living quality. The proposed circular solutions not only improve the ecological systems in the city but also bring in more economic and social welfare opportunities. Apart from the changing policies and subsidies by the ULB, the change in consumer attitude and engagement of local actors/institutions in the delivery of secondary resources, infrastructure and services will increase local autonomy. Thus, the city is a hub for eco-innovative solutions in the food and water resource cycles. The integrated planning system is employed to reach these goals.

Local City: Provide spaces within the city enabling the shift towards localized patterns of resource management within the city - region.

Adaptable City: Offer flexibility to adapt to biophysical changes supported by socially resilient communities inclusive of local actor networks and resources

Develop regulatory frameworks for CE, encourage in sharing the knowledge and support the actors at all the levels of governace

GOVERNANCE



CONSUMER BEHAVIOR

Change in attitude towards utilisation of resources and the waste generated considering the different set of actors involved from source to sink

TECHNOLOGY

Enhancing the existing technology to a broader set of actors as well as proposing new localised eco-innovative solutions.

Source:

Definitions adapted from:
http://circularcitieshub.com/wp-content/uploads/2017/06/Circular-Cities-Strategies-Challenges-and-Knowledge-Gaps-Page.pdf

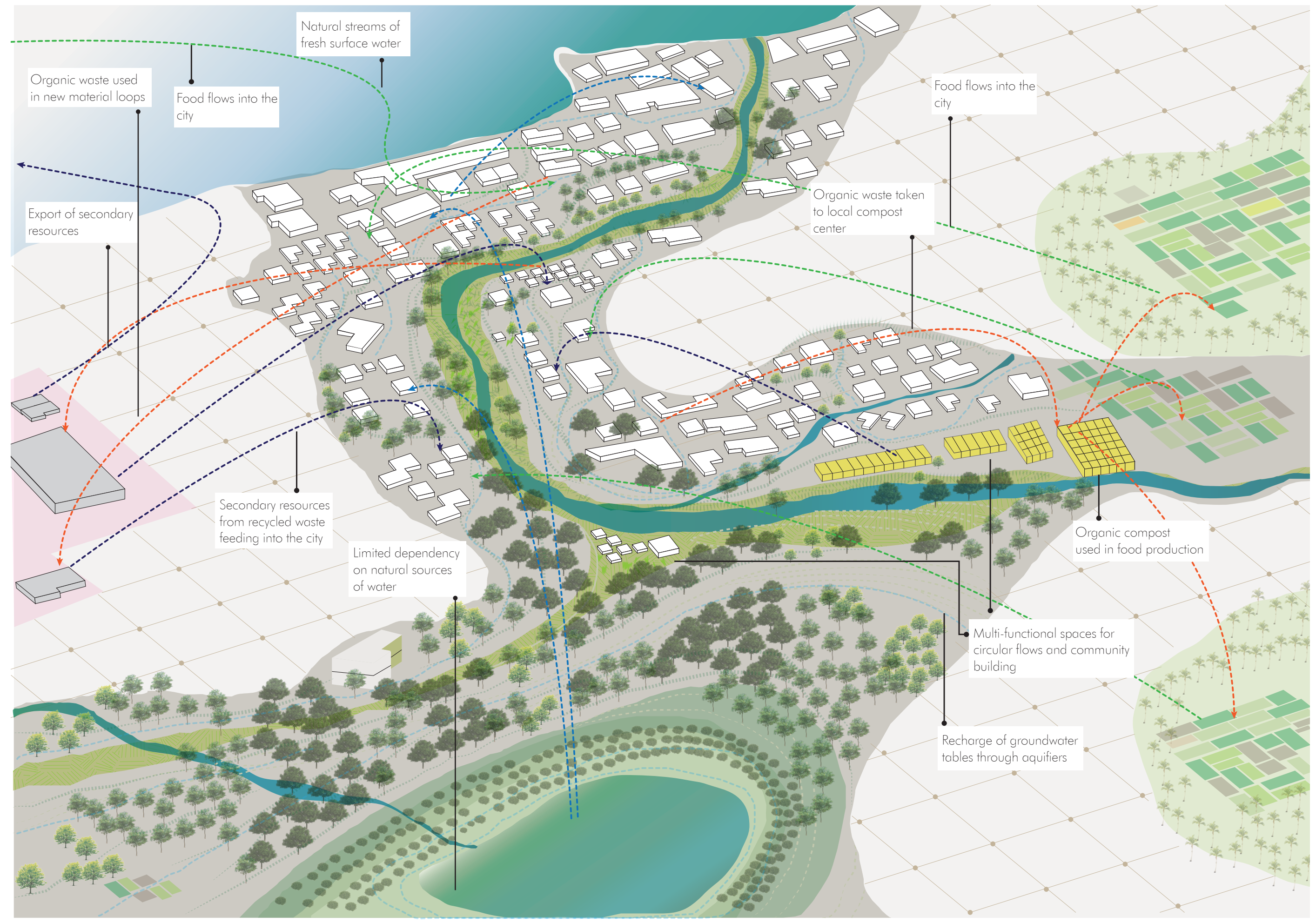


Fig 6.1 Vision of "Local - Adaptable"city

Vision Goals

The vision goals are based on three main focus points. They are

i) Governance
ii) Consumer Behavior
iii) Technology

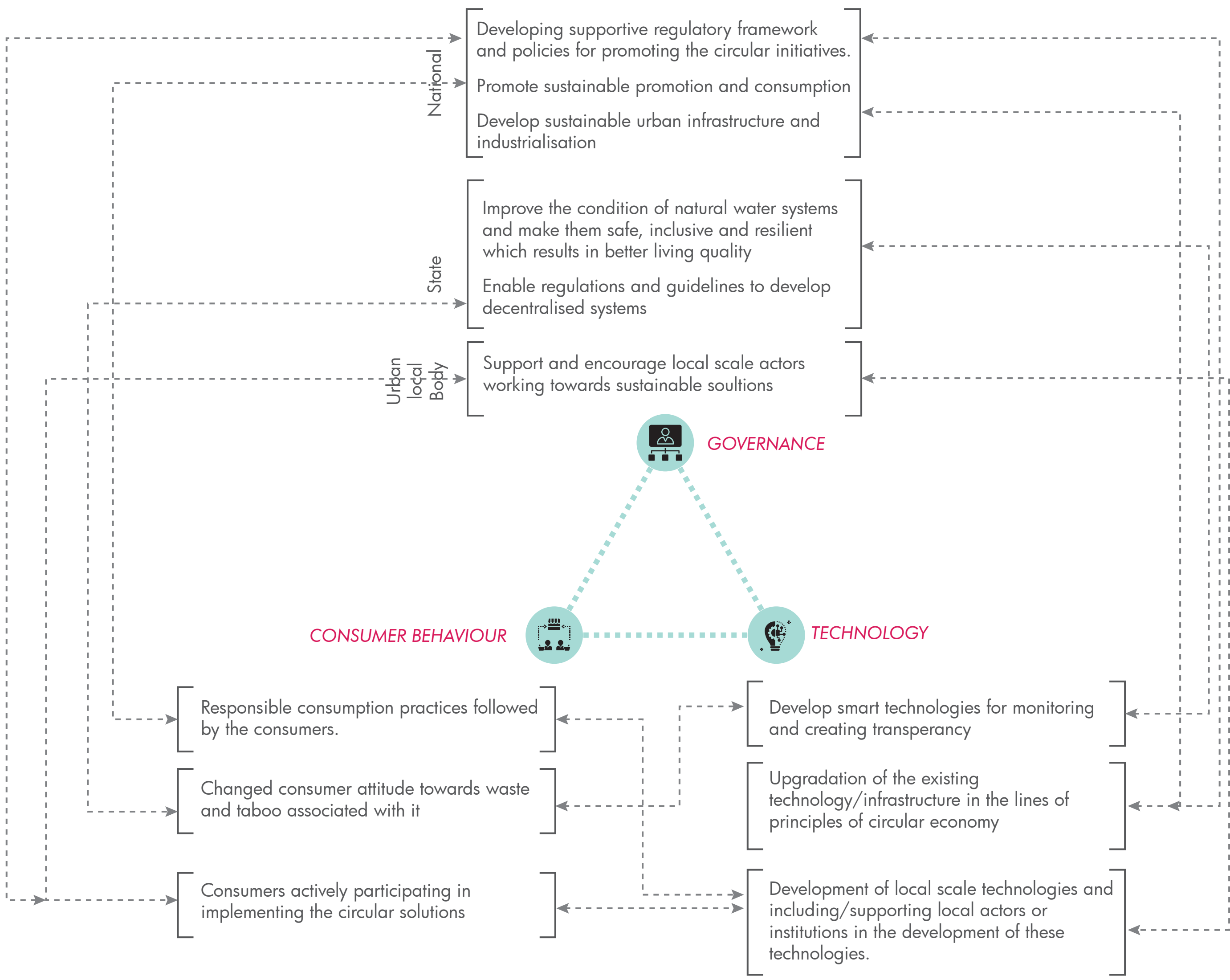


Fig 6.2 Vision Goals

Vision to Strategy

In order to translate the vision of local - adaptable city into a strategy, the first step is to identify the existing systems in place, consumption patterns, waste generation and sections of the loop where there is a scope of utilisation of the resource. In the chapter of resource analysis, the analysis has focussed on the flow analysis from the source to sink. It has highlighted the linearity in the current metabolism and the damages caused to the environment in this process.

The next step of analysis gives an overview of the current infrastructural systems and consumer behavioral patterns of both food and water resource flows. In the following steps, this project develops a strategic plan for both the resource flows in the form of principles to follow, the new loops in the resource flow, systemic diagrams showcasing the spatial requirements, and an analysis of the actors that need to be involved to implement the strategy. The vision is then translated into two strategies
i) Local City
ii) Looping City.

In the following chapter, two pilot projects are considered to propose possible solutions based on the strategies developed and reference projects in the lines of Governance, Socio-ecological systems and Socio-technical systems. A detailed phasing gives an outline of the strategy spanning in different phases with the pilot projects acting as the spin-offs.

Water Strategy

Water strategy is developed by first understanding the current infrastructural facilities of the water flow and its usage. In the earlier chapter of analysing water flows, it is observed that large parts of the city do not have the required infrastructural facilities and the regions with the services are under-equipped. Based on the analysis, the proposed solutions for the water strategies local city & looping city are putforth.

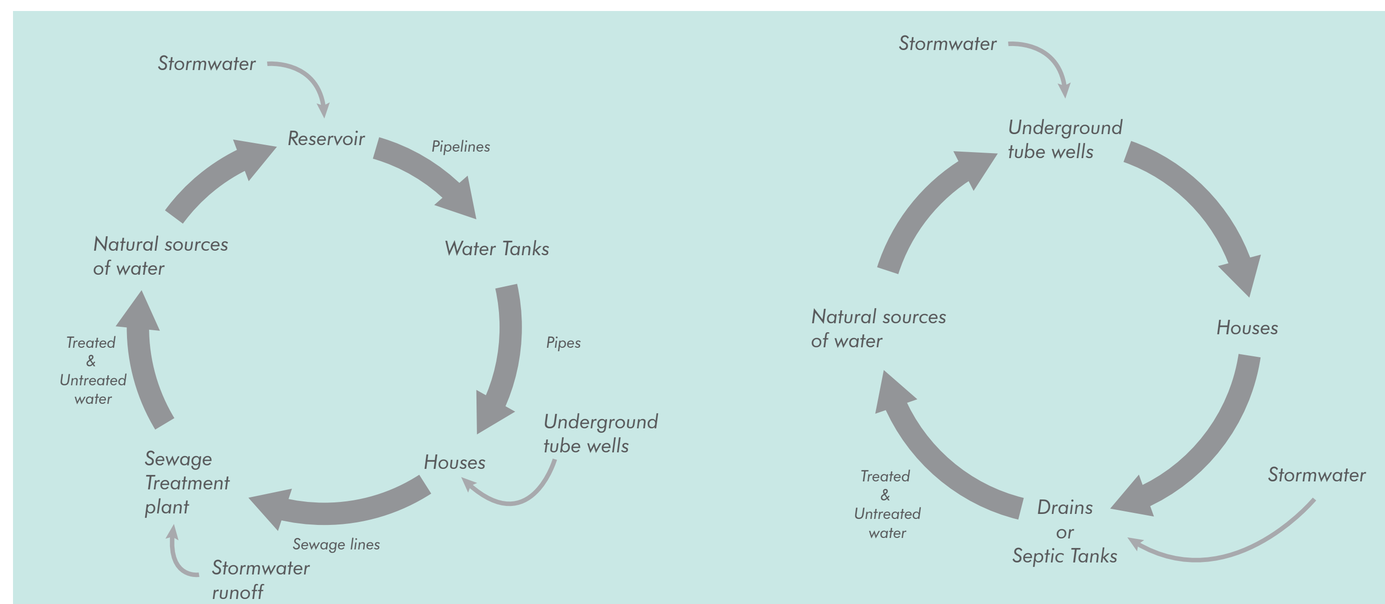


Fig 6.3 Infrastructure for the current water flows in the city

Water Infrastructure Analysis

Drinking Water Infrastructure

Fig 6.5 Map showing the drinking water pipeline connections in the city

Fig 6.5 shows the map of the regions to which drinking water is distributed through either pipelines or tankers in the city and the regions which depend on underground water tubewells. The regions which are already connected to the grid also depend on underground water because of the deficit in the amount of water that is being supplied. As shown in Fig 5.18; one of the sources of water in the city has dried up resulting in a shortage of water. The current demand for water supply is 84MGD and the supply is 66MGD with a deficit of 18MGD.

On average, one house block consumes 500 L/day and the supply from the centralised system is 300 L/days. Because of the deficit in the amount of water received, they tend to depend on groundwater.

Source:
https://www.gvmc.gov.in/wss/static_content/Water%20Supply.jsp
https://www.gvmc.gov.in/wss/image_uploads/pptwatermanagement.pdf

Sewage Network

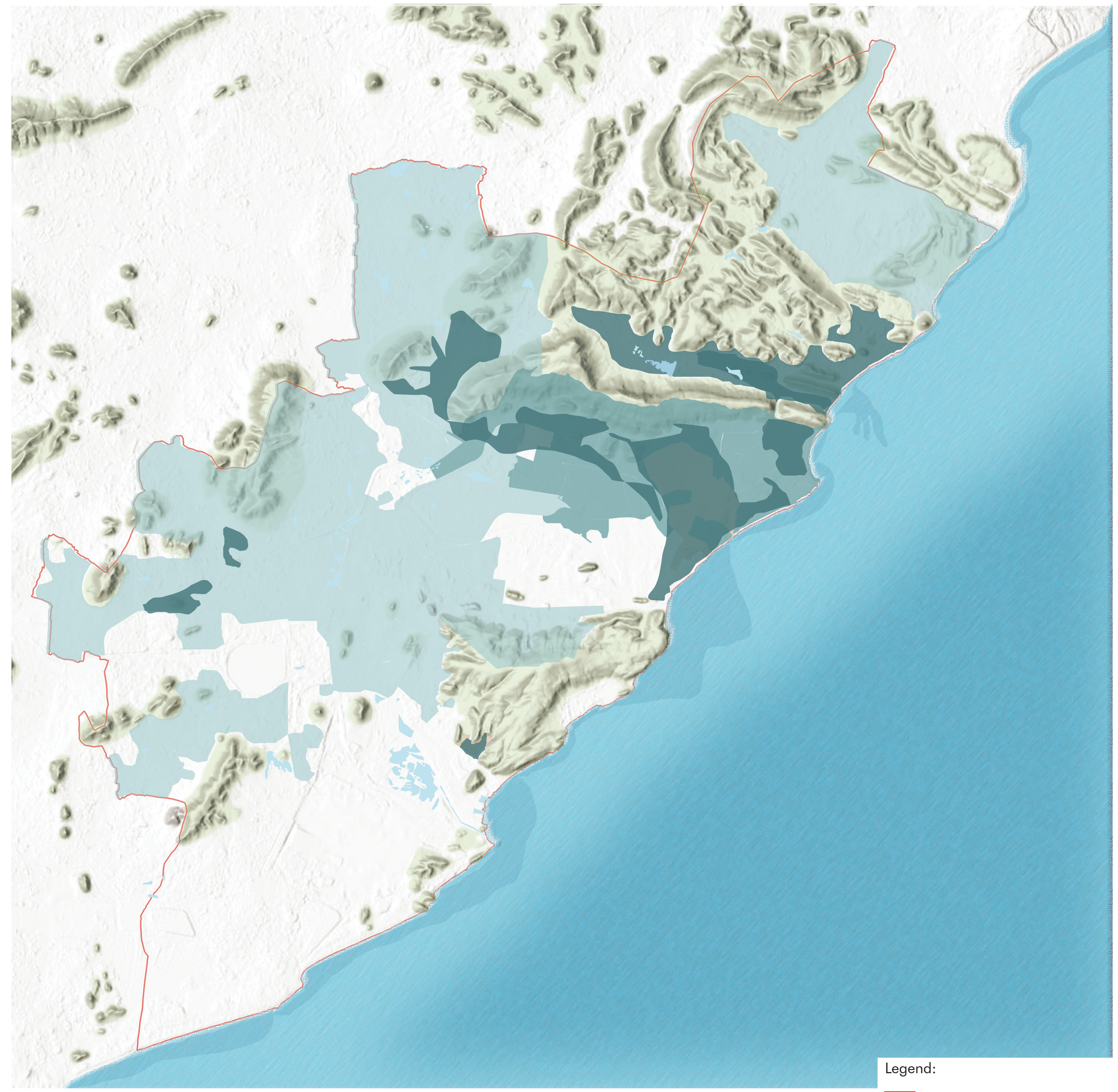


Fig 6.6 Map showing the sewage line connections in the city

The above map (Fig 6.6) shows the regions in the city that are connected to sewer lines and the regions that are under construction and the rest that are not connected to any STP. The STPs in the city are under capacity and only a fraction of water is treated before discharging into natural sources of water. The ULB proposes to increase the capacity of the existing STPs rather than opting for new low-cost water treatment systems. The wastewater from the region which is not connected to the grid releases the wastewater into natural streams of surface water through drains. The STP treats both the wastewater and stormwater runoff together.

Source:
https://www.gvmc.gov.in/wss/static_content/Water%20Supply.jsp
https://www.gvmc.gov.in/wss/image_uploads/pptwatermanagement.pdf

Identifying the two contrast cities

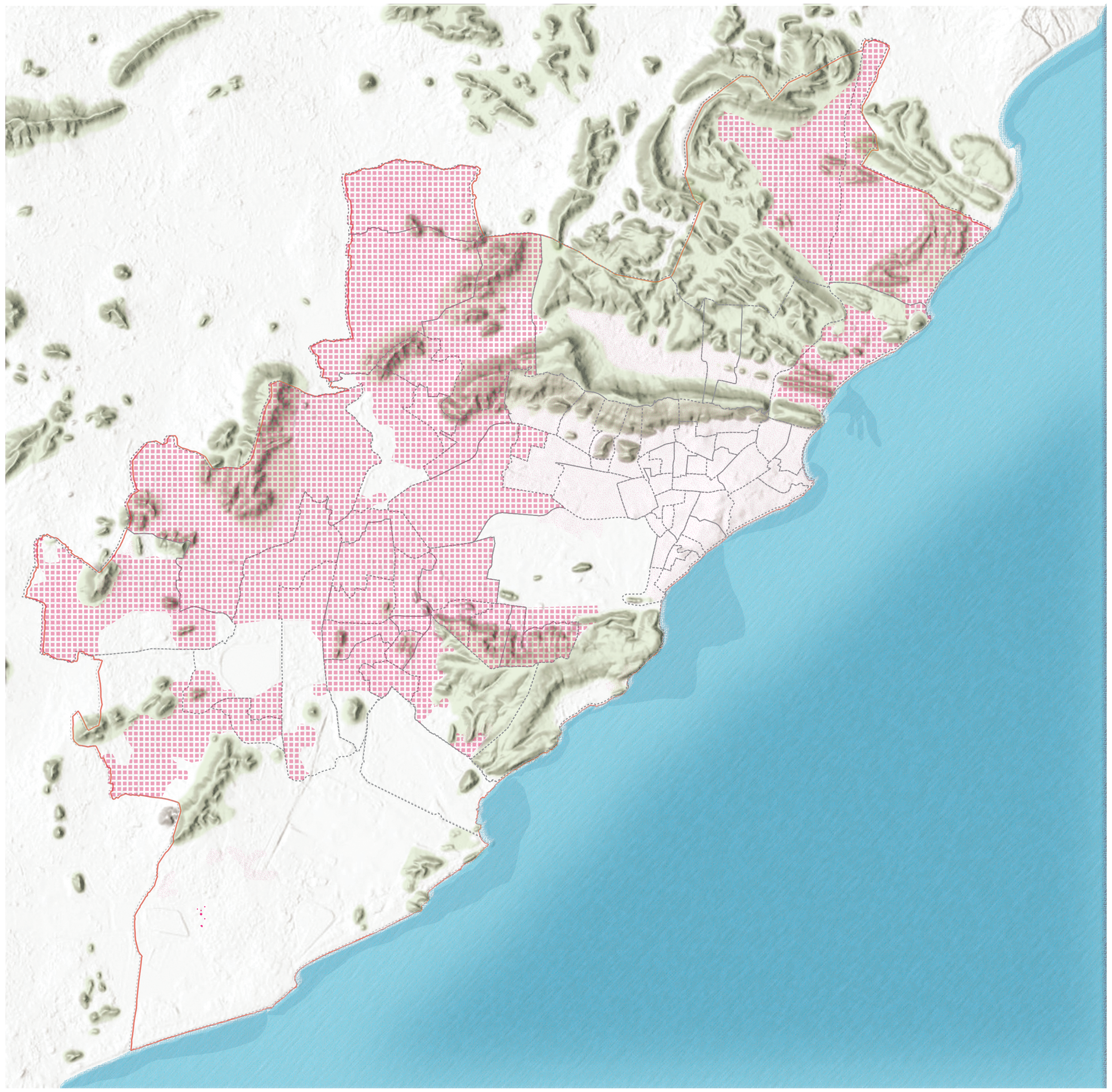


Fig 6.7 Vision map for water - Local city and Looping City

Legend:

Municipal Boundary

Loopping city

Local city

0 5km

Fig 6.7 shows the overlay map of drinking water and sewage treatment infrastructure present in the city. Local city and Looping city are identified based on their functionalities. The local city is the region which is not connected to any central grids in the city and will have decentralised solutions for both drinking water and sewage water treatment. While the looping city will bring circularity to the water flows with the linkage between the infrastructure of drinking water supply and wastewater treatment.

Local City & Looping City

Clusters of Local city and looping city

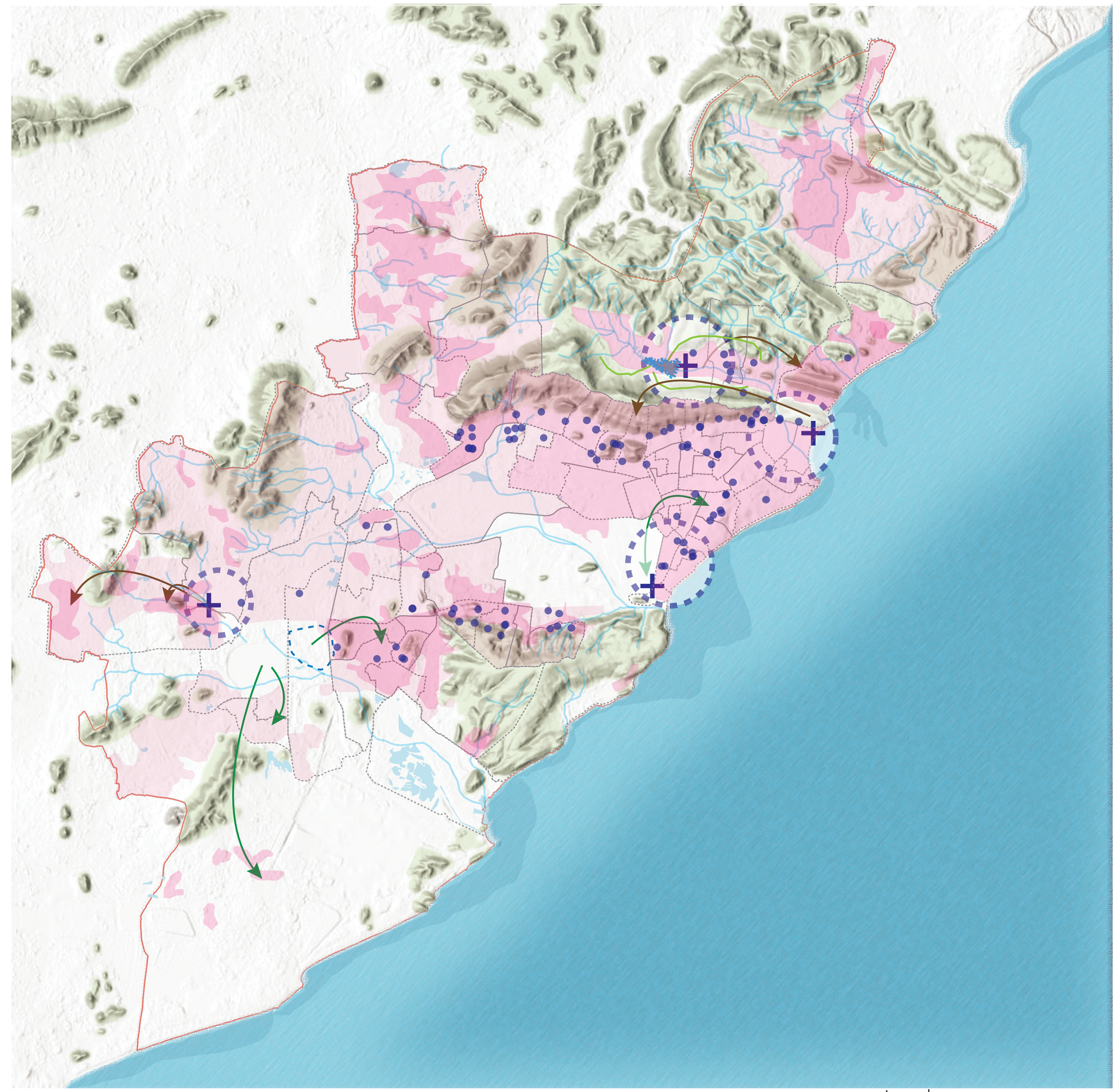


Fig 6.8 Map showing the clusters of looping city

Legend:

Municipal Boundary

Looping City

Local City

Revitalised water streams

Cluster of looping city

Fresh water supply

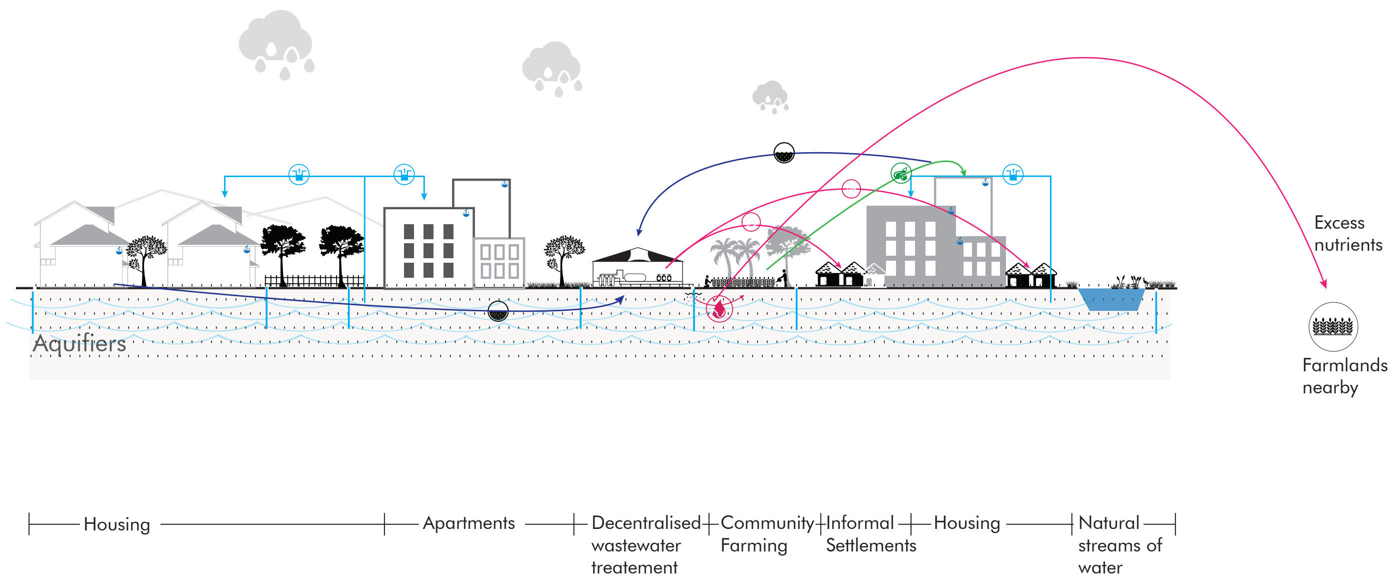
Treated water supply

0 5km

After identifying the two contrasting infrastructural facilities in the city, clusters of looping city are classified based on the availability of the existing infrastructure and the regions lacking the resource infrastructure are identified as local city as shown in Fig 6.8

Local City

Local city is the city which has its resources localised. This city focuses on building decentralised systems and the flows are in local scale



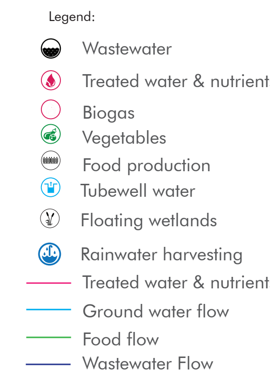
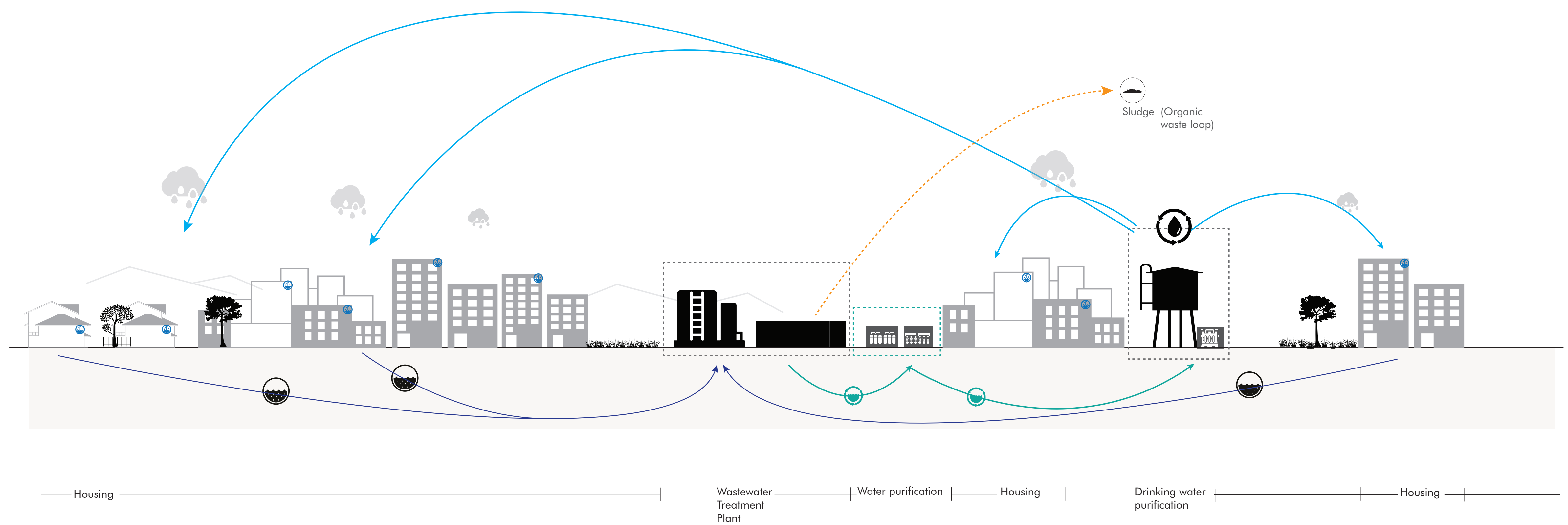


Fig 6.9 Systemic section of local city

Looping City

Looping city functions as a centralised system. The scale of the infrastructure is regional / national scale.



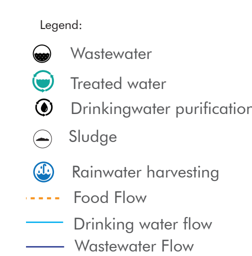
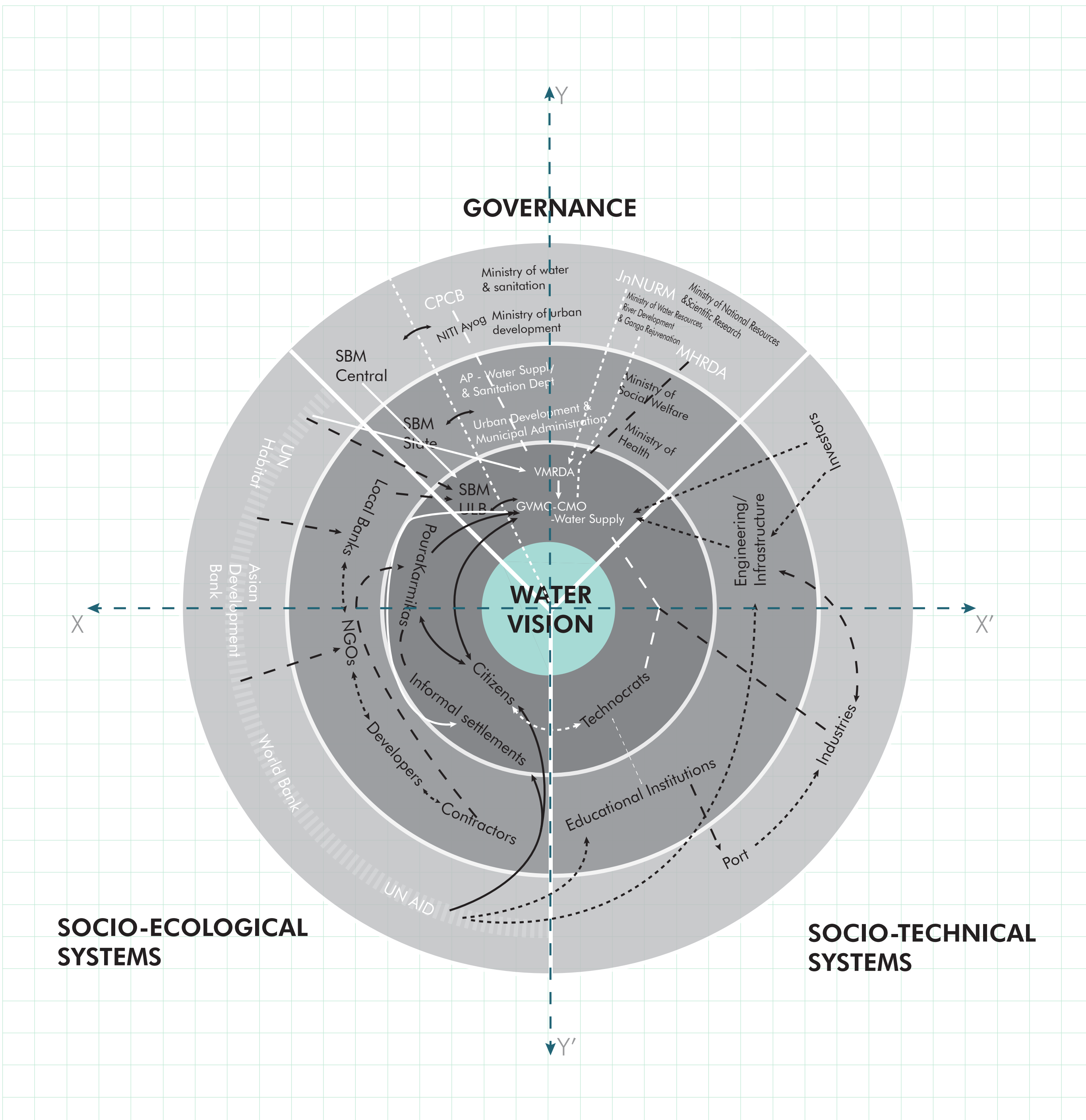


Fig 6.10 Systemic section of looping city

Stakeholder Integration



Legend:

- Macro scale
- Micro scale
- Micro scale

XX' Horizontal Integration - collaboration, coordination and the building of working relationships

YY' Vertical Integration - linkages between different tiers of government

- Strong Based on high frequency and high interdependence of resources
- Ad-hoc Low frequency and low interdependence (e.g. service provision or financing)
- Indirect Contextual relation (e.g. related to legal framework or public opinion)

Fig 6.11 Stakeholder diagram for water strategy

Actors are either considered as an individual person or as an authority or organisation which is actively involved in an urban development project. (Heurkens, 2012). Actors in this analysis are the ones who actively take part in developing the strategy or are the catalysts that help in linking or bringing changes. In order to understand the hierarchy and the interrelations between the actors, the stakeholder onion diagram (Alexander & Robertson, 2004; Czischke, 2016) is used. This diagram helps in categorising the different actors involved at different scales and their level of involvement. The three concentric circles indicate the level of involvement of the strategy which is centrally placed. According to Czischke (2016) - the three levels are:

1. Primary Stakeholders (Micro Scale)
2. Secondary Stakeholders (Meso Scale)
3. Wider Environment (Macro Scale)

In order to show a clear relationship between different systems in place, the onion diagram is integrated with the V-H integration framework for urban planning by Van der leer et al.,2018. The circles are divided into three sectors:

1. Governance
2. Socio-ecological systems
3. Socio-technical systems

In Fig 6.8, the sector of governance is also categorised in the hierarchy of current levels of system i.e., ULB and Regional development authority, State-level ministries, and Central/ National level ministries. Along with the development authorities and ministries, the Clean India Mission is also included at all the three levels to coordinate and act as a platform for resource management.

In the socio-ecological system, the primary stakeholders are the consumer/citizens, the workers employed in the current linear flows and the probable economic beneficiaries in a decentralized system such as people in the informal settlements. In the mesoscale, are the actors from NGOs providing or curating solutions and spreading awareness, the local banks providing loans for the economically weaker sections to install the systems and developers or contractors who have a prominent role in building infrastructure in the looping city. The global organisations listed in the macro scale are the entities that provide surveys, inputs for development and documentation after natural hazards to the ULB. These bodies can act as the knowledge providers from the global scale and try to bring awareness to the consumers.

The socio-technical system involves technocrats in the primary layer supported by the research provided by the educational institutions and start-ups with their technological innovations. In the macro scale are the larger scale industries and investors to develop the infrastructure for looping city.

