WATER-SENSITIVE PLANNING FOR ALUVA MUNICIPALITY

THESIS REPORT

Submitted by

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M. Plan (2021-2023) BATCH

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in

Urban Planning

DEPARTMENT OF ARCHITECTURE
THANGAL KUNJU MUSALIAR COLLEGE OF ENGINEERING
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DECLARATION

I hereby declare that the Project entitled **"WATER SENSITIVE PLANNING FOR ALUVA MUNICIPALITY"** is a bonafide record of mine carried out under the supervision of Prof. **Shahina Muthu S,** Assistant Professor, Department of Architecture. I declare that the work reported herein does not form any part of any other project report or Thesis on the basis of which a degree or award was conferred on an earlier occasion to any other candidate. This study is done as a part of the fourth semester M. Plan (Urban Planning), Post Graduate Degree Course in the Department of Architecture, Thangal Kunju Musaliar College of Engineering, Kollam.

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CERTIFICATE

This is to certify that the Thesis Report **"WATER SENSITIVE PLANNING FOR ALUVA MUNICIPALITY"** submitted by **Anitha A** (TKM21MUP003) of MUP (2021-2023) Batch, in fulfillment of the requirements for the fourth-semester final examination in PL6401–Planning Thesis, under the **APJ Abdul Kalam Technological University** is a bonafide work carried out under our guidance and supervision.

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ABSTRACT

Due to urbanization and climate change, many cities are addressing a wide range of environmental concerns, many of which are linked to natural water resources. However, the increasing urbanization, and densification, which are related to urban challenges of the modern urban environment are increasing the pressure on the water cycle and its preservation. Due to urbanization, the land use land cover of urban areas is highly affected by surface sealing which is the main cause of impact on the water cycle of an area.

The paper reviews adopting water sensitivity at the stage of planning Aluva municipality developments and analyzing it can helpful for maintain the water cycle by managing the supply and demand for water, stormwater, wastewater, and groundwater as well as bring benefits such as resilience reduction in temperature concerning climate change and adaptation of city.

The study uses different types of data to resolve this: Assessment of groundwater potential zones, land use distribution and its changes over the years, slope, soil, geomorphology, drainage density, Water resource, the available park, and open spaces, land cover analysis to assess the pervious and impervious nature of developments. These data are collected through various secondary sources like published reports journals and articles and primary data collection like expert interviews and opinions. The primary survey analysis the major land use distribution, their water usage, and water management considerations at the macro level. From the study it was analyzed that the Aluva municipality gets saturated day by day this leads to the loss of permeable areas and green open areas which is highly affecting the water level and runoff of the town. This urban face become a major reason for climatic risks.

The study offers sensitive planning strategies at different scales for pervious area consideration environmental protection and development, at the macro level, green corridor development to connect the town level ecosystems to connect the water loop, at the meso level, and at the site level and building intervention for efficient water usage, at the micro level, through the integration of water-sensitive planning and design interventions.

Key Words: W*ater-sensitive planning, Surface sealing, Landcover and land use, Parks and open space, green developments, WSUD Strategies.*

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ABBREVATIONS

IUWM Integrated Urban Water Management

IRWM Integrated Water Resource Management

LID Low Impact Development

MII Modern Infrastructural Ideal

NMCG National Mission for Clean Ganga

SUDS Sustainable Urban Drainage System

WS Water Sensitive Cities

WSUD Water Sensitive Urban Design

WSP Water sensitive planning

BMP Best management practices

DPR Detailed project report

MoHUA Ministry of Housing and Urban Affairs

RWH Rainwater harvesting

STP Sewage treatment plant

ULB Urban local bodies

URDPFI Urban and Regional Development Plans Formulation & Implementation

GWPZ Ground water potential zone

CHAPTER 1 INTRODUCTION

This chapter focuses on the background, need of the study and the aim, the study provides briefing of the important of the water cycle management in an urban development for the sustainable future. Studying and analysing the factors depending water cycle its effects and the need of water management in urban planning of an area. Evaluating the Indian scenario water crisis, decline of water level etc. Considering water sensitive planning for the existing development. The methodology adopted to achieve the aim as well as the scope and limitations of the study are discussed here.

1.1 Background study

Urban water systems must contend with drastically shifting environmental factors. Current water issues, such as floods, water scarcity, and restoration expenses, are made worse by the effects of climate change, rising urbanization, and ageing and decaying infrastructure, to the point that cities' capacity to handle them is exceeded.

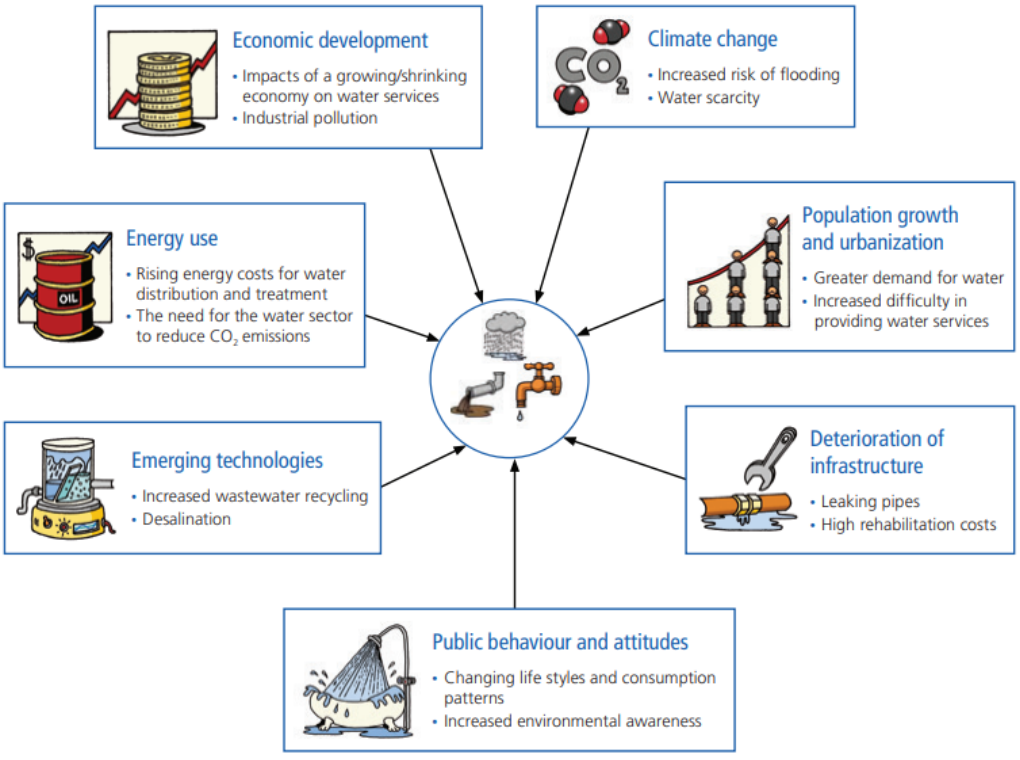


Figure 1 Development challenges for water management in citie

Source: SWITCH Training Kit (2011) Integrated Urban Water Management in the City of the Future. Module 1—Strategic Planning: Preparing for the Future

According to the 2013 World Resource Institute worldwide water-stress rankings, India has a withdrawal to supply ratio between 40 and 80 percent and is under significant water stress. In India, the urban population has rapidly increased during the past several decades. The problem of an expanding gap between water supply and demand, which puts stress on water resources and its delivery needs, is one that all towns and cities are now dealing with. In India, 68 cities will have a population of one million or more by the year 2030. Urbanization and the growth of urban centers have raised a number of difficulties, from local government and management to the delivery of fundamental public services. Consequently, water management is under a lot of strain. In practically all of India's main cities during the past 20 years, the built-up area has increased more quickly than the population. Comparative analysis reveals that between 2000 and 2010, the pace of geographical growth increased. Water supply in the majority of Indian cities refers to the arrangement of infrastructure, including piped water supply lines, sewage lines, sewage treatment plants (STPs), and layout of drainage systems. If the piped water supply is insufficient, private, unregulated groundwater extraction is used to make up the difference, which causes groundwater levels to drop and urban aquifers to become polluted. For their water demands, people either drill wells or tube wells on their properties or purchase water from private tankers that then determine groundwater for selling. The only way we will be able to solve these concerns and encourage sustainable growth is via localized sustainable resource usage and techniques that take urbanization into consideration.

Water-sensitive urban design and planning (WSUDP) combines urban design and planning with the management of the urban water cycle, water supply, wastewater, stormwater, and groundwater. When included with an integrated urban strategy, this method improves livability and sustainability. (CSE 2018) WSUDP is a strategy that completes the water cycle while integrating and optimizing the utilization of existing water sources. (Rohilla,2017) Along with community engagement, the sustainable strategy must incorporate aspects like water quantity, water quality, and environment. A strategy for sustainable development known as "water-sensitive planning" (WSP) incorporates water considerations into both local and urban planning. WSP seeks to foster development and construction that is sustainable. According to the size of urban planning, i.e., city/zonal, neighborhood/institutional, and individual scale, appropriate methodologies and strategies are supplied under WSUDP for impending development. According to various land uses and

water-intensive activities in cities and zones, water-sensitive planning concepts are initially highlighted. Urban designs that consider water quality follow next, followed by designs at the individual level.

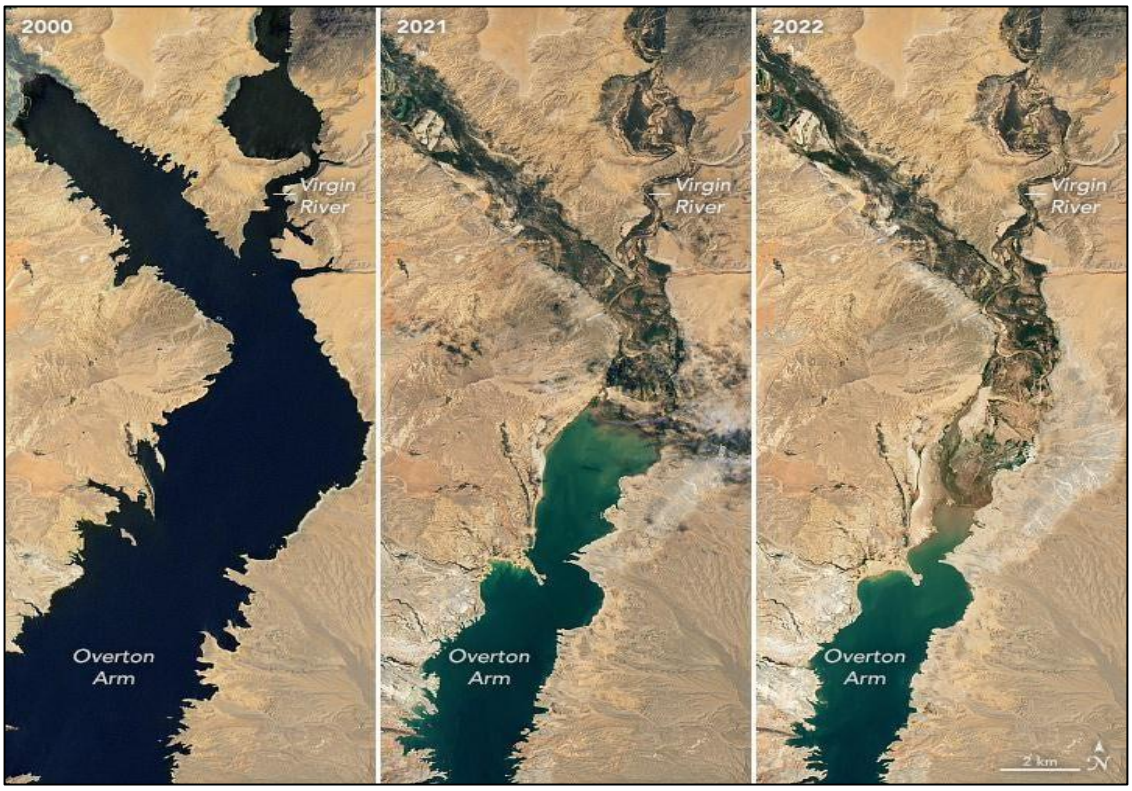


Figure 2: Lake Mead over the years

Source: Shrinking of waterbody 2022

Climate change, population expansion, and urbanisation are all putting strain on our cities. It is understood as a result that making the switch to more integrated urban water management systems is a difficult but essential process. While some places continue to struggle with the provision of essential services like water and sewage, other localities are working to confront and overcome some of the hazards that their current water management systems unintentionally produced. Through a city's water management framework, the concept of water sensitivity offers an intriguing opportunity to accomplish various benefits linked to livability, sustainability, and resilience for both established and developing cities.

Figure 3: Bharathapuzha

Source: The times of India/when main stream flows marginal/7-2017

The "water sensitive city" is a theoretical illustration of this alternate paradigm for urban water systems that focuses livability, sustainability, and resilience in the design of its institutions and infrastructure. It elaborates on approaches for effective urban water management and planning. Urban catchments for water supply, cities that provide ecological services, and urban regions with communities who appreciate water are the three pillars of a water-sensitive city. (Kumar, 2021) Wong and Brown came up with the concept in 2006, and it mainly focuses on making cities more sustainable urban water management systems for the water cycle, supply security, public health protection, flood mitigation, amenity, etc.

Cities that are responsive to water are supposed to be resilient, sustainable, productive, and livable. Such cities will effectively use various water resources, improve and safeguard the wellbeing of urban rivers and wetlands, and reduce the danger of and damage from flooding. Cities that are sensitive to water issues design public areas that boost biodiversity, gather, purify, and recycle water while also lowering the effects of urban heat islands**.** (Cabrera, 2018)

The idea of a "water sensitive city" views the city as a reservoir for water. (Asdak, 2022)

A conceptual model for evaluating the sustainability of the supply of residential raw water from a variety of sources. (Asdak, 2022)

A responsible approach to dealing with ecology, the environment, and resources for sustainable development**.** (Author generated 2022)

Water-responsive cities are intended to be resiliency, sustainability, productive cities that are also habitable. Such cities will efficiently utilise different water resources, enhance and protect the health of urban wetlands and rivers, and lessen the risk of and damage from floods. Water-conscious cities provide public spaces that promote biodiversity, collect, cleanse, and recycle water while also reducing the impacts of urban heat islands**.** (Rohilla, 2017)

The Kerala State Council for Science, Technology, and Environment and the Centre for Water Resources Development and Management are holding a workshop to discuss how Kozhikode may become a water-sensitive city by the year 2060. The workshop is being held as part of the "Water for Change" project: Integrative and functional water-sensitive design framework for rapidly expanding liveable cities. The Netherlands Organisation for Scientific Research, the Government of India, and the Department of Science and Technology all sponsor it. The project is being carried out in Bhopal, Bhuj (Gujarat), and Kozhikode (Madhya Pradesh). (Chithraranjan, 2019)

Innovative approaches, like the concept of water sensitive cities (WSC), combine urban design, environmental engineering, social science, and community engagement to offer an alternate way for dealing with these problems. These initiatives aim to improve the security, sustainability, and resilience of cities by creating new technology, tactics, regulations, and instruments. The research may provide the best way to effectively incorporate the notion of a water sensitive city into the layout of waterfront construction.

1.1.1 Why Water Management and Its Planning become significant

Urban planning involves managing development and land use to deliver social, environmental and economic outcomes that make cities great places to live, work and visit. Development and land use has a large impact on the water cycle, which creates the need for strong integration between urban planning and water management.

Good urban planning includes water as a key focus of decision making to enhance water security and waterway health, reduce flood risk and damage, and create spaces that collect, clean, and recycle water. Study emphasizes the critical role urban planning plays in achieving water sensitive outcomes in infill development (within existing urban areas).

The gap between the urban planning and water management is critically consider in water sensitive planning which is depicted in the flow chart given below.

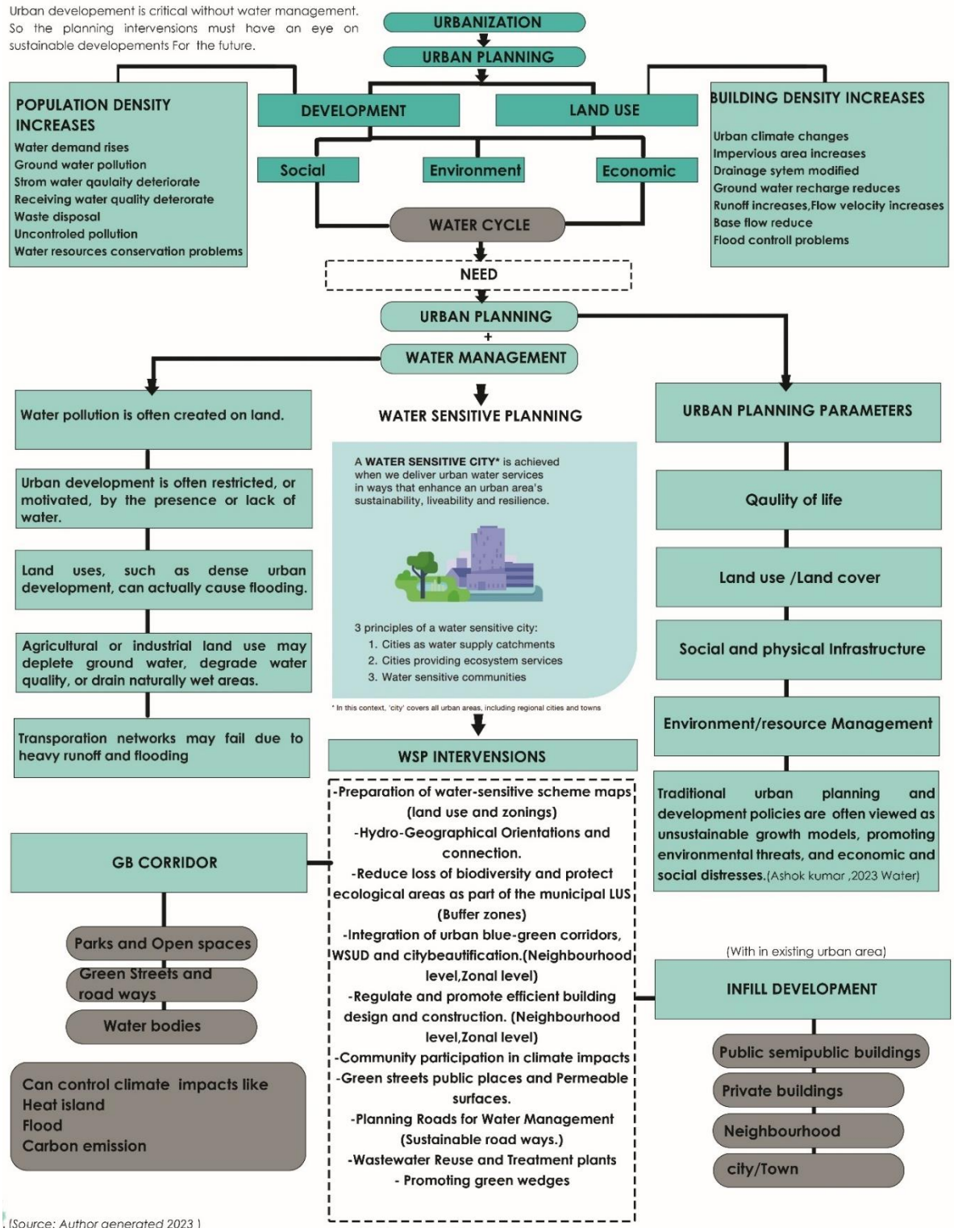


Figure 4: Need for WSP Consideration in urban environment

Source: Author generated from Retrieved Journals and articles related to WSUDP 2023

1.1.2 Factors affecting Urban Water Cycle in Indian small and medium cities and towns

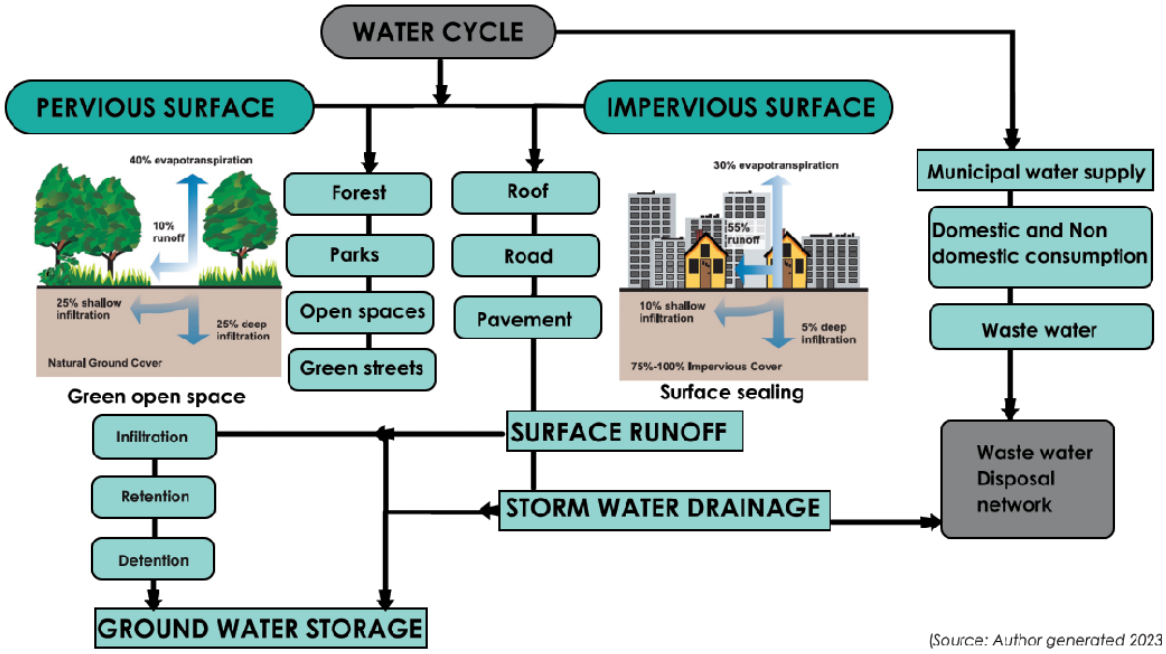


Figure 5:Factors affecting urban water cycle

Source: Author generated with respect to Resource Efficiency in Urban Water Management Case study from Medinipur, WB 2013

Urbanization is both as a social phenomenon and physical transformation of landscapes is the most powerful, irreversible and visible anthropogenic forces on earth. The level to which a given city depends on groundwater to meet its water demand depends on different factors.

1. The first set of factors can be called as physical/Geographic: Surface and subsurface water availability.

2. The second set of factors is determined by the ability of urban area to cope up with its water demand from external sources.

On the overlapping of these two sets of factors one can arrive at the general level of dependence of an urban area on ground water and their vulnerability at the present and future to meeting their water demand from external sources and by proper physical planning.

1.1.3 Urban development and water crisis - current Indian scenario

The global urban population is expected to nearly double to 6.4 billion by 2050, with about 90% of the growth in low-income countries. In India, the number of people living in urban

areas is expected to more than double and grow to around 800 million by 2050. This will pose unpredictable challenges for water management in urban India.

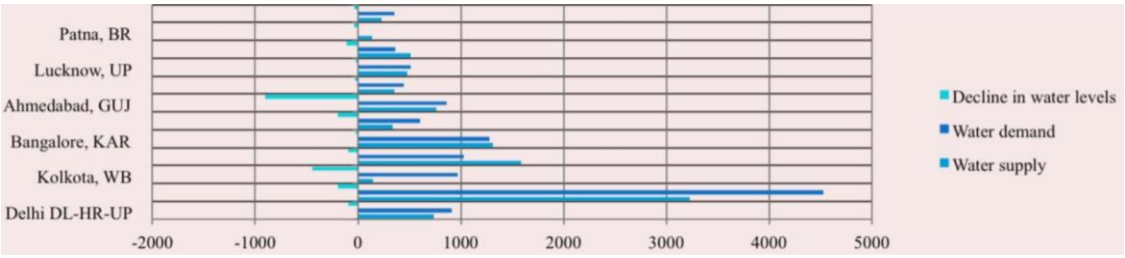


Figure 6:Population projection, density, Land area and water supply demand and supply

Source: Sheetal Sharma 2013 Indian urban centers in need for water sensitive urban planning approach

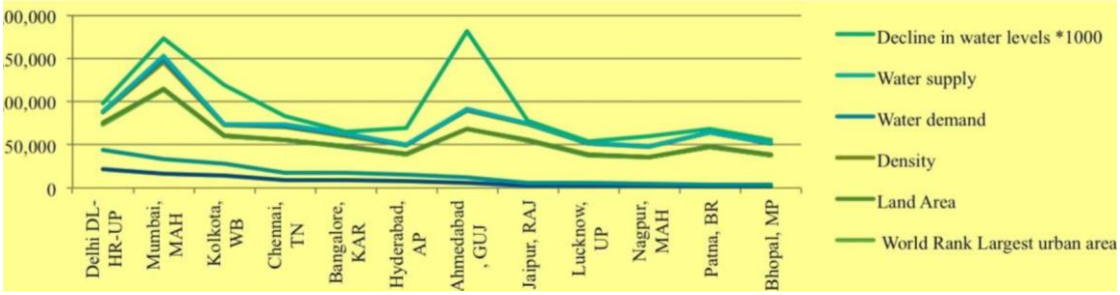


Figure 7:Indian largest urban centres and water supply, demand decline in water level

Source: Sheetal Sharma 2013 Indian urban centers in need for water sensitive urban planning approach

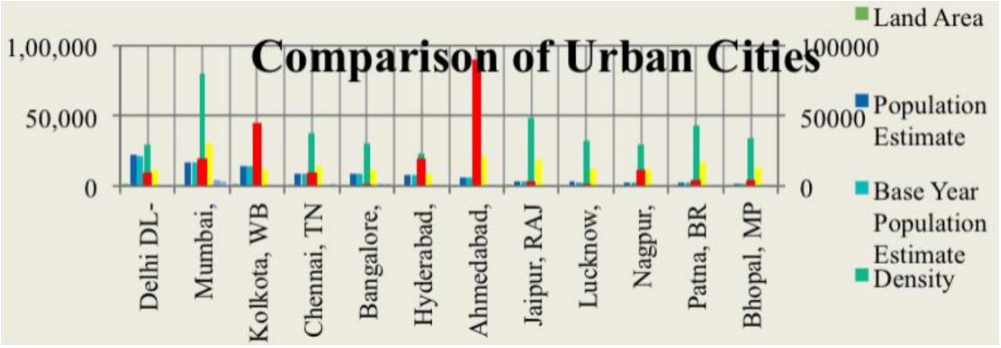


Figure 8:Water supply,demand and decline in water

Source: Sheetal Sharma 2013 Indian urban centers in need for water sensitive urban planning approach

Urban Centers like Ahmadabad and Mumbai are facing high density as well as drastic declining water levels. Jaipur, Kolkata comparatively has average adjustment of water supply due to projects, but Kolkata facing water levels declining. Chennai has developed a network from out sources and fulfilled the demands. Lucknow Jaipur, Bhopal, Patna,

Bangalore though have less declined water levels still have limited capacity of water and total water content would be remaining same. Bhopal recently faced the drying of its Upper Lake in 2009 to 4% of its surface area thus leaving people without water.

This Shows that only 15-25 % of area is kept for recreation, water body and agriculture, which also we see are many times paved and converted into developed ones. This reduces natural recharge of Urban Land surfaces creating less recharge and one more runoff.

“There is a water crisis today. But the crisis is not about having too little water to satisfy our needs. It is a crisis of managing water so badly that billions of people and the environment suffer badly.” World Water Council

1.2 Need for the study

- There is a growing understanding at the national and state levels that the risk of neglecting water management during the initial stages of planning and design results in limitations for new development missed chances for cost savings, poor quality of the urban environment, and overall unsustainable urban development. In order to lessen the growing water footprint and climate change impacts of urban centers, better-integrated land, and water management is required from the beginning. (CSE 2016).
- India, as a growing nation, is encouraging sensitive programs and planning regarding efficient water resources conservation and management such as Smart City mission, Water 4 Change, Urban water management, and Sponge Cities (Discussed in the 2022 budget presentation - Urban planning). This will be a goal-oriented approach for the upcoming developments and planning efforts.
- The Kerala State Council for Science, Technology, and Environment and the Centre for Water Resources Development and Management are holding a workshop to discuss how cities may become water-sensitive cities by the year 2060. As a part of the "Water for Change" project: Integrative and functional water-sensitive design framework for rapidly expanding liveable cities.

a) The Netherlands Organisation for Scientific Research, the Government of India, and the Department of Science and Technology all sponsor it. (CHITHARANJAN, 2019)

WSUDP It is one of the urban reforms which has to be implemented in urban areas in the state to avail special assistance for capital investment from the Centre for 2022-23. Envisaged Kochi Thiruvananthapuram and Kozhikode too. Therefore, this research and its findings can serve as a beneficial model for urban development in Kerala for the future.

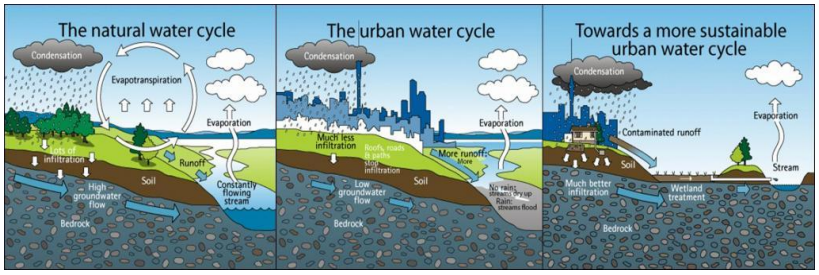


Figure 9 : The watercycle

Source: SSWM info/Concept of water cycle2018

1.3 Research questions

What are the sensitive methods being used in water-sensitive planning to manage urban water cycle effectively?

How can water-sensitive planning be implemented at the Aluva municipal level to promote long-term sustainability?

What are the challenges of preparing water-sensitive planning in Aluva municipality?

1.4 Aim

To develop a water-sensitive plan for Aluva municipality.

1.5 Objective

1.To study the concept of water sensitive city.

2.To identify the applicability of water-sensitive planning in Aluva municipality.

3.To analyze the spatial data based on the identified planning elements.

4.To formulate proposals and prepare water sensitive plan for Aluva municipality.

1.6 Methodology

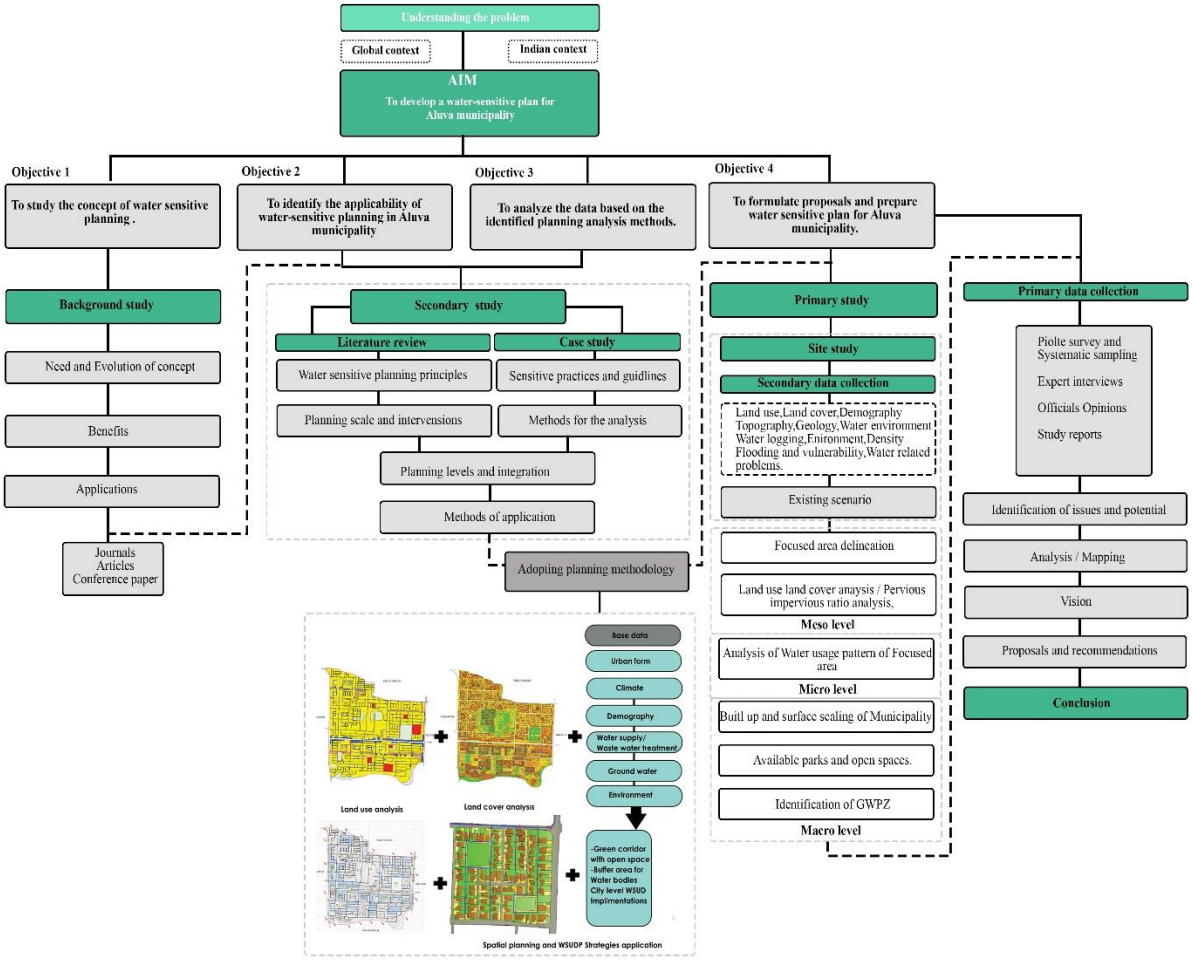


Figure 10: Methodology

Source: Author generated 2023

1.7 Scope & limitation

Turning cities into more sustainable urban water cities are widely recognized as complicated. So, these initiatives and planning parameters can help to address the water and water resource-related issues and challenges in terms of management, Environment, Ecology, Quality, and Quantity.

Innovation of new concepts such as Water Sensitive Urban Design (WSUD) and 'Integrated urban water cycle planning and management' (IUWCM) already exist so these study interventions, strategies and proposals can be integrated to support the planning level interventions too.

WSUDP It is one of the urban reforms which has to be implemented in urban areas in the state to avail special assistance for capital investment from the Centre for 2022-23. Envisaged for Kochi Thiruvananthapuram and Kozhikode too.

Water-sensitive concepts can be applied in a range of circumstances, from the micro to the macro, or from the neighborhood to the whole urban city. Here we analyze the micro which is highly sensitive and has high potential at the same time vulnerable. (Ernakulam-Aluva municipality).