The links between the actors and the systems across scales are divided by the intensity of relations.

i) Strong - high frequency and high interdependence of resources
ii) Ad-hoc - Low frequency and indirect interdependence (e.g. service provision or financing)
iii) Indirect Contextual relation (e.g. related to the legal framework or public opinion)

Food Strategy

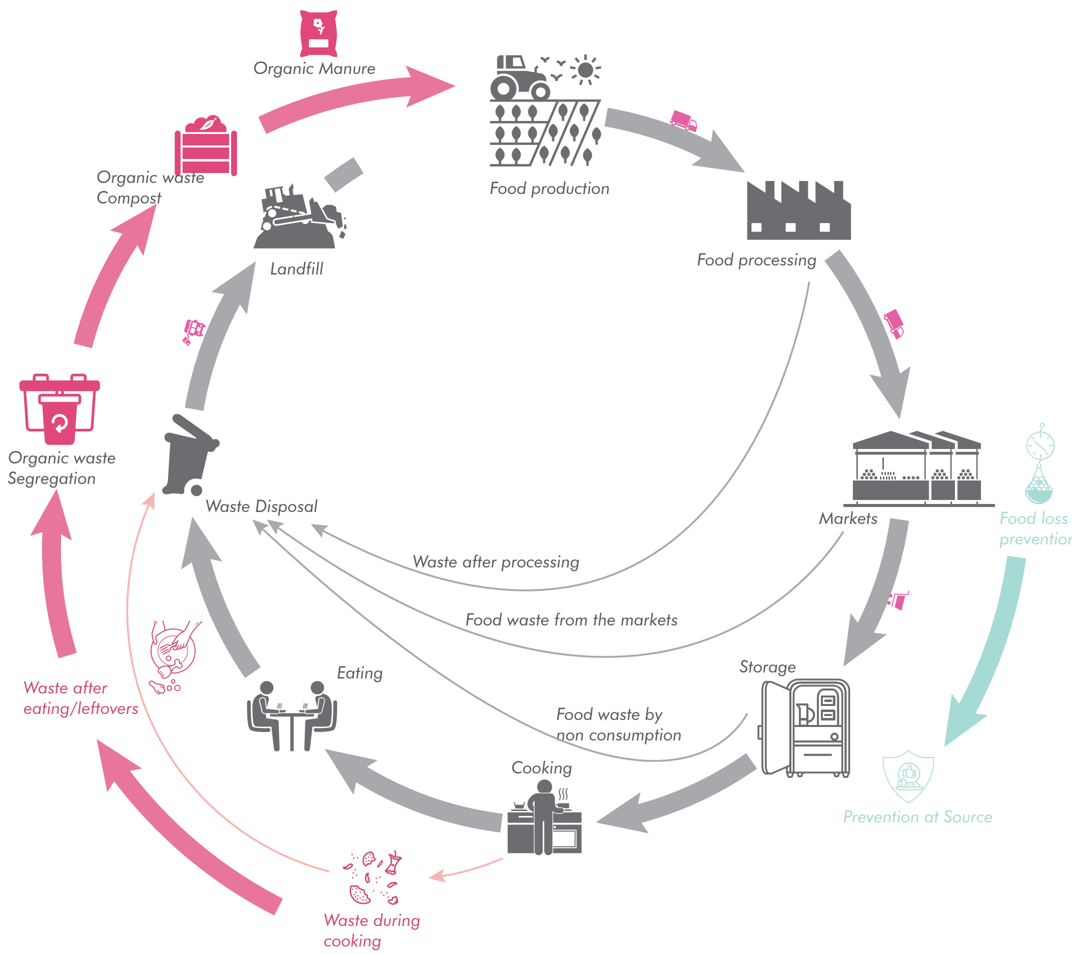


Fig 6.12 Stages of food waste generation and new strategy

Unlike the strategy for water, the food strategy focuses on reducing the waste generation along the cycle and reuse the waste generated in food production. As stated earlier in chapter 5; the majority of the food waste is produced during processing, trade, storage and consumption phase of the cycle. Fig 6.12 shows the current food cycle and how the waste generated at each step ends up in the landfill. Strategies are developed in order to reduce the waste during pre consumption phase and segregation and composting of the organic waste from the households in the post-consumption phase. Below are the strategies and measures to be followed in order to curb the waste generation.

Food loss prevention & Prevention at source

Shopping/Markets

Recovery or redistribution of safe & nutritious food for human consumption

Subsidised prices

- School feeding (Mid day meal scheme)
  https://en.wikipedia.org/wiki/Midday_Meal_Scheme
  Refer appendix for explanation of mid day meals
- Subsidy meals for workers below poverty line
  https://en.wikipedia.org/wiki/Amma_Unavagam
  Refer appendix for explanation of daily worker meals
- Lower price in the markets near informal settlements

Storing & Cooking

Responsible consumption practices by the consumers

- Awareness campaigns on the relation between food waste and environmental issues
- Tax charges for the waste produced
- Smart Technology updating on the food waste produced and storage capacities in the refridgirator
- Community engagement in food sharing
- food sharing apps
- weekly dinners

Eating

Responsible Food consumption and Change in Consumer attitude

- Change in consumer behaviour towards wasting food
- Paying for food waste at restaurants/hotels
- Education at schools about ngative impacts of food waste

Reuse and Recycle

Recycling the organic waste

- Segregation of organic waste at the source
- Guidelines for organic waste segregation and disposal
- Building codes/byblaws with specifications of spatial requirements for waste flows
- Policies and regulations for organic waste compost
- Organic compost sold at lower prices to the farmers
- Encourage new material loops with organic waste

Strategies developed to prevent food loss or waste prevention at source are developed for three stages of the food flow. They are:

i) Shopping/Markets
ii) Storing and cooking
iii) Eating

i) To prevent food loss or waste generation, the shopping markets need to adopt the policy of selling the near expiry food items at lower costs. These can be even sold to social welfare schemes such as "Mid day meals"and "Subsidy meals for economically weaker sections". The availabiility of near expiry food items is advertised using apps or media.

ii) The waste produced during storing and cooking can be prevented through awareness campaigns stating the relation between the waste generated and its impacts on the environment. Usage of smart technologies such as smart fridges, monitoring apps can help in reducing waste generation. A top down approach of levying taxes or fines on the amount of waste generation can also caution people not to waste the food. Community engagements such as sharing weekly dinners and communicating available food items through apps also help in waste prevention in this stage.

iii) Responsible food consumption requires change in consumer attitude and their eaating habits. This is established only through spreading awareness and educating people in schools, colleges and media. In restaurants and cafeterias this can be inculcated through a top down approach of rules for paying for the amount food wasted by the customer/ consumer.

In the final stage after consumption the food waste is segregated from rest of the domestic household waste and recycled. This stage requires policies and regulations for mandatory waste segregation and building codes and bylaws with recommendations for spatial requirements for waste flows. For developing community compost center, there is a requirement for guidelines for the procedure, spatial attributes and the composition and structure of the compost pit/center. The organic compost is sold to farmers at subsidised prices. Farmers incline towards synthetic fertilizers for high yield and subsidised prices. By providing the organic manure at lower costs and their, can reduce ripping the soil off of its nutrients.

Processing, Trade and Retail

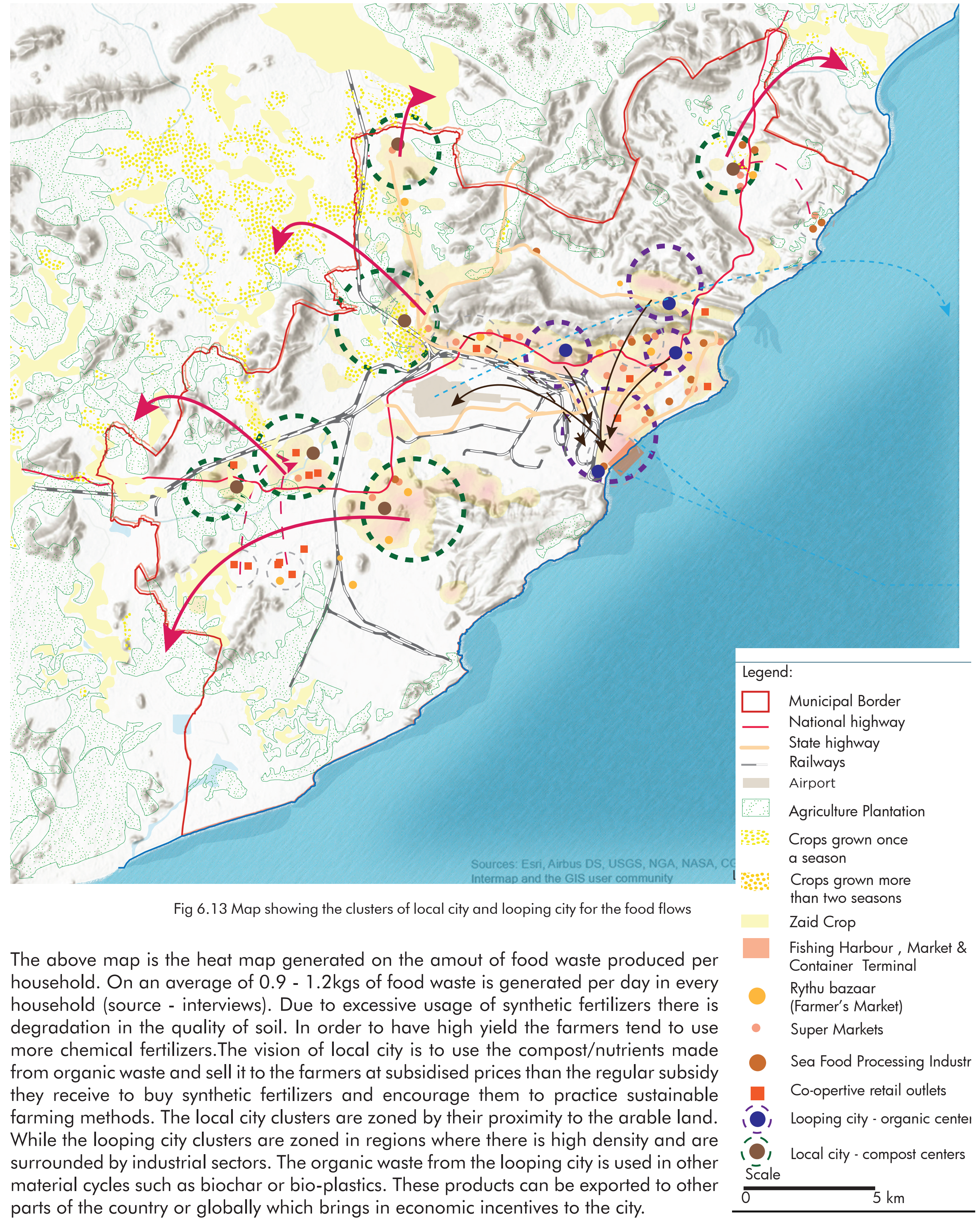


Fig 6.13 Map showing the clusters of local city and looping city for the food flows

The above map is the heat map generated on the amout of food waste produced per household. On an average of 0.9 - 1.2kgs of food waste is generated per day in every household (source - interviews). Due to excessive usage of synthetic fertilizers there is degradation in the quality of soil. In order to have high yield the farmers tend to use more chemical fertilizers.The vision of local city is to use the compost/nutrients made from organic waste and sell it to the farmers at subsidised prices than the regular subsidy they receive to buy synthetic fertilizers and encourage them to practice sustainable farming methods. The local city clusters are zoned by their proximity to the arable land. While the looping city clusters are zoned in regions where there is high density and are surrounded by industrial sectors. The organic waste from the looping city is used in other material cycles such as biochar or bio-plastics. These products can be exported to other parts of the country or globally which brings in economic incentives to the city.

Source:
Urban observatory Data - 2011

Local City

Fig 6.14 Systemic section of local city

Looping City

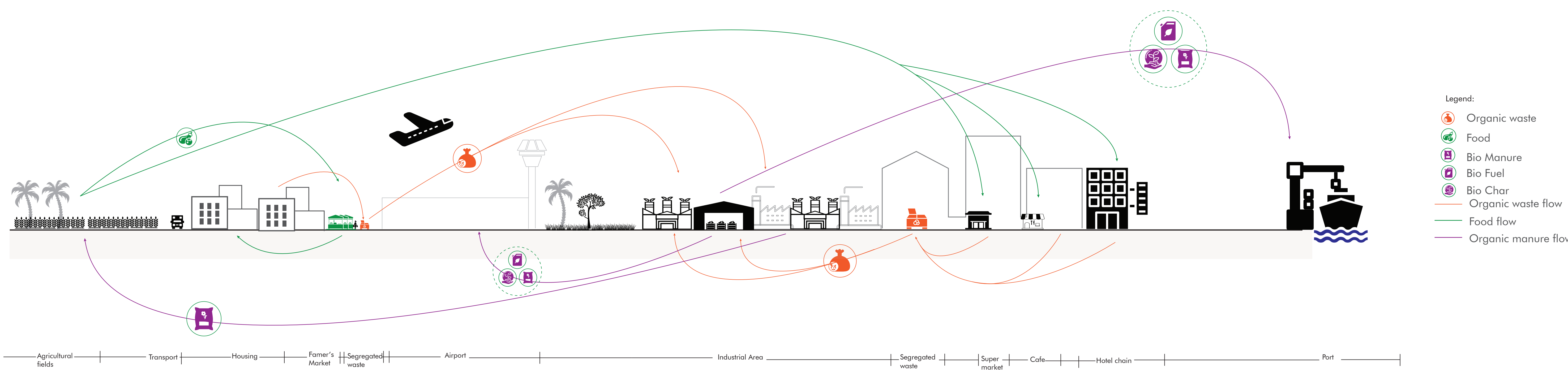


Fig 6.15 Systemic section of looping city

Stakeholder Integration

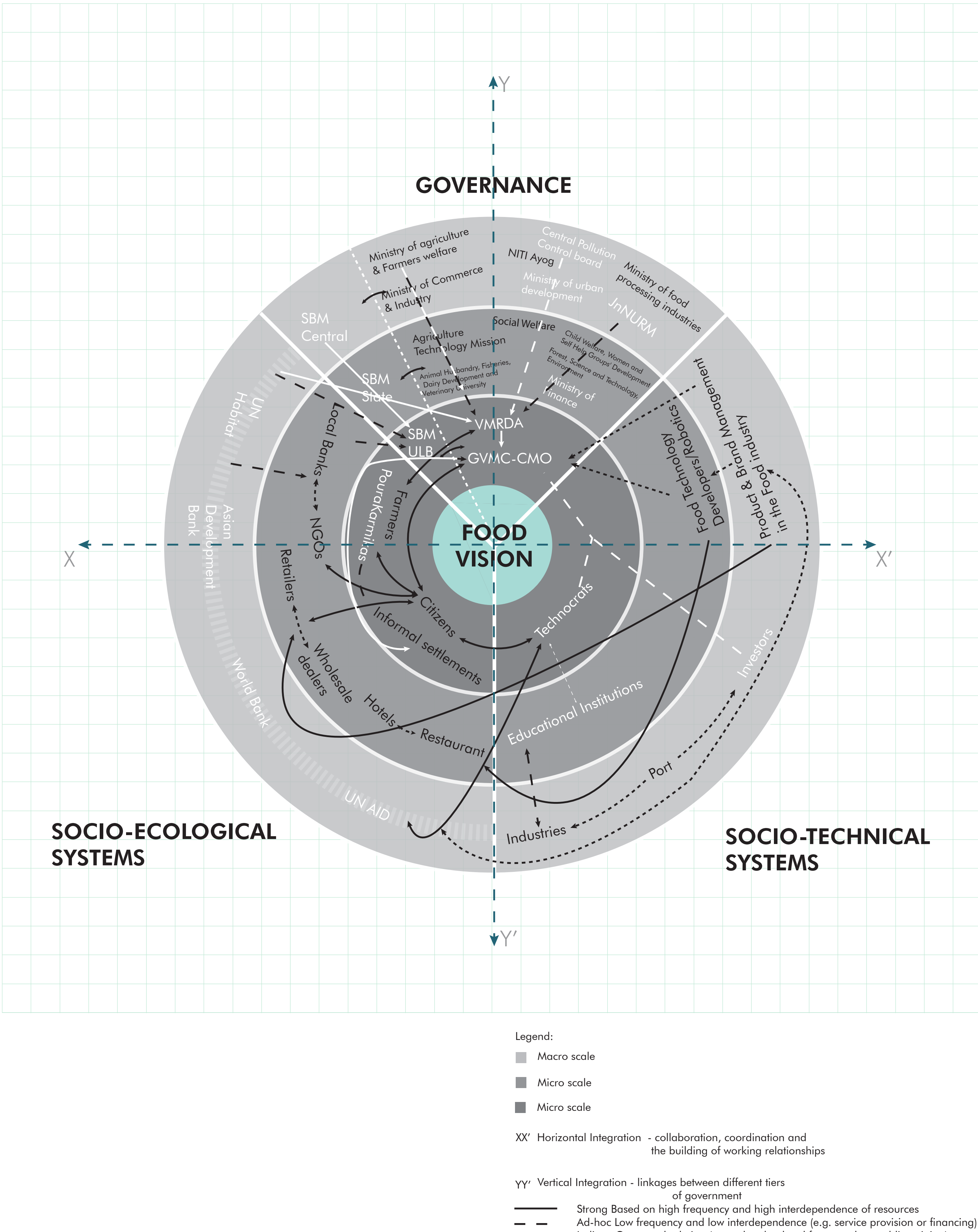


Fig 6.16 Stakeholder diagram for food strategy

The actor analysis for food flows is also developed in the integrated framework of stakeholder onion diagram and V-H integration.

In the Fig 6.18; the sector of governance is also categorised in the hierarchy of current levels of the system i.e., ULB and Regional development authority, State level, and Central/ National level ministries for food production, agricultural and forest, environmental welfare. The Clean India Mission works as a platform coordinating across all sectors and scales.

In the socio-ecological system, the primary stakeholders are the consumer/citizens, the workers, and contractors carrying out the services of waste management, farmers, vegetable vendors and the probable economic beneficiaries such as people in the informal settlements or beneficiaries of social welfare schemes involved in the strategies. In the mesoscale, the primary stakeholders are the larger chain of organic waste generation such as retail or wholesale food dealers, hotels and restaurant chains, and the NGOs providing or curating solutions and spreading awareness. The global organizations listed in the macro scale are the entities that provide surveys, inputs for development and documentation after natural hazards to the ULB. These bodies can act as the knowledge providers from the global scale and try to bring awareness to the consumers.

The socio-technical system involves technocrats in the primary layer supported by the research provided by the educational institutions and start-ups with their technological innovations. Private food research groups, independent organizations working towards sustainable food productions, small scale industries developing new material cycles with organic waste are placed in the meso and macro scales. These actors with their experiments in the field provide guidance to the ULB and collaborate with the citizens and other actors in the mesoscale.

Systemic Goals

In order to achieve the goals, as mentioned earlier there has to be participation across different scales and the role each actor plays to implement the goal is explained in the form of a systemic goals diagram. The following diagrams are made for rainwater harvesting, decentralised wastewater treatment systems and food waste prevention system. Rainwater harvesting and decentralised wastewater treatment are a part of the local city. Food waste prevention policies are part of both local city and looping city.

The systemic goals are developed on an recurring loop of inputs provided by top down approach of governance, consumer behavior and response and the availability of advanced technologies. The first step starts with policy recommendations/regulations from the Macro scale of governance towards the meso and micro scale of governance, and then on the micro scale, the consumers or local actors implementing them. Followed by the inputs from the technology feeding in as knowledge to the levels of governance and simultaneously implemented by the consumers. The response from the consumers/ local actors is taken into consideration and recommended changes are made by the governance. The upgradation of the implemented rules/regulations is proposed to be done periodically.

The different actors/sectors of governance and their relation across different scales is identified in all the three systemic goals. The levels of the technology support and consumers/local actors is listed out in the stakeholder integration diagram Fig 6.11 and 6.16

Systemic Goals - Rainwater Harvesting

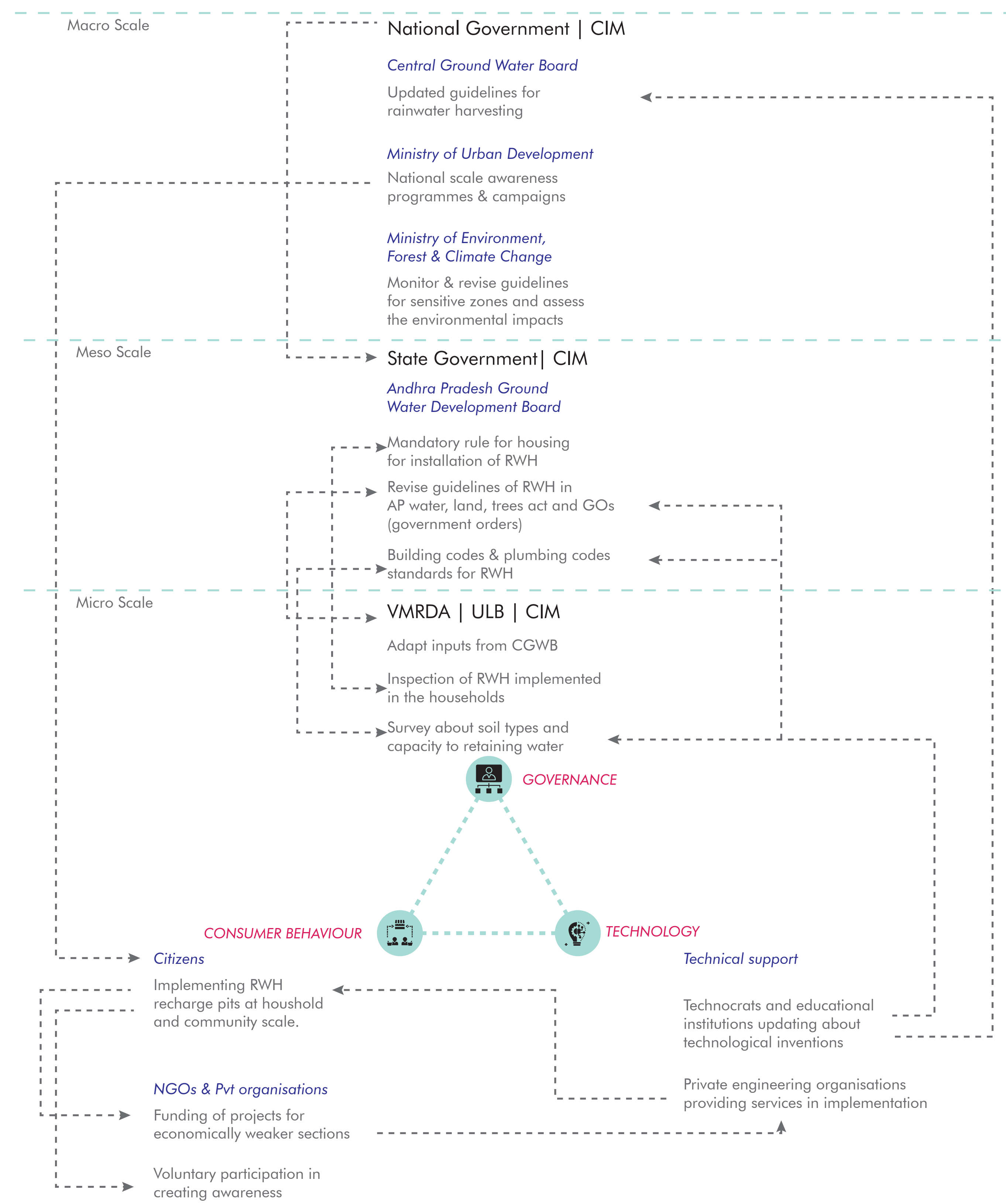


Fig 6.17 Systemic goals diagram for implementing rain water harvesting

Systemic Goals - decentralised wastewater treatment

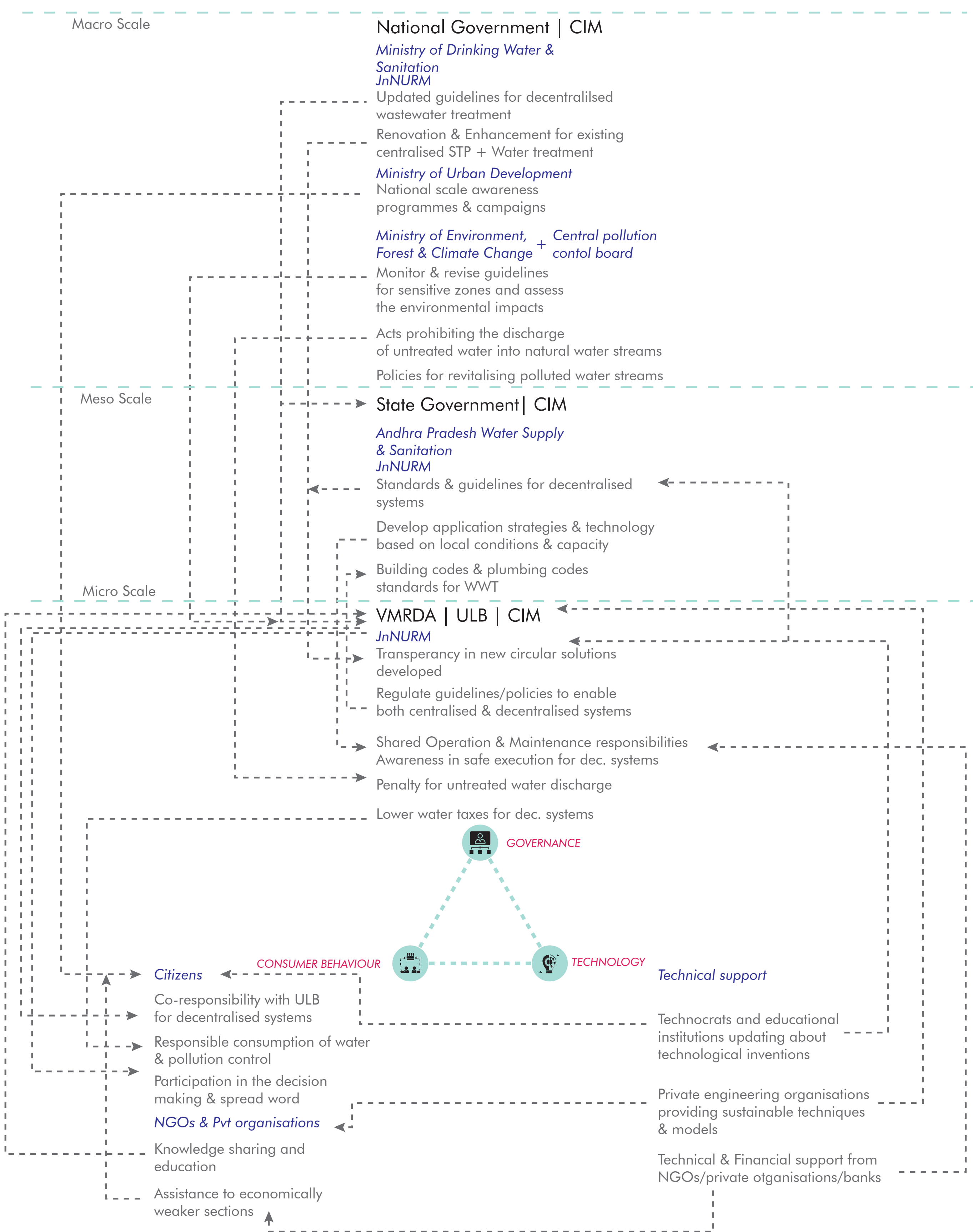


Fig 6.18 Systemic goals diagram for implementing decentralised wastewater treatment systems

Systemic Goals - food waste prevention

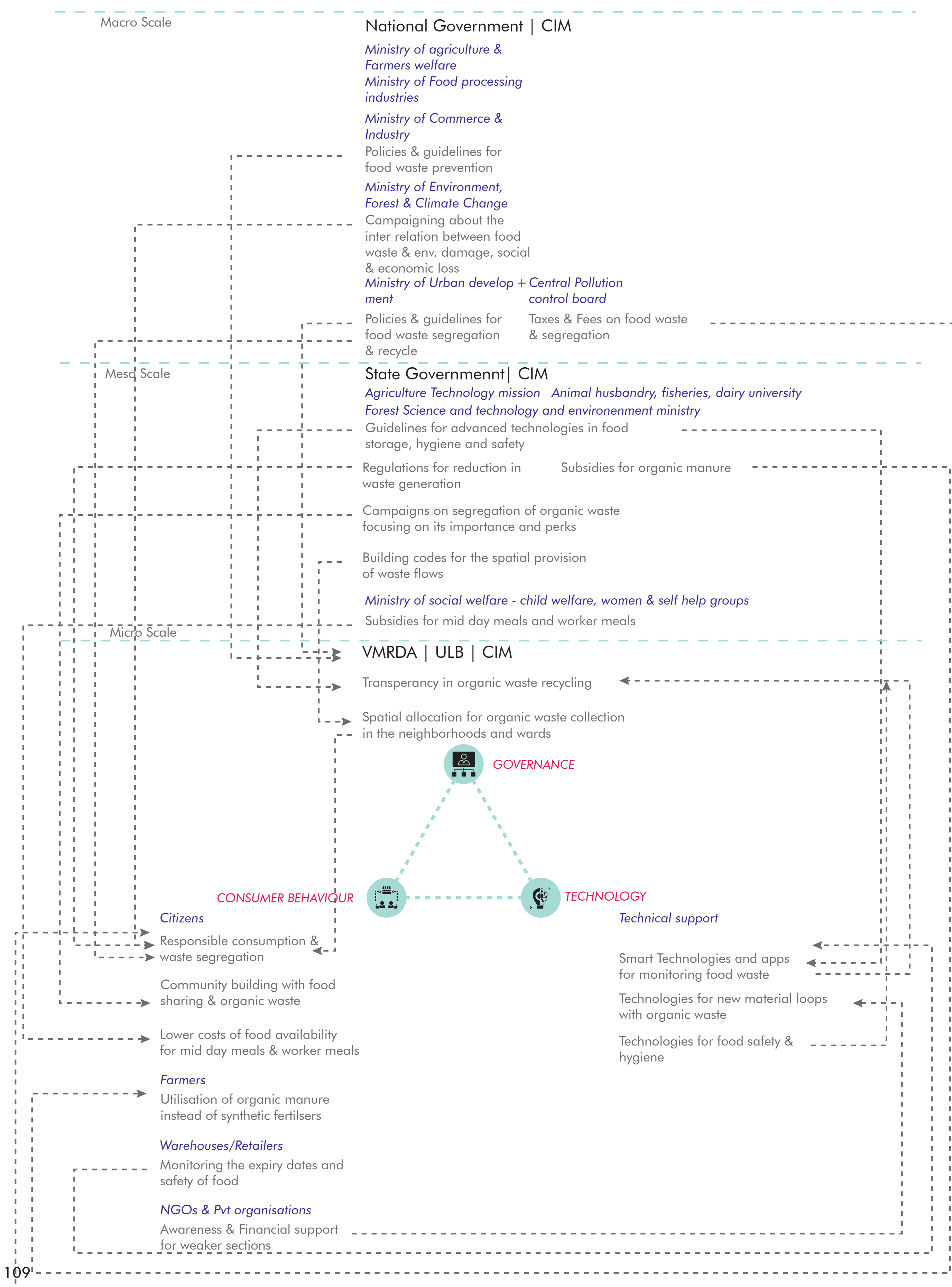


Fig 6.19 Systemic goals diagram for implementing food waste prevention


Source: Author

7

RESOURCE DESIGN

Building possible solutions to the challenges of problematic zone

This chapter discusses the solutions proposed to two chosen pilot projects. The pilot projects are chosen on the basis of highest level of intensity of environmental damages in the problematic zones.

Source: Author

Source: Author

Pilot Projects

The following table discusses the challenges faced in each location, the part of city they belong to, tipping points, systems and scopes, barriers and importance of their role in city scale

Looping City: *Lavender Canal*

Problem:

With the discharge of both treated and untreated water in into the canal, dumping of solid waste into it and the industrial pollutants, the canal is being polluted. It is acting as a medium to carry the pollution into the sea which is effecting the marine life.

Tipping Point:

The canal is carrying pollution into the ocean that is showing negative impacts on the marine life and the fisherman who are dependant on it for their livelihood.

System scope:

- Looping city
- Availability of labour - chance to improve the socio-economic conditions of the loaction

Barrier:

Exposure to pollution as it is located next to the port and the canal is connected to the inner harbour.

Prone to floods and tsunami

Role in the city:

Earlier the canal was part of the port carrying vessels into the sea. After the construction of creek, treated wastewater from the STP is discharged into the canal. The canal is now abandoned and soars in pollution coming from STP and Port.

Local city: *Sagar Nagar*

Problem:

Lack of facilities or connection to the sewer network and openly discharging the wastewater into the ocean has resulted in degradation of the shore and the pollution is causing loss of marine life.

Tipping Point:

Coastal sand erosion and loss of marine life

System scope:

- Local city

Barrier:

Eco-sensitive zone

Role in the city:

The shore of this location is the nesting ground for olive ridley turtles. It is a part of tourist attractions in the city. Though the shore has eroded and the water quality is poor in the sea, it is still an active tourist spot.

Both the locations, looping city and the local city face challenges due to improper treatment of wastewater. And the organic waste that is generated is being ended up in the landfill causing leachate formation and releasing methane gas when combined with other toxic substances. The solutions for these flows are proposed from reference studies which are successful in implementation of eco-innovative solutions. The following section, gives a brief overview of the reference studies facing similar challenges and what are the measures taken in terms of governance, consumer behavior and technology.

Reference Study

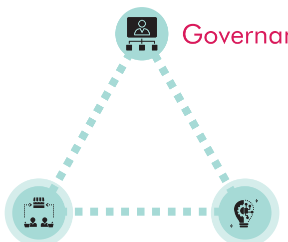
A) Water Flows

1.

Location: Hyderabad, India

Challenges: Polluted lake due to sewage water discharge

Principles: Refurbish - Biological and Chemical



NGO lead initiative

Floating wetland system made of recyclable/reusable materials such as bamboo and recycled plastics with 3500 saplings of wetland plants, mosquito repellants and ornamental plants that can absorb high levels of phosphorus and nitrogen in the sewage water entering the lake and followed by oxygen aeration

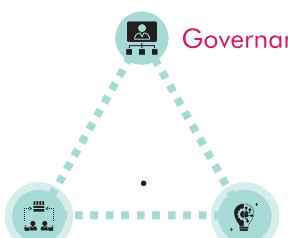
Conclusion: The reference study deals with a similar case of polluted surface water due to discharge of wastewater. The issue is resolved by a bottom up strategy led by an NGO with the technology provided by local research institutes. Later the surroundings of the space is transformed into a park creating a public space, adding a functional value.

2.

Location: Bangalore, India

Challenges: Polluted lake due to industrial and sewage water discharge

Principles: Refurbish - Nano Technology



NGO and technocrats lead innovation

Feed a mixture of nutrients to diatoms- the most basic, single cell life form found in ponds, lakes, canals, rivers and oceans; as the algae formed by diatoms grow and they release oxygen in water. Oxygen released helps aerobic bacteria efficiently breakdown the organic matter and convert pollutants to base constituents. The diatoms are eaten by zooplanktons which are further eaten by fish

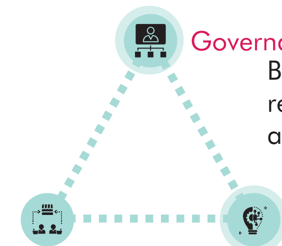
Conclusion: The reference study deals with a problem of polluted surface water due to industrial discharge of wastewater. The issue is resolved by a bottom up strategy led by a technocrat with the help of an NGO and few students. Lower levels of pollution are recorded in the first three weeks. The quality of water has improved but the lake still battles the issue of discharge of polluted water.

3.

Location: Chennai, India

Challenges: Water Scarcity

Principles: Reuse; Recycle - Physical and Chemical



Bylaws and Regulations by urban local body to promote reuse of water and engaging both private and gov. sector agencies.

Only water from toilets is connected to sewer network and post treatment at STP used for industrial purposes while the rest should be used for ground water recharge after simple organic filtration

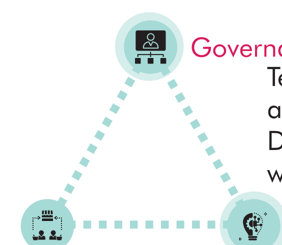
Conclusion: The reference study deals with an issue of water scarcity. With the steps of recycling wastewater, the water is reused for industrial purposes. However, this solution did not cater to the issues of domestic water scarcityand even today the city is facing challenges. The reason behind this is lack of planning for the resources in advance for the growing city.

4.

Location: Singapore

Challenges: Water Scarcity

Principles: Reuse; Recycle - Mechanical and Chemical



Terming wastewater as used water and sewage treatment as water reclamation. Transperancy in data and process. Decrease per capita water consumption and exemption of water conservation tax in tariifs for new water.

Public awareness through advertisements and education in schools

Microfiltration
Reverse Osmosis
UV disenfiction

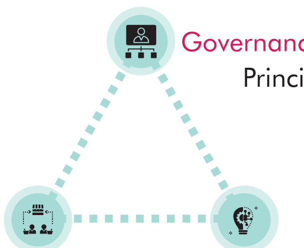
Conclusion: The reference study deals with an issue of water scarcity. The solutions followed here tried to integrate all the three systems by developing policies and regulations which encourage consumers and also bringing awareness in them, followed by centralised infrastructural systems

5.

Location: Nambia

Challenges: Water scarcity

Principles: Reuse, recycle - Mechanical and Chemical



Governance

Principles and bylaws to protect and conserve source water

Consumer Behavior

Creating awareness through education at schools

Technology

Multi barrier approach:
Source Water Protection
Robust water treatment
Water supply network
Monitoring programme

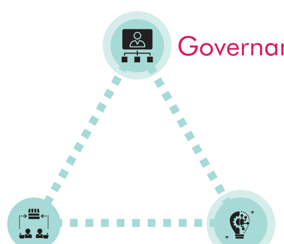
Conclusion: The reference study deals with the issues of availability of water. The solutions provided are both top-down and bottom-up strategies. It has provided principles and guidelines to conserve water and encouraged consumers to reuse water and awareness through education at schools. And the technologies followed are not advanced but they focus on resolving the issues from source to the sink

6.

Location: California

Challenges: Depleting groundwater levels

Principles: Reuse, recycle - Biological, Mechanical and Chemical



Governance

Consumer Behavior

Technology

Pre - Treatment conventional techniques followed by Microfiltration,
Reverse Osmosis
UV light and h2o2 disenfection
pumped to county's aquifiers for another level of filtration

Rainwater harvesting at the households
- Soil
- Ferrocement Tanks
- Plastic Tanks

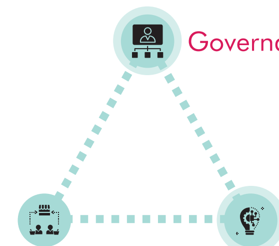
Conclusion: The reference study deals with the issues of depleting underground water levels. The steps taken were top down approach in upgrading the infrastructure. However, the risk of releasing untreated water into the aquifiers and polluting the soil is high in this case study. Rainwater harvesting is encouraged at the houshold scale.

7.