The study is limited to spatial analysis and spatial planning; it is also capable of quantitative analysis and planning, but this is constrained by the lack of data and the time available.

The analyzing part is restricted to three types of land use distribution residential, commercial, and institutional for a thorough analysis for determining the ratio of pervious to impervious surfaces.

CHAPTER 2 LITERATURE REVIEW

This chapter aims to find out some of the keywords or questions that have a direct relation with the projects or which could act as a foundation for the project. Some of them are the 'water sensitive planning, urban water management, Benefits and scale of WSP interventions, Urban WSP and the focuses etc. Integrated water consideration in urban planning and the inferences from the literature study that had been done for this study.

2.1 Introduction

2.2 History of evolvement of water sensitive city Global context

A summary of the many water management concepts across time: Boxes on the left depict aspects of the acknowledged chaos (challenges) in the actual world, while boxes (paradigms) on the right demonstrate how their conciliation is conceptualised. Moving upward does not always imply that previously acknowledged problems have been resolved. The top three difficulties are listed as being institutional in character (in grey boxes). Despite the introduction of opposing paradigms during the lifespan of the current water infrastructure in many cities across the world, the MII (The Marine Influence Index) still rules in most of the world's practical applications. (Cabrera, 2018)

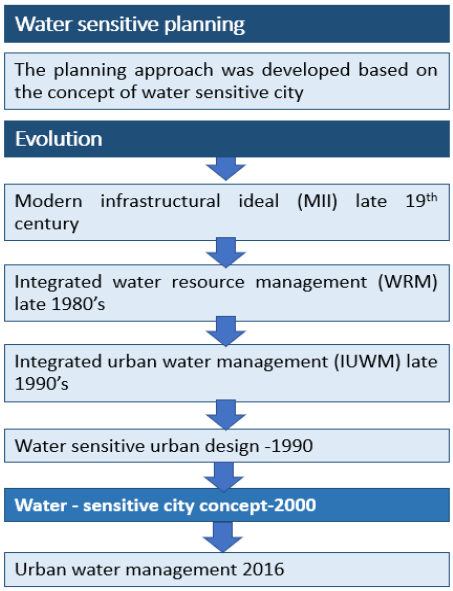


Figure 11:Summary of evolving paradigms in water management

Source: The Water-Sensitive City: Implications of an urban water management paradigm and its globalization 2018

The initial origins of the WSC concept were in Australia, where environmental pollution brought on by untreated stormwater runoff, ageing, inadequate urban infrastructure, and water scarcity during the Millennium drought drove water issues to the top of political and social agendas. The word "sensitivity" comes from the idea of "water sensitive urban design" (WSUD), which is a modern approach to planning and engineering that combines urban planning with the management, protection, and conservation of the water cycle and ensures that urban water management is sensitive to natural hydrological and ecological processes.

2.3 History of evolvement of water sensitive city in Indian context

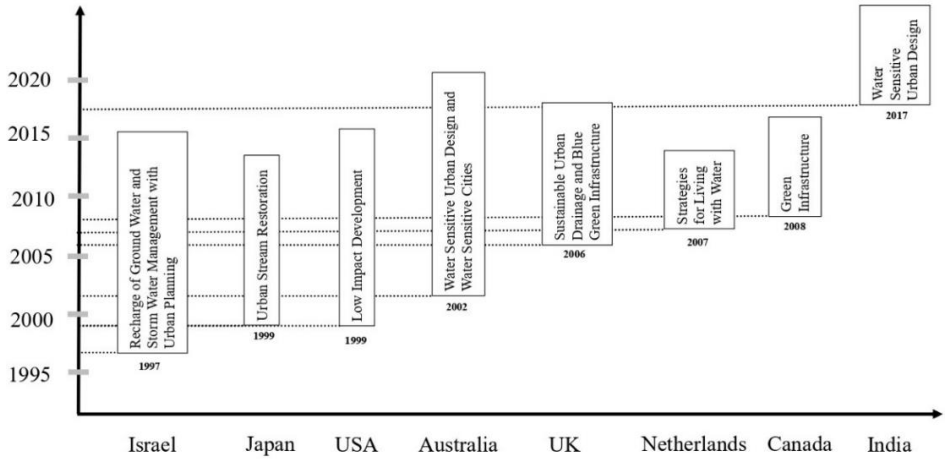


Figure 12:Evolution of water sensitive city concept in India

Source: Water sensitive global south 2021

2.4 Vision for water sensitive city

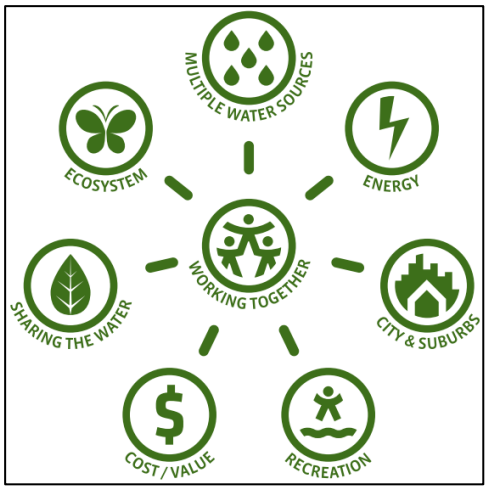


Figure 13 :Vision for water sensitive city

Source: Water sensitive city study tour 2009

Rapid urbanization, diverse weather conditions, and difficult economy are problems that cities all over the world are currently dealing with. These problems are recognized to have an influence on the environment and quality of life. Over the past few decades, various ideas on water management practices have arisen in response. Water Sensitive Cities is one such newly explored idea that envisions a location that wisely uses its current resources, developing resilience for tomorrow by concurrently assuring community engagement for sustainability. (Mishra1, 2020)

The Cooperative Research Centre for Water Sensitive Cities (CRCWSC), which was founded in July 2012, is credited with coining the phrase "Water Sensitive Cities." It was a result of the region's water issue, where the majority of the water supply came from many desalination plants that were erected. While the majority of Australian towns had previously experienced drought, a key cause of their water issue was an abundance of water that was a result of lifestyle choices. The Australians just prefer suburban detached homes, for which they are ready to pay greater costs and which come with their own unique set of hydrological restrictions. Additionally, the growing reliance on desalination resulted in significant costs and carbon emissions. These cultural water concerns received increased attention due to

(a) Rapidly growing population with changing lifestyles;

(b) Changing and highly variable climate and;

(c) A challenging economic environment.

However, it turns out that less complicated solutions, such water price and education campaigns, are more successful than complex technology, which heavily rely on high energy consumptions. The goal of Water Sensitive Cities is to create livable, resilient, sustainable cities. Interestingly, similar problems are present in all rapidly urbanizing regions of the world, hence according to CRCWSC, the idea cannot be limited to just Australian cities. a water sensitive city is envisioned as

(a) Serves as a potential water catchment, providing different water sources at a range of different scales for a variety of uses;

(b) Provides ecosystem services and a healthy natural environment to offer various social, ecological, and economic benefits and;

(c) Involves water sensitive communities where citizens have the knowledge and desire to make wise choices about water and are actively engaged in decision making and demonstrate positive behaviors such as conserving water at home and not tipping down chemicals in the drain. Thus, to summarize, the concept encourages making the most out of current resources, building resilience to provide for tomorrow and community involvement for a sense of belonging. (Mishra1, 2020)

The goal of water sensitive cities is to make the cities livable, resilient, sustainable, and productive, which will help in creating coping capacities and carrying capacities within respective urban areas. Objectives would include

(a) Providing water security for economic prosperity through judicious use of available resources;

(b) Enhancing and protecting the health of waterbodies waterway and wetlands, river basins surrounding them, as well coasts and bays;

(c) Mitigating flood risk and damage and;

(d) Creating public spaces that collect, clean, and recycle water.

Essentially, a city is expected to provide sufficiently, integrate natural water flow, incorporate water resilience, and possess a water collection system (Mishra1, 2020)

People want to live and work in a city that is sensitive to water in the future. It is a location that: serves as a potential water supply catchment, offering a variety of water sources at various scales and for various uses; offers ecosystem services and a healthy natural environment, providing a variety of social, ecological, and economic benefits; and consists of water-sensitive communities where residents have the knowledge and desire to make wise decisions about water, are actively involved in decision-making(Ltd., 2021)

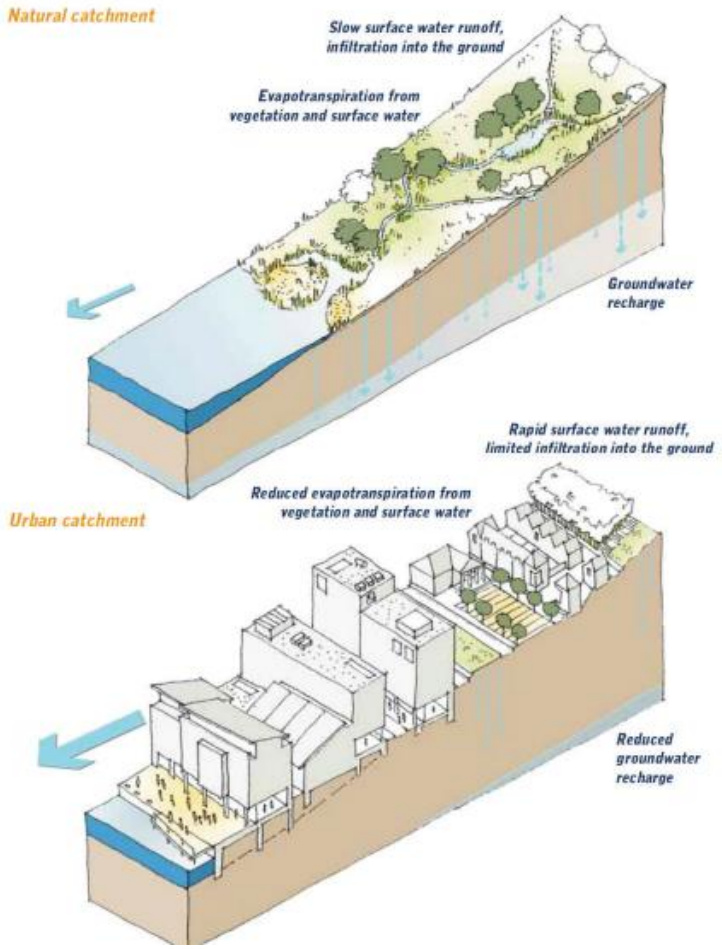


Figure 14:Need of WSP Approaches

Source: Water sensitive planning guide 2018 CSE

2.5 What makes city water sensitive

Water is integral to almost every feature of an urban landscape. Our cities and towns are complex, ever evolving places, and the way we interact with other people constantly changes too. In a water sensitive city,

Interact with the urban water (hydrological) cycle in ways that: Provide the water security essential for economic prosperity through efficient use of diverse available resources; Enhance and protect the health of waterbodies waterways and wetlands, the river basins that surround them, and the coast and bays; Mitigate flood risk and damage; and create public spaces that collect, clean, and recycle water**.**

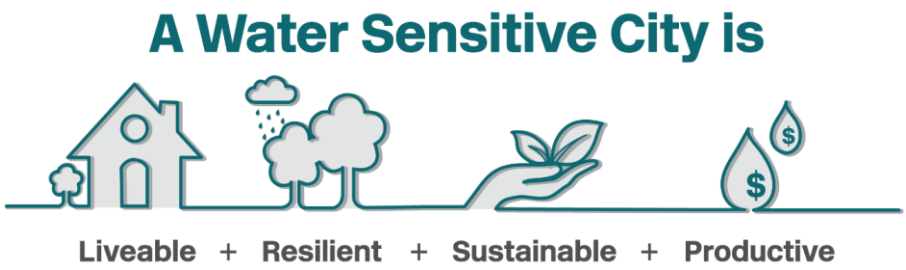


Figure 15:Water sensitive city

Source: Rohilla, water sensitive planning guide 2017

2.6 Benefits of water sensitive developments

There are economic, environmental and social benefits of water sensitive development. Water sensitive development results in capital cost saving construction cost saving, development cost saving, maintenance cost saving, improved resource utilization and improved market value. Environmental Benefits include maintenance of hydro-geological balance, sensitive area protection, waterways restoration impact reduction, enhancement of natural habitat and ground water recharge. The social benefits may include inclusive design and decision making by various communities, visually appealing urban residential landscapes, opportunities to link communities through open spaces and ameliorating urban heat island effect

2.7 Water sensitive planning

Water-sensitive planning (WSP) integrates water considerations into urban and regional planning. WSP aims to promote sustainable development and construction. Its goals are: Improving the planned environment for its users, augmenting water resources and improving their quality, reducing the negative impacts of stormwater, preserving ecosystems and achieving all this in a cost-effective way and with involvement of citizens. Thus, WSP serves simultaneously and synergistically social, environmental and economic goals and objectives.

2.8 WSUDP Scale and interventions

Urban and regional planning are both incorporated into water-sensitive planning (WSP). WSP wants to encourage building and development that is environmentally friendly. Its objectives include enhancing the designed environment for its users, increasing water resources and improving their quality, lowering the negative effects of stormwater, maintaining ecosystems, and accomplishing all of this in a way that is both economical and

involves the public. WSP so supports social, environmental, and economic goals and objectives all at once and in concert.

Scale	Existing documents/provisions	Opportunities
City level: Open spaces—parks and waterbodies, road infrastructure (planning stage)	• Master plans (20 years) • City development plan (five years) • City sanitation plan • Environmental management plan	• Waterbodies, parks, recreational areas, green areas, public and transport • Future locations of storm-water management facilities and proposed STPs
Zone level (planning and designing stages)	• Zonal plan • Storm-water management including water bodies • ULB schemes and sanitation schemes • Detailed project reports (DPRs)	• Parking lots, roads, parks, open space blocks and storm-water management facilities defined in planning documents • DPRs for water supply, sewerage including STPs, sanitation, storm-water drainage
Individual level (designing stage)	• Site plan—guided by bylaws	• Site-specific on-site water-sensitive facilities • Water-efficient fittings, sustainable landscaping, RWH and wastewater recycling and reuse.

Figure 16:Scale and interventions of WSUDP

Source: CSE, WSUDP 2018 Practitioner guide

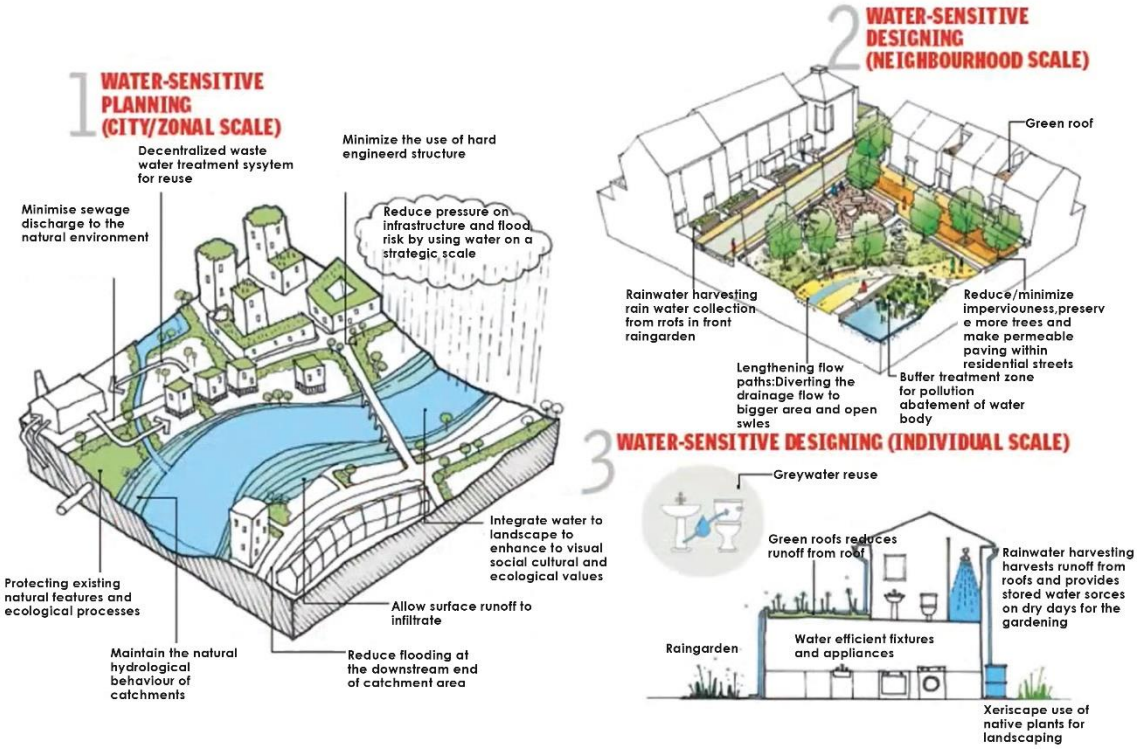


Figure 17:WSP interventions at different scale

Source: CSE, WSUDP 2018 Practitioner guide

2.8.1 Urban WSP

The WSP is primarily intended to be applied in newly developed regions (Greenfields). The majority of WSP's concepts and methods, however, are equally applicable to infill and

redevelopment (brownfield) projects and can be gradually incorporated into already-existing urban fabrics.