Location: Kathmandu, Nepal

Challenges: Water Scarcity

Principles: DEWATS - physical and chemical



Governance

Consumer Behavior

Technology

Primary treatment at households
- sedimentation and floatation
Secondary Treatment
- Hybrid Constructed wetlands
Horizontal and vertical flows

Conclusion: The reference study resolved the issue of water scarcity by adapting decentralised wastewater treatment system in a top-down approach. The technologies implemented could easily embed in the existing landscape, interweaving the service facilities and ecological systems.

7.

Location: China

Challenges: Water Scarcity

Principles: DEWATS - physical and chemical

Governance

Government policies encouraged growth of wastewater reclamation facilities and mandatory upgradation of wastewater treatment plants to wastewater reclamation plants

Consumer Behavior

Technology

Updated the previous mechanical/biological treatment by providing a new membrane bioreactor system.
And a nutrient removal technology comprising simultaneous nitrification and denitrification

Conclusion: The Chinese approach of implementing circular solutions is a top-down approach. The mandatory regulations have led to the upgradation of all the sewage treatment plants and technologies provided by the researchers is taken into consideration.

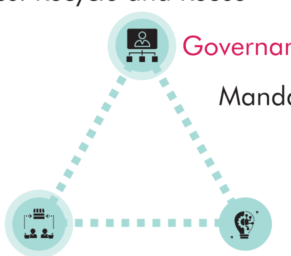
Reference Study

A) Food Flows

1.

Location: Ljublajana, SLovenia

Principles: Recycle and Reuse



Governance

Mandatory rule of segregation of waste.

Consumer Behavior

Technology

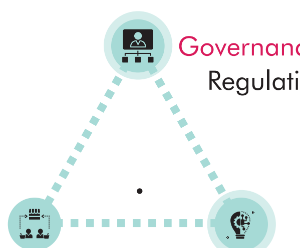
Community based compost of organic waste to grow plants - promoting local food consumption and self sufficiency

Conclusion: The reference study focuses on developing local based organic farming and aim for self - sufficiency of resources. The approach from governance is only on segregation of waste and not on prevention and inorder to achieve self sufficiency, there is no mention of advanced techonological systems that helps in achieving the goals.

2.

Location: Phoenix, USA

Principles: Reuse and recycle



Governance

Regulations for segregation of waste

Consumer Behavior

Technology

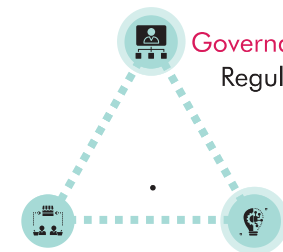
Curbside green organics programmes, development of compost facility for 110,000 tonnnes / year.

Conclusion: In this study, the segregated waste is collected and brought to a common compost facility. Even in this case, the solution is based only on two principles of reuse and recycle.

3.

Location: Toronto, Canada

Principles: Recycle and recover



Governance

Regulations for segregation of waste

Consumer Behavior

Technology

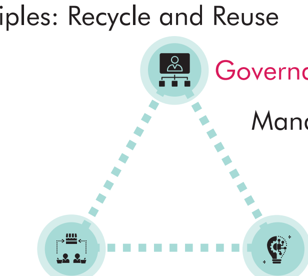
Biofuel for waste collection fleet
- Organic household waste is anaerobically digested and provide to local natural gas distributor

Conclusion: In this study, the segregated waste is recycled into bio-fuel and used as fuel for waste collection fleet. This case study reflects on looping the resources on a local scale. However, recovering fuel from the waste is the final stage in the circular principles.

3.

Location: Stockholm, Sweden

Principles: Recycle and Reuse



Governance

Mandatory rule of segregation of waste.

Consumer Behavior

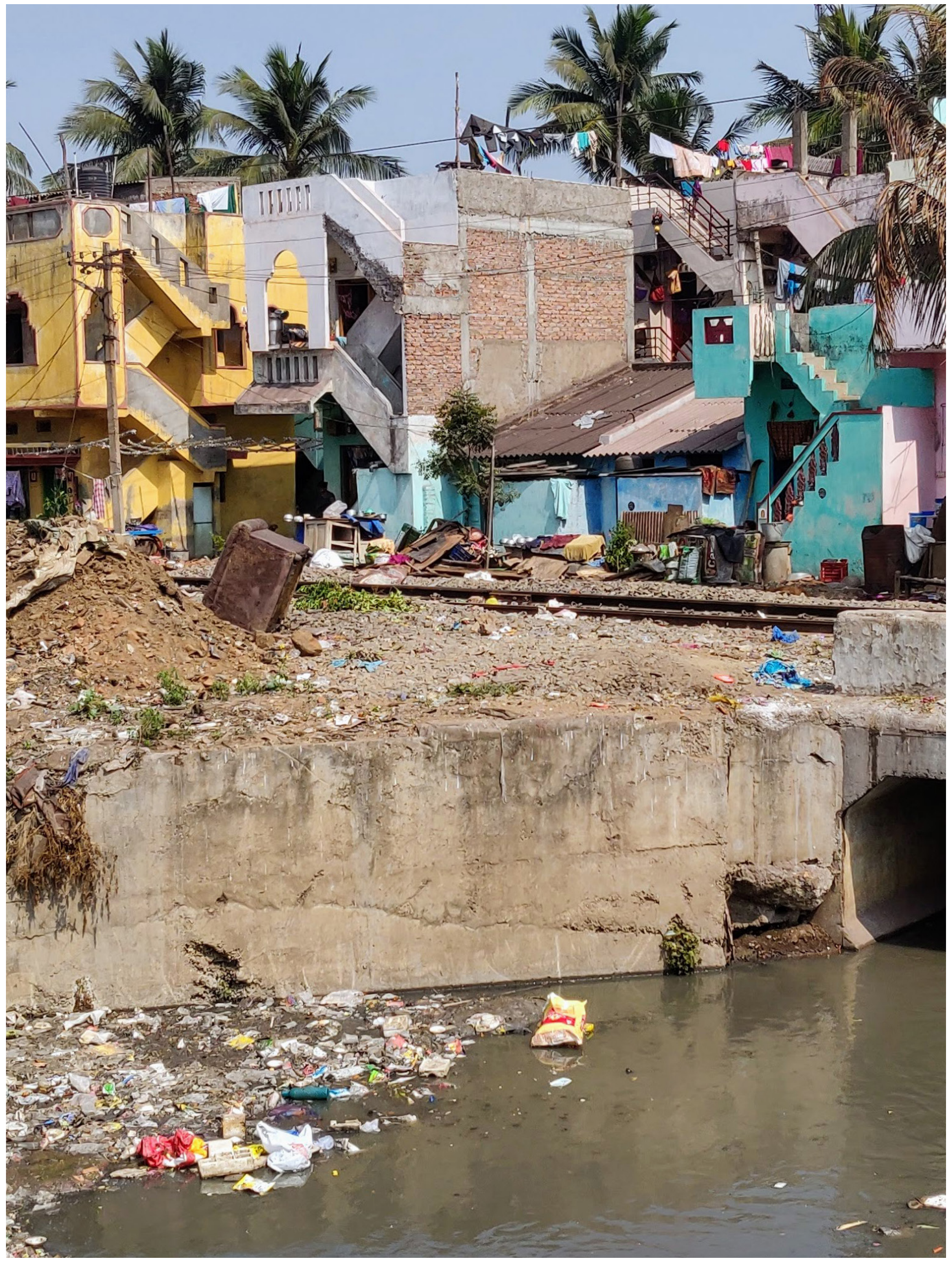
Technology

Creating awareness through education at schools

A charcoal like product that can sequester carbon in soil for thousands of years - used as soil conditioner in public and private beds. Byproduct - pyrolysis gas is used to help generate energy for city's district heating system.
Pilot plant processes 1200 tonnes of organic waste/year

Conclusion: The reference study focuses on all the three - governance, bringing awareness in consumer behavior and eco-innovative solutions where the byproducts are fed into different material loops.

The reference studies have not only helped this project in finding eco-innovative solutions but also understanding the gaps and loop holes in each case that can be avoided by proposing an integrated solution. The case of Nambia, addressed the entire loop of source to sink and implemented a holistic approach; while the case of Stockholm in food cycle used the byproducts in different material loops which can replace natural resources. In the case studies of Singapore and Nepal, the resource flows are integrated with the existing landscape and added functional value to the space. In this way, it not only resolves the issue of resources but also shows social impact. The probable solutions for the pilot cases in the city of Visakhapatnam, will aim at integration of all the three aspects in the proposals and add functional value to the spaces of the secondary resource flows which reflects not only on the environment but also on society and economy.



Looping City - Lavender Canal

Fig 7.1, shows the flows involved in the chosen location. The location as shown in fig 7.2, is located along the coastline surrounded by the fishing harbour, port and industries. The STP and MSW temporary storage site in this location release the waste through canals into the ocean. It is vulnerable to environmental risks, has poorer soil and underground water quality and poor quality of life. Figures 7.3 is the schematic section of intervention site in the zone giving an overview of the land use and existing conditions. Section 7.4 shows the actors involved in this location

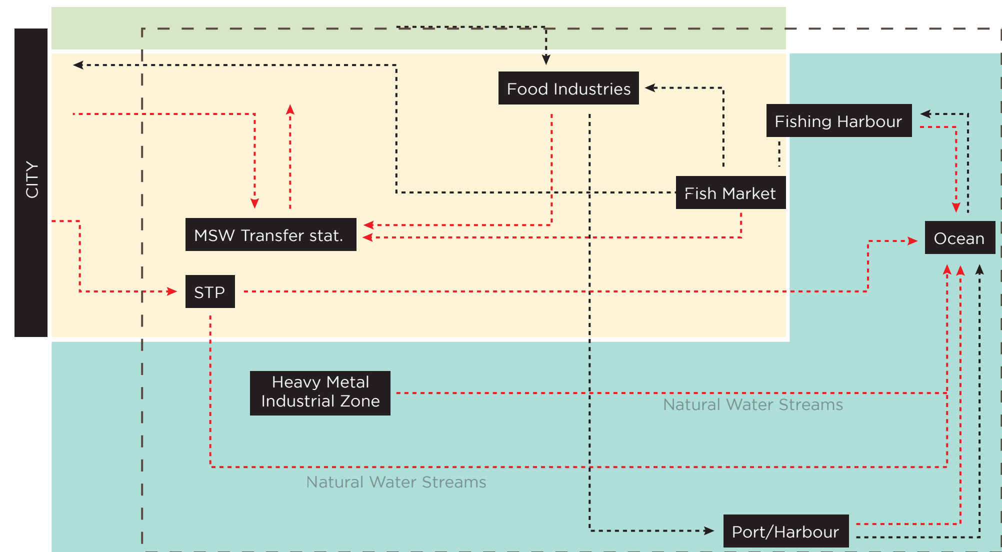


Fig 7.1 Schematic diagram of flows in the region

Fig 7.2 Map of Location 1

Source: Google Earth

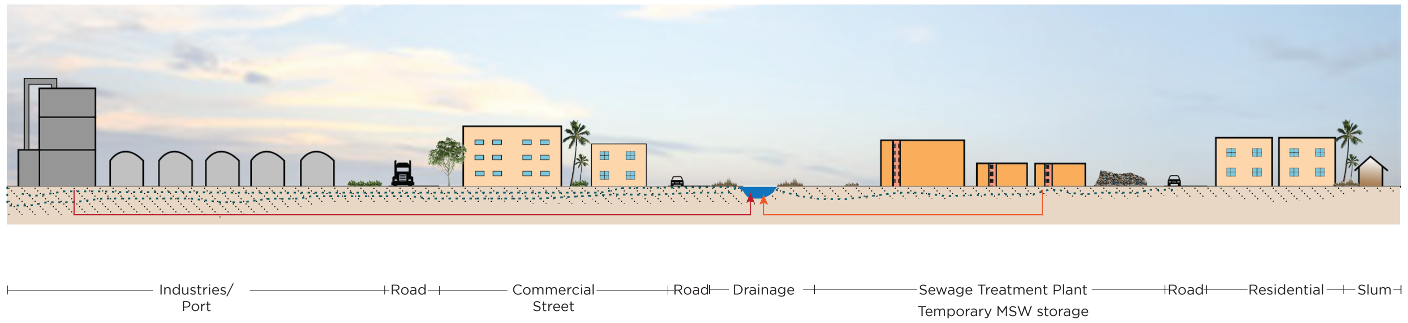


Fig 7.3 Systemic section of location A

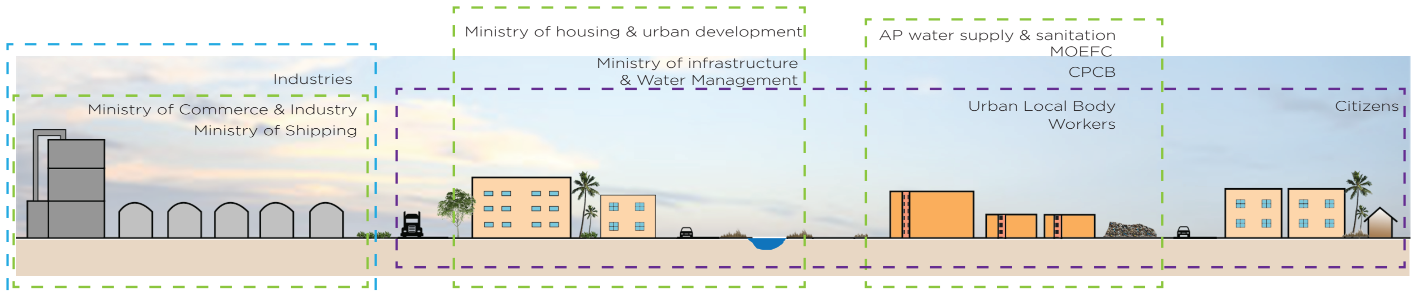


Fig 7.4 Actors involved in location A

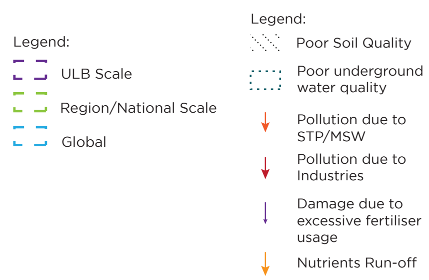


Fig 7.5 Open sewage drain in the location

Fig 7.6 Informal settlements in the location

Fig 7.7 STP in the location

Fig 7.8 Neighborhoods in the location

Fig 7.9 Polluted lavender canal in the location

The images above show the current situation of the location and the level canal water pollution

Fig 7.10 Map showing the existing landuse of the location

Fig 7.11 Master plan of the location for the year 2021

Fig 7.10 showcases the currrent landuse of the location. The location is dense with residential area on one side and port on the other end. The canal acts as a barrier between these two land use typologies. The green corridor along the canal is an unused open space. This green corridor along the canal connectes a historic and tourist site. The green corridor is surrounded with low income group housing, informal settlements and commercial buildings.

Fig 7.11 showcases the master plan of the location made for the year of 2021. The location is viewed as a combination of residential and industrial blocks. This indicates more demand for resources and generation of waste. There are no activities allocated to the green corridor nor for the canal.

Fig 7.12 Map showing the vulnerability of the location

Fig 7.13 Map showing the locations of intervention in the zone

Fig 7.12 shows the vulnerability of the location to natural calamities. The location lies under the coastal regulation zone and is susceptible to flooding due to Tsunami or storm water surge. The proposals made in the vulnerable areas need to be of low cost infrastructure to avoid loss of huge infrastructural investment.

Fig 7.13 shows the two locations along the canal that are chosen as locations of intervetion. Location 1 is the region which has the outlet pipe from STP which has higher conentration of contaminants and location 2 is surrounded by informal settlements with poor living quality and vulnerable to the aforementioned issues.

The proposals for this location involve recommendations in the governance with Policies and Guidelines, and change needed in consumer behaviour and the enhancement of existing STP and connecting to the drinking water system. The polluted canal will be rehabilitated into a productive recreational zone and acts as a buffer zone between the port area and settlements.

GOVERNANCE

Policies & Guidelines

- Prohibition of discharge of waste water into the canals/ natural water sources.
- Storage of stormwater runoff at household and community scale and aquifiers recharging the groundwater levels
- Only water from the toilets be connected to the sewer network and the kitchen water be treated at the community scale
- Provision of tax rebates for using recycled water
- Zoning the canal belt under public/recreational zone in the master plan
- Mandatory organic waste segregation including informal settlements
- Building bylaws and regulations for accomodating waste flows and their segregation
- Regularisation of the small scale organic farming and aquaponics of the informal setllements post the regularisation of their houses.

CONSUMER BEHAVIOR

Education & Awareness, Consumer Attitude

- Public awareness and education by demonstration of sustainable practices led by NGOs, educational institutions, technocrats and other local actors.
- Lowering the consumption of water from natural sources and using recycled water.
- Responsible consumption of food and prevention of waste in pre consumption phase

TECHNOLOGY

Upgradation of iinfrastructure

The current process of treatment involves only filtration and chlorination of wastewater. The sewage treatment plant lacks functioning laboratories and constructed to the capacities for three decades ago. This thesis recommends upgradation of the STP with the capacity estimation of increasing population. And proposes additional steps of purification in order to reuse the water. Following fig 7.14 shows the proposed steps of filtration such as
i) microfiltration,
ii) RO purification and
iii) UV radiation.
Treated water from the STP is further purified in the water treatment unit and pumped to over head tank for distribution.

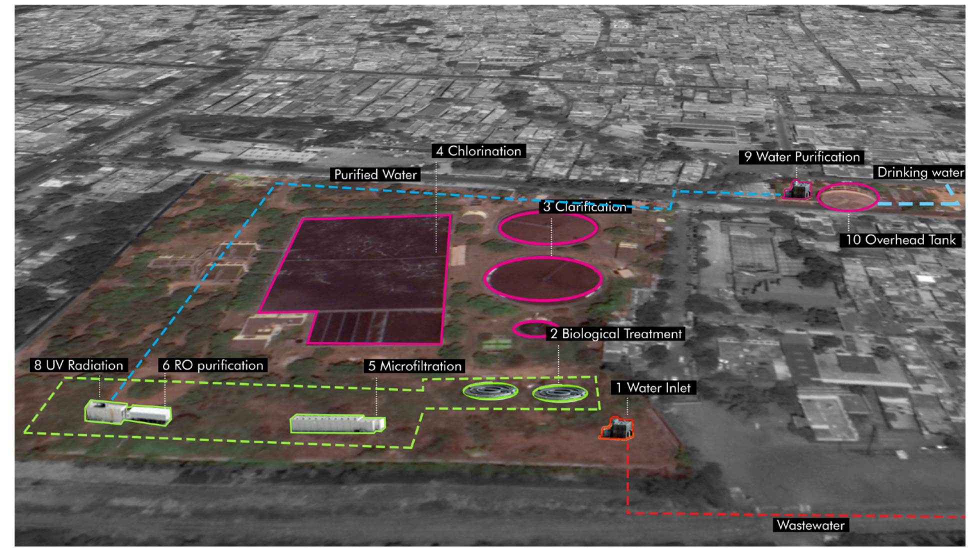


Fig 7.14 Proposed technologies in the looping system

Revitalisation of Lavender Canal

Restoring and Refurbishing the canal.

Location 1: Water purification and repurposing the space as receratìonal belt

Floating Wetland Treatment:

3000Sft. of raft made of bambooo and recycled platics with 3500 saplings of wetland plants, mosquito repellants, ornamental plants - cattails, bulrush, eitonella, canna, fountain grass, flowering herbs etc - absorb high levels of phosphorus and nitrogen in the polluted water and supported by O2 aeration.

It helps in purifying the water that is polluted from the wastewater. The floating wetlands combined with the green belt along the canal creates a recreational space. Along with improving the current condition it adds a functional value to the space.

Location 2: Water purification and improving the zone near informal settlements

Purification using Nano-Technology

Nualgi:

Feed a mixture of nutrients to diatoms - the most basic, single cell life form found in ponds, lakes, rivers and oceans, as the algae formed by diatoms grow , they release O2 into water. O2 released helps aerobic bacteria efficiently breakdown the organic matter and convert pollutants to base constituents. The diatoms are eaten by the zzoplanktons and they are eaten by fish.

This solution is proposed in the zones where the informal settlements are location along the canal.It hepls in purifying the water and create healthy environment free from mosquitoes and other viruses breeding on the water. This aids in reducing the number of cases effected by vector borne diseases.

Fig 7.15 Floating wetland water systems and development of the canal as recreative and production site

Accord Making and Phasing

Fig 7.16, shows the steps taken through different phases for the implementation of the proposals made. The phases are arranged in an order of the level of circuarity implemented in each phase and the levels of systems integration. On the X-axis, is the timeline with phasing of every five years; while the Y axis, represents the level of circularity and Y'axis represents the level of systems integration. The Z axis, shows the evolutionary resilience of the project through different phases, the probable challenges/scenarios which might occur over the course of time and their solutions at each step in relation to the actors integration, change in consumer attitude, economic investments and the vertical - horizontal integration. The steps taken in each phases are developed aiming to achieve the short term goals and long term goals of the project.

The steps taken in these phases are explained in detail in the diagrams from Fig 7.17. Each diagram has sketches of the site intervention and a zonal map representation of looping city and local city to show the flows. A detailed argumentation of policies and guidelines needed to be developed in each phase, the number of actors involved and their integration and steps of planning to address future challenges are explained following the diagrams.

Legend of Accord making and phasing diagram

The actors involved in each phase are grouped into categories of hierarchy of accord and institutions.

Governance

- Governance - National (Macro scale)
- Governance - State and Regional (Meso scale)
- Governance - Urban Local Body (Meso scale)

Investments

- Funding/Investment from Governance
- Subsidy
- Tax
- Crowd funding
- Private Investments

- Infrastructure
- Uncertainity

Research and Technology

- Local Research/ pilot projects
- Reference studies - surveys/feasibility
- Nation research Institutes
- Global research Institutes or organisations
- University Research

Education and Awareness

- Training
- NGO
- Media
- Social Media
- Marketing

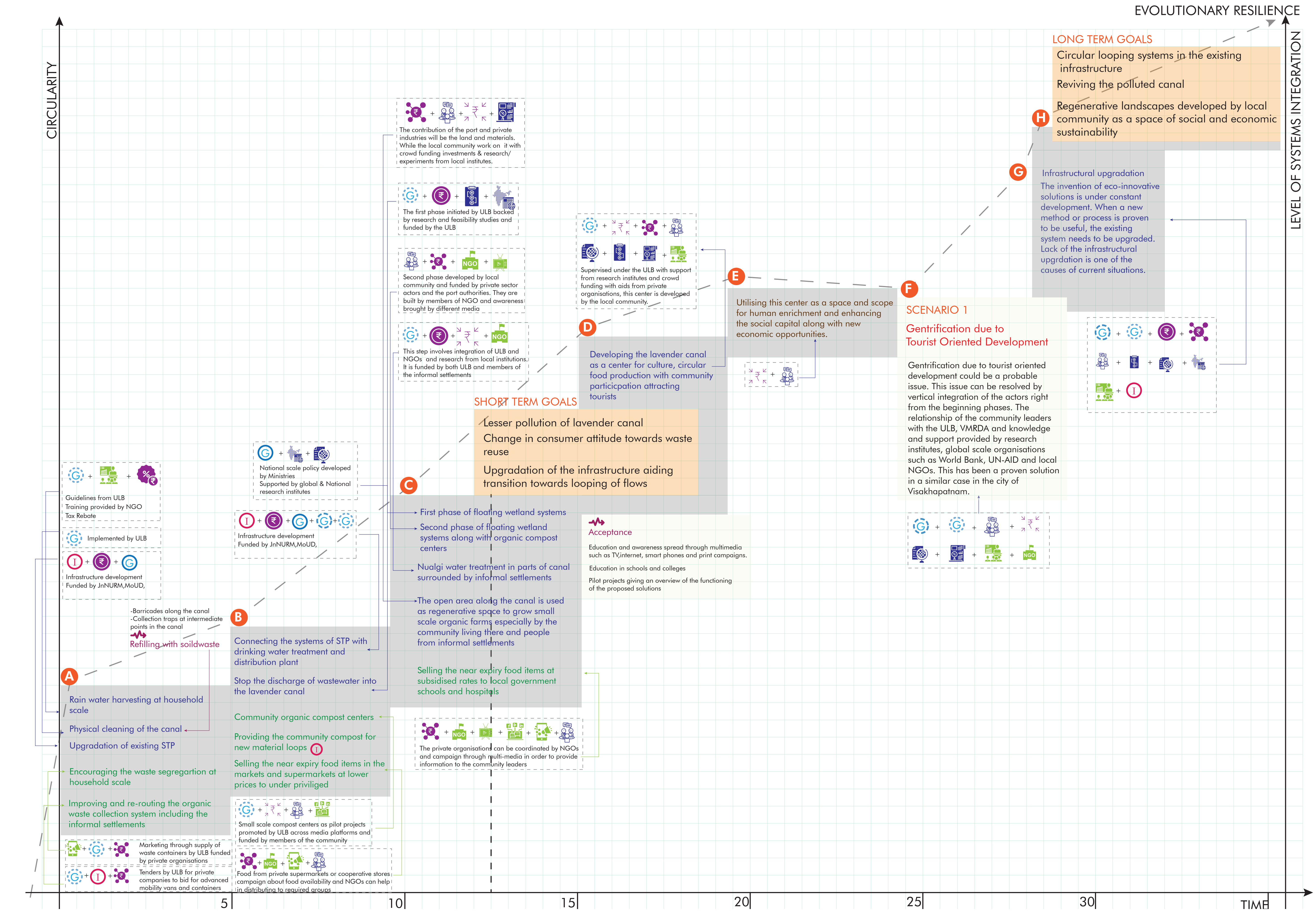


Fig 7.16 Accord making and phasing

Phase - A:

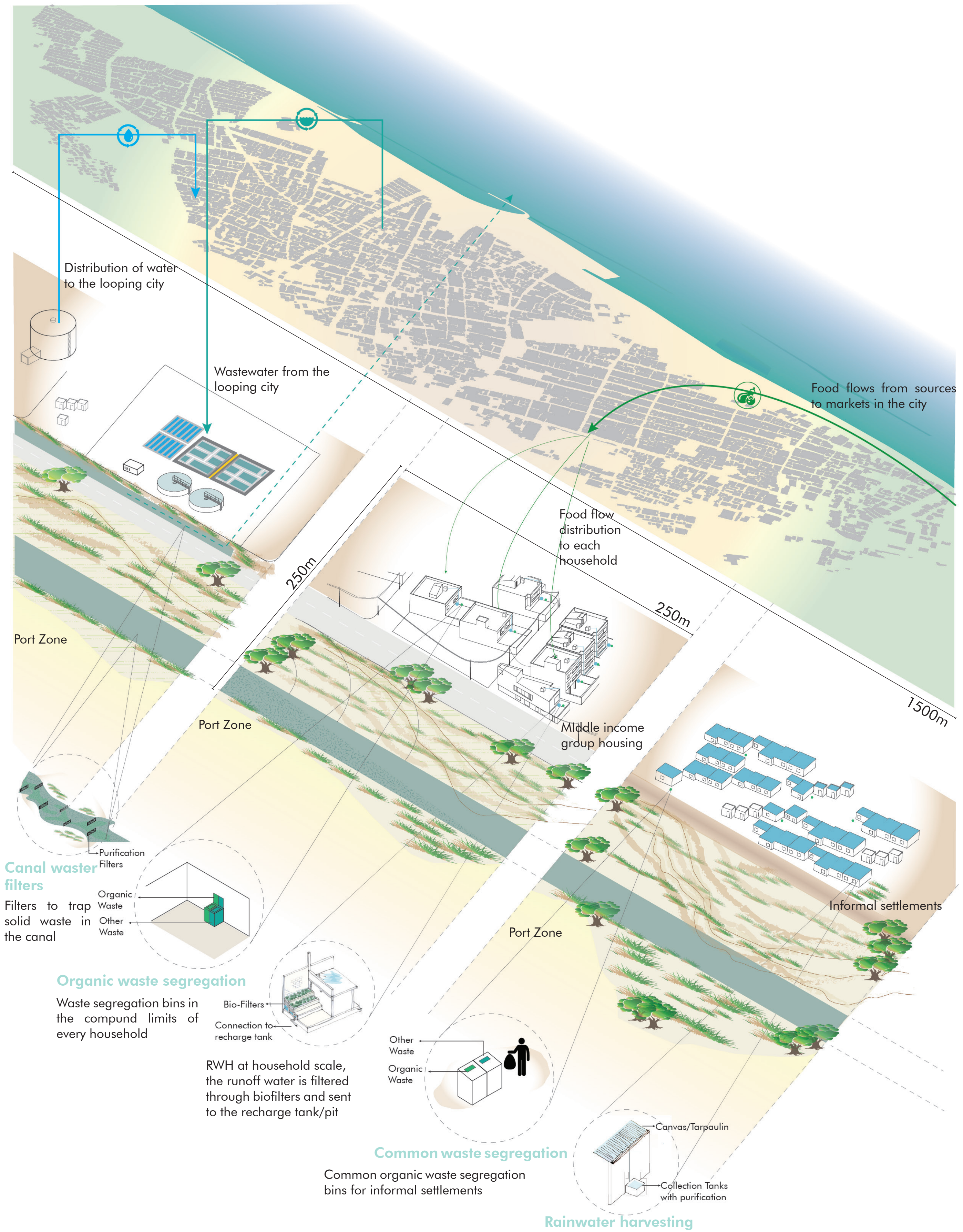


Fig 7.16(a) Phase - A

Phase - A:

The first step in phase - A, is rainwater harvesting at household scale, due to the increasing water scarcity from the natural resources and less underground water availability, it is predicted to be more challenging in comparison to other metropolitan cities which are already facing these issues. The rain water harvesting systems are implemented by following the guidelines provided by the Urban Local Body and assistance from the local NGOs/ research institutes. The cost of implementation for the rainwater harvesting system is a one time investment with less operation and maintenance costs. However, to encourage te consumers to follow this practice, water tax rebates are provided to the house owners in the period of phase A.

The inefficiency of the Sewage Treatment Plant and the levels of pollution of Lavender canal are directly proportional. The drawbacks in the current STP are: under capacity, improper functioning of the STP, inefficiency of the existing infrastructure and discharging the water into the canal without testing the quality level. Hence, the first step to address this issue is to increase the capacity of STP and improve the infrastructure to minimise the levels of toxicity in water before discharging it into the canal. The investment costs for improving the STP is high and projects involving large infrastructural changes are undertaken by National government schemes such as JnNURM. The grants involved for improving the STPs in the city have already been sanctioned. The integration of research institutes in this stage is useful in providing recommendations of new technologies.

The Lavender Canal is not only polluted by wastewater but also improper dumping of solid waste into the water from the surrounding residences and few small scale industries. Thus, the first step towards reviving the canal is physical cleaning of the solid waste. This step is carried out by the ULB.

However, there is an uncertainity of refilling of the solid waste in the canal after cleaning. To avoid this, physical barriers are to be set up at nodes where the solid waste is being dumped and also barriers in the water to trap the incoming waste.

Encouraging the segregation of organic waste from the rest of the waste is already being carried out by the ULB. But, there is no proper segregation. Providing new containers to the consumers with aid of private welfare organisations as an act of bringing motivation is the first step. The second step is re-routing the door to door waste collection system. Re-routing refers to alternating the days of collection of segregated organic waste from the regular waste collection and usage of vehicles run by the fuel extracted from organic waste. These actions create a basic level of transperancy which can motivate more consumers to follow waste segregation. The informal settlements are provided with a common bin in their vicinity to dump the segregted waste and collected by the ULB. This results in cleaner premises in and around their surroundings and the activity of dumping waste into the canal can be reduced.

Phase - B:

In phase B, the upgraded Sewage Treatment Plant is connected to the water purification station. The purified water from the STP post the process of reverse osmosis and UV radiation is sent through underground pipelines to the water purification and distribution center. Water here is further purified and pumped for non-potable water use.

Phase - B:

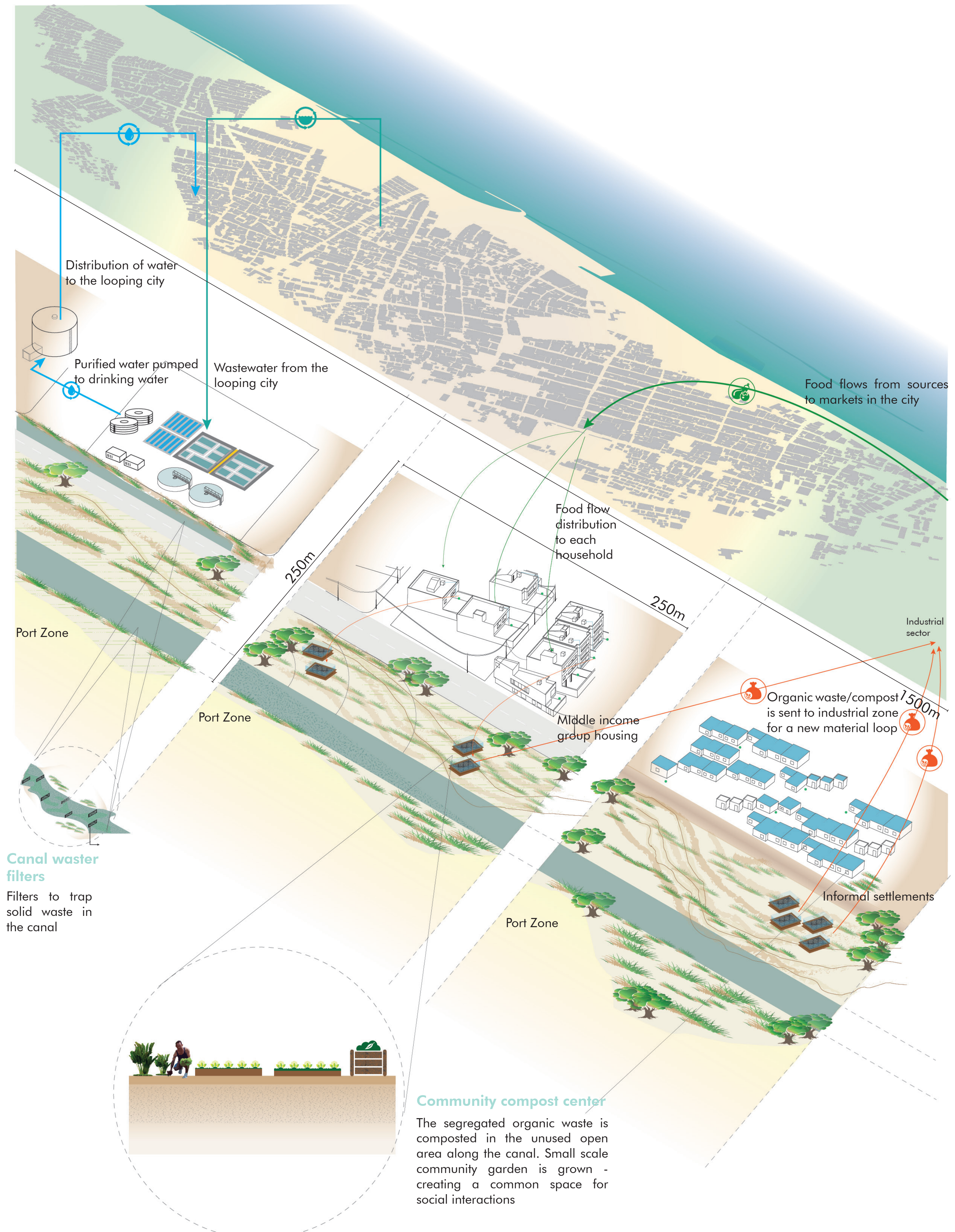


Fig 7.16(b) Phase - B

The major issue with this process is the resistance to use re-used water from the citizens. The social taboo associated with wastewater reuse is prevelant across all economic sections. Through extensive campaigning, creating awareness through educational institutions and providing tax water rebates and developing transperancy in the process, this issue can be resolved. However, this process step does not have a swift transition. It has to be developed in gradual stages from miscellaneous or landscape use to non-potable usage and the final stage of potable usage. The representation in the phasing diagram indicates the start of the process but not the entire one. This process will evolve with time.

The risk of contamination of fresh water in the water distribution center is higher if the water in the STP is not properly treated. Hence, this requires cautious survelience at every stage. This activity is carried out by the ULB on a daily basis with occassional inspections from citizens or local actors.

The discharge of wastewater from STP is gradually decreased with the amount of treated water being distributed to the water pumping stations. This step prevents further pollution of the canal. This step is regularised with changing policies about discharging wastewater from households and industries into natural surface water sources, and is implemented by the Regional develpoment authority and ULB.

Small scale community organic compost centers are developed and crowd funded by the community members and are supported by ULB and NGOs for knowledge and information about the implementation processes.

The compost is later auctioned/sold to small scale industries in the industrial zones which are dependent on organic waste/compost for new material loops. The profits from this are used for the expansion of the compost centers, improving their technology and for community welfare and upliftment. The process of compost needs to be supervised and carried out on a daily basis, thus, providing economic opportunities for the needful.

The first step for food waste prevention is initiated by the local super markets and vegetable markets selling near to expiry food at lower costs, especially to the under priviliged.

The risk of selling expired products for profit is apparent. To cross down this scenario, a member committee of the local leaders and a personnel from the Food Safety and Standards Authority of India (FSSAI) are assigned for regular inspections.

The availability of these products are advertised through media/ social media platforms or through campaigns. NGOs act as mediators in this stage to help spread awareness about food waste prevention.

Phase - C:

In Phase C, purification of the canal water is carried out in different stages. The first stage involves implementation of floating wetland system in the canal. As mentioned earlier, the floating wetland systems are made from recyclable materials and locally available plant species. This reduces the implementation costs compared to the other constructed wetland systems. However, the first stage of construction of floating wetland systems is developed by the ULB with funds from the National and Regional development authorities. The research and technologies involved in this process are developed by

Phase - C:

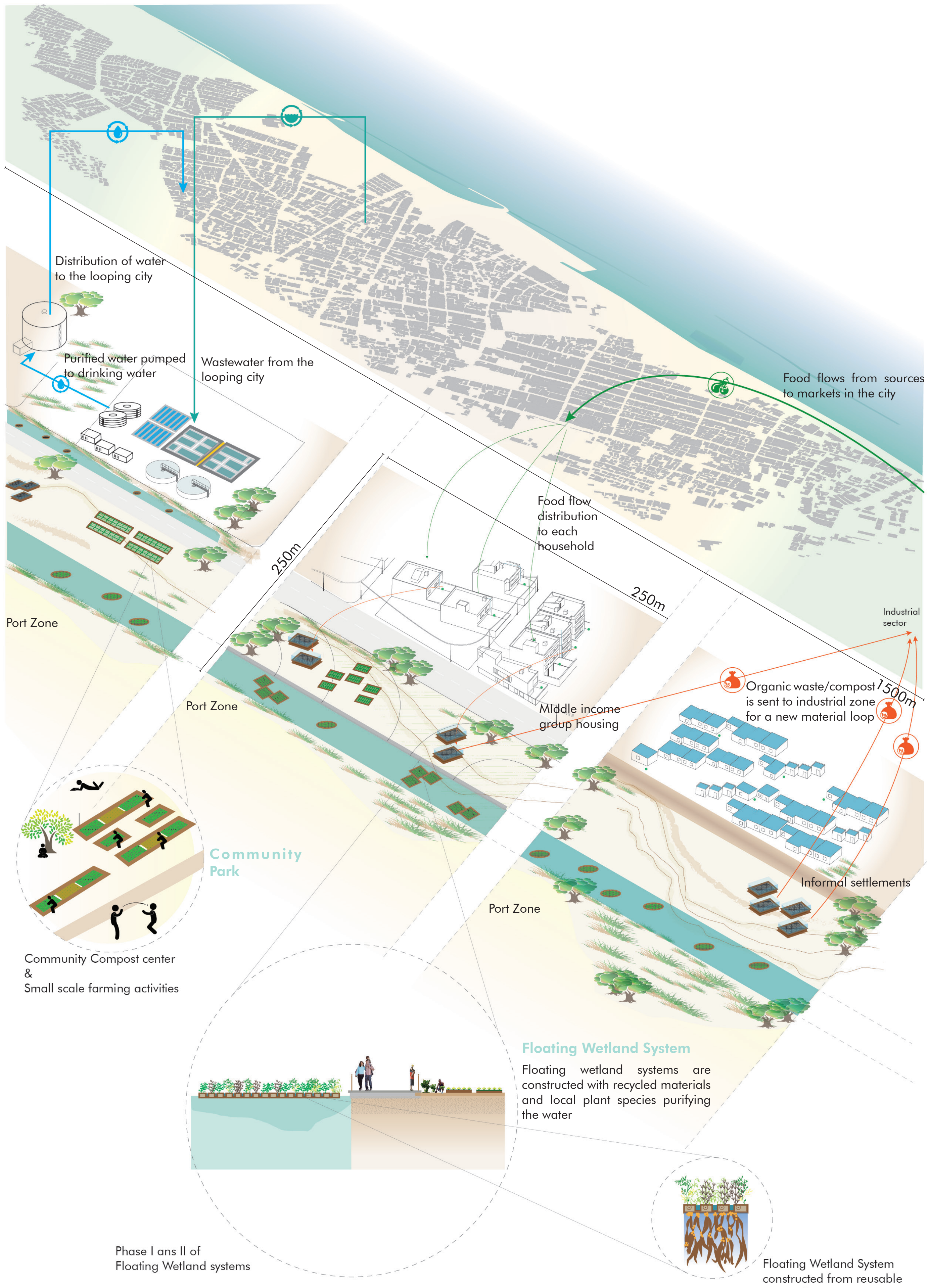


Fig 7.16(c) Phase - C

the local research institutions in collaboration with the national research institutes. The locations of developing the first stages of floating wetlands are chosen by the highest intensity in the level of contamination. In this project, with the inputs from the ULB, these points are identified at the point of wastewater discharge, the node connecting the creek of the port surrounded by informal settlements as shown in Fig 7.16 (c).

The second stage of floating wetland systems is developed by the local community with the help of ULB, NGOs and funded by private organisations with an interest of social welfare or by actors involved in developing eco-innovative solutions from waste and are provided pockets of space to test and try their eco-innovative technologies. Along with the floating wetland systems, small scale community organic farming activities are carried out in small pockets along the lavender canal. These steps bring in functional activity to the unused open spaces along the canal. Along with the compost centers and organic farming activities, these spaces have multifunctional value such as congregational spaces, community interaction and open for social inclusiveness.

Apart from the floating wetland systems, the nualgi water treatment system is proposed in locations surrounded by informal settlements. The nualgi water treatment is an alternative for the purification of polluted water. The purified water is brought into a different loop cycle of production of vegetables through aquaponic system, as shown in Fig 7.16(c). This proposal is made in interest of providing economic opportunities through self support schemes to the economically weaker section. The investment for purification of water is minimal and is carried out by the ULB. The investment for the aquaponic systems is made by the local communities with no interest loans provided by the governmen. And the NGOs helping them in learning the systems, mediating with stakeholders and help them expand their business.

With the success of selling near expiry food at lower prices in phase B, phase C focuses on expanding the horizon of consumers and sell the food to the stakeholders undertaking the mid-day meals at government schools and daily meals for the working low income groups. (Refer appendix for information on these schemes).

The acceptance of using waste streams as secondary resources and the change in attitude in reducing the waste generation by the consumers is a complex process. The change in consumer behavior and attitude is an evolutionary process. Change can be brought through educating and bringing awareness about the consequences of their actions and their responsibility. Pilot projects and engaging in these processes create transperancy and act as catalysts for change.

Phase - D:

With the help of steps taken during the phases A - C, the short term goals of i) lesser pollution of the lavender canal, ii) change in consumer attitude towards waste reuse and iii) creating the circular loop in the existing infrastructure are achieved. By addressing the probable barriers and uncertainities faced in these phases, the steps have been planned in advance and finalised after multiple iterations.

Phase - D:

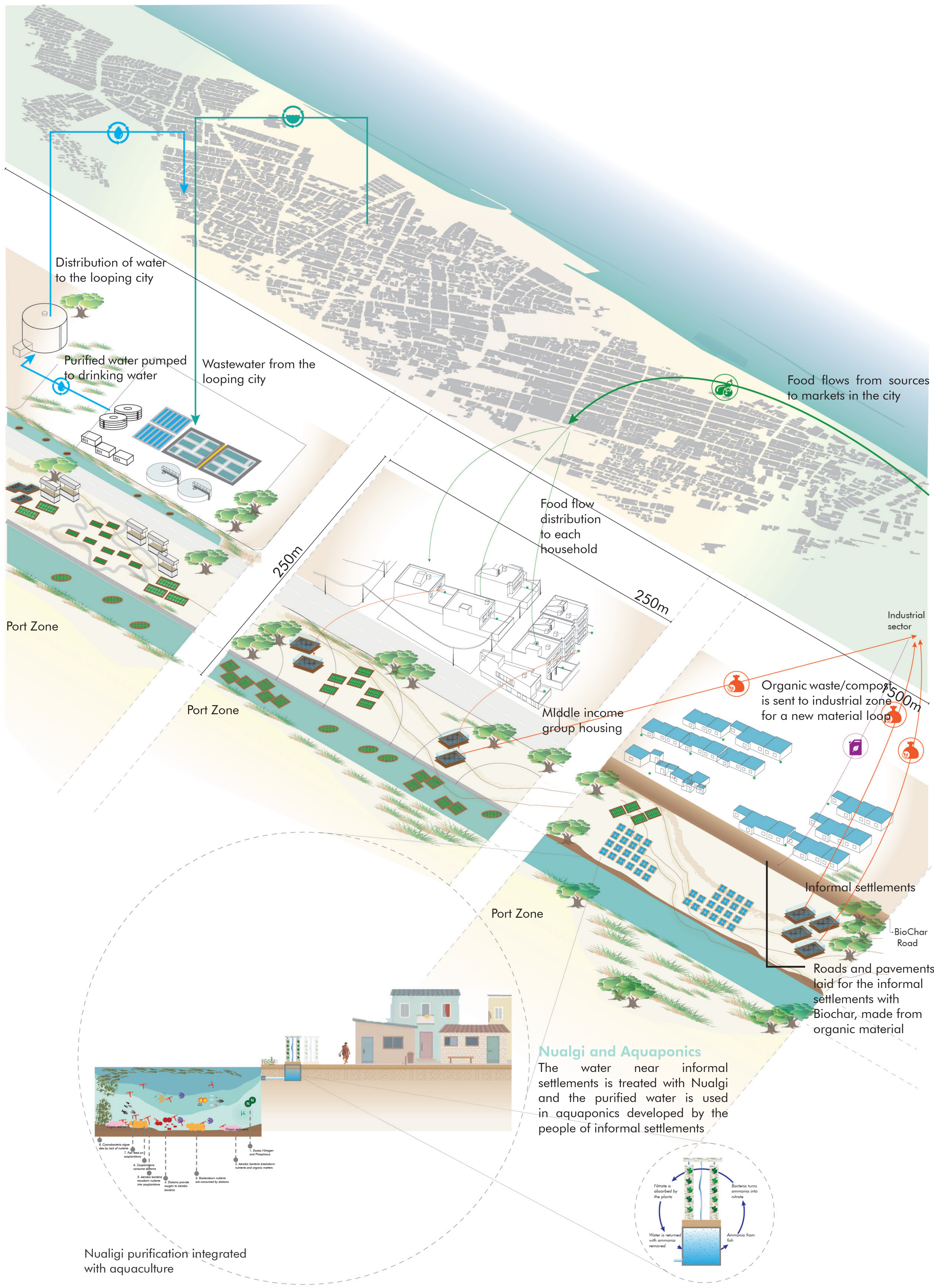


Fig 7.16(d) Phase - D

In Phase D, the focus is laid on developing the corridor along the lavender canal as a centre for culture and circular food production systems. The proximity of the locations to the nearby tourist attractions brings in a new economic capital by developing tourism in these locations. With private participants who have invested in the eco-innovative technologies and the local community actors, a new tourist activity attraction be developed for cultural exchange, pilot projects or display of case studies of circular solution and as a platform for exchange of knowledge. This tourism not only contributes to the welfare of the local community but also reflects on the tourist economy of the city.

Phase - E:

With the steps taken over all the years, there is an improvement in the ecological systems of the location and with the development of circular solutions, new economic opportunities are developed. Along with this, the integration of local actors in these phases brought in a scope for human enrichment and improving their relation with immediate ecological surroundings. Thus, along with the environmental and economic impacts, the social capital of the location is enhanced. The integration activites bring in a sense of responsibility, belonging and community welfare. With the proposals of canal water purification, organic farming and community compost, the social relations also get stronger simultaneously. Below are the brief examples of social benefits.

Probable Scenarios

Threat from developers or other real estate agents.

As shown in Fig 7.4, the 2021 master plan of this location especially the corridor along the canal is recognised as open space. However, as the time progresses, with increasing population and density in the cities, there are chances of converting the open spaces for housing or other economically benefitting developments.

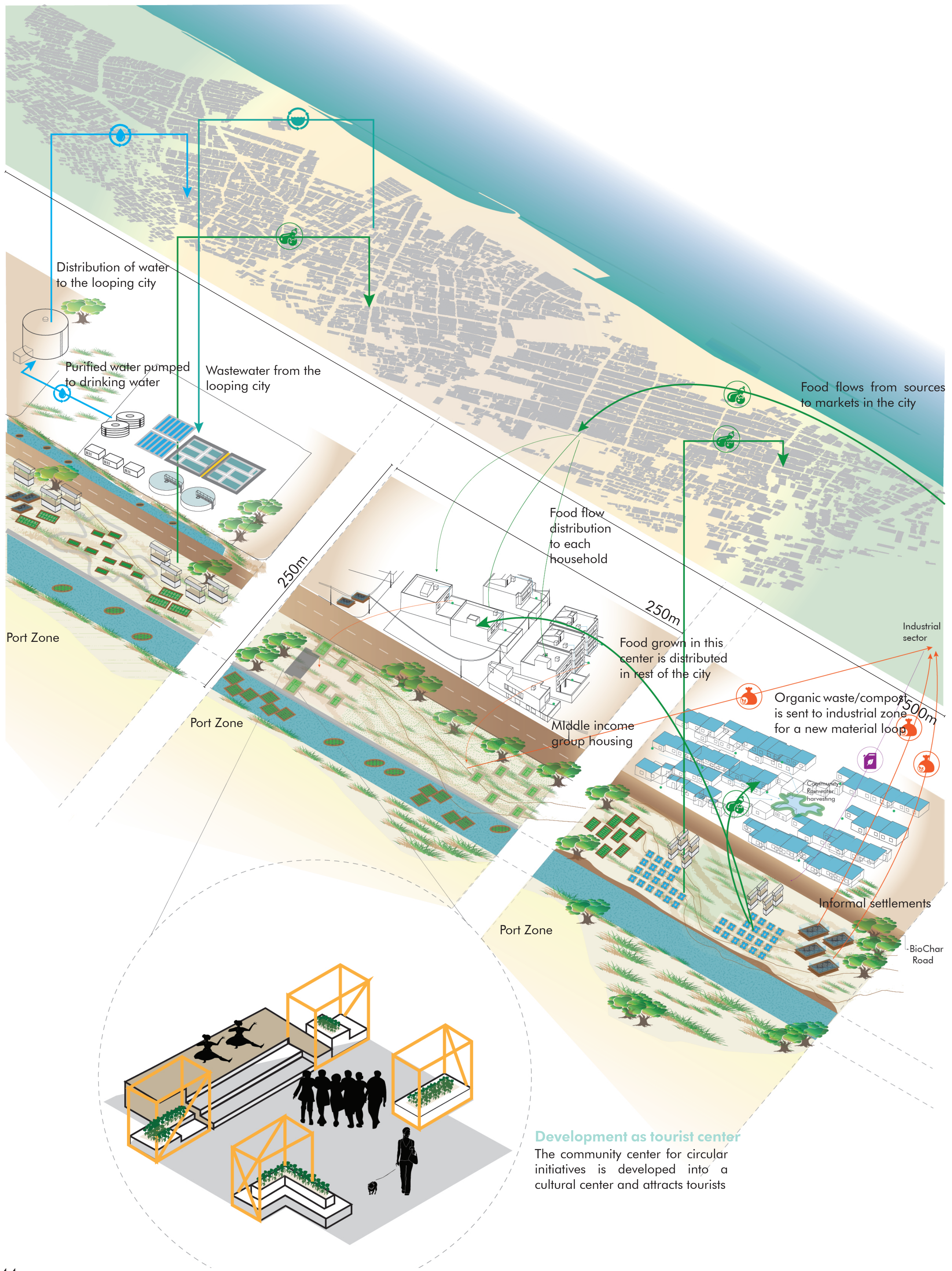
Stringent zoning rules for open space in land use zoning developed by the VMRDA (Visakhapatnam Metropolitan Regional Development Authority) and the ULB help in overcoming these scenarios. The vertical integration of community leaders, politicians and the members of the development authorities in recognizing the public spaces in interest of the development of local community is a perfect solution for this scenario.

Gentification due to Tourist Oriented Development

Gentrification due to tourist oriented development is a possible complex challenge in the future. Gentrification is a much anticipated scenario of the socio-spatial impact on tourism. With the increasing pace of gentrification, the local community loses its power over the neighborhood and discontent with the changes.

This issue can be resolved by the vertical integration of the actors, right from the early phases. The strong relationship of the community leaders with the ULB, VMRDA and knowledge and support provided by research institutes, national welfare organisations and local NGOs help in avoiding this scenario. The control of gentrification through regulations at the macro scale. The approach of a strong vertical integration of actors has proven beneficial for a local fishermen community, earlier in the city. The integration of socio-ecological and socio-technical systems in this community has helped it retain socio-cultural identity and face challenges. This reference study underpins the viability of avoiding gentrification through vertical integration. (Reference Study: https://favelissues.com/2017/03/16/resilience-of-a-slum-what-why-and-how/).

Phase - E:



Phase - G:

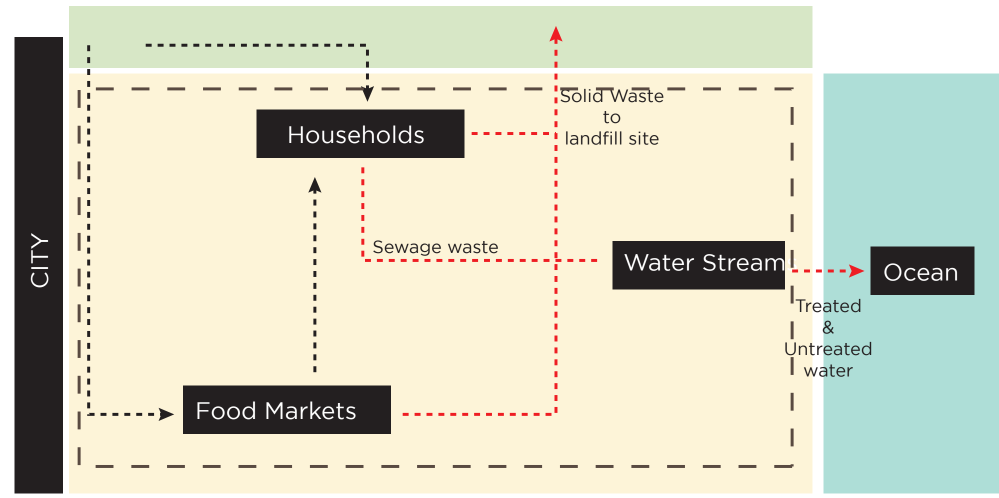
One of the challenges currently (2019) faced by the STP in the city is lack of upgraded technological systems. With new technologies improving the quality of water and efficiency in the amount of treatment, the city has been using the same technology for over 30 years. In order to circumvent the same situation 30 years later, it is important to upgrade the infrstructure in the looping city. This is possible with the integration on all three levels of governance, research institutes across multiple scales, and local actors. All these actors are supposed to be brought together to a common platform to discuss the requirements, set agendas and bring in new eco-innovative solutions. The CIM can be expanded into this platform of sharing knowledge.

By following all these steps, the long term goals of i) bringing circular looping systems in the infrastructure; ii) reviving the polluted canal and iii) regenertive landscapes develpoed by local community as a space of social and economic sustainability can be achieved.

Fig 7.16(d) Phase - D

Local City - Sagar Nagar

Fig 7.17, shows the flows involved in the chosen location. The location as shown in fig 7.18, is located along the coastline near the wild life reserve of the city. The location is sparsely populated and is not connected to the sewer network. The wastewater from households is directly discharged into the sea.



Legend:
ULB Scale
Region/National Scale
Global

Fig 7.17 Schematic diagram of flows in the region

Fig 7.18 Map of Location 2

Legend:
Primary Roads
Secondary Roads
STP & MSW tempor
Port & Industrial Zo
Canals
Ocean

0 250m

Source: Google Earth

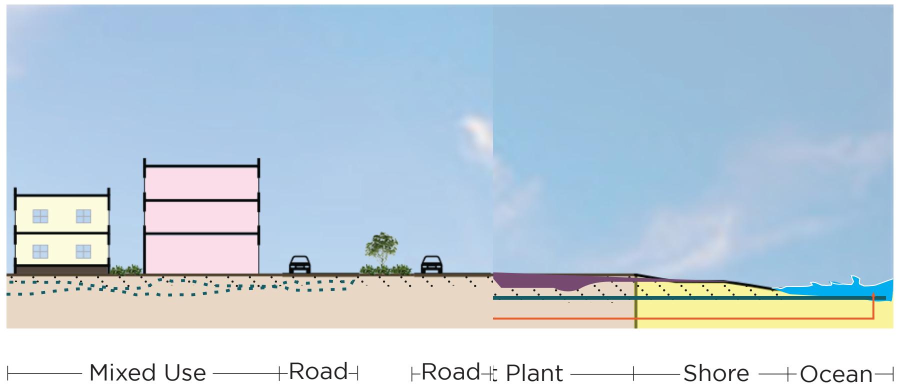


Fig 7.19 Systemic section of location A

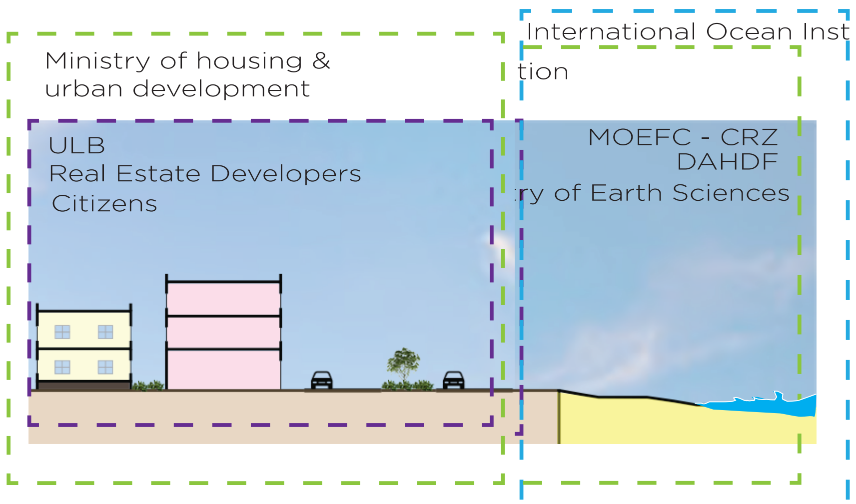


Fig 7.20 Actors involved in location A

Fig 7.21 View of the location from shore

Legend:
- ULB Scale
- Region/National Scale
- Global

Legend:
- Poor Soil Quality
- Poor underground water quality
- Pollution due to STP/MSW
- Pollution due to Industries
- Damage due to excessive fertiliser usage
- Nutrients Run-off

Fig 7.22 Waste water being released into the sea without any treatment

Fig 7.23 Stream of waste water altering the landscape of the shore

The images above show the amount of environmental degradation in the location

Scale - 1:8000

Fig 7.24 Map showing the existing landuse of the location

Fig 7.25 Master plan of the location for the year 2021

Scale - 1:8000

Fig 7.24 showcases the currrent landuse of the location. It is a residential zone located betweeen the foot of a hillock and the shoreline with natural streams of water flowing inot the ocean. The wastewater from the households is discharged in the nearby water streams further polluting the shore and sea.

Fig 7.25 showcases the master plan of the location made for the year of 2021. The location is proposed to be developed as a residential belt. In the future, this zone will grow into a dense urban area. Providing decentralised solutions for the increasing population in the next decades will be a challenge.

Fig 7.26 Map showing the risks and vulnerability of the location

The location comes under the Coastal Regulation Zone II, with a high tide line of 250m. The natural streams of water are prone to occasional flooding during storm surge.

The proposals for this location focus on developing small scale decentralised solutions. As there are no rules and guidelines for decentralised systems at ULB scale, the proposals include policy and guidelines recommendations and consumers to adapt to decentralised systems

GOVERNANCE

Policies & Guidelines

- Prohibition of discharge of waste water into the canals/ natural water sources.
- Storage of stormwater runoff at household and community scale to recharge aquifiers and desalinize the groundwater
- Using the recycled water for non-potable usage
- Lower water taxes and guidance from the municipality to install the decentralised systems.
- Depending on the soil quality, the guidelines for installation of decentralized wastewater system should be determined by the urban local body

CONSUMER BEHAVIOR

Education & Awareness, Consumer Attitude

- Public awareness and education by demonstration of sustainable practices.
- Responsible consumption of resources

TECHNOLOGY

Decentralised systems

Decentralised wastewater treatment and recharging of the underground aquifiers for groundwater consumption are implemented in the local city. The level of decentralisation will progress proportionately to the demand of increasing population.

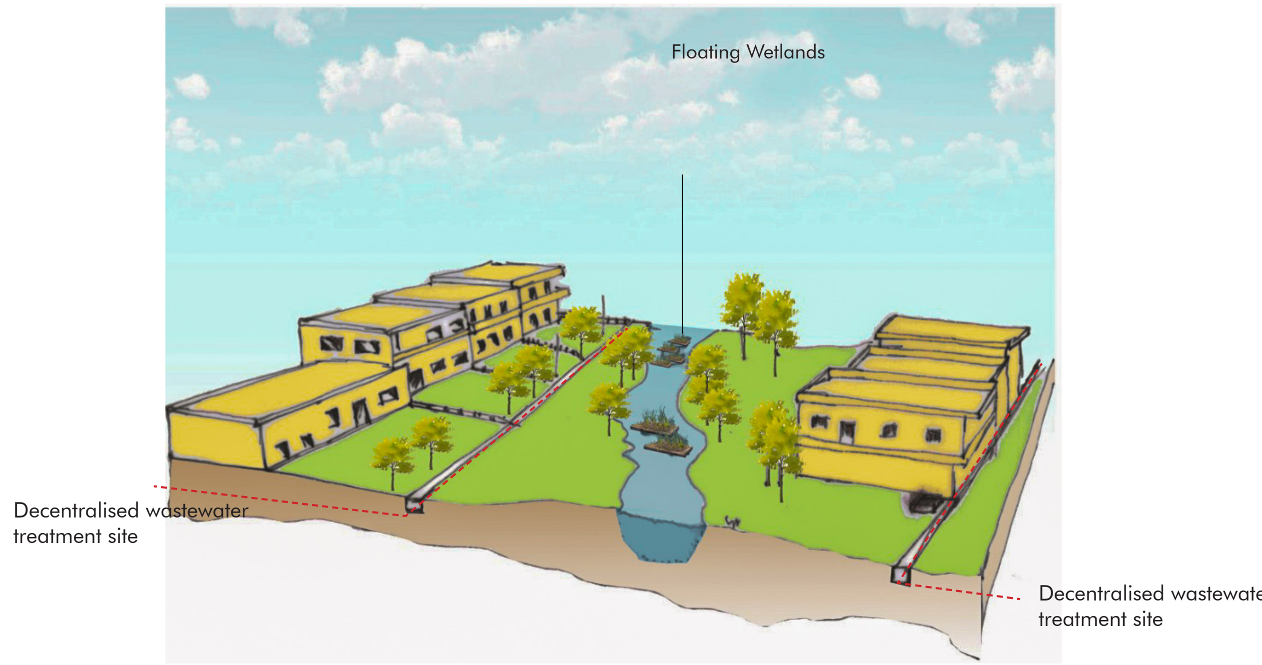


Fig 7.27 Proposal of floating wetland systems for purification of water and collection of wastewater to send to treatment site

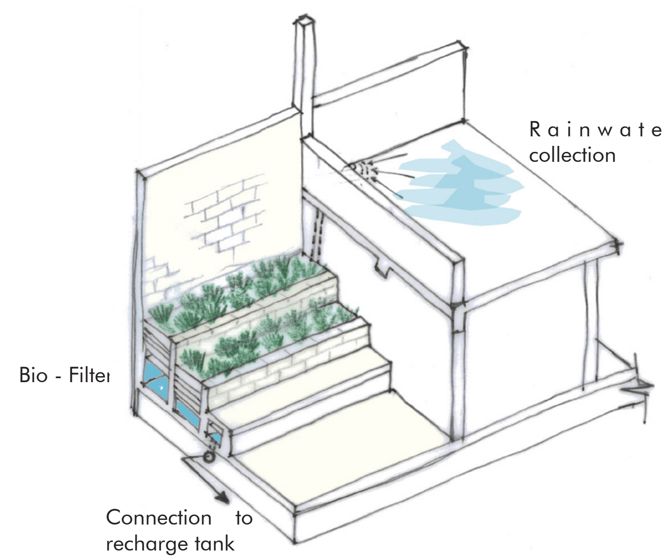


Fig 7.28 Individual house rainwater harvesting and purification system

Fig 7.29 Community scale decentralized wastewater treatment plant and organic waste collection center

Accord Making and Phasing

Fig 7.16, shows the steps taken through different phases for the implementation of the proposals made. The phases are arranged in an order of the level of circuarity implemented in each phase and the levels of systems integration. On the X-axis, is the timeline with phasing of every five years; while the Y axis, represents the level of circularity and Y'axis represents the level of systems integration. The Z axis, shows the evolutionary resilience of the project through different phases, the probable challenges/scenarios which might occur over the course of time and their solutions at each step in relation to the actors integration, change in consumer attitude, economic investments and the vertical - horizontal integration. The steps taken in each phases are developed aiming to achieve the short term goals and long term goals of the project.

The steps taken in these phases are explained in detail in the diagrams from Fig 7.17. Each diagram has sketches of the site intervention and a zonal map representation of looping city and local city to show the flows. A detailed argumentation of policies and guidelines needed to be developed in each phase, the number of actors involved and their integration and steps of planning to address future challenges are explained following the diagrams.

Legend of Accord making and phasing diagram

The actors involved in each phase are grouped into categories of hierarchy of accord and institutions.

Governance

- Governance - National (Macro scale)
- Governance - State and Regional (Meso scale)
- Governance - Urban Local Body (Meso scale)

Investments

- Funding/Investment from Governance
- Subsidy
- Tax
- Crowd funding
- Private Investments

- Infrastructure
- Uncertainity

Research and Technology

- Local Research/ pilot projects
- Reference studies - surveys/feasibility
- Nation research Institutes
- Global research Institutes or organisations
- University Research

Education and Awareness

- Training
- NGO
- Media
- Social Media
- Marketing

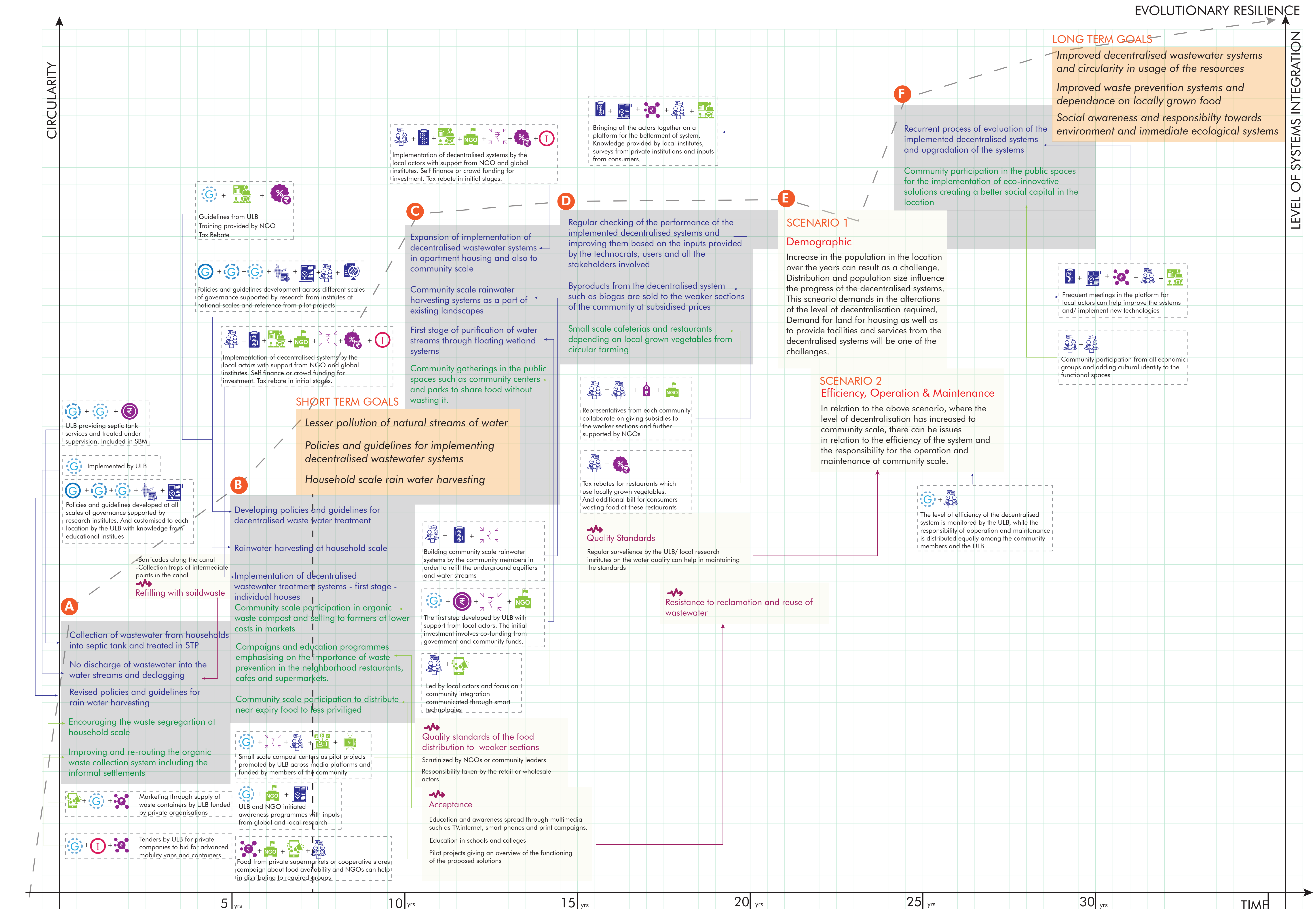


Fig 7.30 Accord making and phasing

Phase - A:

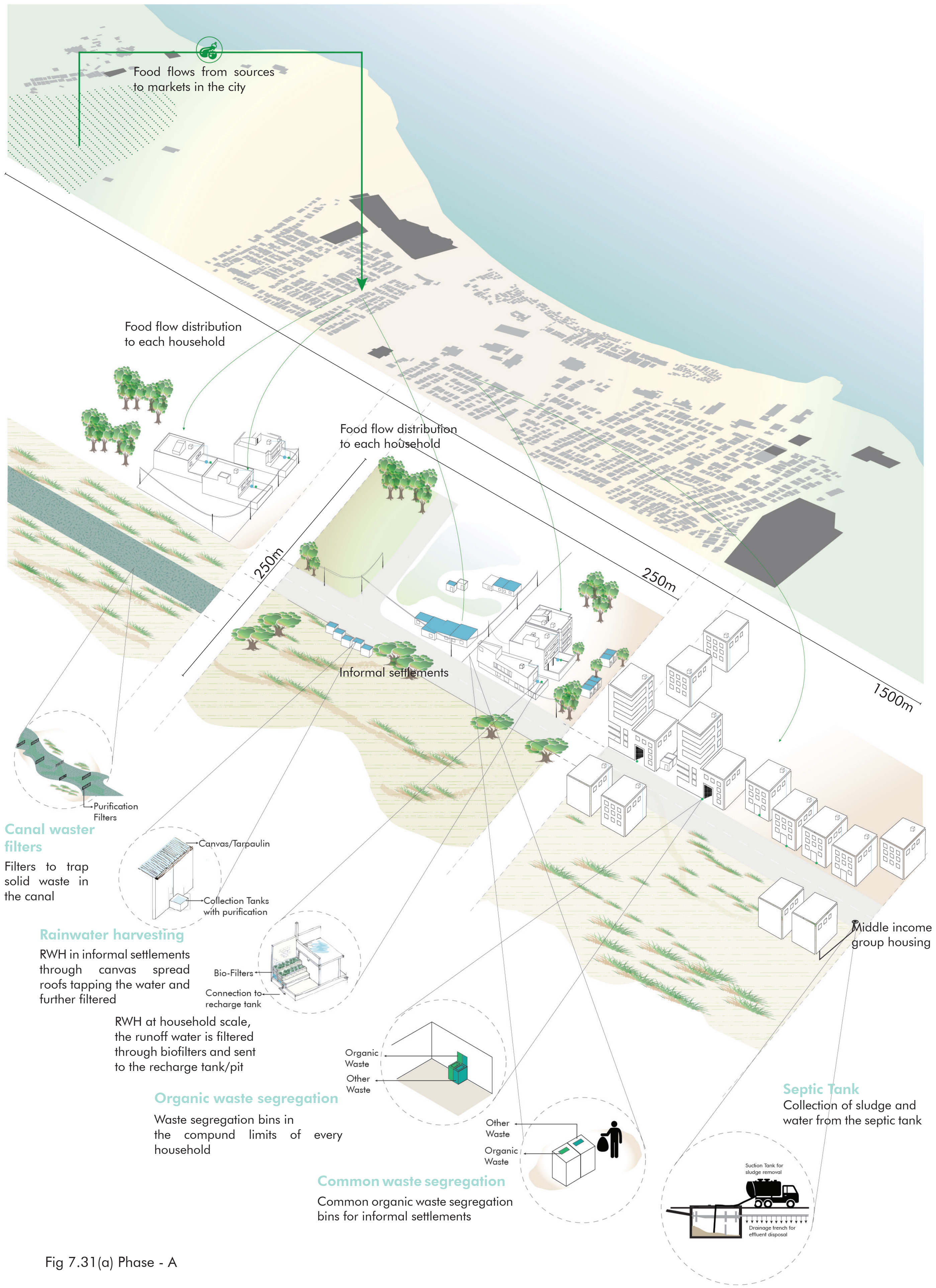


Fig 7.31(a) Phase - A

Phase - A:

Local city focuses on implementing circular loops in decentralised systems. However, on the scale of state, VMRDA and the ULB, there are no policies or guidelines to implement the decentralised rainwater harvesting or wastewater treatment systems. Thus, in phase - A, the steps are focussed on developing policies and zone based guidelines for decentralised wastewater and rainwater harvesting systems. On the national scale, by CIM, it is declared that the guidelines need to be developed by the regional development authorities and ULB, after analysing the land use, soil type, eco-zones and other parameters. These guidelines are developed by surveys done by the authorities and inputs from the research institutes in this phase.

The second step is to restrict the discharge of watewater into the natural streams of water. The wastewater is sent into the septic tanks and the treated liquid effluent is taken to the nearby STP for further treatment and the sludge is removed through trucks and used as fertilisers or in different material loops.

The location is located on the coast of the city falling under the Coastal regulation zone with a high-tide zone upto 500m making it an eco-sensitive zone. Along with this. the location has problems of coastal sand erosion and salt water intrusion. Having an underground septic tank is not sustainable owing to the factors of prevailing vulnerabilitiies. Thus, the usage of septic tank is limited only to the first phase, in order to curb the practice of discharging wastwater into natural streams and its pollution being one of the factors for coastal sand erosion. The policies and guidelines developed for the wastewater treatment need to take the above points into consideration.

Household scale rain water harvesting activities are encouraged in order to use the water for non-potable use of water. The regulations of having a rainwater recharge pit needs to be amended and make it mandatory. The investment for rainwater havestment systems are made by the landlords with the support from ULB and NGOs.

In a similar process, the organic waste is segregated from the rest of the waste at household scale and the steps of providing the containers as an act of encouragement and re-routing the collection methods to increase the efficiency. The informal settlements in this location also follow the system of having a common waste segregation bin, with the help of awareness brought in by the surrounding community members or local NGOs.

Unlike, the looping city, the local city is less denser and has a different urban morphology. The built environment is predominantly multi floor apatrments along with the villas of higher economic group. The scope of development and increase of population is higher in this location compared to the first location. This brings in the scope of integrating the building rules and bylaws for provision of waste collection and segregation system and wastewater treatment system by making it an obligation for the new constructions.

Phase - B:

Phase B, is the first stage of implementation of the decentralised wastewater systems with the guidelines from ULB and VMRDA. They are either funded by the landlord or by crowd funding. In the first stage, the treated water is used for non-potable usage and the by-products such as biogas are sold to the low income groups in the location at subsidised prices. In India, liquid petroleum gas is used for cooking, but the lower income groups use other forms of fuel such as wood as they cannot afford liquid petroleum gas. With this process, all economic groups are profited - where the households selling the bio gas earn some extra income while the lower income groups can afford comfort at a reasonable price.