2.8.2 Placement and plan of public areas open areas and road networks

Placement of open areas and roadways in conformity with the natural hydro-geographic layout is a key WSP principle. The degree of WSP's aims' attainment and the associated cost are largely determined by adherence to this guideline. Prior to locating other land uses, WSP mandates that planners begin the spatial design of an area with such placement. (Shamir, 2010) In addition to serving as recreation areas, stormwater receptors, and fresh air aeration systems, open spaces play crucial roles in city life. All of them, from huge urban parks to a little backyard, hold true for this. By retaining and detaining stormwater, open spaces can also be used to avoid and mitigate floods where they are situated with care for the natural stream system.

2.8.3 Urban stream preservation and rehabilitation

WSP advises cities with streams in or near built-up areas to maintain them, revive them if they have deteriorated, create open spaces along them, and make them accessible to the public in a way that improves their social and ecological functions while preserving their role in the flood protection scheme.

2.8.4 Urban stormwater management

People in ancient times used rainwater that was stored close to their homes. One of the first civilizations to devise advanced strategies to eliminate urban runoff was the Romans, who were excellent city designers. Since their time, it has been customary to view runoff as an annoyance that must be swiftly and properly eliminated from developed places since it produces floods that causes inconvenience and damages. (Shamir, 2010).

1. The 3Ms of stormwater management

1) **Minimize the difference in runoff volume** leaving the area after development as compared with the volume before it.

(2) **Minimize the difference in discharge** leaving the area after development as compared with the discharge before it.

(3) **Minimize the pollutant load** in the runoff leaving the developed area.

The main tools for implementing the 3Ms of storm water management are BMPs that have been developed and studied in several countries.

a) BMPs I: urban land use practices

Urban runoff quantity and quality can be managed using common urban land use techniques. The most notable of them: The various benefits of higher-density development include: social (enabling more and better services), economic (reduced costs), environmental (lower pollution loads), and also - lower runoff per dwelling unit.

According to calculations made by the USEPA in 2005, the following numbers represent the impact of building density on runoff generation: 1 dwelling unit per acre produces 530 m3 of waste per year, 4 units per acre produce 175 m3 of waste per year, and 8 units per acre produce 140 m3 of waste per year. In comparison to medium and high densities, the low density generates three times and 3.8 times, respectively, more runoff per housing unit.

Mixed land use, which combines housing, jobs, and services, can also be viewed as a BMP because it minimizes the need for parking lots and lessens the need for walkways and roadways. Reduced impervious surfaces, which have an adverse impact on water resources and cause flooding, are a result of roads, parking lots, and other places that make up up to one-third of the urban area.

b) BMPs II: land cover design

The most effective way to transform urban runoff from an annoyance into a water resource is through land cover design. The application of BMPs of land cover design for infiltration of stormwater into the ground, primarily for recharging groundwater, may be a key way for augmenting and maybe improving the quality of a rare resource in nations with restricted water resources. (Carmon, 1997)

It is hereby recommended to use the following somewhat easy and affordable land cover BMPs to absorb clean urban runoff: Increase pervious areas and decrease impermeable regions while taking care to maintain vegetation that doesn't use up too much water.

Place pervious regions, where flows from the impervious areas are diverted, between the impervious areas.

It is advised to utilize the following relatively simple and cost-effective land cover BMPs to absorb clean urban runoff: While taking care to preserve vegetation that doesn't use up too much water, increase pervious areas and decrease impermeable ones. Between the impervious sections, place pervious spaces where flows are diverted from the impervious parts.

c) BMPs III: constructed facilities

(a) Point structures, such as a recharge well that collects rainwater from a roof drain or a yard; a sand filter that enhances the quality of runoff before it is discharged into a stream or recharged into the ground; a small neighborhood reservoir that is incorporated into the landscaping; and parking lots with pervious pavement.

(b) Linear structures, such as infiltration channels in parks and large yards, porous underground drainage pipes, and swales alongside roads;

(c) Local reservoirs, such as volumes for wetlands, detention, and retention that are still built into the surrounding area without endangering locals, especially young children. (Shamir, 2010).

2.9 Water sensitive principles and practices

The water-sensitive city is underpinned by 3 key pillars of practice that are seamlessly integrated into the urban environment:

1.**Cities as Water Supply Catchments**: access to a diversity of water sources, supplied by an integrated mix of centralized and decentralized infrastructure

2.**Cities Providing Ecosystem Services**: provision of ecosystem services for the built and natural environment

3.**Cities Comprising Water-Sensitive Communities**: socio-political capital for sustainability and water-sensitive decision making and behaviours

Water- sensitive concept	Water-sensitive planning principle	Water-sensitive planning approach
Minimizing runoff volume	Protecting existing natural features and ecological processes	• Disturbance to soil and landscape minimized by maintenance of natural landforms. Waterways protected by provision of a buffer of natural vegetation to urban development • Natural channel design and landscaping used so that the drainage network mimics natural ecosystem
	Maintaining natural hydrologic behaviour of catchments	• Limiting increase in storm-water runoff volume by using natural drainage paths and infiltration basins • Reducing impervious areas and increasing pervious areas
Minimizing runoff discharge	Integrating water into the landscape to enhance visual, social, cultural and ecological value	• Minimizing use of hard engineered structures • Using native vegetation in storm-water management and all landscaping to maximize habitat values • Passing runoff through vegetated patches and/or through the ground, to cleanse the water from pollutants, especially from suspended sediments
	Minimizing sewage discharge into natural environment	• Wastewater treatment on-site or contribution to municipal wastewater treatment and reuse scheme • Reducing flooding at the downstream end of catchment
Minimizing the pollutant load	Protecting water quality of surface- and groundwater	• Control runoff from disturbed areas during the construction phase of the development • All storm-water runoff from hard surfaces is treated through infiltration, sedimentation, storage or biological treatment before leaving the site
	Minimizing demand on the reticulated water supply system	• Rainwater tanks collect roof runoff to supply toilet, laundry and outdoor uses. Houses connected to (or utilize) a grey-water or sewage recycling system to provide an alternative source of water for toilet flushing and outdoor use. • Houses incorporate water-efficient appliances and plants that need little water (preferably of local provenance) grown extensively in gardens
Reusing treated wastewater	Decentralized wastewater treatment for reuse	• Decentralization facilitates reuse within specified urban area • Preference for natural treatment systems that are not energy intensive and don't require highly skilled labour
	Selection of reuse options based on the quality of treated wastewater	• Treatment of wastewater according to purpose of use. Bulk use of treated wastewater in urban areas for street washing, construction, horticulture, firefighting etc.

Figure 18:Principles and Approaches

Source: CSE, WSUDP 2018 Practitioner guide

2.10 Land use pattern of different urban centers in India as per URDPFI

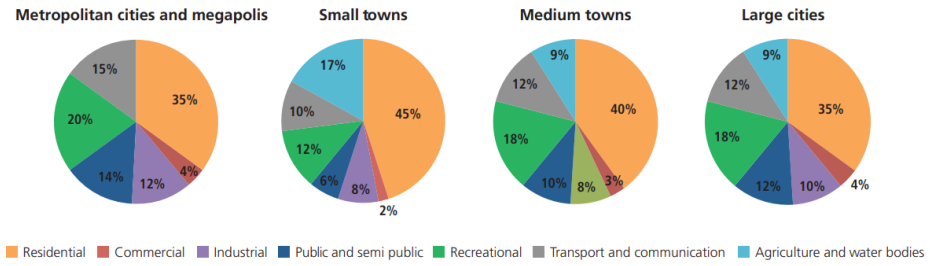


Figure 19:Optimum land use pattern

Source: Urban and regional development plans formulation and implementation (URDPFI) guidelines (2014), Ministry of Urban Development.

This is the standard optimum land use pattern must be followed by metropolitan and megalopolis, small towns, medium towns, large cities etc. Now the present developments drastically follow heavy engineered structure and this become face of urban cities. But these faces have a danger veil of climatic impacts due to the reduction of natural earth surfaces like pervious lands. WSUDP systems that can be implemented in an urban area, depending on the physical and land-use features and must have an eye on the future.

2.11 Significance of open/buffer areas in water-sensitive planning

Wetlands/lakes	Recreational areas	Roads and streets	Inclusion of storm-water streams in urban fabric
Waterbodies and lakes can be planned with a green buffer area that can act as a treatment zone.	Open spaces are located in consideration with the natural stream system	Roads and streets constitute up to 70 percent of the impervious urban area and serve primarily to transport people and goods.	Maintenance of water quality, habitat retention and restoration, water conservation, and a wider choice of recreational opportunities in an integrated fashion.
Waterbodies play a major role in the natural hydrological cycle and offer healthy recreational spaces.	Can be also used to prevent and mitigate floods by retaining and detaining storm water	They also act as important conveyors of stormwater; they constitute the major drainage system that serves as an important flow path, Drainage pipes underneath go beyond their capacity	They provide accessible open spaces to people. Their linear nature also offers opportunities to integrate offroad pedestrian and cycle paths
Since the source of the pollution-degrading waterbody may be unknown, these buffer areas act as protective layers.	Purify and infiltrate runoff, thus recharging groundwater with clean water.		
	Storm water that reaches open spaces may be used for irrigation and as landscaping elements.		

Figure 20:Significance of open spaces

Source: CSE, WSUDP 2018 Practitioner guide.

Table 1:Literaturer reviews and analysis

Literature review	Analysis	Inference
Mainstreaming water sensitive concepts through spatial planning for Bhopal	Despite being blessed with an abundance of natural resources, Bhopal is one of those Indian cities that has been suffering from ongoing environmental degradation over the past few decades due to blatant indifference. Bhopal, which is sometimes referred to be the "City of Lakes," now appears to be gradually losing the value of this very designation as a result of the increased exploitation of its water resources as a result of fast unplanned development. The wetlands in Bhopal's low-lying areas have been invaded by construction, which prevents them from serving as the city's sponges during a severe storm. Reclassification and encroachment of water sensitive property have resulted from flaws in current regulations and land-use plans.	The location, connectivity, land prices, population density, economic and cultural significance indicate its popularity and demand for development. An increase in urban development would also mean a further increase in impervious cover and vegetation decline. Urbanization is key to development; however, if not planned, it could lead to water-sensitive issues.

Roadmap for Implementation of Water-Sensitive Urban Design and Planning in Odisha rainwater harvesting in public parks and open spaces	For the sustainable future of Odisha. It has been decided to put in place a water management system in all the urban areas of the state, which will be capable of catering to the needs of the present and be sensitive to the requirements of the future. Consideration of open spaces, the city has neighbourhood parks and city-level parks. While city-level parks include the city forest areas, botanical garden, and other city-level infrastructure, neighbourhood parks are smaller, ranging from 0.5 acres to 5 acres. For the application of WSP application	The document provides a general description of these cities, providing information on rainfall pattern and statistics, urban planning and provision of public parks and open spaces. For each city, potential sites for implementation are selected. Parks and open spaces of neighbourhood scale and zonal/city scale have been selected as pilot case studies, where RWH potential has been calculated, and certain preliminary design guidelines for each of these parks have been recommended.
Handbook of Water Sensitive Planning and Design	"Start-at-the- source" form of micromanagement based on infiltration. This novel approach, taken across the spatial scale from suburban parking lots to riparian zones, wetlands, and watersheds, is developed and explored in the handbook by renowned practitioners of landscape and water management planning as a true interdisciplinary pioneering effort of water-sensitive planning and design.	(i) water-sensitive design (water-related issues at the local, municipality scale: stormwater management, wetland park creation) and (ii) water-sensitive planning (studies directed to the regional scale: riparian buffer zones and corridors, management of entire watersheds), each opened by an integrating overview. Also included are valuable summaries from taped discussions focused at (i) implementing innovative stormwater management techniques, (ii) moving from single-purpose treatment wetlands to- ward multifunction designed wetland parks, (iii) Issues in managing riparian buffers and corridors.

Source: Author generated with respect to retrieved data of different reviews 2023

CHAPTER 3 STUDY AREA

This chapter is about site selections are carried out in different level for WSP interventions. Here the most Urbanized district and one of its highly urbanized municipalities is chosen at macro level which is the smallest and at the same time high density can observe and selected 3 major land use distribution of this municipality for micro level WSP interventions. For the implementation process analysing the Climatic, Geographical, Physical data's of Aluva Municipality and identify the potential and issues. LULC analysis to calculate the surface sealing of different land use distribution also.

3.1 Study area delineation

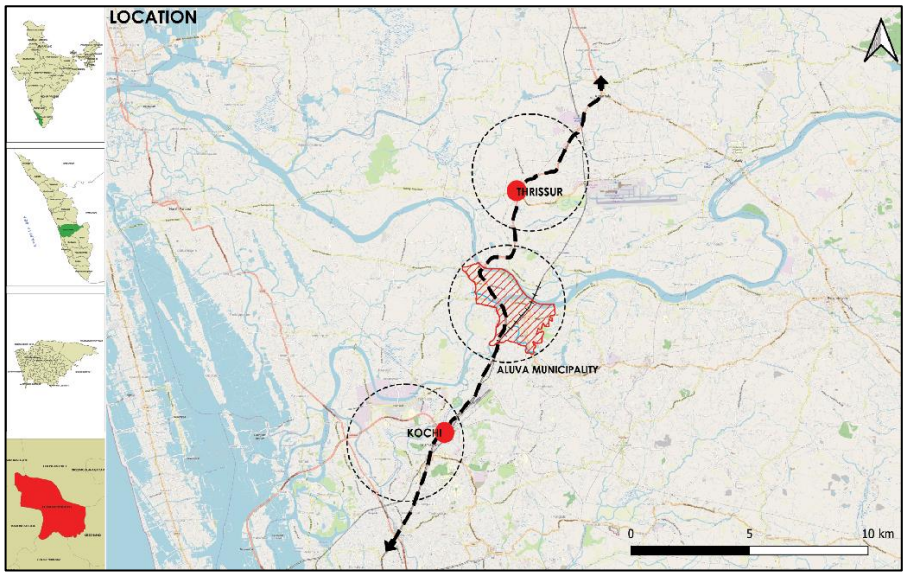


Figure 21: Location of Aluva municipality in Eranakulam district map

Source: Maps India.com 2018

The macro level delineation criteria of the study area are Aluva municipality's growing urban character. The administrative boundary of municipality it self-becoming rapidly urbanized than the nearby panchayat and municipality. At the same time the area become highly vulnerable to the climate impacts. The saturated development demand sensitive approaches to the planning level for sustainable development.

National commission on urbanization (NCU) identified Kochi region as one of the national priority cities (NPC). As per their report Kochi – Thrissur corridor is spatial priority urban region. Aluva is one of the townships in this corridor. The regional linkage of Aluva is shown in Aluva municipality is part of the Kochi urban agglomeration which is the first order urban center of the state as per the state urbanization report (SUR) of Kerala. As per the future

urban profile of the state delineated in the state urbanization report for 2021, Aluva forms part of the delineated urban cluster of Kochi.

3.2 Regional connectivity of Aluva with other urban centers

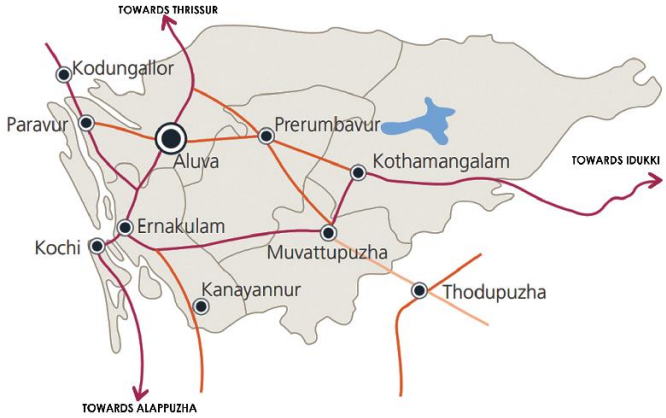


Figure 22:Regional connectivity of Aluva municipality

Source: ATKINS 2015 Future proofing cities -Aluva municipality

Due to its location, Aluva is fast developing into a satellite town in Kochi. The town occupies a strategic position owing to its connectivity to other major urban centers through rail, road and water. By 2030 surrounding municipalities and panchayats such as Kandungallur and Chengamanad will also be increasingly urbanized. Such a development will increase Aluva's current role and sphere of influence in terms of population as key commercial center for the wider area.