Phase - B:

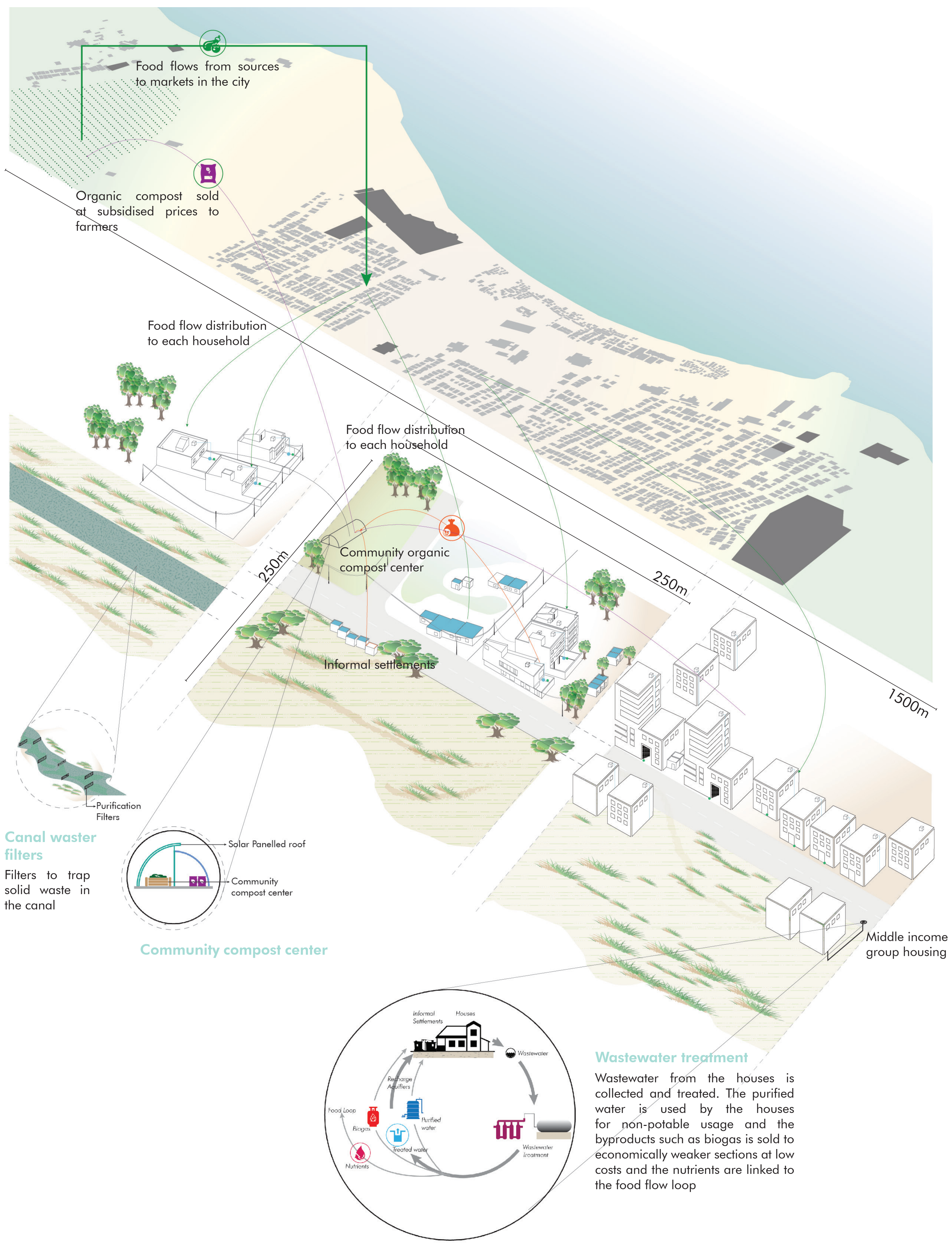


 Fig 7.31(b) Phase - B

Resistance towards change and social stigma associated with using or consuming recycled water is a bigger challenge. The acceptance from the civic society is brought through bringing nore awareness and educating the citizens about the importance and urgency of the transformation. This is done through extensive campaigning and education programmes in schools by ULB and NGOs. The decentralised wastewater treatment implemented in the first stage act as pilot projects creating transparency to the consumers and also act as spin off projects for the development of second stage.

Household scale rain water harvesting practice are implemented in the informal settlements as well. These are installed with the help of fellow upper income group community memebers and funds from private organisations as a part of social welfare or from local NGOs.

The organic waste collected from the households is recycled in the form of organic compost. The compost from these centers is sold to the farmers at subsidised prices than synthetic fertilisers in the farmer's market. In this process, the transportation costs for the distribution of organic compost is cut down. The quality and yield of the organic compost is improved by the new technologies provided by the local institutions.

For food waste prevention, the near expiry food from the super markets, cooperative stores and street shops is sold at lower costs to the consumers. The information on this is broadcasted through smart phone apps, social media advertisements and print campaigns. In the next step, these food items are sold to the local restaurants, caterers and hotels at wholesale prices.

Maintenance of the quality standards of food is essential in this strategy, and this plays a key role. A failure or negligence in this strategy might result in the relapse of the whole idea of preventing the food waste through early consumption. It is vital to have a board of committee with members of FSSAI, local community leaders, and an NGO inspecting the quality of the product. In any case of lower standards of the quality of product, the responsibility lies with the retail or wholesale actors.

All these measures help in achieving the short term goals of this location; i) lesser pollution of natural streams of water, ii) developing policies and guidelines for implementing decentralised wastewater systems and iii) successful implementation of rainwater harvesting at the household scale.

Phase - C:

In phase C, the implementation of decentralised wastewater systems is expanded to the apartment buildings. The wastewater generated per capita daily is 135Litres (https://www.indiawaterportal.org/). The approximate number of consumers in an apartment is >30. Hence, instead of proposing a decentralised system for each housols, the level of decentralisation is increased to the scale of common system at the building level.

In a similar manner, the scale of rainwater harvesting is increased at the apartment building scale to a community level. Along with rooftop water run-off the surface water run-off is captured in small recharge pits and redirected to the natural water streams as well as aquifiers.

Phase - C:

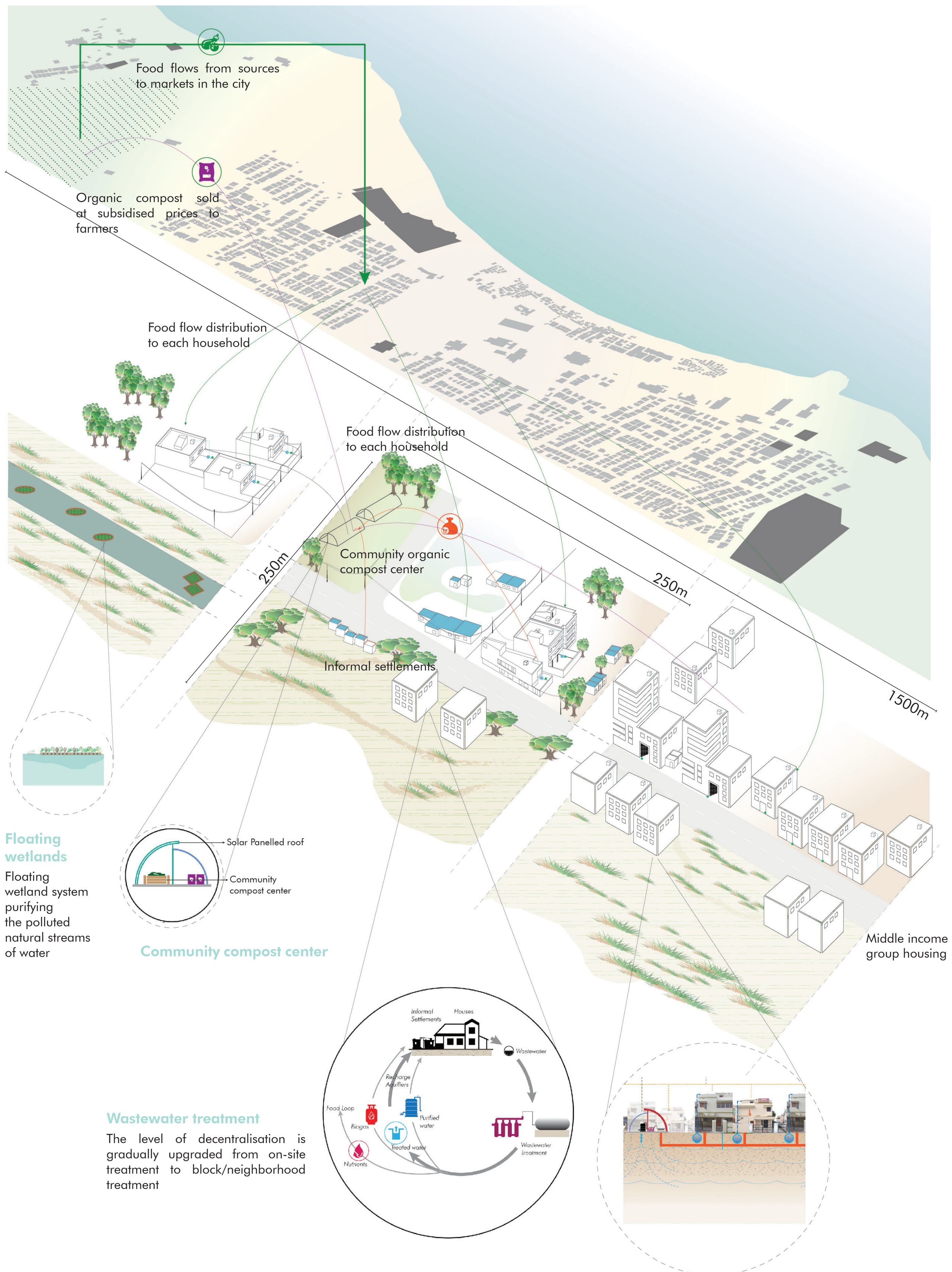


Fig 7.31(c) Phase - C

The location faces the issues of salt water intrusion from the rising sea levels. To curb this issue and preventing the salination of groundwater, the groundwater table of fresh water needs to be higher. WIth the recharge of groundwater levels with aquifiers and the open space enough for water percolation, the issue can be resolved. The community scale rainwater harvesting systems needs to be installed by the members of the commnuity and periodic surveys of groundwater quality and levels of salination by the ULB and local institutes.

The next step involves purification of the natural streams of surface water through floating wetland systems. The process of implementation of the floating wetland systems is same as explained in the pilot case of looping city.

The next step of food waste prevention strategy focuses on sharing the food among the community members by organising community dinners of food sharing in the open spaces within the community. This action not only resolves the criteria of food waste prevention, but also adds a functional value to the space through community building.

Phase - D:

Phase D, progresses with the the implementation of same decentralised solutions for water and working towards the betterment of the installed systems in place. With regular checking of the performance of the decentralised systems and inputs provided by the consumers, technocrats, researchers and stakeholders, the decentralisation can be made more efficient.

The by-products from the dentralised wastewater are distributed to the economically weaker sections in the informal settlements at subsidised prices. The purified water is resued by the households and the remaining solidwaste nutrients are diverted to the food cycle.

The food from the organic farming grown in the location beside the community compost centers are utilised by small scale cafeterias and restaurants. Tax rebates are provided to the cafeterias and hotels which depend on organic vegetables and contribute to the circular food cycle.

Phase - E:

Probable Scenarios

Demographic

Increase in the population in the location can result as a challenge over the years. Distribution and population size influence the progress of the decentralised systems. Demand for land for housing as well as to provide facilities and services from the decentralised systems will be one of the challenges.

This scenario demands alterations in the level of decentralisation. From the level of installing decentralised treatment systems in the household scale to neighborhood and community scale systems. To accommodate these systems building bylaws and regulations need to be amended with spatial requirements to incorporate decentralised wastewater systems.

Phase - D:

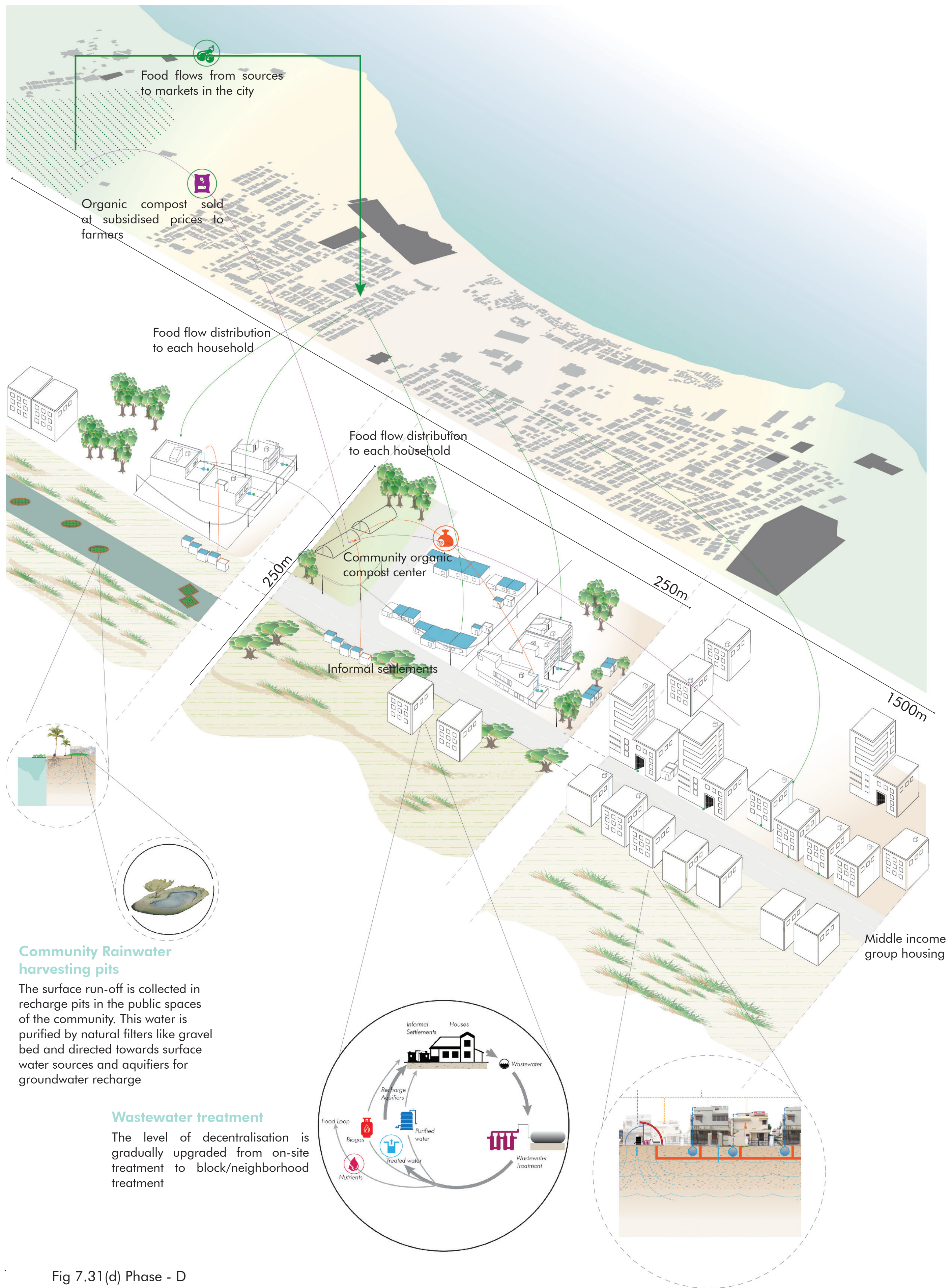


Fig 7.31(d) Phase - D

Operation and Maintenance; Efficiency

In relation to the above scenario, where the level of decentralisation has increased to community scale, there can be issues in relation to the efficiency of the system and the responsibility for the operation and maintenance at community scale.

The level of efficiency of the decentralised system is monitored by the ULB, while the responsibility of operation and maintenance is distributed equally among the community members and the ULB. The community members create a board of members and elect representatives periodically to take initiatives of maintenance.

Phase E, continues with the recurrent process of evaluation of the implemented decentralised systems and upgradation of the systems with the research and new technologies suggested by the local research institutes, ULB, NGOs and global institutions.
Community participation in developing the eco-innovative solutions for food and water cycles creates space for not only better ecological systems but also a better social capital.

With these steps the long term goals of flourishing the i) decentralised wastewater treatment systems and recharging the groundwater levels, ii) Improved waste prevention strategies and dependance on locally grown food and iii) Social awarenss and responsibility towards environment and surrounding ecological systems.

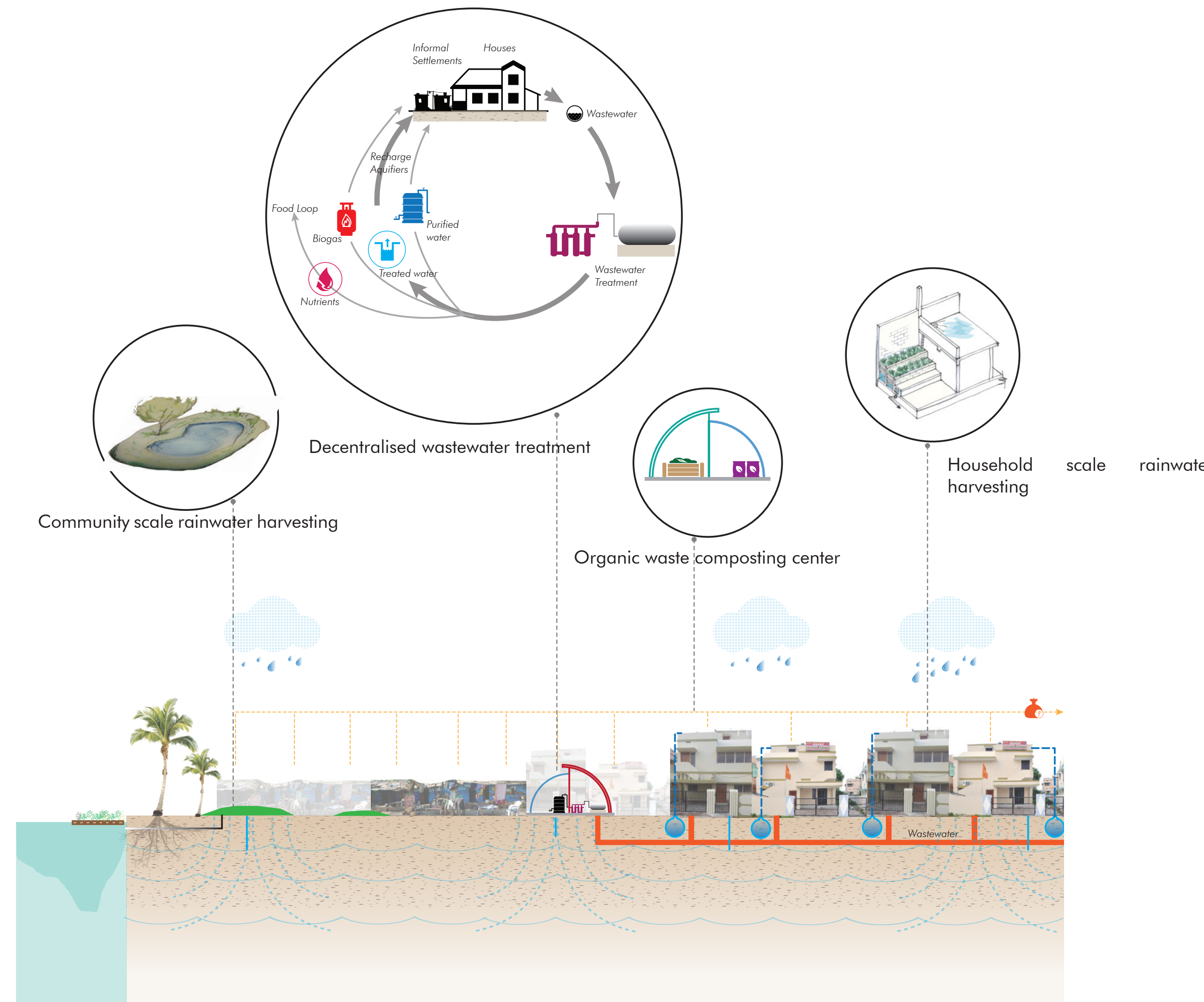


Fig 7.32 Section showing the water and food flows in the location

Impact

The impacts of the proposed solutions are reflected on the environment, economic and social capitals. In relation to the theory of O'Conner's (2006) four spheres of sustainability, the three pillars of sustainability namely social, economic and environment are interdependent and influence each other. The following sections discuss the influence of the proposed solutions in the location and to the resource flows in broader scale.

Environmental Impact:

The proposed solutions are permutations and combinations of successful eco-innovative solutions implemented across the globe. Following are the impacts observed for both the looping city and local city.

a) Surface Water sources depletion/damages:

By reusing the treated water for non-potable uses, the deficit of current water accessibility is met in the looping city, reducing the pressure of demand one the reservoirs and rivers. According to the Bureau of Indian Standards (1993), 200 litres of water is required per capita per day (Economic and Political Weekly, 2007) and with a household of average of 4-5 members require 1000 litres of water per day. The current supply of water from the ULB in the looping city is 400-500 litres, with a deficit of 50% of the total requirement. Approximately, 95% of the total water is used for non-potable usage. The amount of wastewater generated per capita per day is 135 litres (Economic and Political Weekly, 2007), with a recycling rate of minimum of 35%, the deficit in supply due to the lack of water in reservoirs can be fulfilled with the recycled water.

b) Climate Change:

The waste collected from domestic households per day is approximately 450 tonnes (GVMC/Sanitation and solid waste management), and organic waste constitutes for 40% of the total waste. The burning of waste in the landfill site releases harmful gases such as methane in the atmosphere. With the reduce, reuse and recycle of organic waste, and other waste material cycles, the amount of methane generated can be reduced, and the CO_2 released in the process of taking waste to the landfill can also be reduced. With these changes, the release of harmful gases contibuting to the climate changes is reduced.

Social Impact:

The proposals in both local city and looping city emphasize on the integration of local actors of all economic backgrounds. The food waste prevention strategies along with the aim of minimisation focuses on providing those facilities to the weaker economic section at low cost prices. And the byproducts of circular solutions such as bio manure is sold to the farmers at subsidised prices than synthetic fertilizers, bio char and bio gas, are sold to the low income groups at low costs.

Along with providing services at lower costs, the spatial implementation of these circular solutions also help in building social capital. The integration and participation of the community members creates multi-functional values, such as spaces for social cohesion, cultural activities, building social security and inclusiveness. The activities shown in Fig 7.16 (c,d,e) and 7.31 (c) reflect on the social value and identity created for the location.

The vertical integration of the actors or/with organisations have influences over the circumstances of the community (Islam & Walkerden, 2014; Woolcock & Narayan, 2000). The integration of actors proposed in each step of the phasing bridges different institutions together. The changing societal conditions tend to impact the human and nature interactions. With the changing dynamics, in the spatial, temporal, social, natural and complex systems of resources, there is a progression in the socio-ecological systems, reflecting towards Davoudi's evolutionary resilience.

Economic Impact:

The economic impacts is assessed in terms of costs of infrastructural investments as well as the number of economic opportunities brought in by the circular solutions. The proposed technology for decentralised wastewater treatment system (from WASE technologies) costs 14,789 INR (187.9 Euro) for a 2 square meter reactor which can serve upto 20 people. For a zone of 10,000 population, the total cost approximately sums up to 84,00,000 INR (107998.80 Euro). Where as the infrastructural costs for installing a STP for a population > 60,000 people is approximately 350 crores INR (GVMC/water management). The difference in the infrastructural costs and its operation and maintenance costs is huge. The economic benefits of having decentralised systems for the growing city is more than the centralised infrastructural costs.

The local scale circular interventions provide economic opporunities not only to the local community members but also across different institutions and industries. With the implementation of aquaponics or community farming, there are business and employment opportunities. Transforming these into a center for circular food production/ developing as a tourist attraction boosts the economic incentives and opportunities. Producing new material cycles with the organic waste in small scale industries encourages start-up firms in establishing their businesses.

The environmental impacts demonstrate the improvement in the existing ecological conditions and the transition to a circular model would suffice the growing demands for resources. The social impacts reflect on the spatial and societal transformations with integration of multiple actors. The economic impacts act as drivers for adaptation of the new circular system. The inter-relation between these three spheres is complex, due to the changes made in one location for improving the ecological condition, the social and economic impact is projected on different scales and later phases.

8

CONCLUSIONS

This chapter discusses the process and steps involved in the thesis and provides answers to the research question

Discussion

The eco-innovative solutions provided for each of the pilot cases focus on ecological restoration and regeneration of secondary resources along with preventive measures for waste generation. The proposed solutions lay emphasis on looping the resource flows within the city and region and involve integration of multiple actors across different sectors and three different scales (macro, meso, micro – adapted from Zhijun and Nailing;2007), and each stage of the flow in pre consumption phase and post consumption phase. In adapting the principles of circular economy often the emphasis is laid on refuse, reduce and rethink in the pre consumption phase in order to prevent excess usage of reources and waste generation. Post consumption the focus is more on reuse, repair, repurpose, recycle and the final step being recover of the resource. The principles of RESOLVE framework reflect as the systems of industrial ecology due to the technical aspects involved in the process. However, the underlying key element to operationalize the principles is the consumer attitude. In the RESOLVE framework for circular economy, emphasis is laid on the principles of preserving and enhancing the existing resources, optimizing resource yields by bringing circularity and effectiveness in designing out negative externalities. In this framework, though users/consumers are taken into account in the process their role is not represented in detail as it has to be. The users/consumers are the prime catalysts in implementing circular cities. According to Williams (2018), "if citizens do not 'buy into' consuming circular products and services or adopt circular practices, then a circular city is undeliverable". Taking this into consideration and inputs from the field visit, the proposed solutions lay emphasis on change in consumer behavior which is possible through a combination of systems of provision and lifestyle changes. The diagram of stakeholder integration addresses consumers as the important actors who are supported and educated by different organizations for successful implementation of the proposals. The change in consumer attitude is not an overnight step, it requires time to evolve aided by educating the importance of change and developing confidence by providing examples of successful projects. The technology advancements and the education provided by both governance sector and secondary actors on a local scale help in bringing the change. The assessment of a societal change is based on promoting ideal lifestyle in using secondary resources and the changes in the spatial translation of circular systems in the local scale. In today's scenario, local actors act indifferent to their surrounding ecological systems and take no responsibility for their actions.

The spatial translation of the circular systems for secondary resources in the pilot cases brings different land use in the city. Land offers ecosystem services which are essential for regenerative purposes in cities (Constanza et al., 1997). In the case of first pilot study – Lavender canal, the solution of a looping city focuses on enhancing the existing infrastructure and linking the wastewater purification plant and drinking water distribution plant. The land utilization in this proposed loop is developed in the sub-surface layer since the existing infrastructure is linked through underground pipelines. While the open space along the canal is unused and is ground for breeding diseases and stray animals. The proposed solutions focus on transforming this as a corridor with clusters of circular solutions with regenerative landscape and recreational area. The functional value of this space is to bring the local actors together and as well as a tourist location. These values bring economic benefits and a better living quality around the canal. Hence the impact here is not only limited to improved ecological systems but also social and economic benefits. While the second pilot case show utilization of the existing public spaces for implementing the circular solutions. The public spaces have an additional functional value along with the existing land use.

In the analysis of water flows, it is observed that the infrastructure used in these flows have been used for amost three decades and are one of the reasons for causing pollution. The gap in adaptation of new infrastructural systems is observed in different scales, in knowledge of the governing bodies, gaps in handling the increasing capacities and gaps in space availability for the installed systems to expand. This is a serious situation in the

major metropolitan cities in India, since Visakhapatnam being a tier 2 city, there is still scope for availability of land to adapt to new infrastructure/ infrastructural upgradation. In the accord making and phasing section of design implementation, emphasis is laid on renewing and upgrading the infrastructure for both short term and long term goals. Planning in advance in anitcipation for the increasing demands for infrastructure smoothens the process of adaptation compared to that of sudden changes.

Williams (2018), in her paper on circular cities discusses that the current state of the art of circular economy (RESOLVE framework) is inadequate to apply to a city, as it doesnot discuss the relation of the principles to their surrounding complex urban ecosystems. Similar is the current phase of circular economy in India, where the studies focus on only one or two scales and limiting themselves to one section of either socio-ecological or socio-technical systems. The stage of research phase in India, is translated into the V-H integration framework diagram developed by Van der Leer et al., 2018. It is observed that the current research in the country is focused only on one aspect of the framework and maximum across two scales. This thesis as explained above focussed on developing the the consumer beahvior and improve their attitude towards local adaptation of secondary resources. And these adaptation strategies have their influence over the scale and localisation of the flows, followed by changes in the infrastructure and land-use patterns. This thesis has discussed upon integration of different systems across different scales as shown in Fig 8.1. The scope of research and integration is vast in this field and this thesis acts as the first step for the holistic discussion in the Indian context.

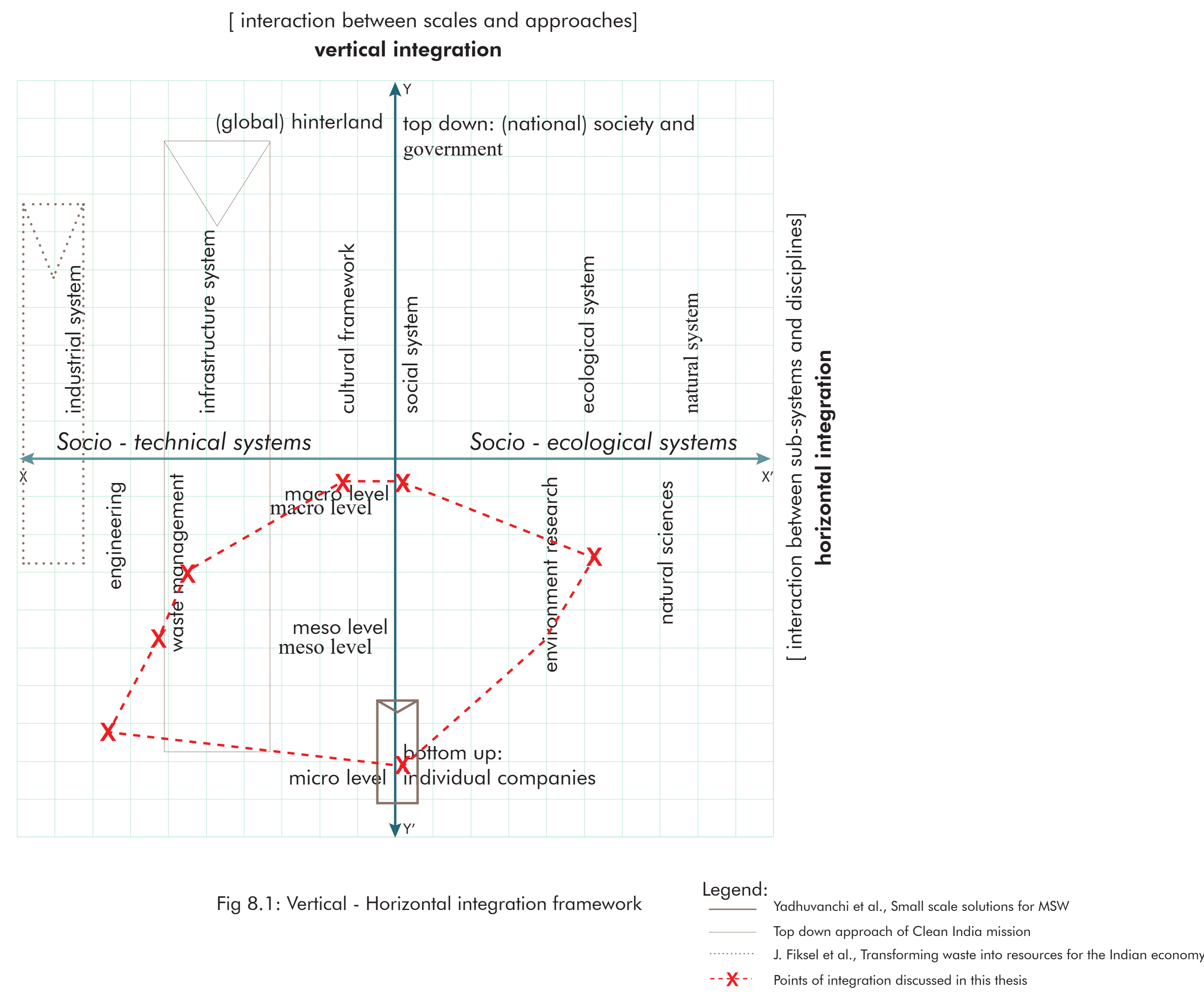


Fig 8.1: Vertical - Horizontal integration framework

CONCLUSIONS

The research question of the thesis is "How to integrate resource management into urban planning in order to develop environmentally sustainable Visakhapatnam?" Sub-questions are formulated in order to investigate this:

Problem Analysis

SQ 1 What is the current approach towards waste flows and what are the main challenges that are causing environmental degredation?

Zoom-in Analysis

SQ 2 How are the major flows of resources in the city (food and water) causing environmental degradation?

SQ 3 What are the socio-economic and spatial characteristics of the problematic zones and what are the socio technical systems and actors involved?

Technical Solutions

SQ 4 How can these resource flows be made circular and be utilized as secondary resources at a local scale?

Design Strategy

SQ 5 How can these solutions be developed across the region and involve multiple actors?

SQ 6 What are the policy recommendations at different scales (bottom up and top down) inorder to initiate/ facilitate towards the proposed local based solutions?

Policy Review

SQ 7 What are the possible solutions to be implemented and what are the spatial requirements?

Spatial design

Problem Analysis

The first two set of sub-questions have focused on analyzing the current issues in the city of Visakhapatnam related to improper waste disposal and their negative impacts on the environment. It is observed that apart from the linear metabolism of resources and their disposal post consumption there are certain gaps in the existing infrastructure that cause the problem, their inter relation and gaps in the current process and gaps in knowledge and lack of spatial allocation to the waste flows. It is observed that organic waste shares the higher fraction of total waste generated per household. And the existing wastewater treatment systems are under capacity to treat the large volumes of waste water. It is first identified that the lack of spatial allocation to any of the waste flows and dumping them in the open and natural streams of water is causing pollution and decrease in the living quality. The reason for this is observed that the city is not a planned city. It has grown organically over the last decades with growing industrialization, and there is no proper infrastructural development. Next to this, there are gaps in knowledge about the waste treatment facilities and also implementation of the linear process of waste disposal. Over the years, the ULB has focused on enhancing the existing infrastructure rather than trying to reduce the waste generation and reusing the waste streams as secondary resources.

Zoom-in Analysis

Analysis of the food and water flows has given the opportunity to understand the scope of reducing waste generation in the loop and causes of environmental degradation. In the case of food flows excessive usage of fertilizers is degrading the quality of soil, processing of food in the industries is causing air pollution and consumer behavior patterns is the cause of food waste generation. Open dumping of organic waste along with other waste and burning them in the landfill is causing damage to the environment. In the case of

water flows, dependence on underground water,lack of planning for increasing demand and discharging both treated and untreated water into natural open streams of surface water is the main problem. Problematic locations in the city are identified by overlapping the flow maps with the environmental degradation map.

The analysis of problematic zones is carried out in the field visit and the issues pertaining to each location are elaborated in chapter 5 and the analysis of the local actors involved is done through interviews. It is identified that each location (which is part of different section of the loop) has different challenges. The underlying reason common for all these locations is the lack of integration of socio-technical systems and socio-ecological systems. Currently the focus of ULB is only on the socio-technical systems, yet they follow outdated technologies.

The interviewees in the local actors analysis are categorized into consumers/citizens and the governance have varying perspectives. In the consumers/citizens it is observed that there is a social dilemma/taboos associated with waste and its reuse, resistance towards change due to lack of knowledge/awareness, confidence in new technologies, backed up by politics and disinterest in few cases. Whereas in the governance structure, though they are trying to be pioneers in bringing change there are gaps and lapse in their proposed solutions and gaps in communication in different sectors across scales.

Technical Solutions

Reference projects are studied to find solutions to the challenges under the lens of integration of the above explained criteria – governance, socio-ecological systems and socio-technical systems. It is often observed that most of the proposed solutions focus only on governance and technology and completely abandonning the consumers/local actors. Only in the case of Nambia, solutions for the entire resource flow are provided along with the consumer integration. Few studies have developed solutions on all the three spheres but they address either the ecological issues or the waste post consumption.

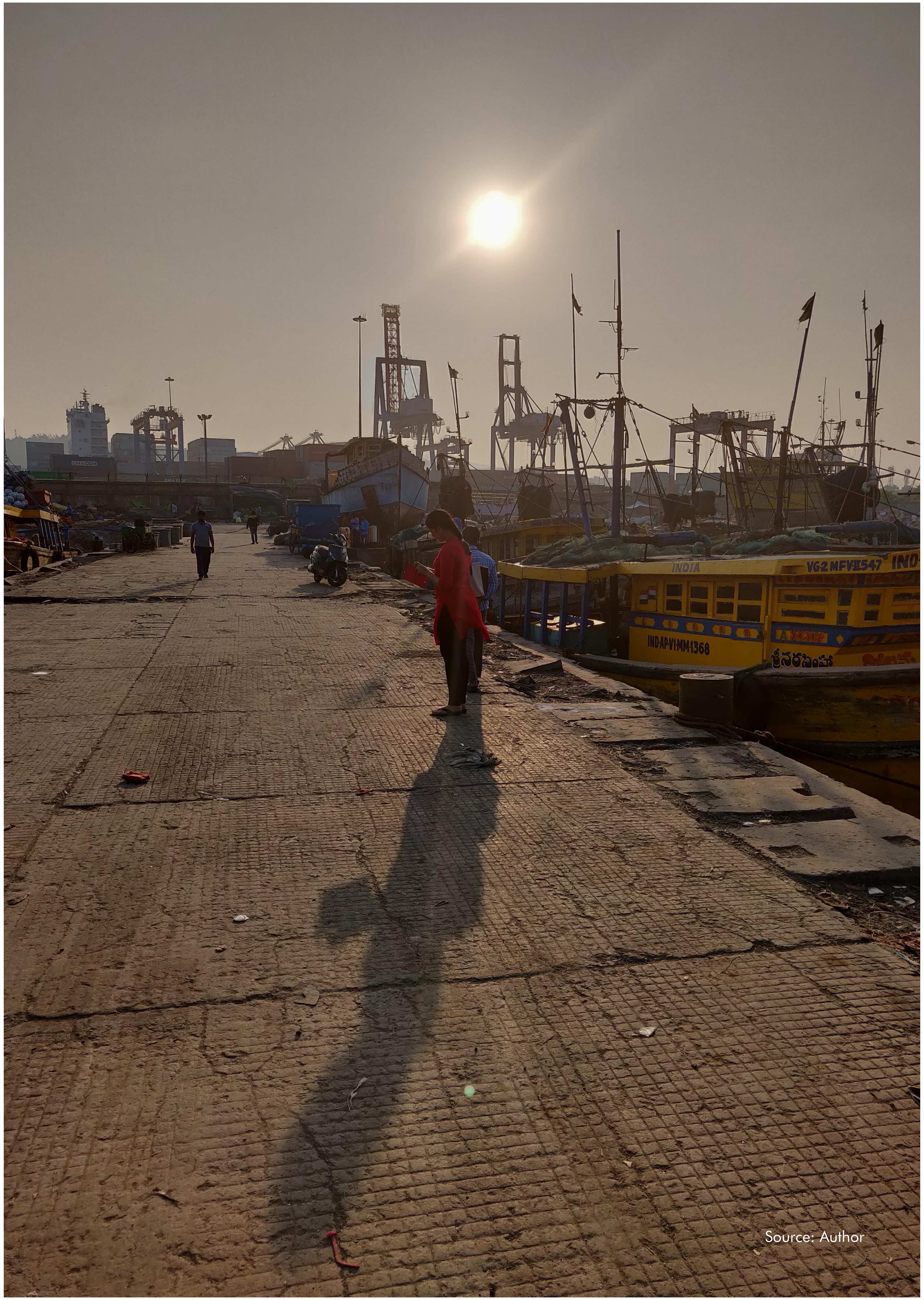
Design Strategy

Developing a vision and regional strategy for both the flows in the city is complex considering the convolutions in the respective resource flows across different scales. The technical systems requirement for both the flows and involving of the actors are slightly different. The thought process behind developing the vision of "local – adaptable" city is to have both centralized and decentralized systems. In the context of developing countries, replacing the entire system with decentralized systems is not feasible owing to the factors of scale of infrastructure development, investments, labor and other factors that are already involved in the existing system. Thus, the idea of adapting with additional infrastructure and forming a circular loop within the centralized systems is translated as looping city. While the local city where there are no existing facilities have decentralized systems within its community clusters. The vison of "local – adaptable" city aims to develop pilot projects progressing towards circular loops, involve local actors and create transparency, awareness about resource consumption and responsibility towards environment. Hence, it is important to have both the centralized and decentralized systems in place.

Spatial Design and Policy recommendations

The involvement of actors and their integration is equally important for both local and looping systems. It is vital to have policies and guidelines developed across different levels of governance for both the systems as they act as drivers for implementing the possible solutions. One of the key findings in this thesis is the importance of consumer attitude. Thus, more emphasis should be put in encouraging the consumers and developing their relation with their immediate ecological systems (socio-ecological systems). The changes in the microscale and success or learnings from the pilot projects will help in modifying the policies and guidelines in the macro scale and required infrastructural changes in the meso scale. This will be a constant iterative process of changes, adaptation and mitigation across the three scales, intra relation between human and nature interactions and inter dependency of socio-ecological systems and socio technical systems as explained in the evolutionary resilience section of the theory paper and indicated in the stakeholder diagram.

In conclusion, as explained above with the integration of socio-ecological systems and socio-technical systems of resources in the urban planning process, it is possible to develop an environmentally sustainable (reduced pressure on the environment) Visakhapatnam.



Source: Author

REFLECTION 9

This chapter gives personal reflection o nthe entire process of one year, learnings and contribution

Reflection

The research question of this project was to integrate resource management into urban planning by developing local scale spatial strategies for environmentally sustainable city. The projects lays emphasis on improving the socio-ecological systems and at the same time discusses its integration with socio—technical systems for a holistic implementation of circular principles. The last nine months of the thesis period was rigorous and an iterative process of research analysis followed by cumulative design proposals.

i) Relation between Research and Design

The thesis has started with a personal motivation of developing environmentally sustainable cities and special interest in the concept of circular economy. The thesis follows research based design methodology. The problem analysis is both inductive and deductive study, construction of problem statement, research of the existing theories and current practices in the field of circular economy, building the methodological framework and the flow analysis form a strong research foundation of the project. The analysis of the current practices has given an overview of the negative impacts of linear metabolism, negligence of socio-ecological systems in planning and the gaps in knowledge and implementation in a multi sectoral governance system.

The understanding of the theoretical analysis came out stronger with the help of fieldwork. The interviews from the actors in micro scale such as waste collectors from household, consumers; meso scale actors – technocrats, industrialists, contractors, famers and fisherwoman and the macro scale- governance/ responsible authorities have given an overview of the complex relations, their gaps and points of perspective. The fieldwork played a major role in synthesizing the theories and practicality together. This has also had a crucial role in developing the vision and strategies. All through the research analysis the main focus of the thesis was on developing decentralized solutions but with the help of field work and analyzing the current dynamic on the site, it resulted in a combination of both centralized and decentralized systems favoring the current situation. The design proposals resulted in integrating the spatial strategies for circular solutions as a part of public space design in the contrasting cities of centralized and decentralized systems.

ii) Relation between my graduation (project) topic, the studio topic, my master track, and my mas¬ter programme.

The topic of research is reusing the waste streams as secondary resources by which there is reduced pressure on the environment for resource demand through which the cities can be sustainable. The topic is directly related to the studio of urban metabolism, in the aspect of understanding the current metabolism of the city. Resource flow analysis plays a crucial role in this thesis. The design section of the project contributes to the discussion of "spatial translation of circular metabolism". The method of Material flow analysis followed focuses along the lines of spatial impacts of the flows.

With the growing complexities in the expanding cities across the globe, transition into sustainable development is quite crucial. This thesis contributes to the knowledge of developing sustainable cities, an ongoing discussion and major goal in every master of Urbanism track.

iii) Elaboration on the research method and approach chosen

The major goal as well as challenge of this project is to combine research and spatial translation of the vision. A set of seven sub-questions are formulated in order to answer the main research question. These seven steps are:

Problem Analysis – Resource Flow Analysis – Zoom in Analysis – Technical Solutions – Vision and Strategy – Policy review – Spatial design and actors integration

The step of problem analysis is an iterative process. The problem analysis is not confined to the analysis of the linear systems of resource consumption and disposal but also the existing campaigns working on waste/resource management. Finding out the gaps in the existing practices and the agendas of Clean India Mission has helped in finding the line of focus for proposing possible solutions and identify what are the measures that have to be taken into consideration.
The second stage of analysis is the resource flow analysis. Due to limitation of time for the graduation project, the resource flows analysis focused on two major flows in the city – food and water. From the problem analysis it is identified that food waste is the major waste generated in the MSW and wastewater being released into natural streams of water is one of the causes of water pollution. The flow analysis was supposed to be both qualitative analysis and quantitative analysis. However, due to unavailability of data, the quantitative analysis is confined to simple flow calculations and the losses which were based on National Statistical Data. Defining the territories for study in the food and water flow analysis was quite a challenge. Tracking the flows of food expands from household production of vegetables to global imports and the variety of food and the actors involved is beyond the time limit. And the sources of water that is distributed in the city vary from household tube wells to rivers and reservoirs in the region. Taking these factors into account the resource flow analysis is limited to the regional scale and the food flows are limited to production of fruits and vegetables. In this stage, few locations were identified which are facing environmental degradation due to the flows.
The third step involved zoom in analysis of the problematic locations. This analysis is performed in the form of field trip. The field visit has played an another important role in designing the thesis. The inputs received from the actors in these locations, technocrats and the authorities has made the challenges of my thesis more evident and understand the ground reality. The major breakthrough is understanding the attitude of the consumers and their role in bringing change.
The following stages involved developing a vision for the city, propose possible solutions and develop into a regional strategy. In the phase of developing a vision, it was a hard task to figure out to have a totally centralized or totally decentralized systems. The field trip experience has given me enough validation for both the cases, as there were problems and benefits with both centralization and decentralization. Further, the comparative studies of existing practices has helped me in deciding to have both the systems in place. Apart from this, there is huge investment already made in the existing infrastructure and actors involved in it have their income from this. And to centralize the entire city will require more investments and infrastructure. Hence the vision of the city is developed as "Local – Adaptable city" where both the systems exist in place. The goals of the vision are classified into changes in policies and guidelines at the governance scale, change in attitude of the consumers and the changes required in the technology. With this the systemic goals are developed and the actors are identified who are capable of implementing this and placed in an onion diagram. The onion diagram has helped me to identify the actors across different scales and sectors and link them to create the accord. Two pilot projects were chosen on the basis of severity of the environmental damage they are facing and possible solutions are proposed based on the part of the city they are located in. Each pilot case study has a challenge of its own, so it is difficult to propose the same solutions to every case, thus, the solutions have to be tailored according to the issue and the scenario. This implies to every case study not only in this city but also to other cities facing similar challenges. The solutions also result in continuous change in the relation of human and natural systems, an evolutionary resilience as explained by Davoudi (2012).

iv) Elaboration on the research method and approach chosen

This project is a contribution to the growing discussions of circular economy in India and the study of implementation through integrating it into the framework of urban planning. This study has focused on creating the link between socio-ecological systems, socio-technical systems and governance. During my study I came across reference studies that are dealing with similar situations and had developed small scale eco-innovative solutions. But these cases worked independently and in isolation from the broader spectrum, developed by technocrats or NGOs and are less known to the citizens or other locations in the country. With an integrated approach, there is more scope for betterment across all the sectors of governance, socio-ecological and socio-technical systems.

This project has dealt only with two flows that are causing environmental degradation. However, there are many other waste streams/resource flows that are causing damage such as plastics, textiles, metals and inert wastes that do not damage the environment but occupy volumes of space in the landfills. So the scope of study of resources is huge in the fields of agriculture, industrial metals/alloys, e-waste, textiles, etc. This study has focused on the relations between governance, socio ecological systems and socio technical systems where each entity has its own scope of research in implementing circular economy. The study of circular economy in India is still in its initial stages and there is more need for research in this field which can help in sustainable development. The thesis is developed in a holistic approach on considering the entire loop of flow cycle. Each section within the loop can also be studied under the perspective of urban planning, since majority of the studies are limited to the perspective of industrial ecology.

v) The ethical issues and dilemmas I have encoun¬tered in (i) doing the research, (ii, if applicable) elabo¬rating the design and (iii) potential applications of the results in practice.

The ethical issues and dilemmas in thesis have been a constant part in the entire process. The principles of the thesis focus predominantly on the reuse and recycle of waste streams. The question of successful transition has been a hinderance while formulating research question and proposing design strategies. Change is not an overnight process. Changes in society take more time compared to others. The change in the society reflects as breaking down of a belief system and developing a new one. If there is any section of new systems that goes wrong, there are high chances of risks in tearing down the entire effort. Hence, there is higher responsibility in proposing the solutions.

The proposed solutions recommend integration of actors and focus on changing the consumer behavioral patterns. The proposals made in the thesis are ensured that the recommendations for change in consumer behavior are not top down but mostly bottom up and motivating. The role of the actors especially in the local community members is divided equally irrespective of their economic background. This is a conscious decision made observing the current scenario in the country. In India, even today, the actors participating or working in the facilities of waste flows is carried out by the economically weaker sections and socially identified/implied backward community members. Working with the waste flows is considered as taboo and looked down up on. With this attitude, it is difficult to bring change. Thus, the proposed solutions try to create a cleaner working environment to some extent (odour from the organic compost can be controlled but not totally eliminated), encouraging the other economic group members of the community to participate. The employees of the waste collection logisctics, street sweepers are mostly women and only men in large infrastural systems. In the proposed solutions, it is expected to have gender equity in the roles of implementing the solutions.

APPENDIX 10

This chapter consists of references, additional information on points discussed in the earlier chapters and the theory paper.

References:

Albrechts, L. 2006a. “Bridge the Gap: From Spatial Planning to Strategic Projects.” European Planning Studies 14 (10): 1487–1500. Albrechts, L. 2006b. “Shifts in Strategic Spatial Planning? SomeEvidence from Europe and Australia.” Environment and Planning A 38 (6): 1149–1170.

Allen, C. R., D. G. Angeler, A. S. Garmestani, L. H. Gunderson, and C. S. Holling. 2014. “Panarchy: Theory and Application.” Ecosystems. Springer US17 (4): 578–589.

Burke Johnson, R. et al. (2007) Towards a Definition of Mixed Methods Research, Journal of Mixed Methods, 1(2): 112-133.

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

Devi, S. M., Balachandar, V., Lee, S. I., & Kim, I. H. (2014). An Outline of Meat Consumption in the Indian Population - A Pilot Review. Korean journal for food science of animal resources, 34(4), 507-15.

Fang, Y., Côté, R.P., Qin, R., 2007. Industrial sustainability in China: practice and pro- spects for eco-industrial development. J. Environ. Manag. 83 (3), 315–328. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0301479706001216 [Accessed March 6, 2017].

Gandhi V. P., Koshy A. Wheat marketing and its efficiency in India. Working paper No. 2006-09-03. Indian Institute of Management; Ahmedabad, India: (2006).

Geissdoerfer, M., Savaget, P., Bocken, N.M.P., Hultink, E.J., 2016. The Circular Econ- omy e A new sustainability paradigm? J. Clean. Prod. https://doi.org/10.1016/ j.jclepro.2016.12.048.

Ghisellini, P., Cialani, C., & Ulgiati, S. (2016). A review on circular economy: the expected transition to a balanced interplay of environmental and economic systems. Journal of Cleaner Production, 114, 11–32. https://doi.org/10.1016/j.jclepro.2015.09.007

Gunderson, L. H., and C. S. Holling. 2002. Panarchy: Understanding Transfor- mations in Human andNatural Systems. Washington

Hajer, M., and W. Zonneveld. 2000. “Spatial Planning in the Network Society- Rethinking the Principles of Planning in the Netherlands.” European Plan- ning Studies 8 (3): 337–355.

Heshmati, A. (n.d.). A REVIEW OF THE CIRCULAR ECONOMY AND ITS IMPLEMENTATION. Retrieved from www.entreprenorskapsforum.se

Jackson, M., Lederwasch, A., Giurco, D., 2014. Transitions in theory and practice: managing metals in the circular economy. Resources 3 (3), 516–543. Available at: http://www.mdpi.com/2079-9276/3/3/516/ [Accessed March 21, 2017].

Kalmykova, Y., Sadagopan, M., & Rosado, L. (2018). Circular economy - From review of theories and practices to development of implementation tools. Resources, Conservation and Recycling, 135, 190–201. https://doi.org/10.1016/j.resconrec.2017.10.034

Karvounis, A. 2015. “UrbanMetabolism.” In UnderstandingUrbanMetabolism: a Tool for Urban Planning, 3–13. New York: Routledge.

Kennedy, C., Cuddihy, J. and Engel-Yan, J. (2007), The Changing Metabolism of Cities.

Kennedy, C., Pincetl, S., Bunje, P. (2010) The study of urban metabolism and its application to urban design and planning.

Kirchherr, J., Reike, D., & Hekkert, M. (2017, December). Conceptualizing the circular economy: An analysis of 114 definitions. Resources, Conservation and Recycling. https://doi.org/10.1016/j.resconrec.2017.09.005

Lieder, M., and A. Rashid. 2016. “Towards Circular Economy Implementation: A Comprehensive Review in Context of Manufacturing Industry.” Journal ofCleaner Production. Elsevier Ltd115: 36–51.

Mylan, J., H. Holmes, and J. Paddock. 2016. “Re-introducing Consumption to the “Circular Economy”: A Sociotechnical Analysis of Domestic Food Provisioning.” Sustainability 8 (8): 1–14.

Merli, R., Preziosi, M., & Acampora, A. (2018, March). How do scholars approach the circular economy? A systematic literature review. Journal of Cleaner Production. https://doi.org/10.1016/j.jclepro.2017.12.112

Murray, A., K. Skene, and K. Haynes. 2015. “The Circular Economy:An Interdis- ciplinary Exploration ofthe Concept and Application in a Global Context.” Journal ofBusiness Ethics 140: 369–380.

Naustdalslid, J. (2014). International Journal of Sustainable Development & World Ecology. https://doi.org/10.1080/13504509.2014.914599

Ness, D., 2008. Sustainable urban infrastructure in China: towards a factor 10 improvement in resource productivity through integrated infrastructure sys- tem. Int. J. Sustain. Dev. World Ecol. 15, 288e301.
Ny, H., Robèrt, K.-H., Thompson, A. W., Wälitalo, L., Lindner, P., Mooij, C., & Rogers, H. (2017). Circular Economy in Cities: A Strategic Approach Towards a Sustainable Society? Retrieved from http://www.diva-portal.org/smash/get/diva2:1108675/FULLTEXT02

O'Connor, Martin. (2006). The “Four Spheres” framework for sustainability. Ecological Complexity - ECOL COMPLEX. 3. 285-292. 10.1016/j.eco

Population Of Visakhapatnam 2018. (n.d.). Retrieved from http://indiapopulation2018.in/population-of-visakhapatnam-2018.html

Potting, J., et al., 2017. Circular Economy: Measuring Innovation in the Product Chain. Available at. http://www.pbl.nl/sites/default/files/cms/publicaties/pbl-2016- circular-economy-measuring-innovation-in-product-chains-2544.pdf.

Preston, F. (2012). A global redesign? shaping the circular economy. Energy, Envi- ronment and Resource Governance, 2,1e20.

Reddy, D. (2015, September 04). Know Your Smart City: Andhra Pradesh & Telangana. Retrieved from https://www.business-standard.com/article/current-affairs/know-your-smart-city-andhra-pradesh-telangana-115090400522_1.html

Reike, D., Vermeulen, W. J. V., & Witjes, S. (2018). The circular economy: New or Refurbished as CE 3.0? — Exploring Controversies in the Conceptualization of the Circular Economy through a Focus on History and Resource Value Retention Options. Resources, Conservation and Recycling, 135, 246–264. https://doi.org/10.1016/j.resconrec.2017.08.027

Shi, H., Chertow, M., Song, Y., 2010. Developing country experience with eco-industrial parks: a case study of the Tianjin Economic-Technological Development Area in China. J. Clean. Prod. 18 (3), 191–199. Available at: http://linkinghub.elsevier.com/ retrieve/pii/S0959652609003242 [Accessed March 7, 2017].

Stead, D., and E. Meijers. 2009. “Spatial Planning and Policy Integration: Concepts, Facilitators and Inhibitors.”

Van Berkel, R., T. Fujita, S. Hashimoto, and Y. Geng (2009). Industrial and urban sym- biosis in Japan: analysis of the eco-town. Journal of Environmental Management 90, 1544-1556.

van Buren, N., et al., 2016. Towards a circular economy: the role of dutch logistics in- dustries and governments. Sustainability 647. Available at: http://www.mdpi.com/ 2071-1050/8/7/647 [Accessed February 24, 2017].

van der Leer, J., van Timmeren, A., & Wandl, A. (2018). Social-Ecological-Technical systems in urban planning for a circular economy: an opportunity for horizontal integration. Architectural Science Review, 61(5), 298–304. https://doi.org/10.1080/00038628.2018.1505598

Voskamp, I. M., Spiller, M., Stremke, S., Bregt, A. K., Vreugdenhil, C., & Rijnaarts, H. H. M. (2018). Space-time information analysis for resource-conscious urban planning and design: A stakeholder based identification of urban metabolism data gaps. Resources, Conservation and Recycling, 128, 516–525. https://doi.org/10.1016/J.RESCONREC.2016.08.026

Yuan, Z., J. Bi, and Y. Moriguichi. 2006. “The Circular Economy: A New Devel- opment Strategy in China.” Journal ofIndustrial Ecology 10 (1–2): 4–8.

Zhang, Y., Yang, Z., & Yu, X. (2015). Urban Metabolism: A Review of Current Knowledge and Directions for Future Study

Zhijun Yan Nailing, F. A. (n.d.). Putting a circular economy into practice in China. https://doi.org/10.1007/s11625-006-0018-1

https://www.scribd.com/document/355091180/Agriculture-is-the-Main-Occupation-in-India

The following is the list of SDGs that this research would contributr along with the National indicators and actors from the government involved.

Sustainable Develoment Goals	Actors/Gov. institutions involved
GOAL 3 Ensure healthy lives & promote well being for all at all ages	Ministry of Health & FW
3.3.3 : Malaria incidence per 1,000 population 3.3.4 : Viral Hepatitis (including A & B) incidence per 100,000 population 3.3.5 : Dengue: Case Fatality Ratio (CFR) 3.3.6 : Number of Chikungunya cases	
3.9 : By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination	Home Affairs & NCRB
GOAL 6 Ensure availability and sustainable management of water and sanitation for all	
6.3 : By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally	MOEF&CC(CPCB)
6.3.1 : Percentage of sewage treated before discharge into surface water bodies 6.3.2 : Percentage of industries(17 category of highly polluting industries/grossly polluting industry/red category of industries) complying with waste water treatment as per CPCB norms. 6.3.3: Proportion of waste water treatment capacity created vis-à- vis total generation	
6.a : By 2030, expand international cooperation and capacity-building support to developing countries in water- and sanitation-related activities and programmes, including water harvesting, desalination, water efficiency, wastewater treatment, recycling and reuse technologies	MoWR,RD&GR
6.a.2 : Number of MoU/Co- operation agreements for capacity building and technology transfer	
6.b : Support and strengthen the participation of local communities in improving water and sanitation management	MoWR,RD&GR
GOAL 8 Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	
8.4 : Improve progressively, through 2030, global resource efficiency in consumption and production and Endeavour to decouple economic growth from environmental degradation, in accordance with the 10-Year Framework of Programmes on Sustainable Consumption and Production, with developed countries taking the lead	
8.4.1 : Renewable energy share in the total final energy mix	Renewable Energy
8.4.2 : Per capita fossil fuel consumption	Petroleum & Natural Gas/ Coal
8.4.3 : Proportion of waste recycled vs. waste generated	MOEF&CC(CPCB)
8.4.4 : Proportion of sewage recycled vs. sewage generated	MOEF&CC(CPCB)
GOAL 9 Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation	
9.4 : By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities	
9.4.1 : CO2 equivalent emission per unit of value added	MoEF&CC

Sustainable Develoment Goals	Actors/Gov. institutions involved
9.5 : Enhance scientific research, upgrade the technological capabilities of industrial sectors in all countries, in particular developing countries, including, by 2030, encouraging innovation and substantially increasing the number of research and development workers per 1 million people and public and private research and development spending	
9.5.1 : Percentage share of expenditure in R&D to total GDP 9.5.2 : Researchers (in full time equivalent) per million inhabitants	Finance Science and Technology(DoST) Commerce and Industry(DIPP)
9.b : Support domestic technology development, research and innovation in developing countries, 9.b.1 : Share of Intellectual Property Products in total Gross Fixed Capital Formation	MOSPI(NAD)
GOAL 11 Make cities and human settlements inclusive, safe, resilient and sustainable	
11.6 : By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management	Ministry of Housing & Urban development Authority
11.6.1 : Proportion of urban solid waste regularly collected and with adequate final discharge out of total urban solid waste generated, by cities	MOEF & CC Home affairs
11.a : Support positive economic, social and environmental links between urban, peri-urban and rural areas by strengthening national and regional development planning 11.a.1 : Proportion of population living in cities that implement urban and regional development plans integrating population projections and resource needs, by size of city	Ministry of Housing & Urban development Authority
GOAL 12 Ensure sustainable consumption and production patterns	
12.1 : Implement the 10-Year Framework of Programmes on Sustainable Consumption and Production Patterns, all countries taking action, with developed countries taking the lead, taking into account the development and capabilities of developing countries	
12.1.1 : Formulation of national SCP framework and integration of SCP with national/State planning process	MOEF & CC
12.2 : By 2030, achieve the sustainable management and efficient use of natural resources 12.2.1 : Percentage variation in per capita use of natural resources	MOEF & CC
12.3 : By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses	Agriculture & Co-operation
12.3.2 : Post harvest storage and distribution losses of Central/States Pool stocks of wheat and rice	Consumer affairs Food & Public Distribution
12.4 : By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment	
12.4.1 : Developing national secondary resource policy framework 12.4.2 : Development of national policy for environmentally sound management of hazardous chemical and waste	MOEF & CC

Sustainable Develoment Goals	Actors/Gov. institutions involved
12.5 : By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse 12.5.1 : Number of waste recycling plants installed 12.5.2 : Number of municipal corporations using waste segregation techniques	MHUA
12.6 : Encourage companies, especially large and transnational companies, to adopt sustainable practices and to integrate sustainability information into their reporting cycle 12.6.1 : Proportion of companies publishing sustainability reports	Corporate Affairs
12.7 : Promote public procurement practices that are sustainable, in accordance with national policies and priorities 12.7.1 : Green public procurement policy developed and adopted by the Central Ministries/States/UTs (Numbers)	Finance
12.8 : By 2030, ensure that people everywhere have the relevant information and awareness for sustainable development and lifestyles in harmony with nature 12.8.1 : Develop icon on sustainable development	MoEF&CC
GOAL 14 Conserve and sustainably use the oceans, seas and marine resources for sustainable development	
14.1 : By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land- based activities, including marine debris and nutrient pollution 14.1.1 : Health index of area of coastal water (percentage change) 14.1.2 : Number of sewage treatment plants installed along the coast and construction of toilets under Swachh Bharat Mission 14.1.3 : Percentage change in use of nitrogen fertilizers in the coastal States	Earth Sciences MHUA/Drinking Water & Sanitation Agriculture & Co- operation

Working labor meal:

Anna Canteen:

The scheme requires municipal corporations in the state to establish canteens at multiple places in cities and sell subsidised food at very low prices.

Mid day meal:

The Midday Meal Scheme is a school meal programme of the Government of India designed to better the nutritional standing of school-age children nationwide.[1] The programme supplies free lunches on working days for children in primary and upper primary classes in government, government aided, local body, Education Guarantee Scheme, and alternate innovative education centres, Madarsa and Maqtabs supported under Sarva Shiksha Abhiyan, and National Child Labour Project schools run by the ministry of labour

a) Soil Condition:

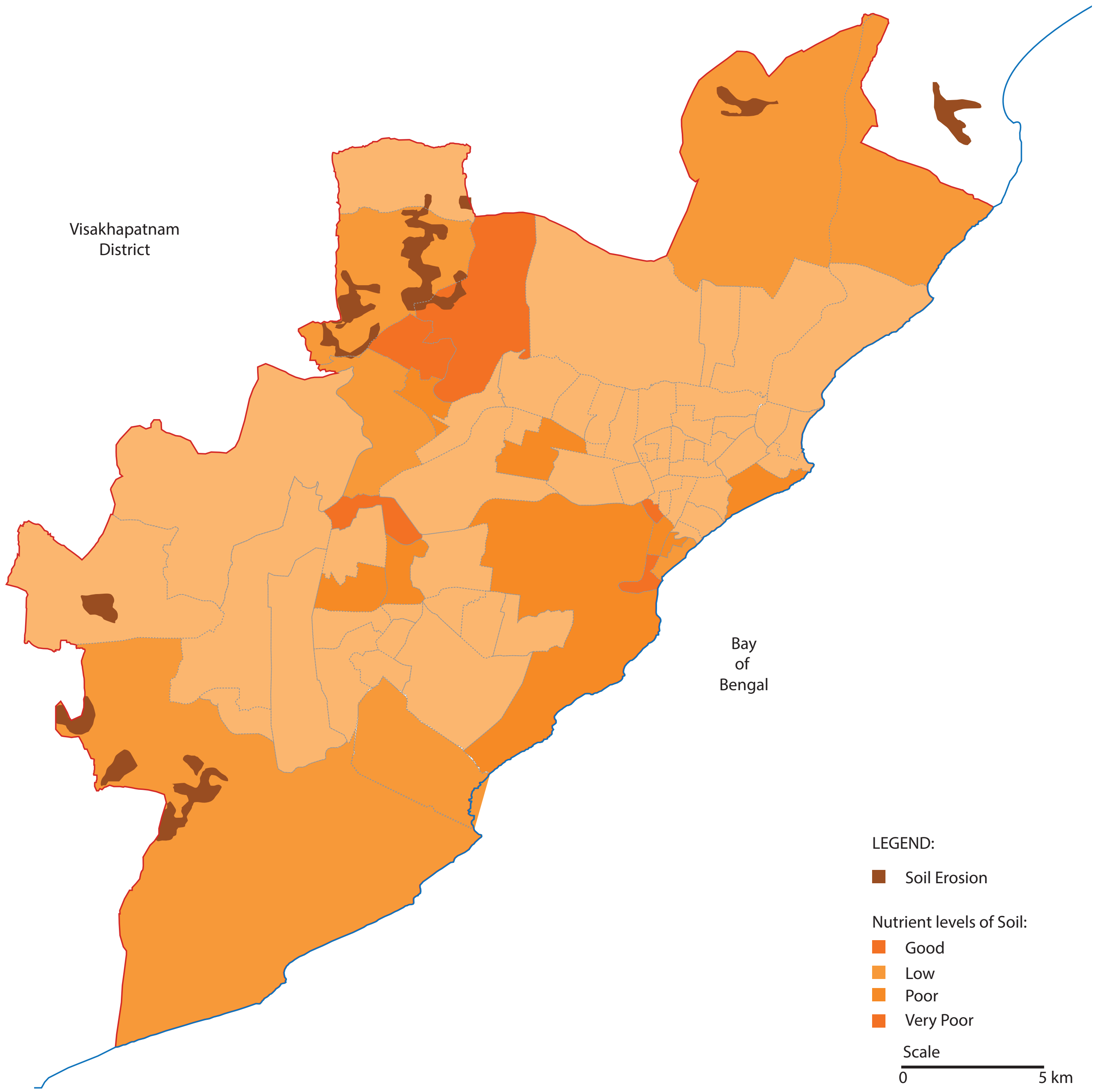


Fig 2.15: Existing soil conditions in the city

The type of soil in Visakhapatnam is red soil. Crop of rice, corn and cashews are predominantly grown in this region. The above map indicates the zones of soil erosion due to the factors of deforestation, water and wind erosion. Due to heavy industrialisation and increase in the density of urban structures, excessive usage of fertilizers, the phosphorus levels in the soil are low, resulting in poor nutrient levels.

Source: Multi-Hazard Risk and Vulnerability Analysis for the City of Visakhapatnam, Andhra Pradesh

Adapted : Author

b) Underground Water Quality

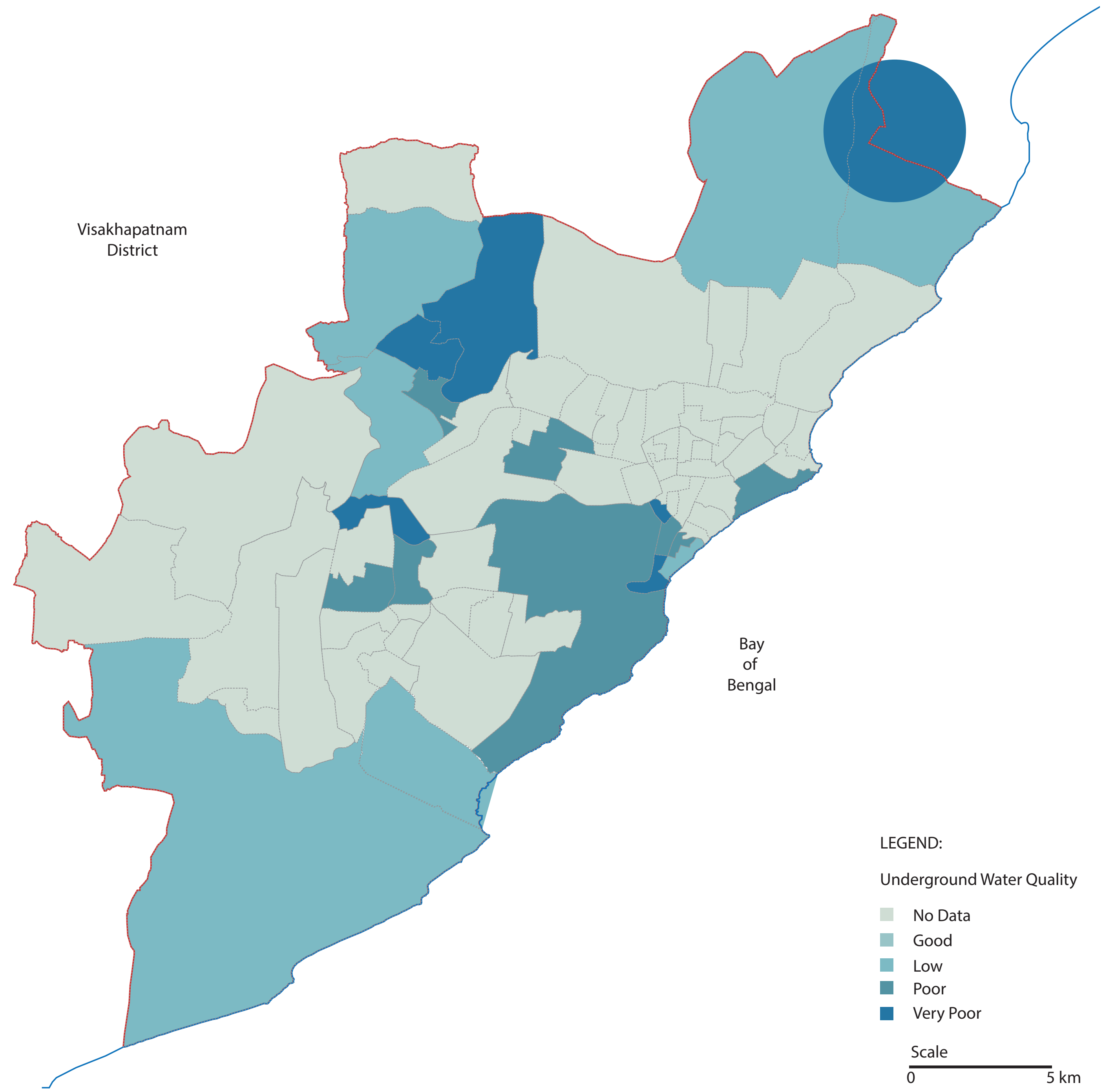


Fig 2.16 : Existing Underground water quality in the city

The above map shows the underground water quality in the city. The zones which have poor or very poor status are the zones surrounding industrial areas and areas of waste disposal. The circle represents the radius of 2500m from the landfill site which has been contaminated due to leachate formation.

Source: Multi-Hazard Risk and Vulnerability Analysis for the City of Visakhapatnam, Andhra Pradesh

Adapted : Author

c) Vector borne diseases - Malaria

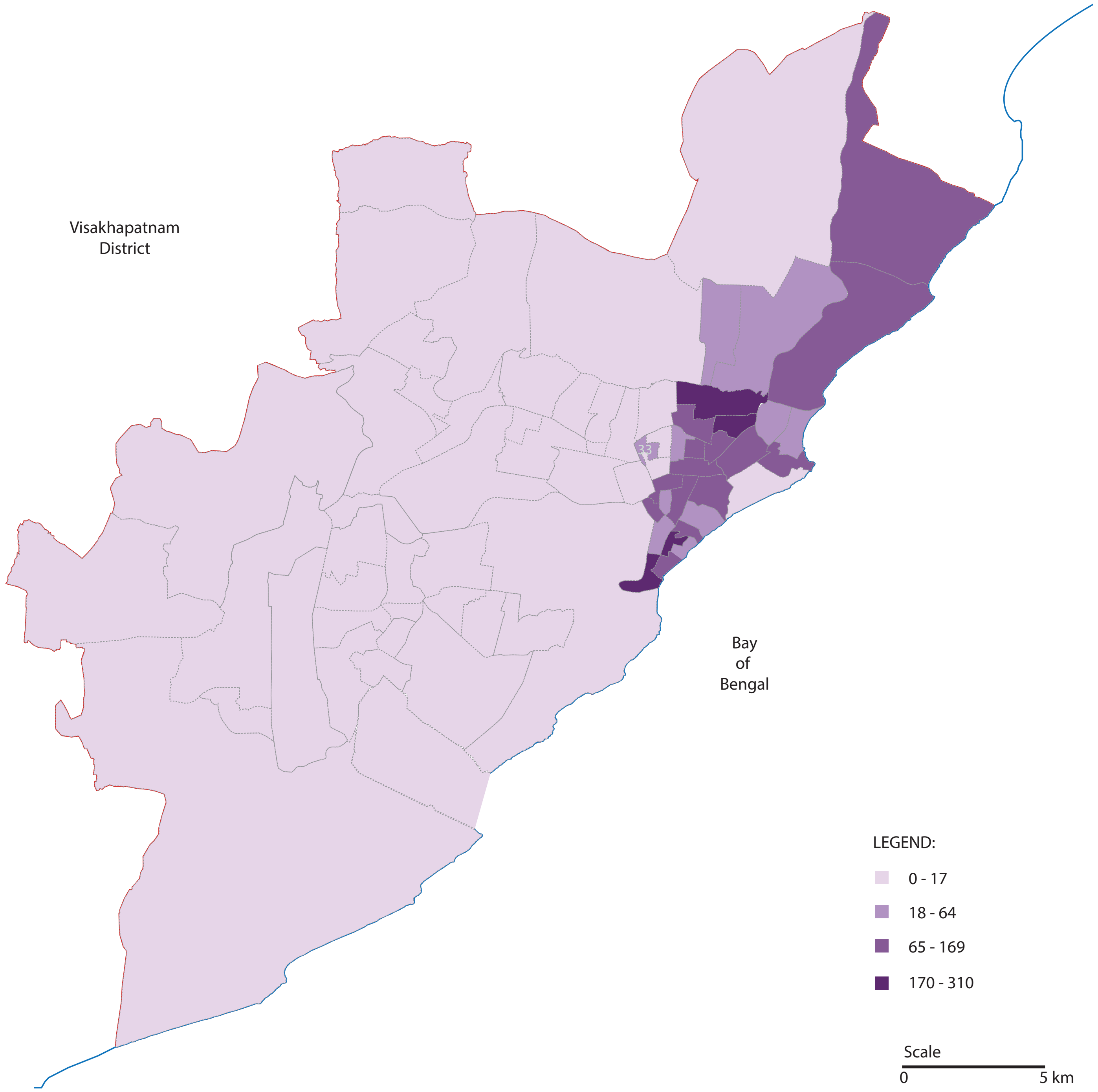


Fig 2.17: The number of registered cases for VBD Malaria in 2011

Vector borne disease in tropical countries occur due to demographic, climate changes, poor and unhygienic environmental conditions. The above map shows the number of Malaria cases registered in the year 2011. In 2017, this number has increased to 1680 (New India Express, 2017)

Source: Multi-Hazard Risk and Vulnerability Analysis for the City of Visakhapatnam, Andhra Pradesh

Adapted : Author

d) Vector borne diseases - Dengue

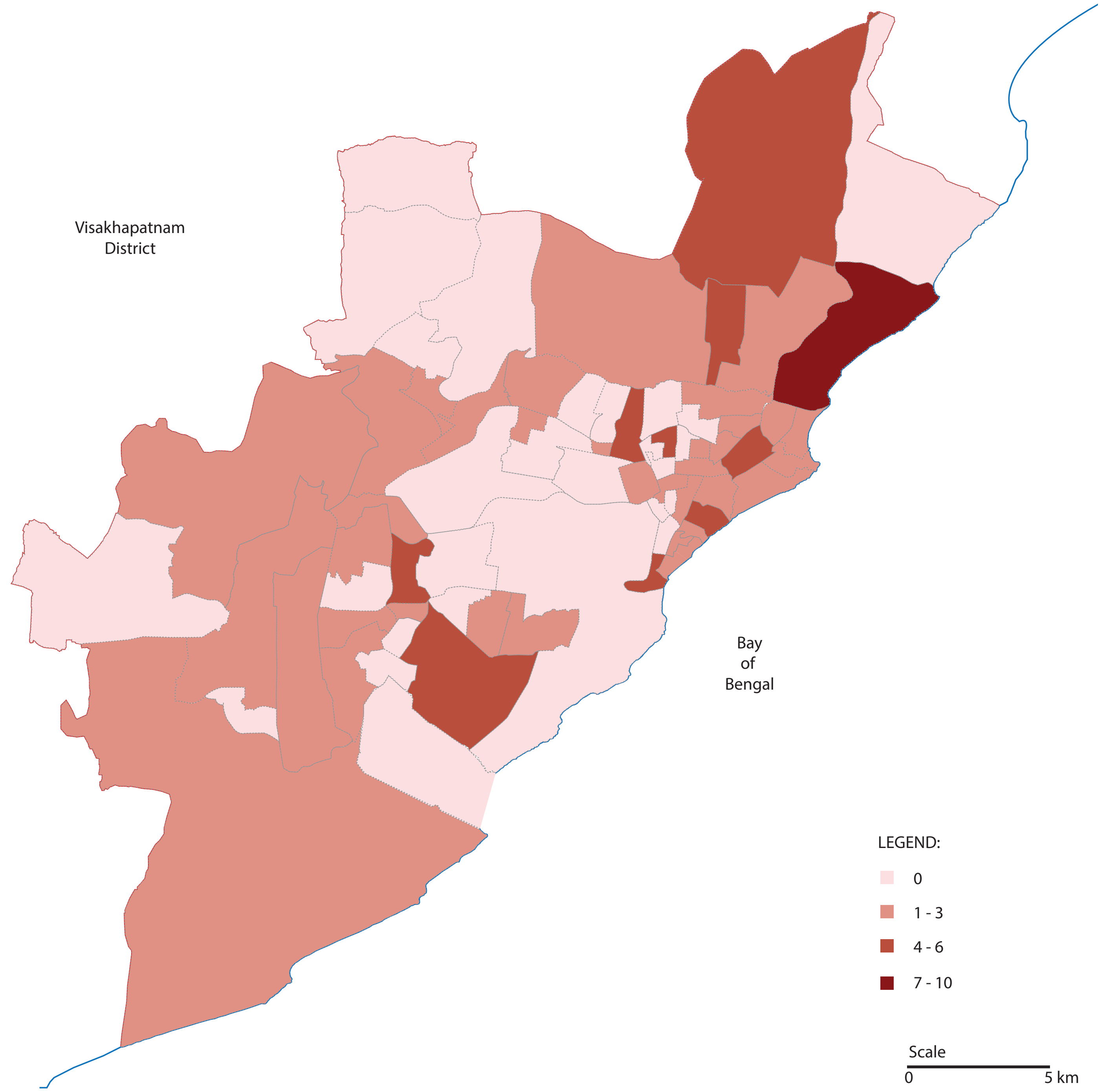


Fig 2.18 : The number of registered cases for VBD Dengue in 2011

The number of cases of people affected by dengue has been rising every year. The above map shows the number of dengue patients in the year 2011. According to 2017 statistics, the number raised to 710 (The Hans India, 2018).