3.2 Population Density

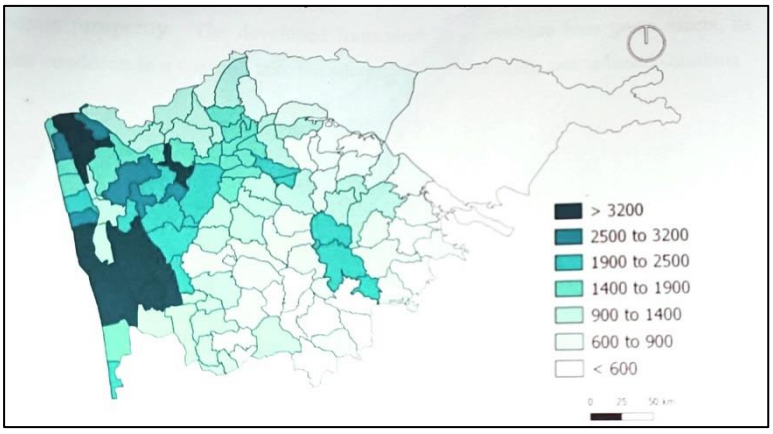


Figure 23:Population density of LSG within Ernakulam district

Source: Thesis Report of 2020 -2022 BGI network in Kochin

3.3 Administrative subdivisions in Ernakulam district

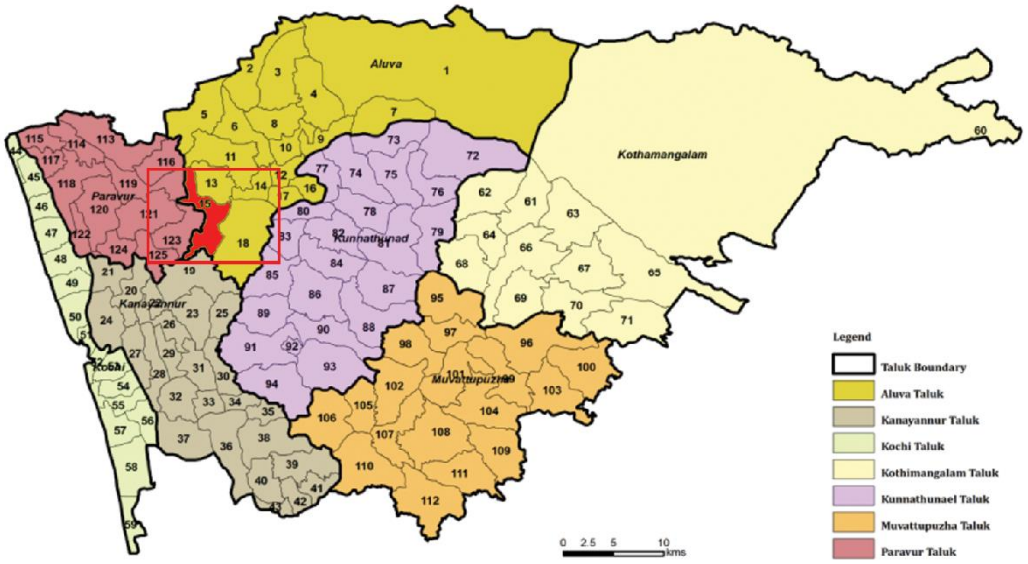


Figure 24:Administrative subdivision of Erankulam District

Source: Disaster management plan Ernakulam district 2015

3.4 Functional character

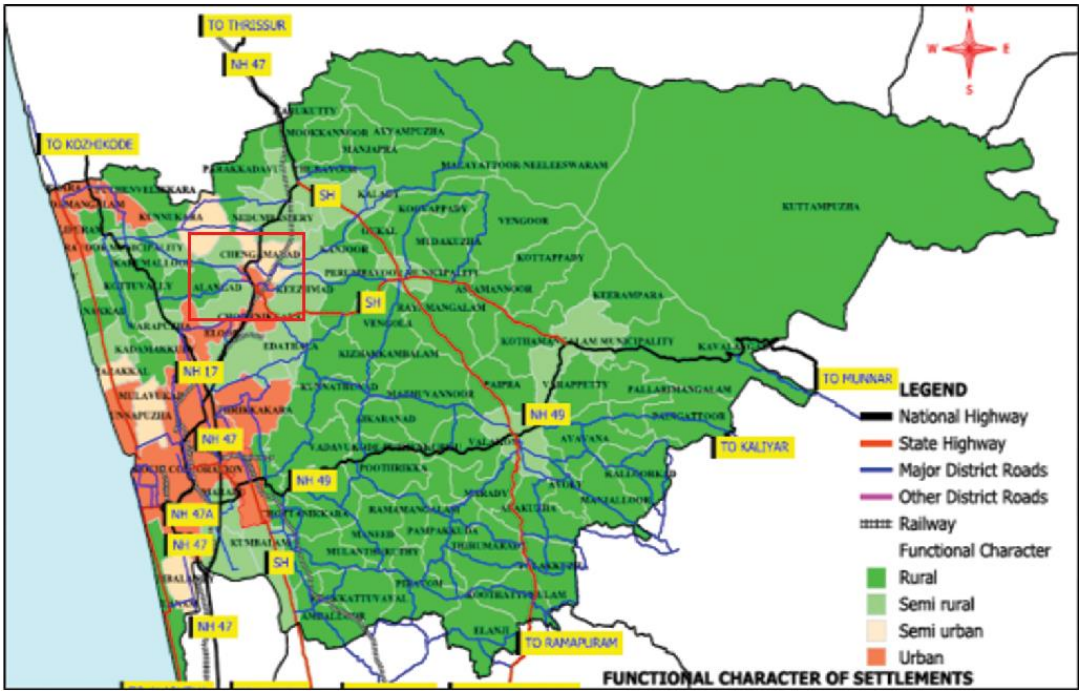


Figure 25:Functional character of Aluva municipality

Source: Ernakulam District urbanization report 2011

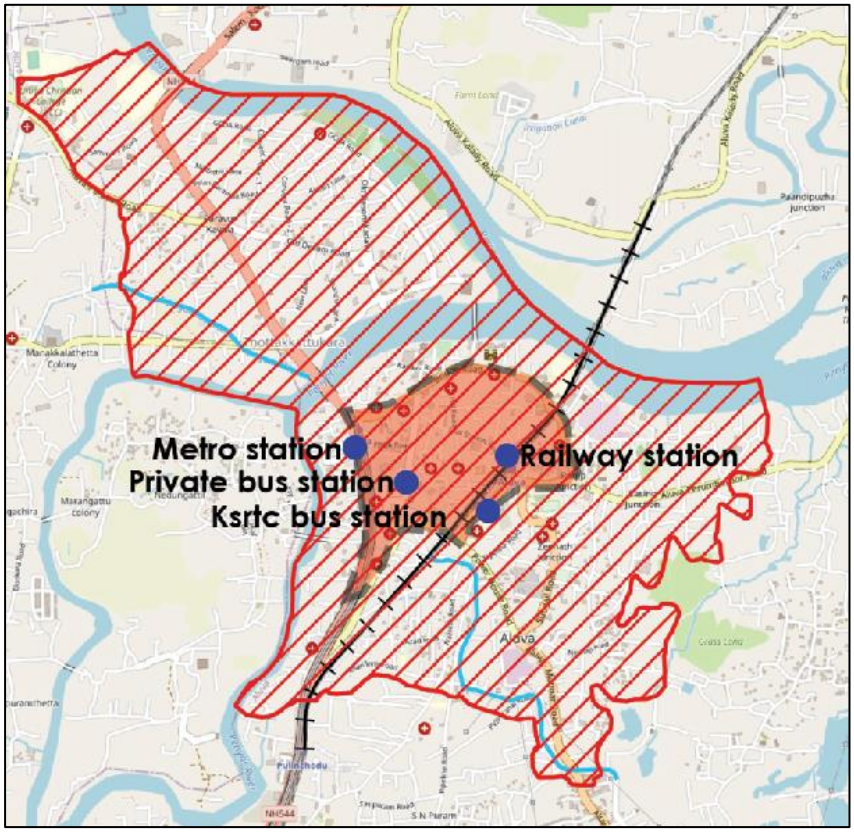


Figure 26:Aluva municipality Transportational hub

Source: Author generated using GIS 2023

Kochi Metro, added the commercial and residential attractiveness of the town, while the old market continues to function as one of the major wholesale markets of the region. Aluva also functions as the single major source for drinking water to the district of Ernakulam, which makes the tram an important part of the regional support network. Rapid urbanization and development pressures due to Aluva's transformation into a major transport hub for nearby towns, the identification of dedicated IT zone along NH47 and influx of NRI investments has led to a change in development typology, from low density low rise to high density-high rise. Due to the urban character than another panchayat and municipality Aluva comes under second order settlement Being a second order town, Aluva has to cater the demands for various higher order facilities of these settlements. When the functional character of settlements is studied based on land use and average plot size, the functional character of the town is found to be urban, and also based on the occupation pattern of the workers, the activities of the town come under secondary and tertiary activities indicating that the people in the town are engaged mainly in the nonagricultural activities, i.e., urban activities.

3.5 Activity character

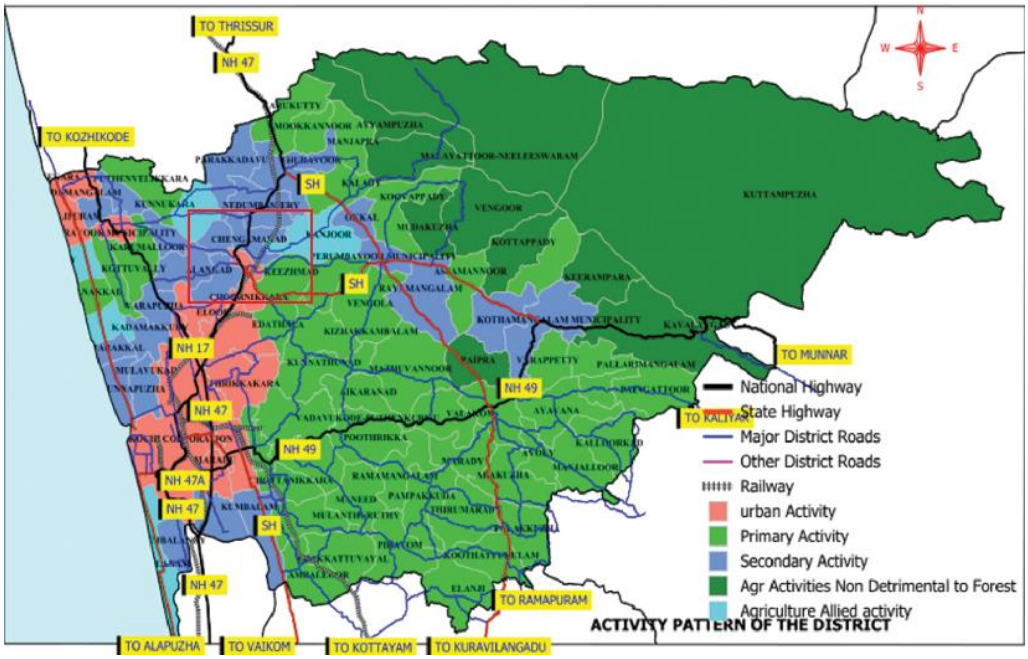


Figure 27: Activity character of Aluva municipality

Source: Ernakulam District urbanization report 2011

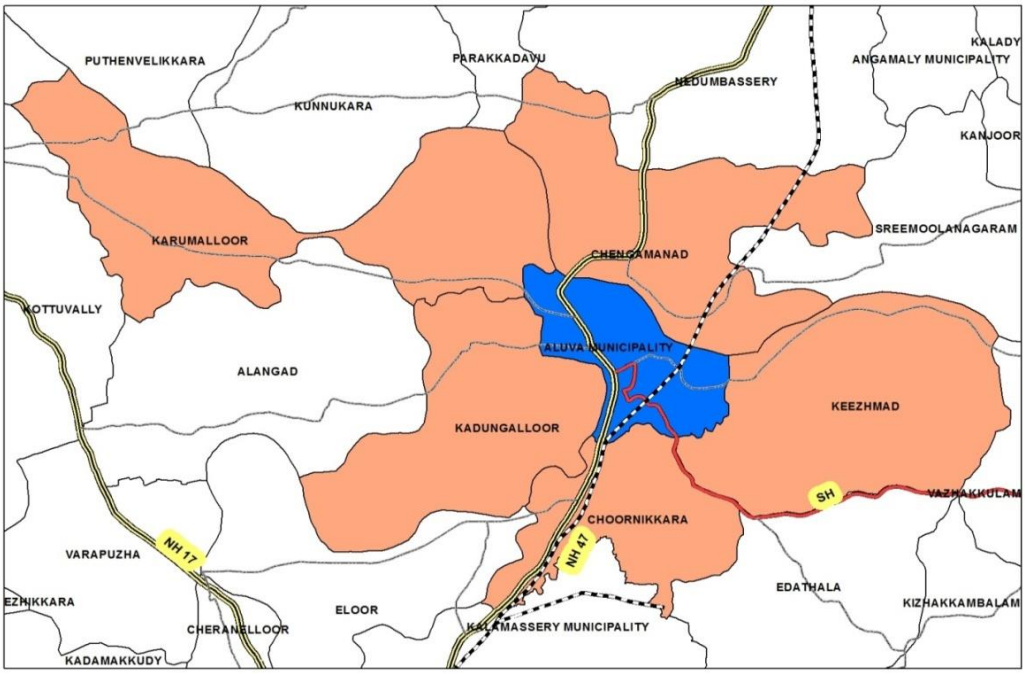


Figure 28: Nearby panchayat of Aluva municipality

Source: Aluva municipality master plan report TKMCE 2019-21 BATCH

Table 2:Functional character of nearby panchayat

Settlement	Urban profile	Functional character	Land use concentration
Karumalloor	Non-urban	Semi-rural	Agriculture
Chengamanad	Urban	Semi-urban	Urban
Kadungalloor	Urban	Semi-rural	Agriculture
Keezhmad	Urban	Semi-rural	Agriculture
Choornikkara	Urban	Urban	Urban
Alangad	Urban	Rural	Agriculture

Source: District Urbanization Report 2018

Most of the adjacent grama panchayats are showing functional character as semi-rural or rural, except for Choornikkara grama panchayat showing urban character and Chengamanad grama panchayat showing semi urban character. However, considering that physical aspect and contiguity of development, the planning area is taken as Aluva municipal area itself.

3.6 Influence area of the town

Aluva town influences the surrounding grama panchayats in many ways. A large number of State and Central Government offices are functioning in Aluva. For the administrative needs, people from the nearby local bodies are depending on Aluva town. The famous Shivarathri Manappuram situated on the bank of Periyar is in Aluva municipal area. People from all parts of Kerala visit Aluva Manappuram for “balitharppanam” on Shivarathri day. Aluva is well connected to other urban centres through rail, road and waterway. This is one of the major stations on the Thiruvananthapuram - Shornur railway line. Aluva is a major collection and distribution centre, catering to the needs of the neighbouring towns and villages. One of the terminal stations of the proposed metro rail is inside the Municipal area. In future, people from surrounding areas will have to depend on Aluva for metro rail. The town serves as a feeder town to the surrounding panchayats and other municipalities’ viz. Chengamanad(P), Karumalloor(P), Kadungalloor(P), Choornikkara(P), Keezhmad(P), Perumbavoor(M), Kothamangalam (M)

Aluva market is one of the major whole sale markets of the region. People from surrounding local bodies also depend on Aluva market. Other commercial establishments of the town also attract people from surrounding panchayats' 544 (Old NH 47) provides the road connection to other parts of the state. Also because of the Aluva railway station, KSRTC bus stand, private bus stand which help to provide connection to many other places, nearness to Nedumbassery Airport, and because of the Aluva-Munnar road, Aluva-Perumbavoor road etc, Aluva acts as a major transportation hub. And large number of KSRTC buses and private buses pass through or begins or ends their trip in Aluva town. A large number of educational institutions including higher education centres are functioning in and around Aluva town. The District Hospital (old Taluk Hospital) is functioning at Aluva which is a major government hospital. For medical and educational purposes, the people from surrounding local bodies and even beyond depend on Aluva town. Considering the above facts, Aluva municipality, the panchayats of Choornikkara, Karumalloor, Kunnukara, Alangad, Keezhmad and Chengamanad have been considered as the influence area of Aluva town.

3.7 Highly sensitive area

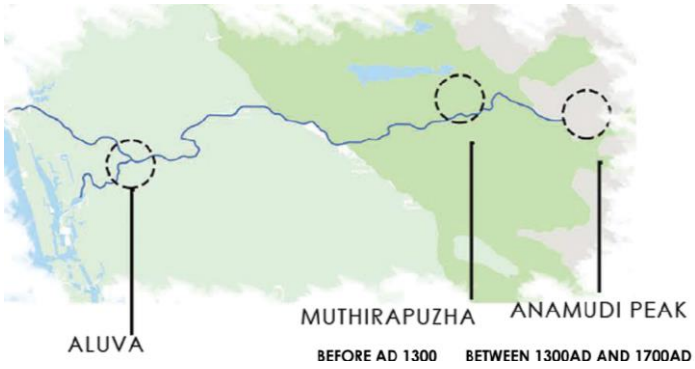


Figure 29:Periyar river basin and Aluva Town

Source: Author generated 2023

Periyar river flowing through Muthirapuzha and Nallathani Originating from Anamudi peak in Idukki district. After the flood of 1341 one branch flows through mangalapuzha to Kadungalloor backwaters and the other flow towards Arabian sea. - When the water level increases water will flow through the land between the river. The flow of water will be faster than other region in the river because the area is low lying area than other. And it will cause more damages and loss.

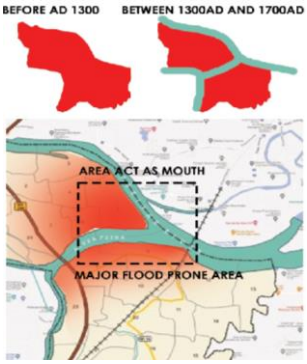


Figure 30:Aluva puzha

Source: Author generated 2023

One the flooding reason of Aluva municipality is opening of Dam. And Heavy Upstream catchment causes rapid floods in Aluva municipality. The idea of constructing dam and its impacting influence is heavy debated by the people and authority.