Source: Multi-Hazard Risk and Vulnerability Analysis for the City of Visakhapatnam, Andhra Pradesh

Adapted : Author

e) Vulnerability Map - Cyclonic Wind

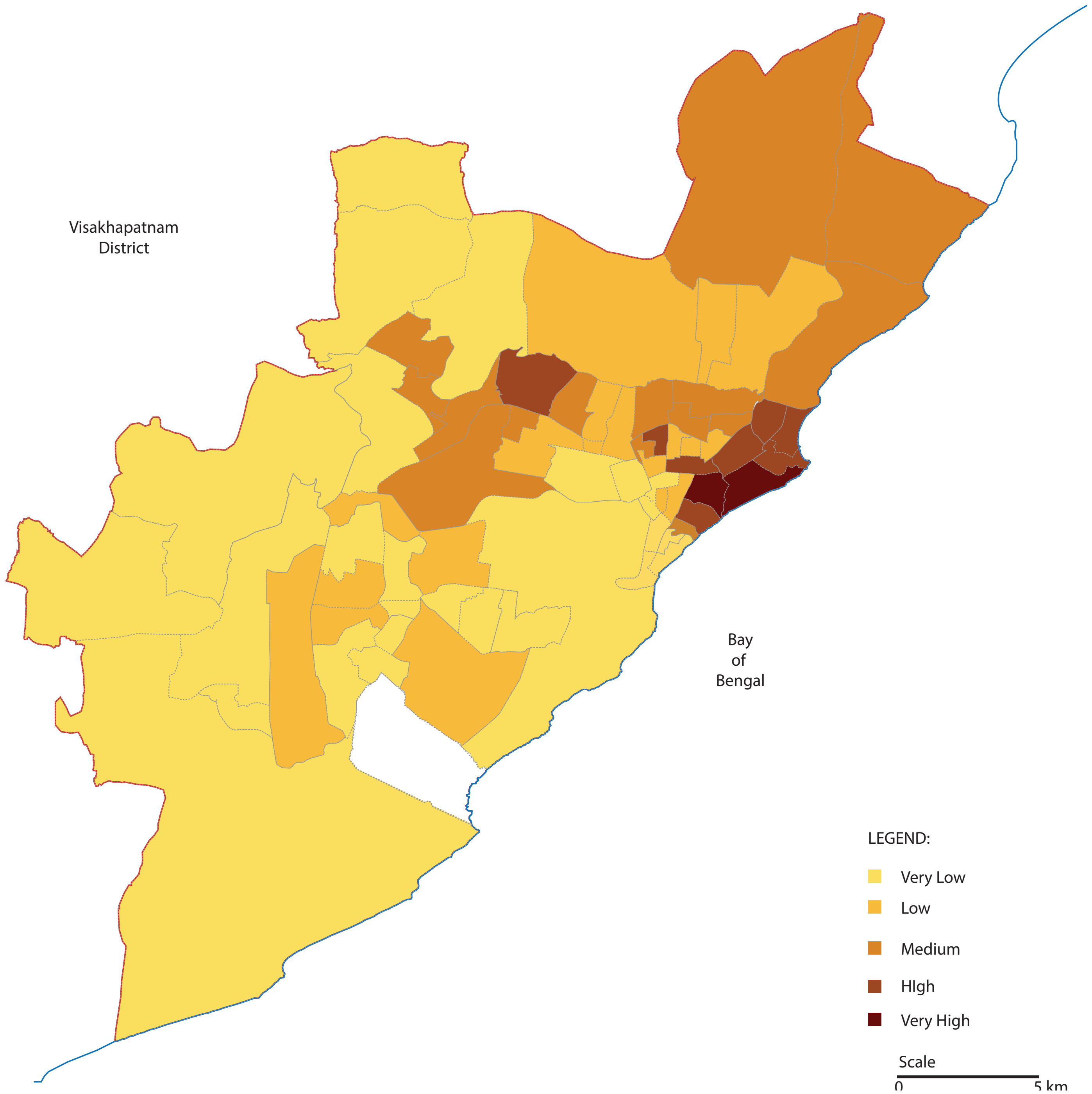


Fig 2.19: Zones which experience higher economic loss during cyclone

The above map illustrates the zones which experience higher economic loss during cyclones and heavy winds.

Source: Multi-Hazard Risk and Vulnerability Analysis for the City of Visakhapatnam, Andhra Pradesh

Adapted : Author

f) Vulnerable areas during storm surge

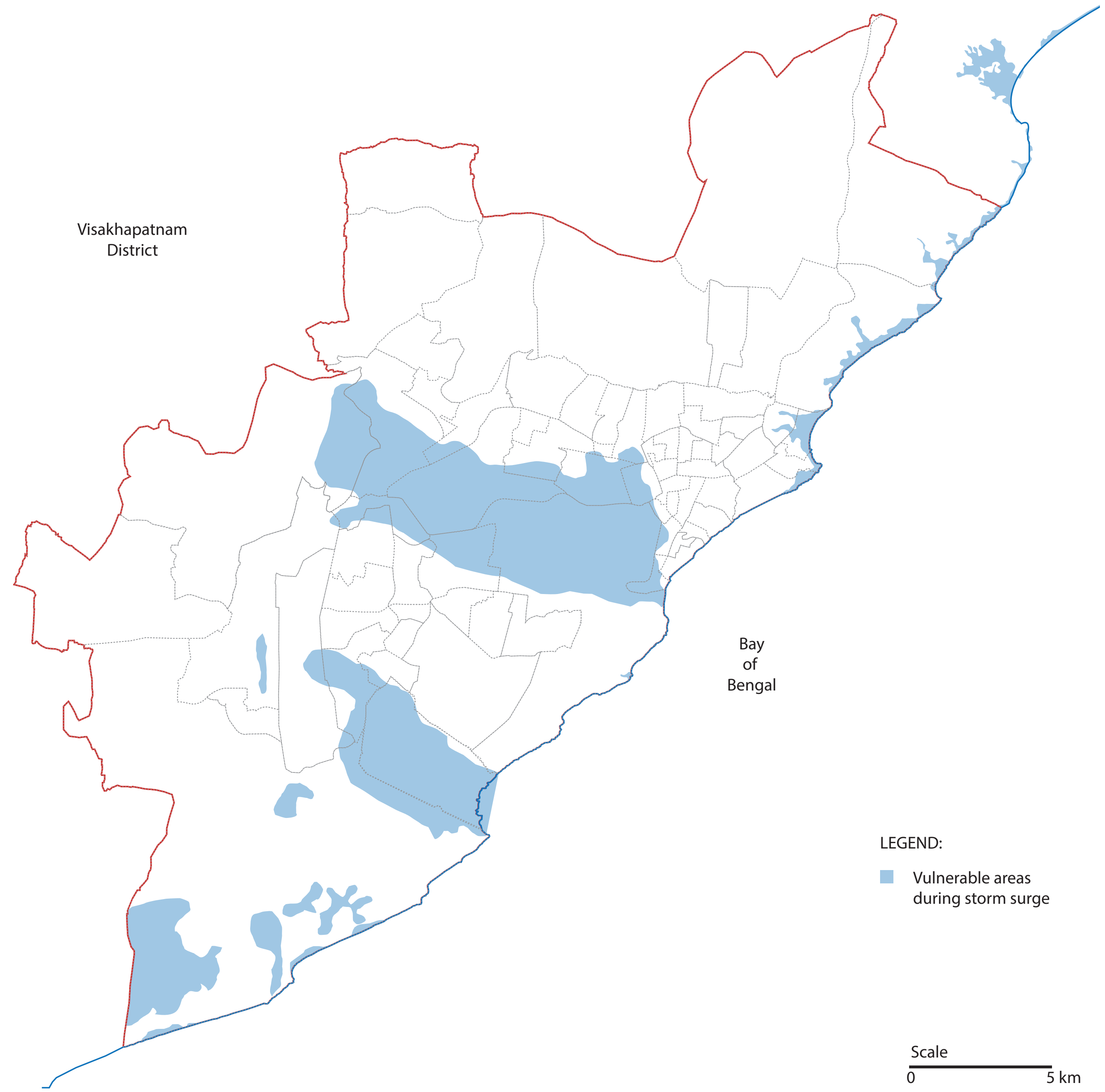


Fig 2.20: Map showing vulnerable areas of flooding during storm surge

The above map illustrates the zones of flooding that are vulnerable during storm surge.

Source: Multi-Hazard Risk and Vulnerability Analysis for the City of Visakhapatnam, Andhra Pradesh

Adapted : Author

g) Vulnerable zones during Tsunami

Fig 2.21: Map showing the affected zones during Tsunami in 2006

In the year 2006, the city of Visakhapatnam had Tsunami with a magnitude of 8.5. The above map shows the affected regions along the shoreline.

Source: Multi-Hazard Risk and Vulnerability Analysis for the City of Visakhapatnam, Andhra Pradesh

Adapted : Author

g) Identifying the vulnerable areas affected by all the above criteria

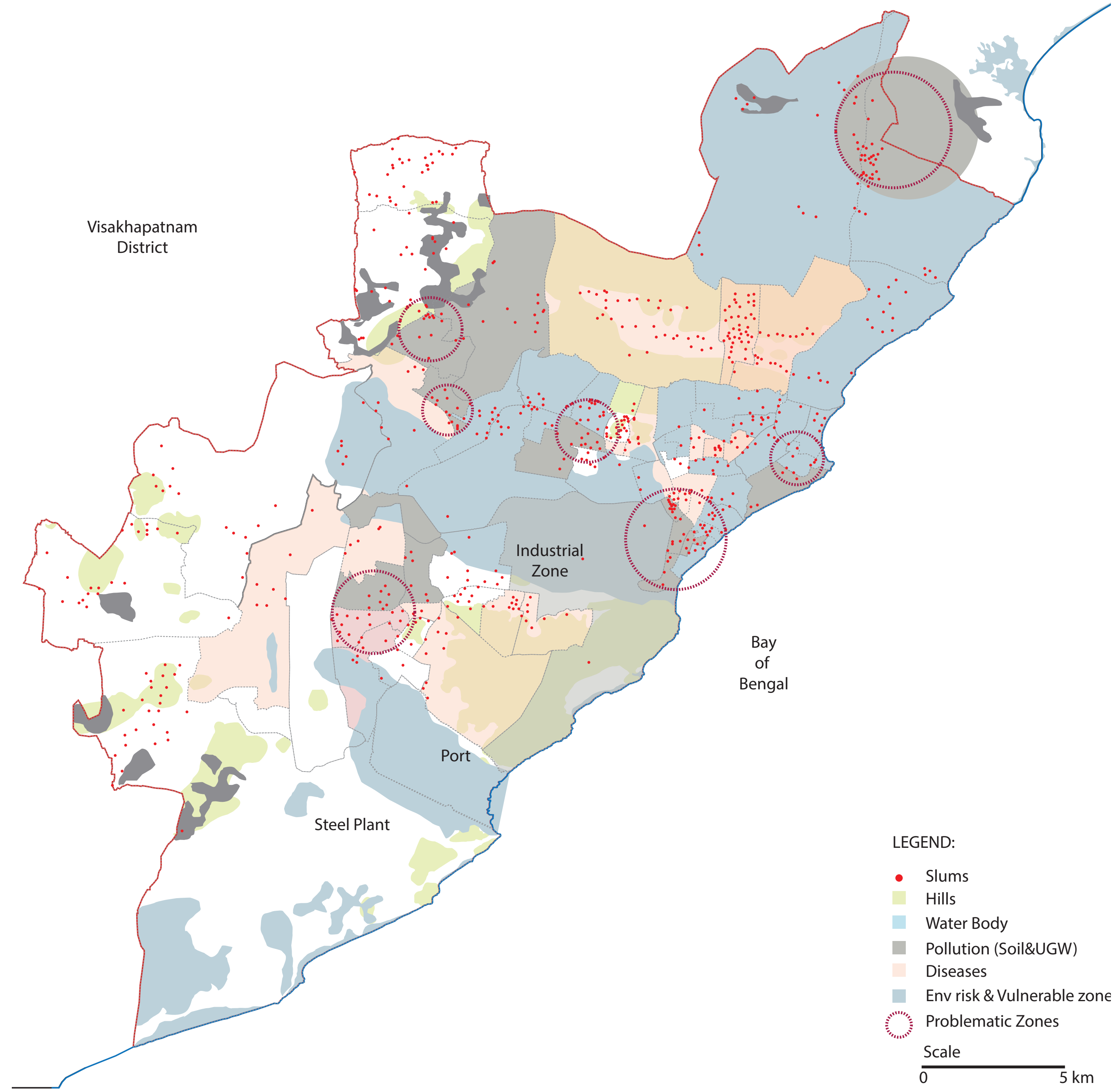


Fig 2.22: Overlapping all the layers of above listed problems

The above map is layered with all the discussed problems such as pollution (Soil and UG water contamination); Vector borne diseases and Vulnerable zones to environmental hazards and climatic changes. Another layer of informal settlements has been added to identify the socially vulnerable clusters.

Location 3: Mudasarlova Park

Fig 7.30, shows the flows involved in the chosen location. The location as shown in fig 7.31, is located in a valley that has been identified as eco-sensitive zone. The STP and MSW temporary storage site in this location release the waste into the natural streams of water. The location is not susceptible to any environmental hazrds but due to excessive extraction of under ground water- UGW sources are depleting, followed by the clogging of natural streams of water which feed the reservoir.

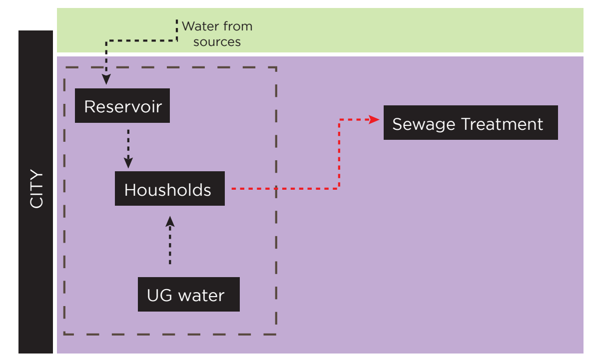


Fig 7.30 Schematic diagram of flows in the region

Legend:
ULB Scale
Region/National Scale
Global

Fig 7.31 Map of Location 1

Legend:
Primary Roads
Secondary Roads
STP & MSW tempor.
Port & Industrial Zor
Canals
Ocean

0 250m

Source: Google Earth

Fig 7.32 Mixed use development in the location

Fig 7.33 Informal or low income group settlements

Fig 7.32 and 7.34 show the current growth and development along the state highway in the location. They depend on underground water for drinking water sources.

Fig 7.34 Dried reservoir

Fig 7.35 Small pools of water in the reservoir

Fig 7.34 and 7.35 represent the current state of the reservoir which is completely dried out due to blockage of natural streams of water.

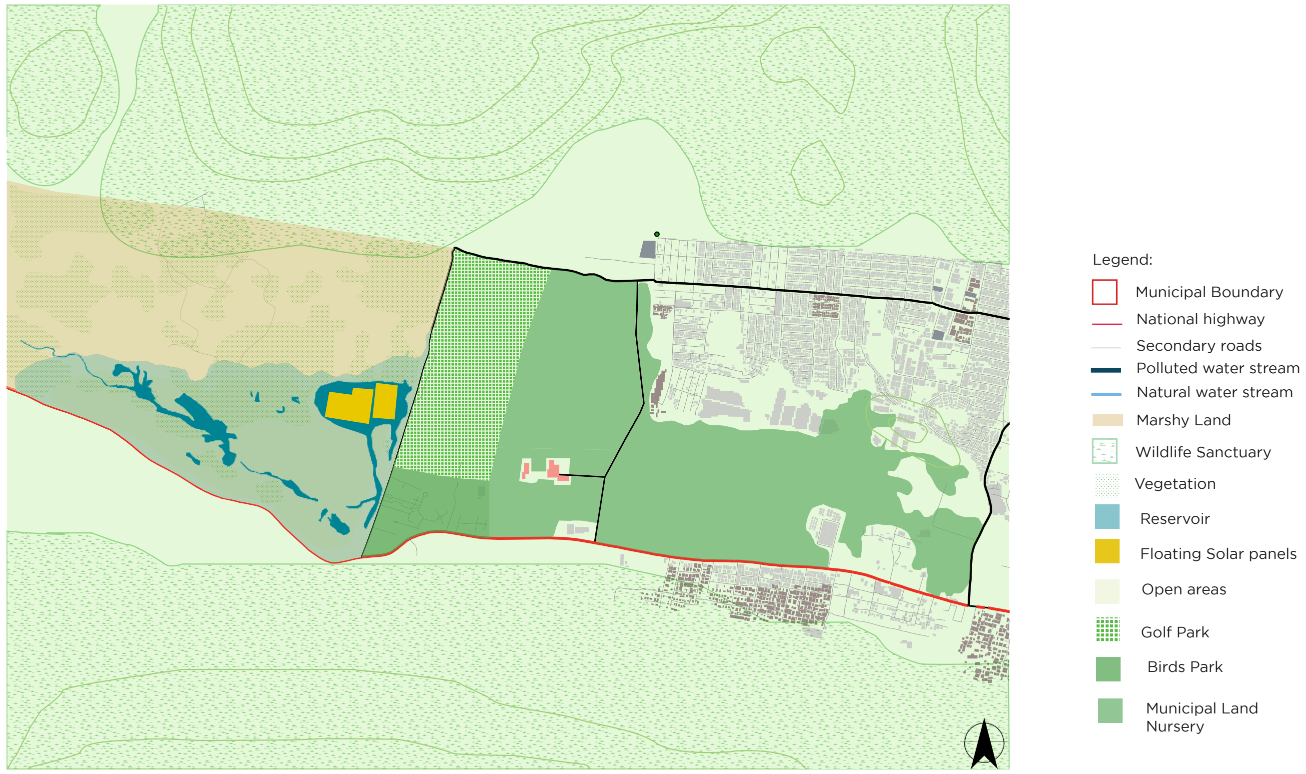


Fig 7.36 Map showing the existing landuse of the location

Scale - 1:8000

The above map showcases the currrent landuse of the location. It is a residential and mixed use development zone located in a valley. The reservoir is dried up for more than a year now, the agendas of the municipality to revive the reservoir is bringing in water from natural sources such as rivers in the region.

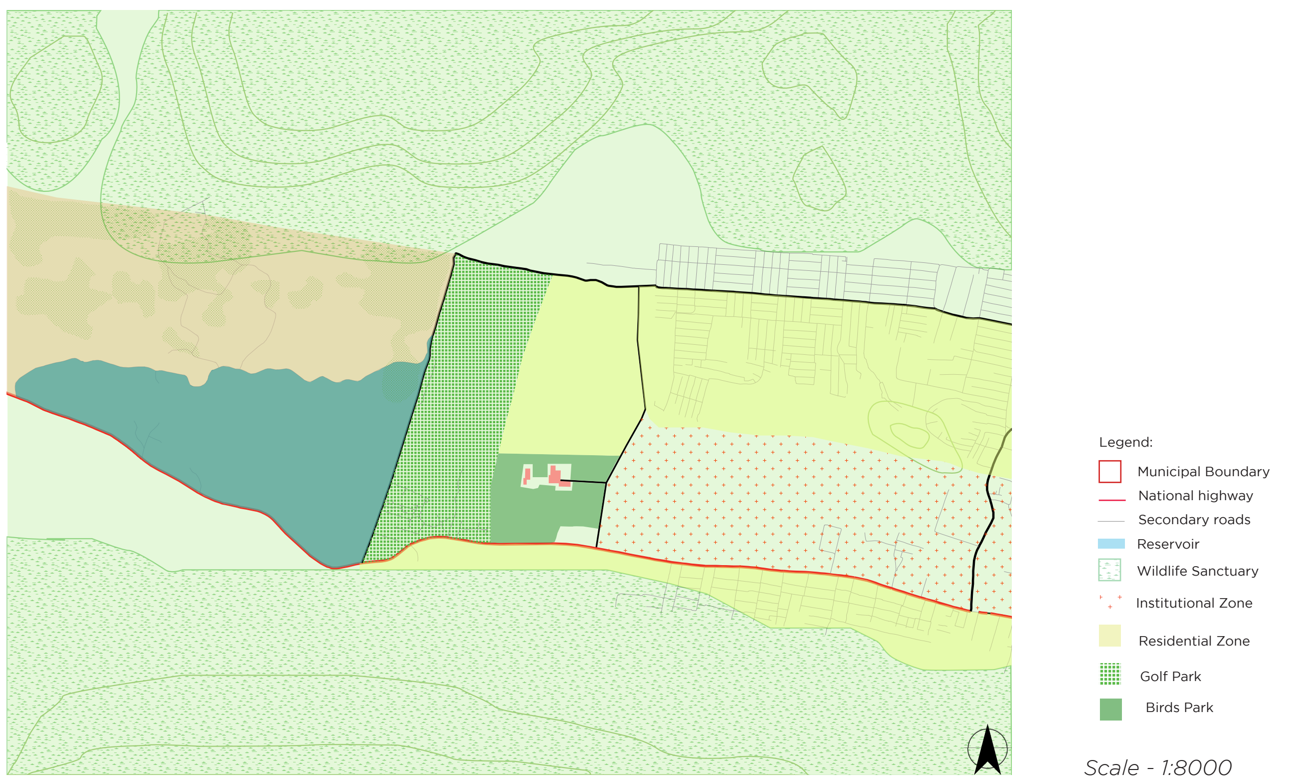


Fig 7.37 Master plan of the location for the year 2021

Scale - 1:8000

The above map showcases the master plan of the location made for the year of 2021. In this master plan, the location is divided into two different belts: mixed use development along the state highway followed by residential belt. The proposed mixed use belt has not been developed yet.

Policies & Guidelines

Prohibition of discharge of waste water into the canals/ natural water sources.

Storage of stormwater runoff at household and community scale

Lesser taxes for using recycled water

Discouraging the permissions for deepwell usage or imposing High fines for illegal construction activities in or along natural streams of water

Source water protection, Robust water treatment, water supply network and monitoring programme.

Regular monitoring on source water and ground water aquifier levels, monitoring the usage of water at household scale.

Consumer Behavior

Public awareness and education by demonstration of sustainable practices.

Responsible consumption of resources

Community led initiatives to save water and regulate the usage of water

Improving current Technology

Fraction of treated water from the STP pumps water into underground aquifiers for groundwater recharge

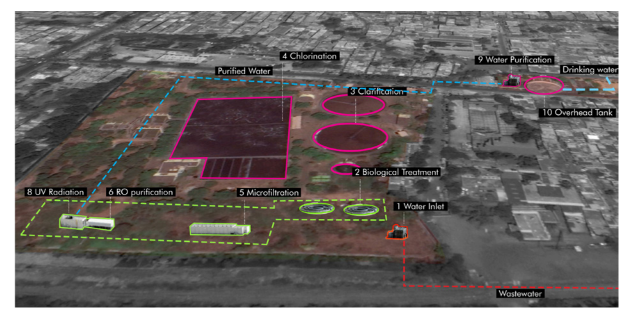


Fig 7.38 Proposed technologies in the looping system

Fig 7.39 Recharge of groundwater aquifiers
Source:ttps://www.asla.org/2017studentawards/320399.html

Unclog Water streams

Physical Removement:

Clearing the solid waste from the water streams physically before the process of biological purification treatment of the water.

Nualgi:

Feed a mixture of nutrients to diatoms - the most basic, single cell life form found in ponds, lakes, rivers and oceans, as the algae formed by diatoms grow , they release O2 into water. O2 released helps aerobic bacteria efficiently breakdown the organic matter and convert pollutants to base constituents. The diatoms are eaten by the zzoplanktons and they are eaten by fish.

Timeline for implementation of strategies across the city

A timeline spanning over 30 years (Fig 3.40) demonstrates the steps to be taken to implement the strategies across the city. It highlights the policies, short term goals, long term goals and similar projects in other locations.

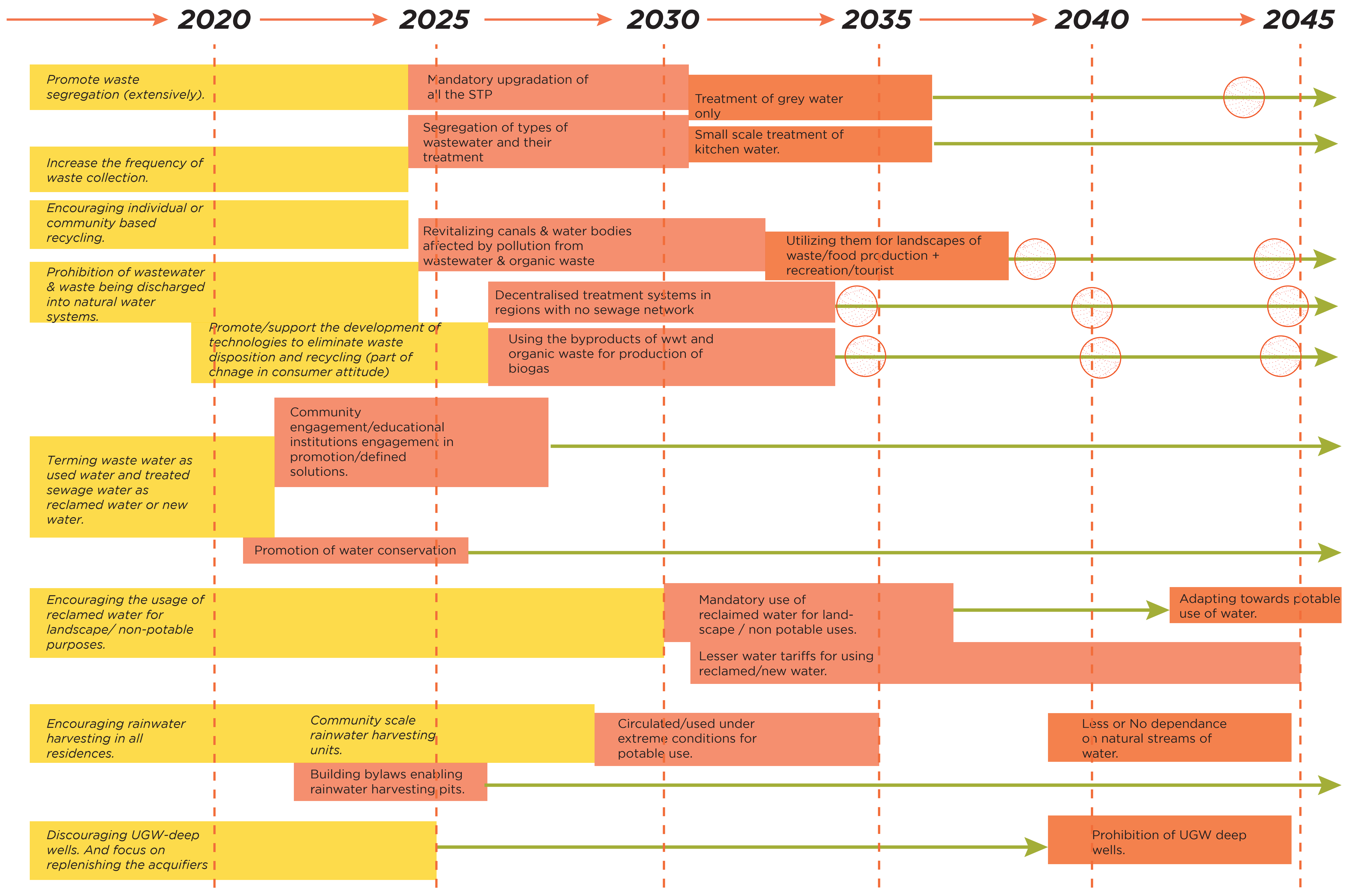


Fig 7.40 Timeline for implementing circular strategies

THEORY PAPER

INTRODUCTION

India is currently going through a phase of rapid transformation, especially in its developing metropolitan cities with growing urban population and increasing affluence. Due to its sustained economic growth, increasing living standards of the people and changing production and consumption dynamics, there is an increase in the amount of waste generated. In this linear process of take, make and dispose, the value of the resources is lost. The linearity in both resource consumption and waste disposal processes is resulting in environmental degradation by significant air, soil and water pollution and poor public health as well. This is a major challenge for developing countries like India, as industries are the heart of economic growth and they are dependent on the natural resources. To overcome this challenge of loss of resources from the natural environment, loss of value of these resources in the linear model and the repercussions of improper waste disposal, there is an urgent need to shift to a circular process.

The subject of Circular Economy (CE) is gaining interest all over the world as a way to curb the current linear system of wasteful production and consumption patterns in the society and move towards a sustainable development. CE has mostly been associated with waste management, many countries have adapted it as a tool to develop environmental and waste management policies. But the concept of CE is not limited to implementing waste management solutions, but it looks at the larger perspective of the resources extracted from the natural environment, throughput in the production of goods and the reuse potential of the resource. CE can be stated as a field favouring the resource management rather than only waste management which is only one subsector of the entire loop (Merli R. et al., 2018). Murray, Skene, and Haynes (2015) have defined CE as: 'an economic model wherein planning, resourcing, procurement, production and reprocessing are designed and managed, as both process and output, to maximize ecosystem functioning and human well-being'.

The transition towards CE is not a single step approach or just technological advances catalysing the change in the cycle, rather it is a complex process. It is challenging to shift from linear resource oriented industries and mind-set of the society (Leider and Rashid., 2016), it also requires changes in different subsystems on various scales (Van Buren et al, 2016). It is even more challenging to implement CE in Indian cities as it requires a long-term systemic behaviour change for all the stakeholders including government institutions, corporations, NGOs, civil society organisations, development agencies, and individuals. Apart from being hubs for resource consumption, these cities have complex dynamics such as socio-economic and cultural diversity. Hence, in order to implement CE in these developing cities, it needs to be incorporated in urban planning which is an integrative discipline: it needs to integrate physical, socio-cultural infrastructure, the economy and the environment into its fabric and the planning and development process (Karvounis 2015; Rotmans, van Asselta, and Vellinga 2000; Van Der Leer J. et al., 2018). Therefore, this paper seeks to discern the possibilities of integrating the principles of CE into urban planning in the context of Indian cities.

METHODOLOGY

It is essential to understand the concept and theories relating to CE, before focussing on how to implement it. Hence papers from Web of Knowledge and Google scholar related to Circular Economy theories and practices have been shortlisted and reviewed (Chapter 1). Further analysis is done on papers which focus on how CE stimulates sustainable development in cities. The next step is to analyse the state of the art in CE implementation. This is carried out by studying papers related to the existing policies and practices across different fields and scales. The existing practices were analysed through the CE implementation framework developed by Zhijun and Nailing (2007), pointing out the integration of different scale levels and subsystems. A detailed analysis is performed on the case studies which have evaluated the CE implementation in two different countries based on vertical-horizontal (V-H) integration framework in urban planning (Chapter 2). Further analysis is done on the current studies in India on CE (Chapter 3). The conclusions from the analysis of the case studies provide guidelines for the implementation of CE in India (Chapter 4).

CHAPTER 1

Circular Economy and its principles

In recent years the concept of CE has gained the attention of institutions, scholars and firms (Ghisellini et al., 2016). CE is assumed as a theory that underlines the importance of shift in the "take-make-dispose" linear path (Fig. 1a) of production and consumption (Geng and Doberstein, 2008). Ellen MacArthur Foundation 2014 has defined it as:

"A CE accommodates resources flowing through man-made and natural systems in renewable ways, creating or retaining value through slowed, closed or narrowed loops, rather than rapidly destructing value through the creation of waste. This value can manifest itself in monetary principles as well as other social, ecological or economic principles, taking account of potential trade-offs."

CE has been adopted as a guiding principle in many countries' policies, which have approached its implementation in different ways (George et al., 2015; R. Merli et al., 2018). Several CE definitions exist, evidence that this concept has undefined boundaries, while changing the actors and point of view. Therefore, there is no commonly accepted definition of CE (Yuan et al., 2006). Over the last years, CE has received great attention from scholars, both for its theoretical conceptualization and for its practical implementation strategies (Geissdoerfer et al., 2016). These studies are being done extensively across multiple fields, Kircherr, Reike and Hekkert (2017) identified more than 114 definitions in 17 dimensions in their literature study.

Principles:

"R" Framework

Kircherr, Reike and Hekkert (2017) distinguish between two types of core principles of CE. First one pertaining to "R" frameworks and the second being the systems perspective. Various formats of "R" frameworks have been used by academia as well as practitioners. The 3R framework [Reduce, Reuse and Recycle] is the most prominent framework. This

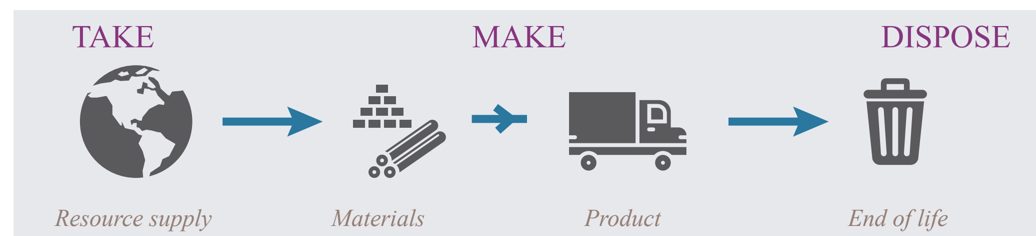


Fig 1 a) Linear Economy

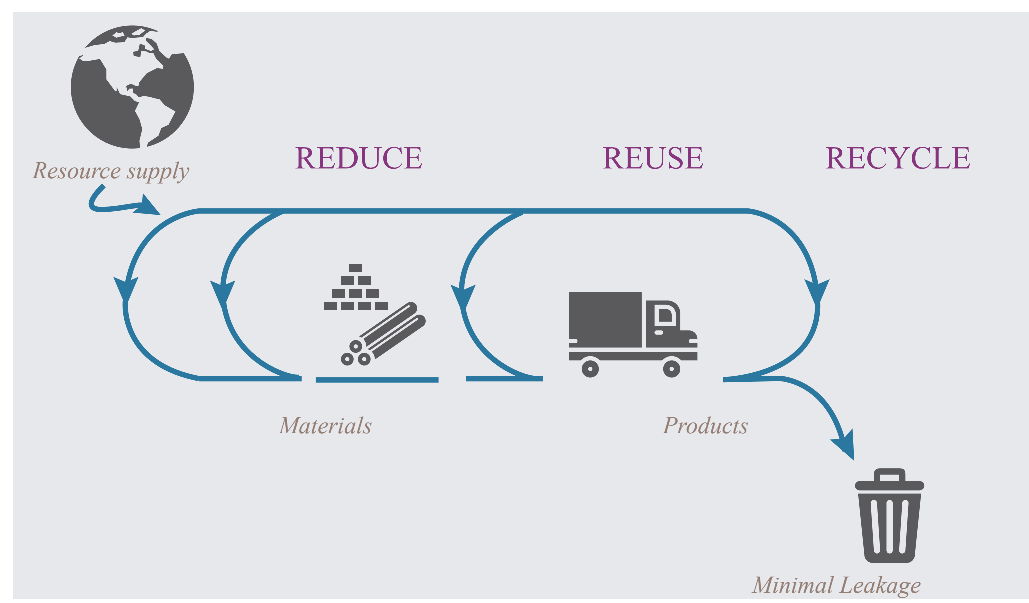


Fig 1 b) Circular Economy

framework is not a linear concept though arranged in that format, rather it is an order of preference where the first step is reduce or prevention. While reuse and recycle play an important role in the decision making of resource management. It requires efficient and effective recycling methods in order to reuse as a secondary material. In certain instances, the cost effect plays an important role in decision making of recycling the product. The European Union Waste Framework Directive introduced Recover as the fourth "R", through which energy can be recovered by incineration of the material. Many scholars have

Smarter product use and manufacture	R0 Refuse	Make product redundant by abandoning its function or by offering the same function with a radically different product
	R1 Rethink	Make product use more intensive
	R2 Reduce	Increase efficiency in product mahufacture or use by consuming fewer natural resources and materials
Extend lifespan of product and its parts	R3 Reuse	Reuse by another consumer of discarded product which is still in good condition and fulfils itts function
	R4 Repair	Repair and maintenance of defective product so it can be used with its original function
	R5 Refurbish	Restore an old product and bring it up to date
	R6 Remanufacture	Use parts of discarded product in a new product with the same function
	R7 Repurpose	Use discarded productcts or its parts in a new product with a different function
Useful application of materials	R8 Recycle	Process materials to obtain the same (high grade) or low grade quality
	R9 Recover	Incineration of material with energy recovery

Fig 2) The 9R Framework. Source: Adapted from Potting et al. (2017, p.5)

developed different frameworks such as 6R and 9R. The 9R framework by Potting et al (2017) (Fig 2) gives a holistic approach towards CE and prioritises Refuse and Rethink over reduce. This hints towards a change on the global scale resource consumption, reducing the usage of natural resource dependencies and develop solutions which have revived value. In continuation with Reuse, it proposes multi reuse of the product in different loops with the steps of Repair, Refurbish, Remanufacture and Repurpose. And the final steps in his framework suggest recycle and recover.