Flood is usually an overflow of large amount of water beyond its lower limits especially over what is normally dry lands. The Aluva municipality is rapidly becoming extremely urbanized, which has a negative impact on the natural water cycle management and an extremely scarce amount of green open space. Aluva is located 16-20km inland and a mean altitude of 12.3m above MSL, maximum high-water level is +0.6m above MS. Flooding in Aluva is caused either by rivers (fluvial flooding) or by increases in water tides (tidal flooding). however, the risk of tidal flooding is low due to its position

3.8 Aluva Municipality

TOTAL AREA OF MUNICIPALITY - 7.18 SQ.KM

Population	22428
Decadal growth	-6.98%
Floating Population	2000
Slum Population (if any)	100
Tribal Population	0
Population Density	3472 persons/sqkm
Households	6205

Figure 31:Demographic detail Aluva municipality

Source: Census 2011, Annual report 2011

Without adequate planning measures, the town risks both losing its identity and heritage value, and a huge decline in leisure areas Now the green open areas are inadequate in the municipality. Forcing out current residents through gentrification and importantly missing

out on the opportunity to provide efficiencies such as reduction in carbon emissions. The current trend of commercialization of central area consists of transportation hub, government hospital and public buildings are coming under CBD area (Proposed mater plan 2031)

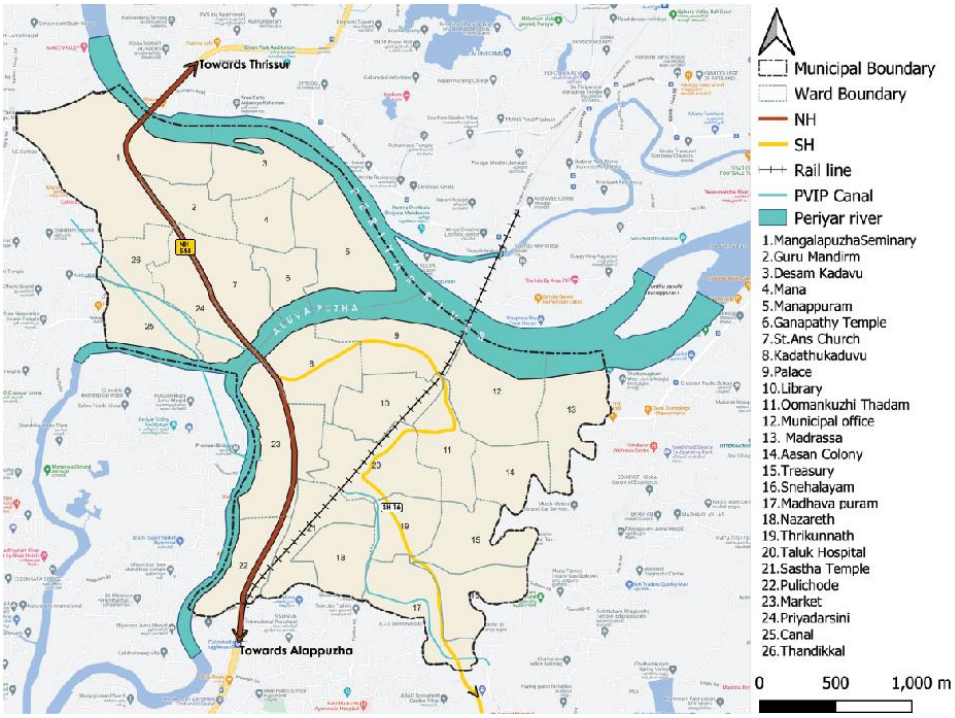


Figure 32: Base map of Aluva municipality

Source: Author generated using GIS with reference to TPO 2011

3.9 Focused area

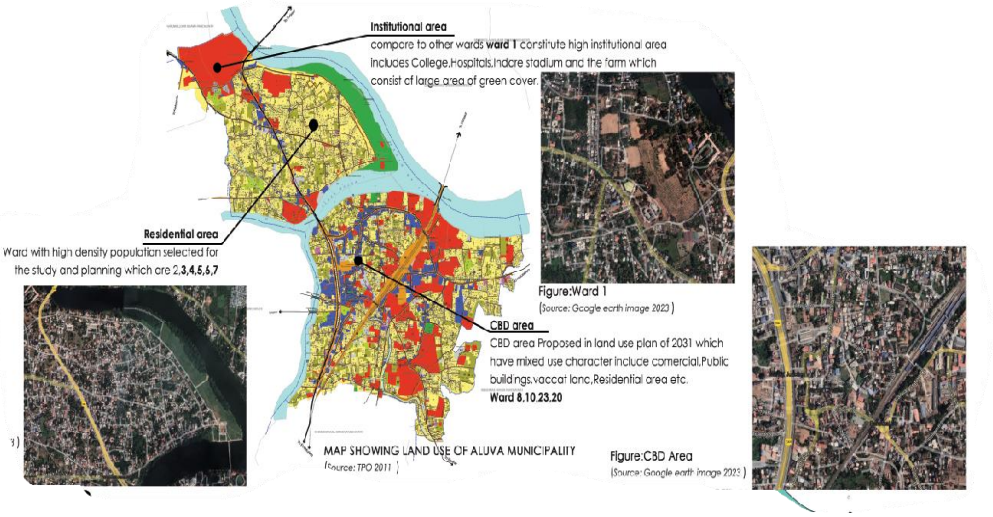


Figure 33: Focused area

Source: Author generated with respect to land use map of 2011

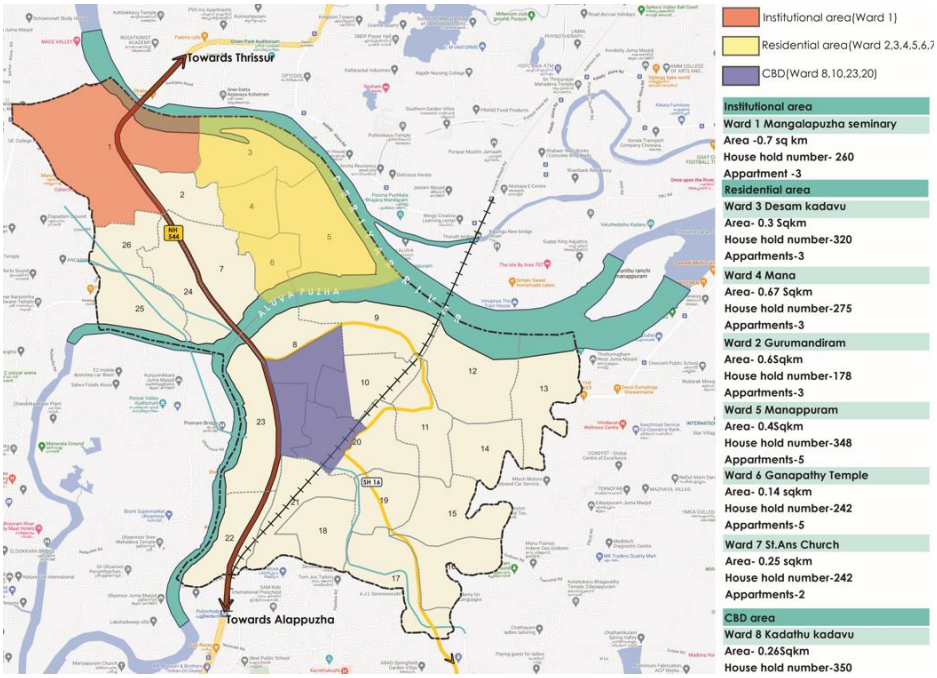


Figure 34:Focused area and selection criteria

Source: Author generated with respect to land use map of 2023

The meso level delineation based on the major land use distribution. Development and land use has a large impact on the water cycle, The core of water sensitive planning is land use and its distribution. Now all the urban development and land use distribution have different character and function which directly impacting the water cycle.

In Aluva municipality green and open space lacking in existing land use and this will be highly affecting climate and future developments. So, the sensitive planning must consider the green development also. So, for the deep assessment selecting 3 types of land use such as **1. Residential area, 2. Institutional area, 3. Commercial area** separately to assess the pervious area and runoff etc. Public and semipublic area 17.67% Of the total area One of the critical opportunities in terms of water sensitive development. Because the municipality lacking the open spaces so these institutional huge areas can be utilized for sensitive practice.

3.10 Study area analysis and inferences

3.10.1 Land use

Land use 2011

As per the land use survey conducted in 2010, the major land uses in Aluva town were Residential, Commercial, Public & semi-public, Industrial, Agricultural Park & Open spaces, Traffic and Transportation, Water bodies & Burial grounds etc.

At present, the Aluva municipal area is divided into 26 wards, which include an area of 6.46 sq.km. As per the land use survey conducted, the total developed area (excluding water body and paddy land uses) of the town is 568.64 hectares.

Table 3:1 Existing Land use break up of Aluva Town 2011

Land Use	Area (Ha)	% Total area	% Developable area
Residential	229.56	35.54	40.37
Commercial	39.86	6.17	7.01
Industrial	2.54	0.39	0.45
Public & Semi-public	114.15	17.67	20.07
Traffic & Transportation	79.12	12.25	13.91
Park & Open Space	24.49	3.79	4.31
Mixed crop (Active)	47.89	7.41	8.42
Mixed crop (non-Active)	0.38	0.05	0.07
Coconut	2.4	0.37	0.42
Wet Land	4.32	0.67	0.76
Vacant Land	23.93	3.71	4.21
Developable area	**568.64**		
Paddy (uncultivated)	1.85	0.29	
Water Body	75.51	11.69	
Total	646	100	100

Source: Aluva municipality master plan report TKMCE 2019-21 batch

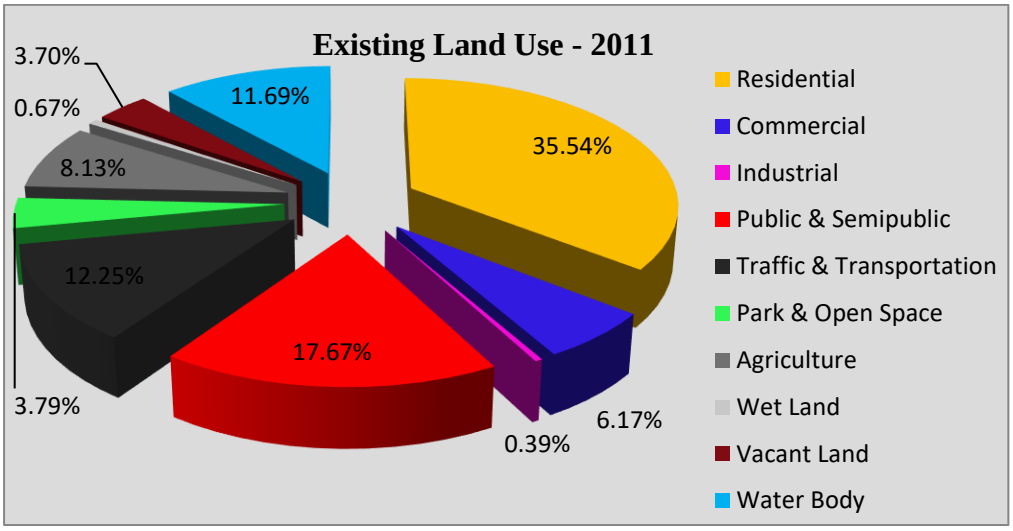


Figure 35:Landuse break up of Aluva Municipality 2011

Source: Aluva municipality master plan report TKMCE 2019-21 BATCH

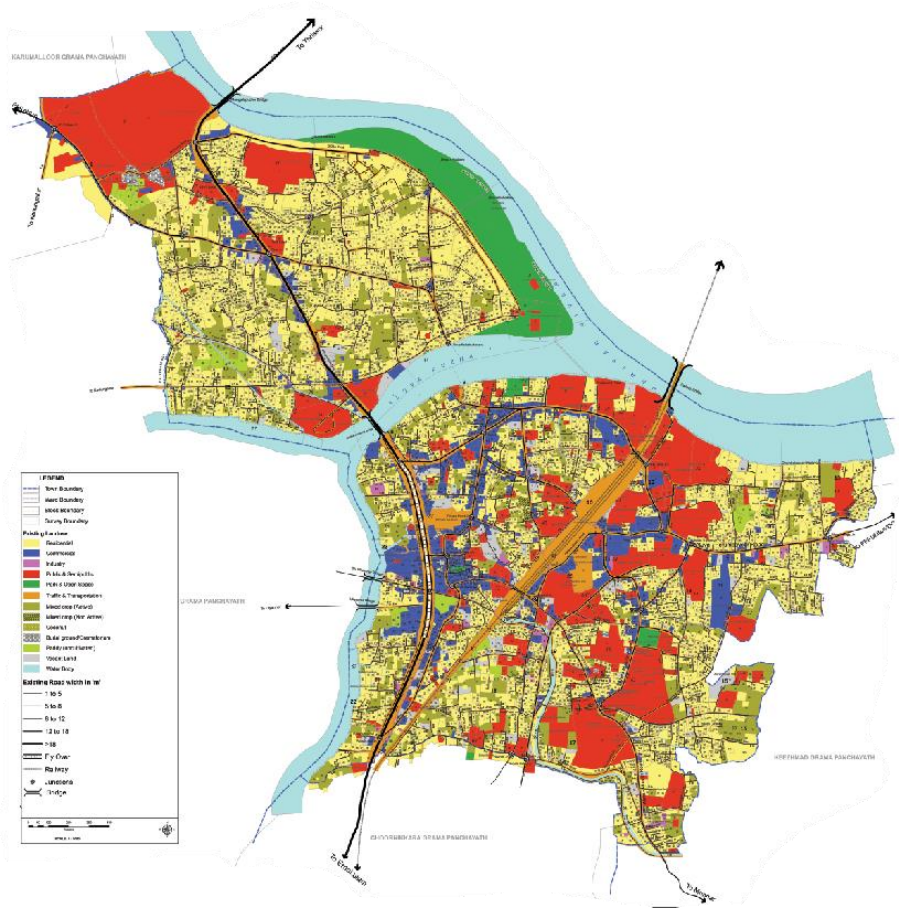


Figure 36:Existing land use map.

Source: Aluva municipality master plan report TKMCE 2019-21 BATCH

a) Temporal variation of land use

A comparison of land use breaks up of Aluva municipality of 1991 and 2010 has been made. It was found that 59.76% of the developable area was under Residential land use, which was the highest percentage of usage. The temporal variation of land use of Aluva municipality is shown in **table 4**. On comparison, it can be noted that the land uses under commercial, public & semi-public and traffic and transportation uses are on the increase. The change in area of land under residential use is due to the change in categorization of land uses between the two periods.

Table 4:Land use break up of 1991and 2010 of Aluva Town

Sl No	Type of Land use	Existing Land use area in Ha		Existing Land use area in percentage	
		1991	2010	1991	2010
1	Residential	316.70	229.56	59.76	40.37
2	Commercial	22.03	39.86	4.16	7.01
3	Industrial	9.14	2.54	1.73	0.45
4	Public & Semi Public	103.57	114.15	19.54	20.07
5	Traffic and Transportation	5.32	79.12	1.00	13.91
6	Road and railway	54.03	-	10.2	-
7	Green and open space	2.35	48.42	0.44	8.52
8	Dry cultivation	12.47	54.99	2.35	9.67
9	Marshy	4.33	-	0.82	-
	Developed land	529.94	568.64	100	100

Source: Aluva municipality master plan report TKMCE 2019-21 BATCH

Land use 2023

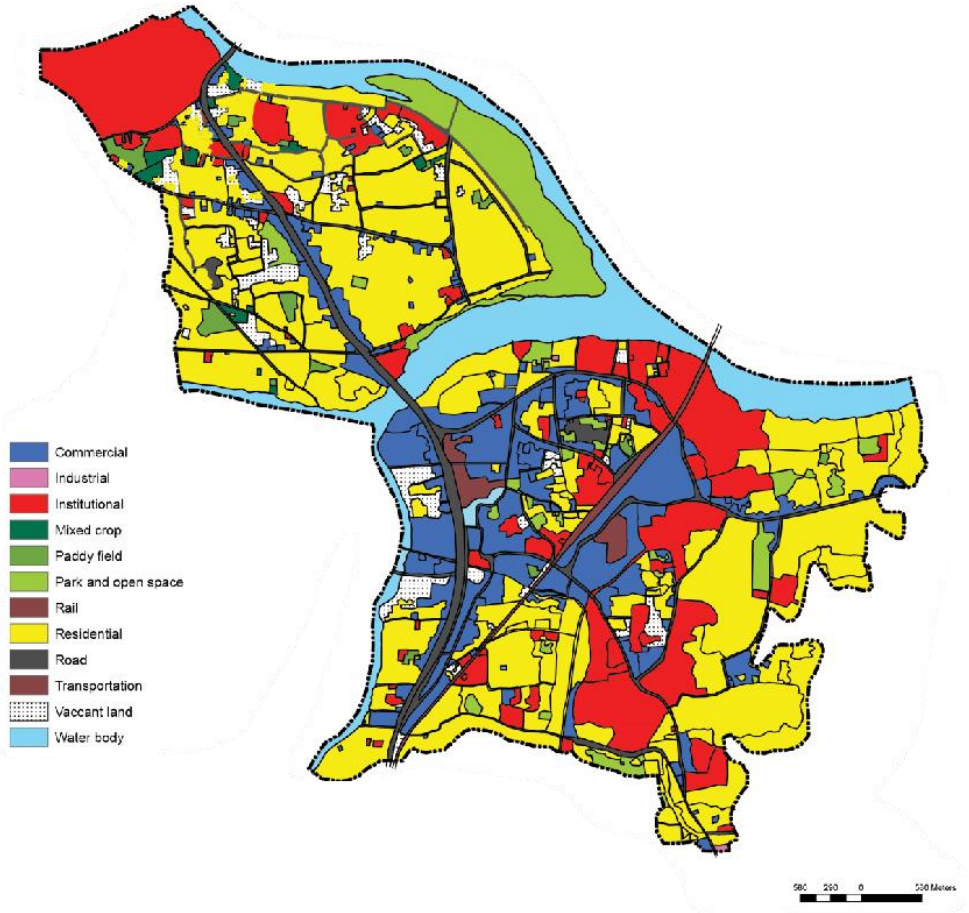


Figure 37: Map showing landuse map of Aluva municipality 2023

Source: Author generated with reference to Google earth pro using ArcGIS 2023

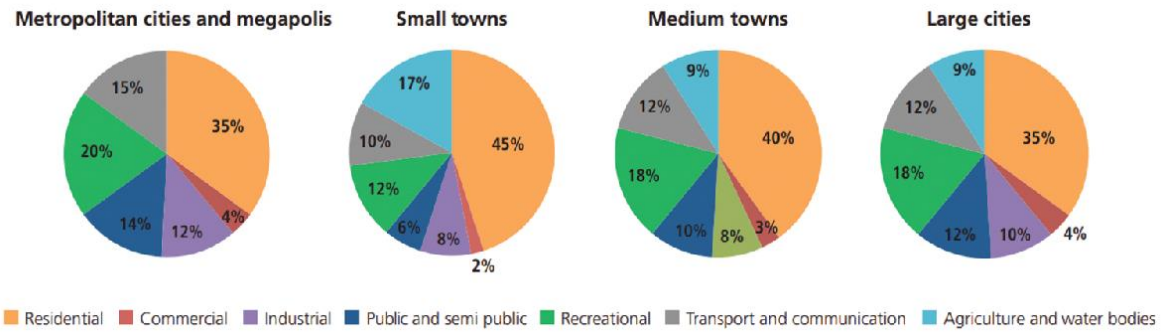


Figure 38: Standard Land-use pattern for different urban centres of India

Source: Urban and regional development plans formulation and implementation (URDPFI) guidelines (2014), Ministry of Urban Development.

b) green infrastructure and public spaces

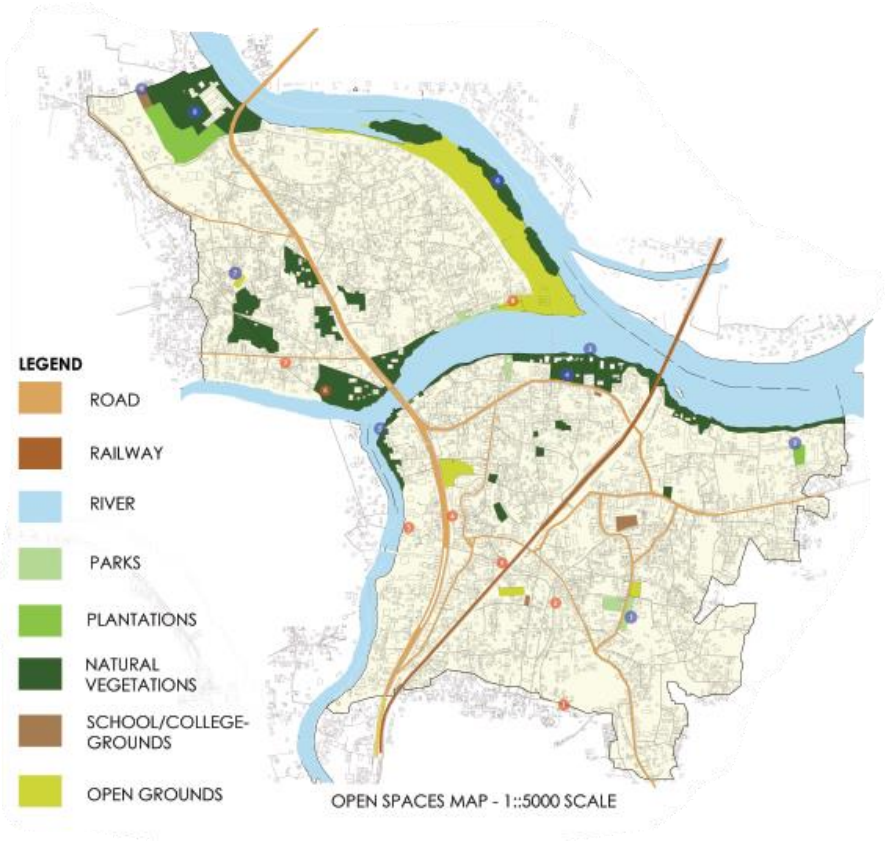


Figure 39:Park and open space analysis

Source: Author generated with respect to 2011 land use map

While analyzing the land use with standard land use distribution given by URDPFI Aluva needs 18% of Park and open space for the better water cycle preservation but the available percentage of park and open space in the municipality in 2023 is 6%. From this we can analyses that the municipality now is in the saturated state needs more green addition to WSP interventions and its implementation.

When we analyzing the land use changes during 2011 to 2023 understand that there is a drastic change occur in land use distribution of Residential, Commercial, and institutional lands that means from 6.17% to 22 % of Commercial land use change,17.67% to 21% of Institutional change,35.56 % to 26% residential land use change and park and open space is reduced to 3.79% to 2%. There is a visible trend of commercialization occurs along transportation networks.

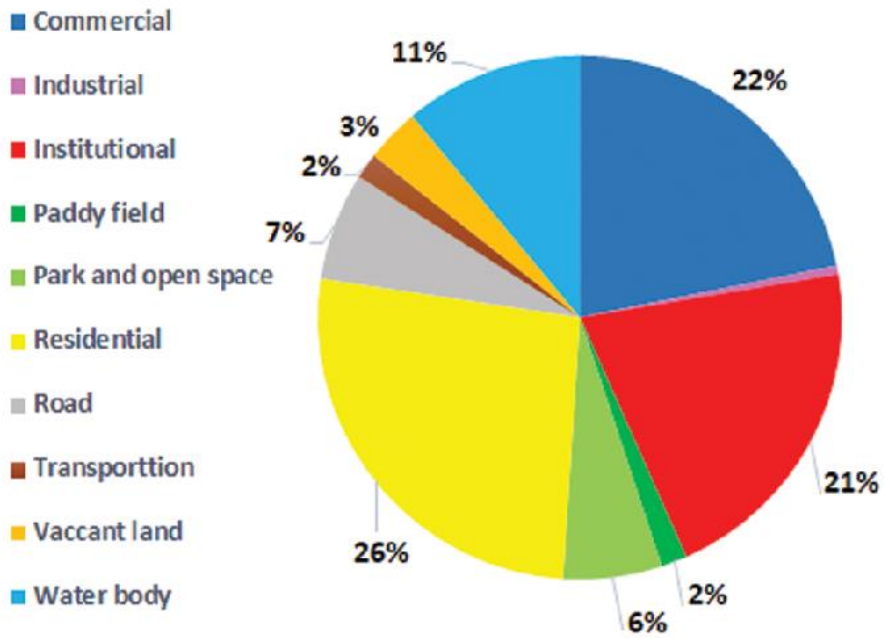


Figure 40:Percentage of land use distribution

Source: Author generated 2023

c) Analysis

There is an overall lack of adequate open spaces and safe pedestrian paths. A major portion of Aluva's open space area consists of the Manappuram to the north of the Periyar, however most of other green spaces consist of mainly trees within private properties. Planned parks and open spaces are few – one to the north of the river and two to the south. A few other are maintained as sports facilities Aluva's public realm is composed of streets, a few parks and public buildings. Natural assets like the Periyar River & riverside, slopes and shade trees have been used to create limited public spaces. Existing river walk on the south is broken by private properties. Development along the river create an inconsistent built edge with the riverfront Planned public spaces are isolated and pedestrian friendly connections between them are absent. Maintenance and management of designated spaces is a challenge – as experienced at the Municipal Park and the dedicated pedestrian path adjacent to the Aluva Palace.

There are few planned and safe pedestrian paths located in the city. Well defined pedestrian links are not only important to enable efficient movement between places but is also crucial to ensure the safety of residents and visitors, particularly women and girls, through well-lit connections and public spaces. Furthermore, certain areas like the existing river walk are inaccessible to all, due to lack of rumps. Paths are shared between commercial activities and

movement while there are no defined or segregated cycling paths across Aluva which provide a further disincentive to move away from car based commuting patterns.

d) Inference

Aluva becomes saturated year by year. Urban functional characters of municipality is one most affected factor of land use change. This urban character and the land use changes directly affecting environment and the natural resources. Green and open space reducing and surface sealing of urban environment increasing rapidly. Due to increase of surface sealing, it may result to high runoff and waterlogging, flooding issues.

3.10.2 Demography

a) Population

The population growth had shown a convex pattern from the year 1961 to 2011 as per the census details. From 1961 onwards a steady increase in population has been observed, reaching the highest figure of 25278 in 1981. The 1991 census showed a declining population growth which was the start of a reverse in trend. This trend continued in the succeeding censuses of 2001 and 2011.As per census 2011, the population of Aluva town is 22428 which is 0.68% of the total population of the Ernakulam district.

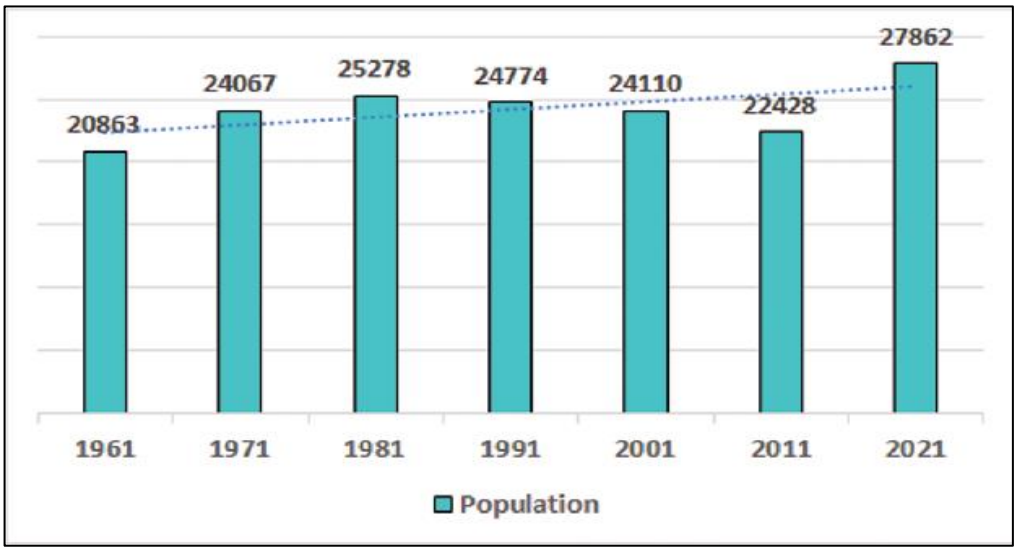


Figure 41:Year wise population of Aluva municipality

Source: Census report 2011

Due to land prize people started to migrate and the introduction of metro rail attract more people to stay there so there is sudden increase in population. Estimated population of 2023 is 30700.and the projected population of 2031 is 38500.

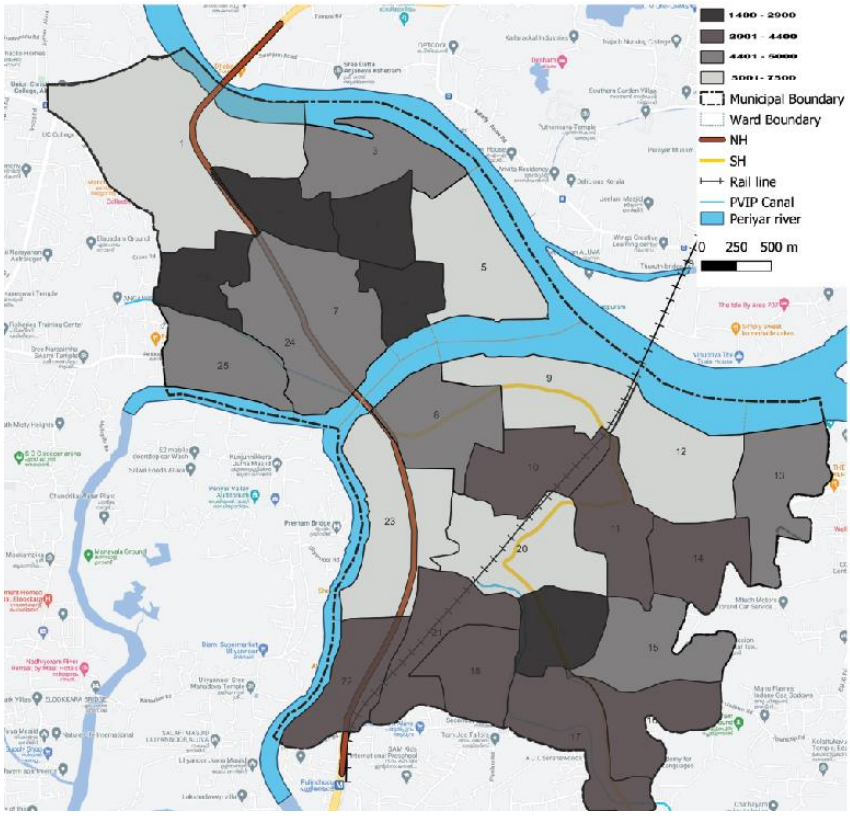


Figure 42: Population Density map of Aluva municipality

Source: Census report 2011

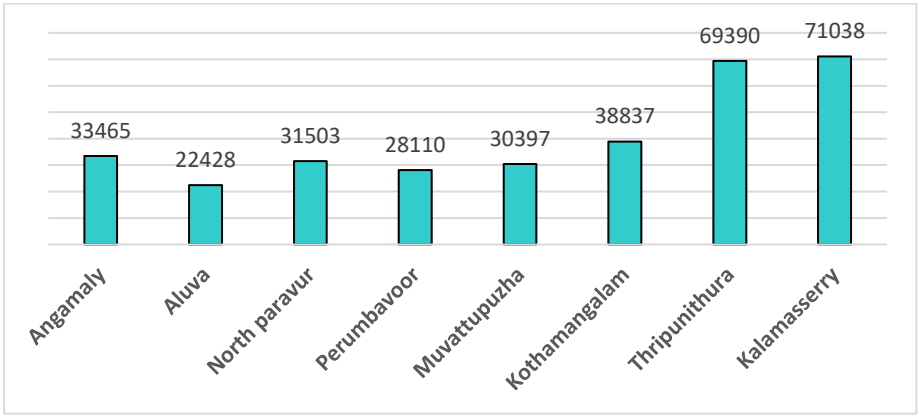


Figure 43:Comparison of population with near towns-2011

Source: Author generated with respect to the report of Aluva municipality master plan batch of 2020-2021 TKMCE 2023

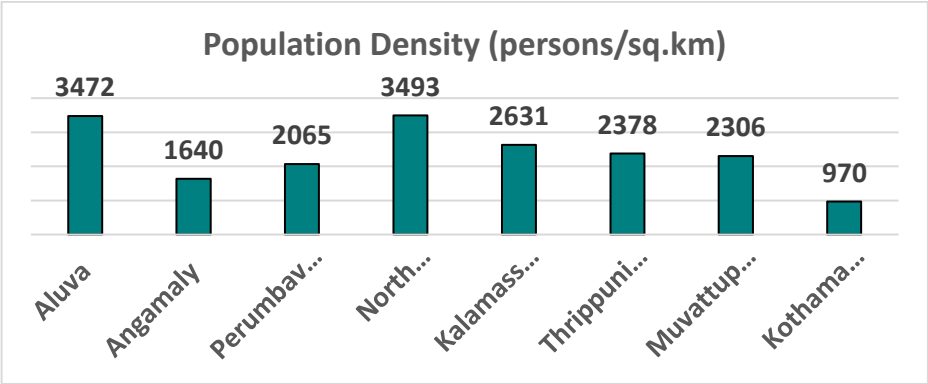


Figure 44:Population density with near municipalities

Source: Author generated with respect to the report of Aluva municipality master plan batch of 2020-2021 TKMCE 2023

b) Inference

Urban character of Aluva municipality changes rapidly due to the potential of high means of transportation facilities. Based on that the Population and population density is increases in the municipality. The urban function pulls more people towards the city for easiness of commute for job is become prime motive of migrant people to live here So, there is visible change in land use pattern. So, the land fair also become high and land availability is major concern of development and people. Urban population day by day increases and the development must have an eye on Quality of life.

3.10.3 Physical infrastructure

a) Water supply

Majority of the people in Aluva town depend on the water supplied by Kerala Water Authority (KWA). Aluva water works of KWA is one of the efficient water treatment plants in Asia. The plant is situated in ward 12 in the heart of Aluva town on the banks of Aluva puzha. The source of water for the Aluva treatment plant is Periyar river. Now Aluva treatment plant has a capacity of 225 MLD and the type of treatment is conventional.

Before the expansion of Aluva water treatment plant, a pipeline was laid parallel to the railway line from Chowara in the old Kochi kingdom for distributing water in Aluva area and Kochi. To increase the supply of water to Ernakulam area, there was a booster pumping

station near Kalamassery poly technique. In 1965, 48 MLD capacity treatment plant was installed and water was supplied to Ernakulam by 36-inch pipeline. In 1975, 72 MLD capacity treatment plant was installed and water was supplied to Ernakulam by 45-inch pipeline. In 1993, 70 MLD capacity treatment plant was installed with the help of World Bank. As the years passed, due to the large water consumption, water treatment and distribution requirements were increased in Aluva itself. Coverage of Aluva water works includes full area of Aluva town. Two overhead water tanks having capacity of 10 MLD and 6 MLD are situated near St. Mary's high school.