Systems perspective:

Systems perspective is the second core principle of CE. Zhijun and Nailing (2007). Jackson et al., (2014) discuss that the transition to CE should happen at three levels which can be interpreted as the three levels of the CE system: the *micro level*, *meso level* and *macro level*.

Macro-systems perspective highlights the need to adjust industrial composition and structure of the entire economy,
Meso-systems perspective usually focuses on eco-industrial parks as systems (Heeres et al. (2004), Shi et al. (2010)).
Micro-systems perspective usually considers products, individual enterprises and requirements to increase their circularity as well as consumer behaviour (Jackson et al., 2014; Sakr et al., 2011).

Fang et al. (2007) and Lieder et al. (2017), mention that CE requires fundamental changes simultaneously at the micro, meso and macro system.

CHAPTER 2

Global Scenario - principles and implementation of Circular Economy

CE emerges in literature as the 3R's principles: Reduce, Reuse and Recycle. The European nations, USA, Japan, Korea and Vietnam implement CE and its principles in sectoral initiatives mainly related to waste management policies. Their broader goal is the achievement of synergistic effects with national strategies towards landfill prevention, procurement of resources, reduction of GHG emissions and management of hazardous waste following circulation of materials (Sakai et al., 2011; Resources 2015). On the contrary, China has a different take on implementing the principles of CE. Considering the large scale of the country and characteristics of their economy, Chinese have a "top-down" government mandatory approach, whereas other countries are designing environmental and waste management policies utilizing a "bottom-up" approach. Its implementation is structured following both a horizontal and a vertical integration approach (Zhijun and Nailing., 2007).

Micro Level:
At the micro scale, the production companies carry out different strategies to improve the circularity of its production system and also cooperates with other companies over the supply chain for the achievement of a more effective circular pattern (Wrinkler, 2011). *Eco-design* was promoted across Europe, USA and China. In the *consumption sector*, promotion of consumer's responsibility and green procurement was essential. Functional instruments for green consumers are specific information and labelling systems covering food, non-food products as well as services. The labelling systems are developed across all continents: in Europe, Asia, Northern and Southern Americas and Australia. And in the *waste management sector*, importance is given for recovery of resources and environmental impact prevention.

Meso Level:
At the meso level, the international experiences of industrial symbiosis are both top down (Eco-Industrial Parks (EIP), e.g. in US, Canada and Asia) and bottom up (industrial symbiosis districts or industrial ecosystem as Kalundborg) strategies, due to the fact that the former are the result of a preventive planning and design while the latter derive from spontaneous agreements among the participant companies (Cutaia and Morabito, 2012). The Chinese promoted both EIP and industrial symbiosis as models of industrial and technological development at the political level - SEPA (State Environmental Protection Administration).

Macro Level:
At the macro level: Circular economy development in cities, provinces or regions involves the integration and the redesign of four systems: *the industrial system, the infrastructure system, the cultural framework and the social system* (Mirata and Emtairah, 2005; Feng and Yan, 2007; Ness,

2008; Naustalslid, 2014). The concept of *eco-towns* was started in the USA, with an aim to redesign cities according to more ecological concepts. Further Japanese developed eco towns which involved urban and industrial centres in symbiosis. More examples of eco cities have been developed across Germany, Sweden, UK and China. The success of such programs is due to legal, social, economic and technological factors, such as the evolving legislative framework towards the adoption of a recycling oriented society, the shared responsibility of society over the need for environmental protection, the reduction of enterprise's risks and capital expenditure by means of subsidies, the diversification of enterprise's activities and the improvement of technological capacity within particular industrial sectors (Van Berkel et al., 2009b). *Collaborative consumption* models are recognized as one of the best available options on consumer side to shift from the present business-as-usual model to CE (Ness, 2008; Preston, 2012; Van Meter, 2013). Innovative waste management and zero waste programs are developed and promoted. San Francisco has achieved the highest possible rate of zero waste target with more than half of the waste materials being recovered followed by Stockholm. (Reference) The European Union has also included the zero-waste policy in their 7th Environment Action Plan.

Implementation of circular economy by integrating it into urban planning:

The implementation of CE theory is challenging because of the current linear mind-set and the structures in industry and society (Lieder and Rashid 2016) and because it requires changes in different subsystems on various scales (Van Buren et al. 2016; J Van Der Leer et al., 2018). It is important to find ways to incorporate a CE based approach in urban planning practice (Owen and Liddell 2016) in order to accommodate resources to flow through man-made and natural systems in renewable ways while creating or retaining value. (J Van Der Leer et al., 2018). According to He et al. (2011) urban planning can be defined as an interdisciplinary and comprehensive approach for a balanced regional development and physical organization of space. In order to identify how to integrate a CE approach into urban planning it is necessary to first understand the integrative dimensions of urban planning. Urban planning aims to change or manage spatial development by constructing new ideas, visions, actions, means for implementation, processes and other ways of understanding (Albrechts 2006a, 2006b). It is an integrative discipline in which often two (organizational) dimensions are discerned: horizontal integration and vertical integration (Holden 2012; Stead and Meijers 2009). Horizontal integration has the aim to deepen specific knowledge (Albrechts 2006a) and emphasizes 'collaboration, coordination and the building of working relationships' (Albrechts 2006b, 1158) across policy domains, local agencies and departments (Hajer and Zonneveld 2000; Stead and Meijers 2009). Vertical integration is related to linkages between different scale levels (Albrechts 2006b), levels of government i.e.; national, provincial and municipal (Hajer and Zonneveld 2000) and different tiers of government (Stead and Meijers 2009) (J. Van Der Leer et al., 2018). Figure 3 illustrates the horizontal and vertical integration in urban planning.

Zhijun and Nailing (2017) describe that implementation of CE should first start at the level of enterprises, then in industrial parks, then in cities and regions, moving from micro to the macro level. Each of these levels serve as the basis for the next level above, and as a platform for the level immediately below. At the *micro level* (enterprise or individual firm), the focus is on cleaner production, economy of raw materials, reduce in toxicity and design/produce environmental friendly products. At the *meso level* (industrial park/network), material flow and energy flow level should be redesigned in principles of CE. At the *macro level* (city or regional level) pollution prevention becomes paramount; this is characterized by material and energy circulation and has, as its ultimate objective, sustainable social, economic, and environmental development, including maximum energy and resource use and reduction of waste discharge.

On the horizontal dimension, Zhijun and Nailing (2017) describe the industrial system, infrastructure, cultural setting and social consumption as interdependent large complex systems. First step towards building CE based industrial system is industrial and material symbiosis. Second step is the development of required infrastructure. A CE oriented urban infrastructure is based on circulation of materials, efficient use of energy and information sharing within the system, integration of clean production, eco-industry and eco-agriculture, and

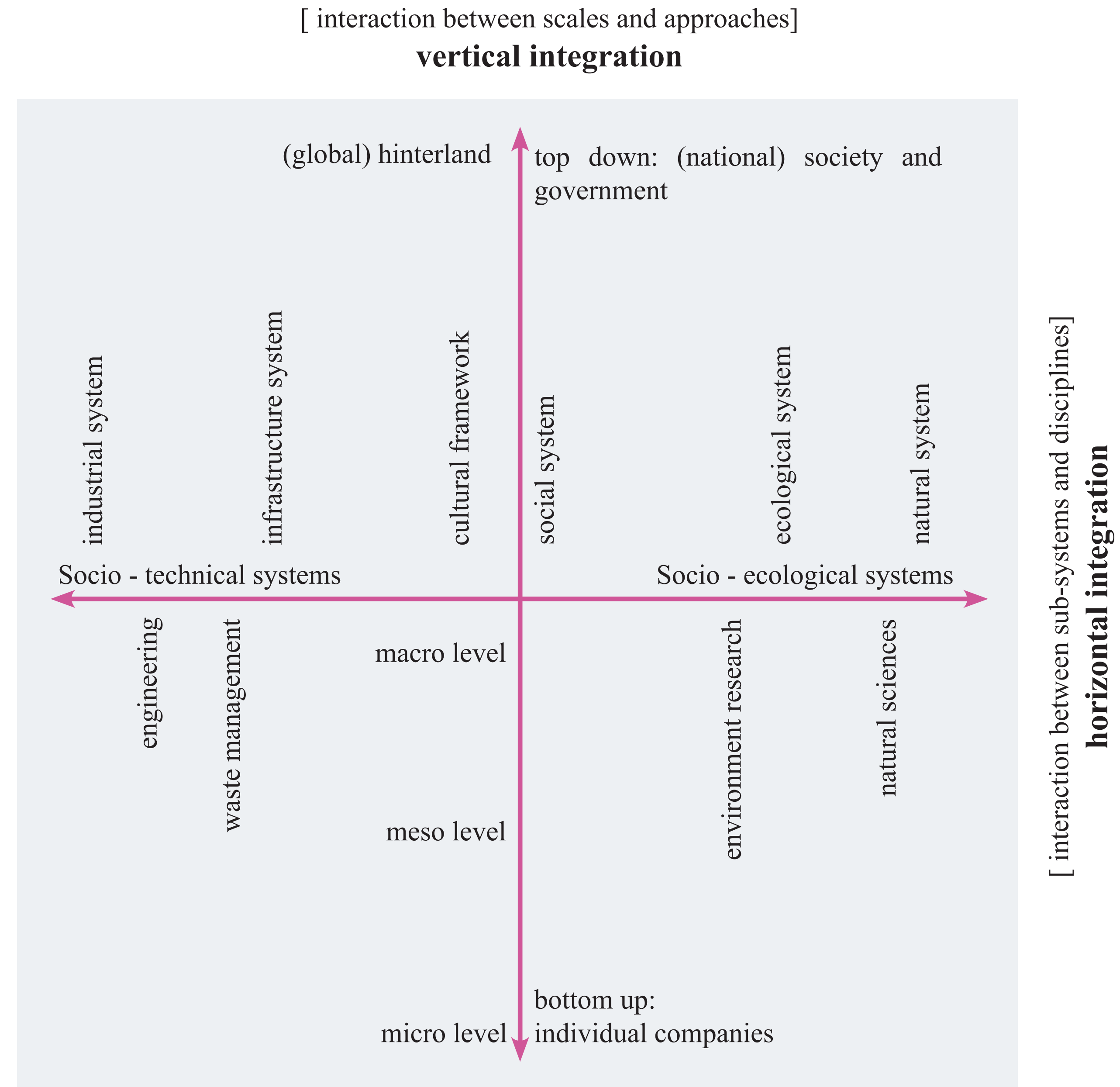


Fig 3) (Fig z) For the practical implementation of CE, Zhijun and Nailing (2017), emphasize that there should be integration of scales vertically and integration of subsystems horizontally.
Source: Van Der Leer J. et al., 2018

formulation of a holistic strategy. The third step is to build an eco-friendly human habitation environment that helps to restore the ecosystem in cities and boost the quality of life. In order to sustain the health of ecosystems resource use, production and waste disposal should be conducted below the ecological threshold. The final step elaborates on balanced consumption patterns. Consumer preferences, behaviour, and patterns should be oriented toward environmental protection, ecological balance, and sustainable social development, with governments adopting policy measures to ensure the formation of a circular consumption mechanism.

J. Van Der Leer et al (2018), narrate that research into such large complex systems is often divided into socio-ecological systems and socio-technical systems. At the core of a socio-technical approach lie the interactions between technologies, material artefacts and human activities and actors (Mylan, Holmes, and Paddock 2016, J. Van 2018). Socio-ecological systems aim to integrate ecological and social sciences with a view to studying coupled human and natural systems (Liu et al. 2007). Feedback and interaction between ecosystems and humans are key in socio-ecological systems. A better understanding of the processes of human-environment interactions that affect the resource flows of cities is essential for sustainable resource management (Pahl-Wostl 2007; VanTimmeren 2006; Voskampet al. 2016).

CE implementation in China:

China follows different approach of implementation of CE compared to other countries. CE in China is a direct outcome of the national political strategy (top down approach), and its implementation is structured following both a horizontal and a vertical approach (Feng and Yan, 2007). Chinese national governmental policy aims to transform not only the industry but also the socio-economic organization of the society at all levels (Naustdalslid, 2014). The vertical approach in China implies the shift of CE from the low level of analysis micro (company or single consumer level) to the higher hierarchical levels meso (e.g. eco-industrial parks) and macro (cities, provinces and regions) while the horizontal dimension implies a link between "industries, urban infrastructures, cultural environment, and the social consumption system" (Ghisellini, Cialani, and Ulgiati 2016). Several Chinese studies analysed CE implementation following both horizontal and vertical approach (Yuan et al., 2006; Feng and Yan, 2007; Ren, 2007; Geng and Doberstein, 2008; Su et al., 2013). Though they have an elaborate framework for implementing CE, the process of implementation is slow. The implementation of CE in China is less developed than its principles and its theory (Naustal). Su et al., lists out the factors that are slowing down the implementation of CE as i) lack of reliable data and information; ii) Shortage in the advanced technologies in CE; iii) poor enforcement legislations and development strategies; iv) weak or absent economic innovations; v) lack of public awareness and vi) lack of bottom up involvement - low level public intervention. Analysing these points on the V-H framework, it can be observed that lack of bottom up strategies is one of the major drawback and the policies developed are inadequate to develop CE. There is less focus on the socio-ecological structure.

CE implementation in Netherlands:

Netherlands has a bottom - up approach towards CE. Their approach towards CE is nimble and agile. It integrates multiple stakeholders on multiple scales and there are innovations in materials business models related to CE. J. Van Der Leer et al., (2018) have studied the planning documents of AMA (Amsterdam Metropolitan Area) and its surrounding areas with the V-H CE framework which had both top-down and bottom up strategies. It was observed in the AMA CE planning documents that the emphasis on the global scale in the vertical integration is lesser compared to the macro and meso scale. On the horizontal dimension, it was observed that the socio-ecological system integration was lacking. The paper also highlighted that there wasn't adequate attention paid to the Global scale hinterlands. To move forward in the development of successful CE strategies in urban planning, an integration between the socio-technical systems and socio-ecological principles is necessary.

In both the cases it is observed that there is not adequate focus given on socio-ecological systems. The reason for this can be assumed that the research and policies developed are coming from an Industrial ecology perspective. While less focus on the global scale can be accounted as less analysis being done on the flows. To analyse urban complexity Wilkingson et al. (2013) show that a socio-technical approach has been traditionally used and state that a socio-ecological approach needs to be integrated. By combining and integrating a socio-technical and a socio-ecological approach, a "SETS" (social-ecological-technical-systems) approach can be utilized; in which social, ecological and technological aspects of environmental phenomena are considered leading to a better understanding, support and management of urban ecosystems (Groffman et al. 2016; Ramaswami et al. 2012). The main challenge is the further development of this multidisciplinary approach, the integration of theories and methods of engineering and design disciplines with natural and social sciences (Groffman et al. 2016) and its implementation in urban planning practice.

CHAPTER 3

India's approach towards principles of CE and gaps in its implementation:

The Municipal Solid Waste Rules (2016) brought in principles of CE (Recovery, Reuse and Recycle) in order to mandate waste segregation and channelize waste to wealth. In recent campaign of "Clean India Mission", more emphasis is laid on these principles. The program envisages area-wise solutions and considers the region-specific economic and environmental aspects. But the implementation of these policies is still lackadaisical due to not having proper socio economic, spatial and technical systems.

There is limited research in India in the field of circular economy, the main focus lies only on recycling and converting waste to energy (WTE) as the solution to overcome the increasing volumes of waste. This reflects as an end of pipe solution without using the value of the resource. Even the WTE concept is in initial stages of implementation across different cities. Yadhuvanshi et al., (2016) in their research on CE for sustainable development discuss the small-scale initiatives developed by the urban local body (ULB) in two different cities in India. These cities have implemented advanced technologies in waste management system and small-scale recycling. The focus is more on addressing the solution for waste rather than identifying it as a resource. Apart from the municipal solid waste, India also faces issues with the agricultural waste and hazardous industrial waste. J. Fiksel et al., (2018) researched on transforming waste to resources in Indian economy, highlight the different sectors in which waste can be utilised as secondary resources. They have discussed the measures taken by large scale industries in the country towards lower resource consumption and their policies to reuse the waste material as substitute secondary resources in another scales or processes. Considering the above points, it is observed that the approach towards CE has started in different sectors at different scales, but there is still a gap in implementation. This is due to fragmented studies and practices.

Gaps in implementing CE in India:

The gap in implementing CE in India is due to lack of prolific agenda or policy regulation of CE. This is due to the limited knowledge and research in the subject in the country. The limited knowledge in CE might be due to the lack of life cycle thinking and resistance to change. Missing links between the policy, business and technology sector are lack of new business models in CE, limited academic - business collaboration in CE practices, absence of organizational and social innovations pertaining to CE deployment in India (P. Modak., 2018). This nexus is missing in urban India and abridging this gap is vital for successful deployment of CE.

CHAPTER 4

Discussion

To implement CE in India, a holistic approach is needed. The existing 3R framework needs to be revised into a comprehensive 9R framework. A detailed flow analysis has to be made to understand and implement the framework. This has to be realised at all the three levels: micro, meso and macro. Since India being a vast country with diverse socio economic, cultural and ecological system, it is difficult to determine the same principles and policies in a top down approach. It needs to be a collaborative between top down approach and bottom up approach by bringing in diverse actors. Hence there is need for a platform to exchange the ideas and practices being developed in the field and there should be involvement of actors at multiple scales and all phases of the resource flow. Policies have to be developed as a top down approach by the government by collaboration of different sectors such as industries, environmental agencies, financial institutions and more academic research should be encouraged. A symbiotic relationship among all the actors are important to achieve the goals of circular economy. Circular Economy rests on cooperation and collaboration. Collaboration and sharing can result in the dissemination and wider adoption of CE goals. Circular transitions rest on several factors which call for strong and active collaboration among stakeholders. And such changescan be realised only through "technical, social, ecological and organisational innovations throughout the value chain, while bridging production and consumption activities".

From the discussed cases of China and Netherlands, emphasis is made on integrating the socio ecological systems along with the socio technical systems. By combining the socio ecological and technical systems (SETS approach), social, ecological and technological aspects of environmental phenomena are considered leading to a better understanding, support and management of urban ecosystems (Groffman et al. 2016; Ramaswami et al. 2012). Ramaswami et al. (2012) point out that 'complex, cross-scale interactions between the natural system, the transboundary engineered infrastructures, and the multiple social actors and institutions that govern these infrastructures' are necessary for the sustainability of city systems. While CE planning might not solve climate change and resource scarcity, it offers opportunities for planning and design of new and existing areas based on the principle of decentralized, interconnected, polycentric circular urban systems (J. Van Der Leer et al). Along with the research towards transforming into CE, research on integrating the SETS into the current system of urban planning in the country should be made.

Conclusion:

This paper has analysed the theories of CE and identified the gaps between theory and practice, using the V-H CE framework. It has discussed the practices across the world, their drawbacks and highlighted the importance of multi scale and sub systems integration. It has also analysed the importance of integration of SETS approach in the urban planning framework. To develop CE in India, which is still in the preliminary stages of discussion, this paper has pointed out the important theories and steps that have to be taken. However, the flows and changes in the value chain, the economy and socio ecological priorities vary across different countries. Transferability of the same approach might not be feasible, but the issue of resource demand is the same all over. Hence, it is ideal to analyse the flows, economy and socio technical systems in place and follow the guidelines which are important for the implementation.

References:

Albrechts, L. 2006a. "Bridge the Gap: From Spatial Planning to Strategic Projects." European Planning Studies 14 (10): 1487–1500. Albrechts, L. 2006b. "Shifts in Strategic Spatial Planning? SomeEvidence from Europe and Australia." Environment and Planning A 38 (6): 1149–1170.

Allen, C. R., D. G. Angeler, A. S. Garmestani, L. H. Gunderson, and C. S. Holling. 2014. "Panarchy: Theory and Application." Ecosystems. Springer US17 (4): 578–589.

Ellen MacArthur foundation. 2014. "Towards the Circular Economy: Eco- nomic and Business Rationale for an Accelerated Transition."

Fang, Y., Côté, R.P., Qin, R., 2007. Industrial sustainability in China: practice and pro- spects for eco-industrial development. J. Environ. Manag. 83 (3), 315–328. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0301479706001216 [Accessed March 6, 2017].

Fiksel, J., & Lal, R. (2018, June). Transforming waste into resources for the Indian economy. Environmental Development. https://doi.org/10.1016/j.envdev.2018.02.002

Geissdoerfer, M., Savaget, P., Bocken, N.M.P., Hultink, E.J., 2016. The Circular Econ- omy e A new sustainability paradigm? J. Clean. Prod. https://doi.org/10.1016/ j.jclepro.2016.12.048.

Geng, Y., Doberstein, B., 2008. Developing the circular economy in China: challenges and opportunities for achieving'leapfrog development'. Int. J. Sustain. Dev. World Ecol. 15, 231e239. https://doi.org/10.3843/SusDev.15.3.

Ghisellini, P., Cialani, C., & Ulgiati, S. (2016). A review on circular economy: the expected transition to a balanced interplay of environmental and economic systems. Journal of Cleaner Production, 114, 11–32. https://doi.org/10.1016/j.jclepro.2015.09.007

Goyal, S., Esposito, M., & Kapoor, A. (2018). Circular economy business models in developing economies: Lessons from India on reduce, recycle, and reuse paradigms. Thunderbird International Business Review, 60(5), 729–740. https://doi.org/10.1002/tie.21883

Hajer, M., and W. Zonneveld. 2000. "Spatial Planning in the Network Society- Rethinking the Principles of Planning in the Netherlands." European Plan- ning Studies 8 (3): 337–355.

Heeres, R.R., Vermeulen, W.J.V., deWalle, F.B., 2004. Eco-industrial park initiatives in the USA and the Netherlands : first lessons. J. Clean. Prod. 12 (8–10), 985–995. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0959652604000873 [Accessed March 7, 2017].

Heshmati, A. (n.d.). A REVIEW OF THE CIRCULAR ECONOMY AND ITS IMPLEMENTATION. Retrieved from www.entreprenorskapsforum.se

Jackson, M., Lederwasch, A., Giurco, D., 2014. Transitions in theory and practice: managing metals in the circular economy. Resources 3 (3), 516–543. Available at: http://www.mdpi.com/2079-9276/3/3/516/ [Accessed March 21, 2017].

Kalmykova, Y., Sadagopan, M., & Rosado, L. (2018). Circular economy - From review of theories and practices to development of implementation tools. Resources, Conservation and Recycling, 135, 190–201. https://doi.org/10.1016/j.resconrec.2017.10.034

Karvounis, A. 2015. "UrbanMetabolism." In UnderstandingUrbanMetabolism: a Tool for Urban Planning, 3–13. New York: Routledge.

Kirchherr, J., Reike, D., & Hekkert, M. (2017, December). Conceptualizing the circular economy: An analysis of 114 definitions. Resources, Conservation and Recycling. https://doi.org/10.1016/j.resconrec.2017.09.005

Lieder, M., and A. Rashid. 2016. “Towards Circular Economy Implementation: A Comprehensive Review in Context of Manufacturing Industry.” Journal ofCleaner Production. Elsevier Ltd115: 36–51.

Liu, J., T. Dietz, S. R. Carpenter, M. Alberti, C. Folke, E. Moran, A. N. Pell, et al. 2007. “Complexity of Coupled Human and Natural Systems.” Science 317 (5844): 1513–1516.

Lo, A. Y., & Liu, S. (2018). Towards sustainable consumption: A socio-economic analysis of household waste recycling outcomes in Hong Kong. https://doi.org/10.1016/j.jenvman.2018.03.029

Mylan, J., H. Holmes, and J. Paddock. 2016. “Re-introducing Consumption to the “Circular Economy”: A Sociotechnical Analysis of Domestic Food Provisioning.” Sustainability 8 (8): 1–14.

Mirata, M., Emtairah, T., 2005. Industrial symbiosis networks and the contribution to environmental innovation: the case of the Landskrona industrial symbiosis programme. J. Clean. Prod. 13, 993e1002.

Merli, R., Preziosi, M., & Acampora, A. (2018, March). How do scholars approach the circular economy? A systematic literature review. Journal of Cleaner Production. https://doi.org/10.1016/j.jclepro.2017.12.112

Modak, P. (n.d.). Creating Circular Economic Potential as a way for Achieving Smart and Sustainable Cities. Retrieved from http://www.uncrd.or.jp/content/documents/5770FINAL-Background paper_Prasad Modak.pdf

Murray, A., K. Skene, and K. Haynes. 2015. “The Circular Economy:An Interdis- ciplinary Exploration ofthe Concept and Application in a Global Context.” Journal ofBusiness Ethics 140: 369–380.

Naustdalslid, J. (2014). International Journal of Sustainable Development & World Ecology. https://doi.org/10.1080/13504509.2014.914599

Ness, D., 2008. Sustainable urban infrastructure in China: towards a factor 10 improvement in resource productivity through integrated infrastructure sys- tem. Int. J. Sustain. Dev. World Ecol. 15, 288e301.
Ny, H., Robèrt, K.-H., Thompson, A. W., Wälitalo, L., Lindner, P., Mooij, C., & Rogers, H. (2017). Circular Economy in Cities: A Strategic Approach Towards a Sustainable Society? Retrieved from http://www.diva-portal.org/smash/get/diva2:1108675/FULLTEXT02

Pahl-Wostl, C. 2007. “The ImplicationsofComplexity for IntegratedResources Management.” Environmental Modelling and Software 22 (5): 561–569.

Petit-Boix, A., & Leipold, S. (2018a). Circular economy in cities: Reviewing how environmental research aligns with local practices. Journal of Cleaner Production, 195, 1270–1281. https://doi.org/10.1016/j.jclepro.2018.05.281

Petit-Boix, A., & Leipold, S. (2018b, September). Circular economy in cities: Reviewing how environmental research aligns with local practices. Journal of Cleaner Production. https://doi.org/10.1016/j.jclepro.2018.05.281

Potting, J., et al., 2017. Circular Economy: Measuring Innovation in the Product Chain. Available at. http://www.pbl.nl/sites/default/files/cms/publicaties/pbl-2016- circular-economy-measuring-innovation-in-product-chains-2544.pdf.

Preston, F. (2012). A global redesign? shaping the circular economy. Energy, Envi- ronment and Resource Governance, 2,1e20.

Ranjith Kharvel Annepu Advisor, by, & Themelis Stanley-Thompson Professor Emeritus, N. J. (2012a). Sustainable Solid Waste Management in India. Retrieved from http://www.seas.columbia.edu/earth/wtert/sofos/Sustainable Solid Waste Management in India_Final.pdf

Ranjith Kharvel Annepu Advisor, by, & Themelis Stanley-Thompson Professor Emeritus, N. J. (2012b). Sustainable Solid Waste Management in India. Retrieved from http://www.seas.columbia.edu/earth/wtert/sofos/Sustainable Solid Waste Management in India_Final.pdf

Reike, D., Vermeulen, W. J. V., & Witjes, S. (2018). The circular economy: New or Refurbished as CE 3.0? — Exploring Controversies in the Conceptualization of the Circular Economy through a Focus on History and Resource Value Retention Options. Resources, Conservation and Recycling, 135, 246–264. https://doi.org/10.1016/j.resconrec.2017.08.027

Rotmans, J., M. van Asselta, and P. Vellinga. 2000. “An Integrated Planning Tool for Sustainable Cities.” Environmental Impact Assessment Review 20 (3): 265–276.

Sakai, S. ichi, Yoshida, H., Hirai, Y., Asari, M., Takigami, H., Takahashi, S., ... Chi, N. K. (2011). International comparative study of 3R and waste management policy developments. Journal of Material Cycles and Waste Management. https://doi.org/10.1007/s10163-011-0009-x

Shi, H., Chertow, M., Song, Y., 2010. Developing country experience with eco-industrial parks: a case study of the Tianjin Economic-Technological Development Area in China. J. Clean. Prod. 18 (3), 191–199. Available at: http://linkinghub.elsevier.com/ retrieve/pii/S0959652609003242 [Accessed March 7, 2017].

Smol, M., Kulczycka, J., & Avdiushchenko, • Anna. (n.d.). Circular economy indicators in relation to eco-innovation in European regions. https://doi.org/10.1007/s10098-016-1323-8
Thu, T., Nguyen, P., Zhu, D., & Le, N. P. (2015). Factors influencing waste separation intention of residential households in a developing country: Evidence from Hanoi, Vietnam. https://doi.org/10.1016/j.habitatint.2015.03.013

Van Berkel, R., T. Fujita, S. Hashimoto, and Y. Geng (2009). Industrial and urban sym- biosis in Japan: analysis of the eco-town. Journal of Environmental Management 90, 1544-1556.

van Buren, N., et al., 2016. Towards a circular economy: the role of dutch logistics in- dustries and governments. Sustainability 647. Available at: http://www.mdpi.com/ 2071-1050/8/7/647 [Accessed February 24, 2017].

van der Leer, J., van Timmeren, A., & Wandl, A. (2018). Social-Ecological-Technical systems in urban planning for a circular economy: an opportunity for horizontal integration. Architectural Science Review, 61(5), 298–304. https://doi.org/10.1080/00038628.2018.1505598

Voskamp, I. M., Spiller, M., Stremke, S., Bregt, A. K., Vreugdenhil, C., & Rijnaarts, H. H. M. (2018). Space-time information analysis for resource-conscious urban planning and design: A stakeholder based identification of urban metabolism data gaps. Resources, Conservation and Recycling, 128, 516–525. https://doi.org/10.1016/J.RESCONREC.2016.08.026

Wrinkler, H., 2011. Closed-loop production systems e a sustainable supply chain approach. CIRP J. Manuf. Sci. Technol. 4, 243e246.

Yaduvanshi, N. R., Myana, R., & Krishnamurthy, S. (2016). Circular economy for sustainable development in India. Indian Journal of Science and Technology, 9(46). https://doi.org/10.17485/ijst/2016/v9i46/107325

Yuan, Z., J. Bi, and Y. Moriguichi. 2006. “The Circular Economy: A New Devel- opment Strategy in China.” Journal ofIndustrial Ecology 10 (1–2): 4–8.

Zhijun Yan Nailing, F. A. (n.d.). Putting a circular economy into practice in China. https://doi.org/10.1007/s11625-006-0018-1

References:

Albrechts, L. 2006a. “Bridge the Gap: From Spatial Planning to Strategic Projects.” European Planning Studies 14 (10): 1487–1500. Albrechts, L. 2006b. “Shifts in Strategic Spatial Planning? SomeEvidence from Europe and Australia.” Environment and Planning A 38 (6): 1149–1170.

Allen, C. R., D. G. Angeler, A. S. Garmestani, L. H. Gunderson, and C. S. Holling. 2014. “Panarchy: Theory and Application.” Ecosystems. Springer US17 (4): 578–589.

Burke Johnson, R. et al. (2007) Towards a Definition of Mixed Methods Research, Journal of Mixed Methods, 1(2): 112-133.

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

Devi, S. M., Balachandar, V., Lee, S. I., & Kim, I. H. (2014). An Outline of Meat Consumption in the Indian Population - A Pilot Review. Korean journal for food science of animal resources, 34(4), 507-15.

Fang, Y., Côté, R.P., Qin, R., 2007. Industrial sustainability in China: practice and pro- spects for eco-industrial development. J. Environ. Manag. 83 (3), 315–328. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0301479706001216 [Accessed March 6, 2017].

Gandhi V. P., Koshy A. Wheat marketing and its efficiency in India. Working paper No. 2006-09-03. Indian Institute of Management; Ahmedabad, India: (2006).

Geissdoerfer, M., Savaget, P., Bocken, N.M.P., Hultink, E.J., 2016. The Circular Econ- omy e A new sustainability paradigm? J. Clean. Prod. https://doi.org/10.1016/ j.jclepro.2016.12.048.

Ghisellini, P., Cialani, C., & Ulgiati, S. (2016). A review on circular economy: the expected transition to a balanced interplay of environmental and economic systems. Journal of Cleaner Production, 114, 11–32. https://doi.org/10.1016/j.jclepro.2015.09.007

Gunderson, L. H., and C. S. Holling. 2002. Panarchy: Understanding Transfor- mations in Human andNatural Systems. Washington

Hajer, M., and W. Zonneveld. 2000. “Spatial Planning in the Network Society- Rethinking the Principles of Planning in the Netherlands.” European Plan- ning Studies 8 (3): 337–355.

Heshmati, A. (n.d.). A REVIEW OF THE CIRCULAR ECONOMY AND ITS IMPLEMENTATION. Retrieved from www.entreprenorskapsforum.se

Jackson, M., Lederwasch, A., Giurco, D., 2014. Transitions in theory and practice: managing metals in the circular economy. Resources 3 (3), 516–543. Available at: http://www.mdpi.com/2079-9276/3/3/516/ [Accessed March 21, 2017].

Kalmykova, Y., Sadagopan, M., & Rosado, L. (2018). Circular economy - From review of theories and practices to development of implementation tools. Resources, Conservation and Recycling, 135, 190–201. https://doi.org/10.1016/j.resconrec.2017.10.034

Karvounis, A. 2015. “UrbanMetabolism.” In UnderstandingUrbanMetabolism: a Tool for Urban Planning, 3–13. New York: Routledge.

Kennedy, C., Cuddihy, J. and Engel-Yan, J. (2007), The Changing Metabolism of Cities.

Kennedy, C., Pincetl, S., Bunje, P. (2010) The study of urban metabolism and its application to urban design and planning.

Kirchherr, J., Reike, D., & Hekkert, M. (2017, December). Conceptualizing the circular economy: An analysis of 114 definitions. Resources, Conservation and Recycling. https://doi.org/10.1016/j.resconrec.2017.09.005

Lieder, M., and A. Rashid. 2016. “Towards Circular Economy Implementation: A Comprehensive Review in Context of Manufacturing Industry.” Journal ofCleaner Production. Elsevier Ltd115: 36–51.

Mylan, J., H. Holmes, and J. Paddock. 2016. “Re-introducing Consumption to the “Circular Economy”: A Sociotechnical Analysis of Domestic Food Provisioning.” Sustainability 8 (8): 1–14.

Merli, R., Preziosi, M., & Acampora, A. (2018, March). How do scholars approach the circular economy? A systematic literature review. Journal of Cleaner Production. https://doi.org/10.1016/j.jclepro.2017.12.112

Murray, A., K. Skene, and K. Haynes. 2015. “The Circular Economy:An Interdis- ciplinary Exploration ofthe Concept and Application in a Global Context.” Journal ofBusiness Ethics 140: 369–380.

Naustdalslid, J. (2014). International Journal of Sustainable Development & World Ecology. https://doi.org/10.1080/13504509.2014.914599

Ness, D., 2008. Sustainable urban infrastructure in China: towards a factor 10 improvement in resource productivity through integrated infrastructure sys- tem. Int. J. Sustain. Dev. World Ecol. 15, 288e301.
Ny, H., Robèrt, K.-H., Thompson, A. W., Wälitalo, L., Lindner, P., Mooij, C., & Rogers, H. (2017). Circular Economy in Cities: A Strategic Approach Towards a Sustainable Society? Retrieved from http://www.diva-portal.org/smash/get/diva2:1108675/FULLTEXT02

O'Connor, Martin. (2006). The “Four Spheres” framework for sustainability. Ecological Complexity - ECOL COMPLEX. 3. 285-292. 10.1016/j.eco

Population Of Visakhapatnam 2018. (n.d.). Retrieved from http://indiapopulation2018.in/population-of-visakhapatnam-2018.html

Potting, J., et al., 2017. Circular Economy: Measuring Innovation in the Product Chain. Available at. http://www.pbl.nl/sites/default/files/cms/publicaties/pbl-2016- circular-economy-measuring-innovation-in-product-chains-2544.pdf.

Preston, F. (2012). A global redesign? shaping the circular economy. Energy, Envi- ronment and Resource Governance, 2,1e20.

Reddy, D. (2015, September 04). Know Your Smart City: Andhra Pradesh & Telangana. Retrieved from https://www.business-standard.com/article/current-affairs/know-your-smart-city-andhra-pradesh-telangana-115090400522_1.html

Reike, D., Vermeulen, W. J. V., & Witjes, S. (2018). The circular economy: New or Refurbished as CE 3.0? — Exploring Controversies in the Conceptualization of the Circular Economy through a Focus on History and Resource Value Retention Options. Resources, Conservation and Recycling, 135, 246–264. https://doi.org/10.1016/j.resconrec.2017.08.027

Shi, H., Chertow, M., Song, Y., 2010. Developing country experience with eco-industrial parks: a case study of the Tianjin Economic-Technological Development Area in China. J. Clean. Prod. 18 (3), 191–199. Available at: http://linkinghub.elsevier.com/ retrieve/pii/S0959652609003242 [Accessed March 7, 2017].

Stead, D., and E. Meijers. 2009. “Spatial Planning and Policy Integration: Concepts, Facilitators and Inhibitors.”

Van Berkel, R., T. Fujita, S. Hashimoto, and Y. Geng (2009). Industrial and urban sym- biosis in Japan: analysis of the eco-town. Journal of Environmental Management 90, 1544-1556.

van Buren, N., et al., 2016. Towards a circular economy: the role of dutch logistics in- dustries and governments. Sustainability 647. Available at: http://www.mdpi.com/ 2071-1050/8/7/647 [Accessed February 24, 2017].

van der Leer, J., van Timmeren, A., & Wandl, A. (2018). Social-Ecological-Technical systems in urban planning for a circular economy: an opportunity for horizontal integration. Architectural Science Review, 61(5), 298–304. https://doi.org/10.1080/00038628.2018.1505598

Voskamp, I. M., Spiller, M., Stremke, S., Bregt, A. K., Vreugdenhil, C., & Rijnaarts, H. H. M. (2018). Space-time information analysis for resource-conscious urban planning and design: A stakeholder based identification of urban metabolism data gaps. Resources, Conservation and Recycling, 128, 516–525. https://doi.org/10.1016/J.RESCONREC.2016.08.026

Yuan, Z., J. Bi, and Y. Moriguichi. 2006. “The Circular Economy: A New Devel- opment Strategy in China.” Journal ofIndustrial Ecology 10 (1–2): 4–8.

Zhang, Y., Yang, Z., & Yu, X. (2015). Urban Metabolism: A Review of Current Knowledge and Directions for Future Study

Zhijun Yan Nailing, F. A. (n.d.). Putting a circular economy into practice in China. https://doi.org/10.1007/s11625-006-0018-1

https://www.scribd.com/document/355091180/Agriculture-is-the-Main-Occupation-in-India