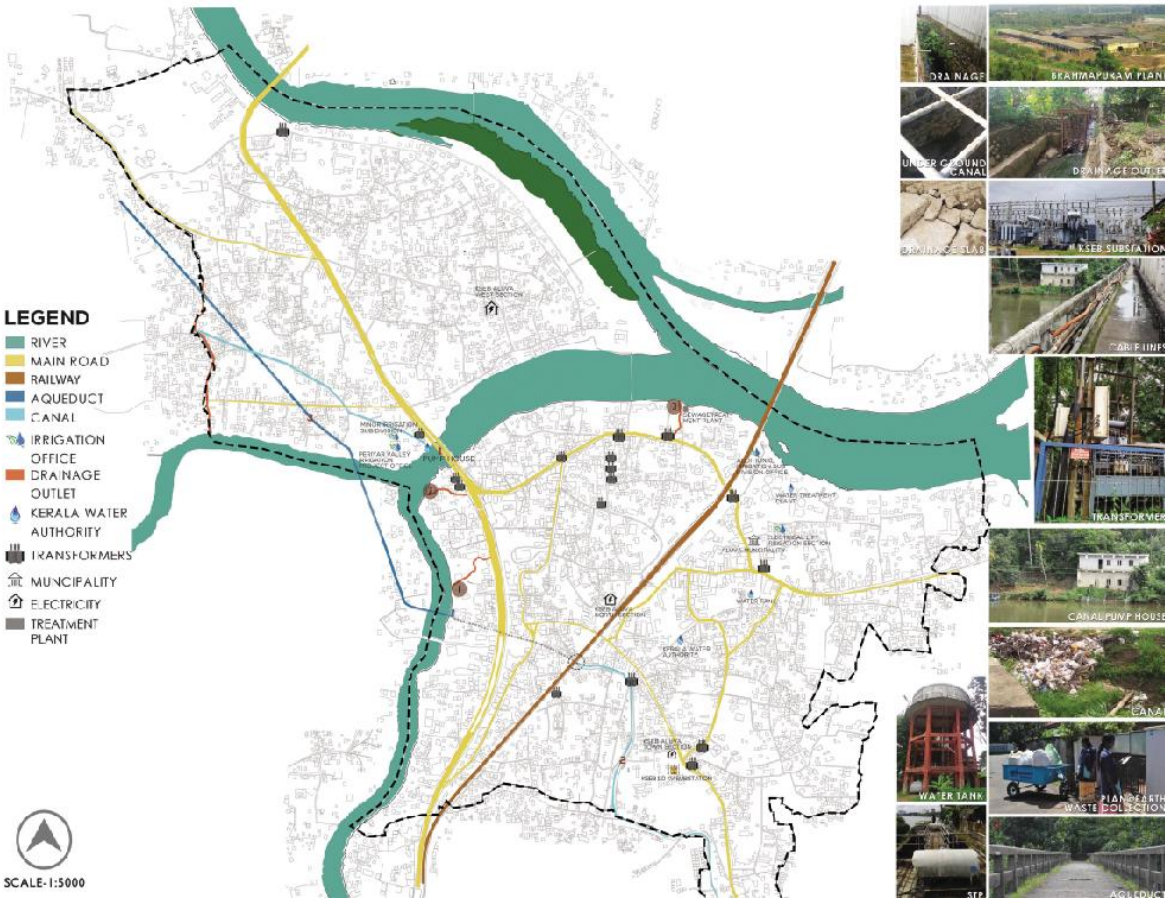


Figure 45:Map showing Physical infra structure of the municipality

Source: Author generated with respect to the report of Aluva municipality master plan batch of 2020-2021 TKMCE 2023

b) Source of water

As per socio-economic survey conducted by the T&CP department in 2010, about 94.5% of people are using KWA water as their source of water and 4.24% of people are using own wells as their source of water. About 16.07% of people are using both KWA water and own

well as their source of water. Community wells, public bore well, own pond, etc. are also used, even though to a limited extent.

Table 5:Soruce of water

Sources of water	KWA	Own well	Community Well	Public bore well	River	Own Pond	Community Pond	Others
% of people using each category	94.5	4.24	0.21	0.21	0	0.21	0	0.63

Source: Author generated with respect to the report of Aluva municipality master plan batch of 2020-2021 TKMCE 2023

c) Water demand Projection

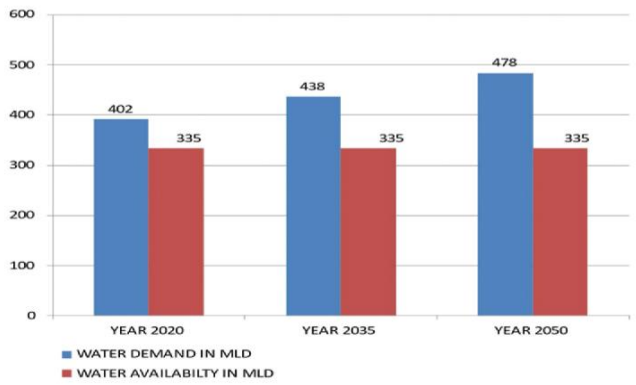


Figure 46:Water demand of Ernakulam district

Source: KWA Project report 2022

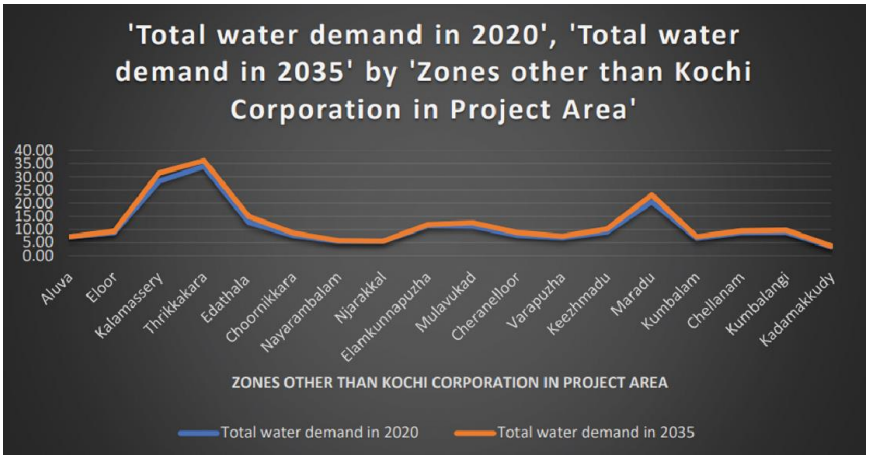


Figure 47:Projected water demand of Other zones include Aluva

Source: KWA Project report 2022

Sl. No.	Name of the zone	Estimated water demand in MLD by 2050	Quantity of treated water in MLD from new WTP
1	Aluva	7.19	7.19
2	Kalamassery	33.92	33.92
3	Eloor	9.77	9.77
4	Thrikkakara	42.00	42.00
5	Edathala	17.40	17.40
6	Choornikkara	9.68	9.68
7	Keezhmad	11.55	11.55
8	Pachalam	13.68	5.08
9	Varappuzha	7.95	5.95
TOTAL		153.14	143.00

Figure 48:Water demand of Aluva municipality

Source: KWA Project report 2022

d) STP and WTP Proposals

Due to heavy flooding issues the existing water treatment plant now under maintenance condition. But it may take long time to retain its actual condition. So, there is new debate on New or enlarged STP proposal for Aluva municipality.

Water Treatment Plant (WTP)benefitting directly and indirectly Corporation of Kochi and surrounding areas of Municipalities and Grama Panchayaths. For the project area consisting of one Corporation, 5 Municipalities and 13Grama Panchayaths, a master plan for drinking water distribution has also been prepared which can be modified in accordance with better possibilities in future. The proposed WTP is to be constructed in the 1.57 Hectares of land owned by KWA at Aluva which is very near to the present WTP complex.

e) Inference

Sufficient consideration in water supply. Future demand is in consideration which will benefits the municipality more in water supply. Wastewater treatment plant Proposal also be a benefit for the WSP implementation.

3.10.4 Social infrastructure

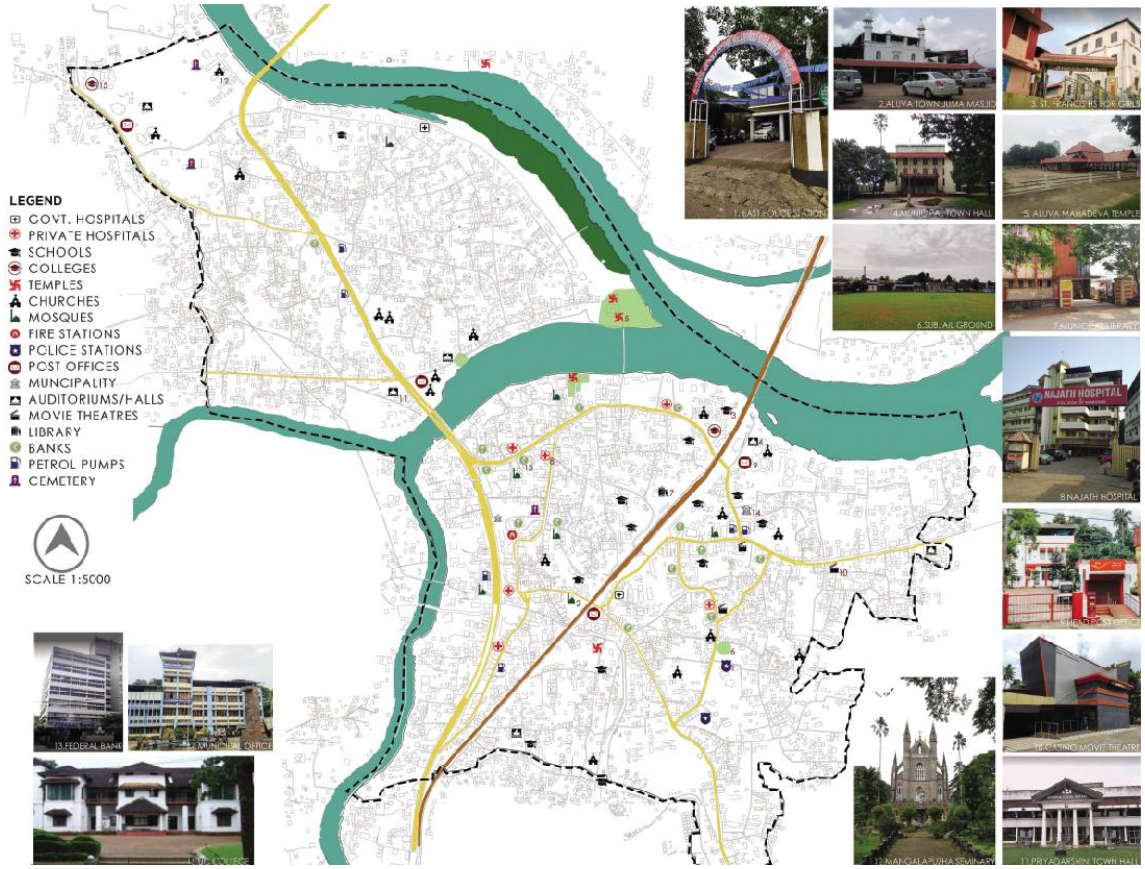


Figure 49:Social infrastructure of Aluva municipality

Source: Author generated with respect to the report of Aluva municipality master plan batch of 2020-2021 TKMCE 2023

When we analyzing the existing land use pattern, we will understand that there is high contribution pubic semipublic land in the municipality around 21 % than the commercial and residential area. This institutional land has high percentage of open area in their plot level. These institutions used as mitigation centers during the flooding.

a) Inference

High concentration of institutional land is possibility of WSUDP. Adding Public and semipublic building and land to the proposals get benefited both the public and private.

3.10.5 Urban form

Figure 50:Map showing build-up of Aluva municipality

Source: Author generated with respect to the report of Aluva municipality master plan batch of 2020-2021 TKMCE and the current google earth image 2023

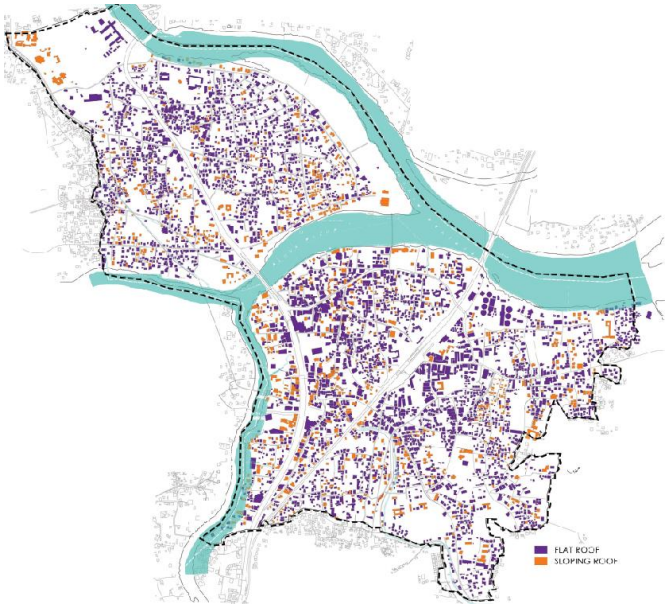


Figure 51:Map showing roof typology of Aluva municipality

Source: Author generated with respect to the report of Aluva municipality master plan batch of 2020-2021 TKMCE and the current google earth image 2023

a) Analysis

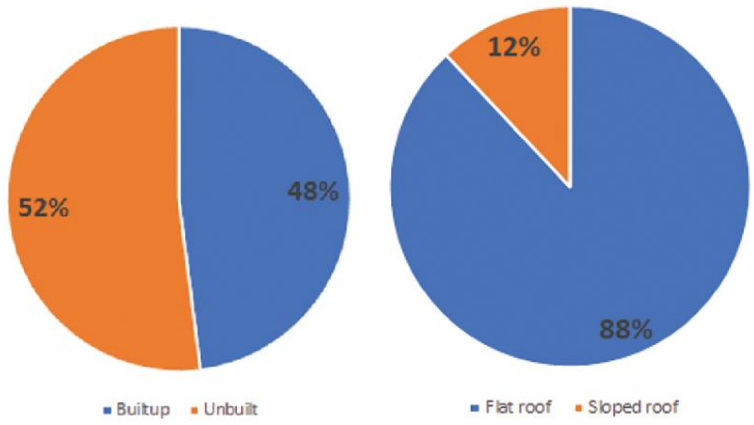


Figure 52:Analysis of built and non built area and the Flat and sloped roof

Source: Author generated 2023

b) Inference

Built density is high in the municipality, which possess high impervious rate also.it extremely affecting the natural water cycle of an area.

3.10.6 Environment

Flood is usually an overflow of large amount of water beyond its lower limits especially over what is normally dry lands. Aluva is located 16-20km inland and a mean altitude of 12.3m above MSL, maximum high-water level is +0.6m above MSL. Flooding in Aluva is caused either by rivers (fluvial flooding) or by increases in water tides (tidal flooding). however, the risk of tidal flooding is low due to its position.

A) Geo graphical features

It is located at the north-west part of the district. Aluva town lies in the midland region and mainly consist of plain topography. Periyar, a beautiful river and second largest in the state is the life line of Aluva. Alappuzha divides the Aluva main land into two - the north and the south parts. The altitudes of Aluva vary from 4m to 40m above MSL. Digital elevation of Aluva town.

b) Climate rainfall and soil conditions.

The town has three seasons namely the dewy, the hot and the rainy. The dewy season lasts from December to February, the days are hot, the nights are chilly and there is heavy dew

fall at night. The hot season begins in February and lasts till June, both the days and nights are hot but occasional showers and sea breeze provides relief. The rainy season extends from June to November. The south-west monsoon starts in June and lasts till August. June and July are the rainiest months when 45% of the annual rainfall is received. The north-east monsoon strikes in October and continues till November. On an average there are about 132 rainy days in a year.

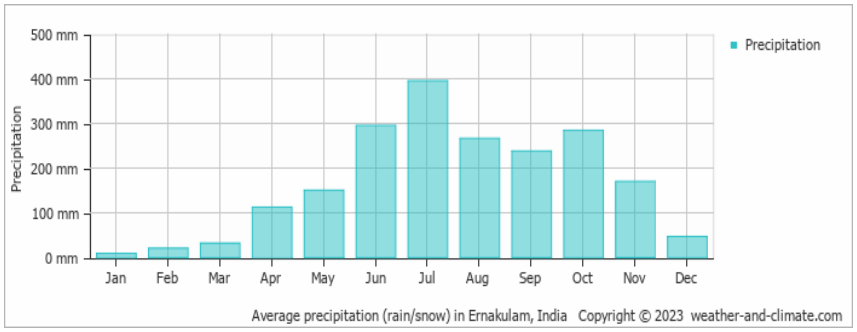


Figure 53:Rainfall of Aluva Municipality

Source: Weather and climate.com 2023

The air is highly humid throughout the year. The relative humidity is generally above 70%. The wind flows in the town, with moderate force and it prevails throughout the year. During south-west monsoon season, the wind flows mainly on western or north-eastern directions. The rest of the year wind is flowing towards north-east and eastern directions in the morning and south-west and western directions in the afternoon.

The land slopes from east to west. The soil of the town can be classified as sandy clays and laterites. The clay found here is inferior type of clay and used for manufacturing of tiles and bricks. Laterite is popularly used for building construction. All garden crops including recant and coconut are grown in this soil.

c) Bio diversity

In Aluva municipality only 0.57 sq.km. of area is under agricultural land use, that comes to 8.80% of total area of Aluva and the categories under agricultural land use are coconut, mixed crop etc. The details given by the agricultural department contains a cultivation of 2 ha of rice, also which comes under the dry cultivation and not under paddy.

d) Topography

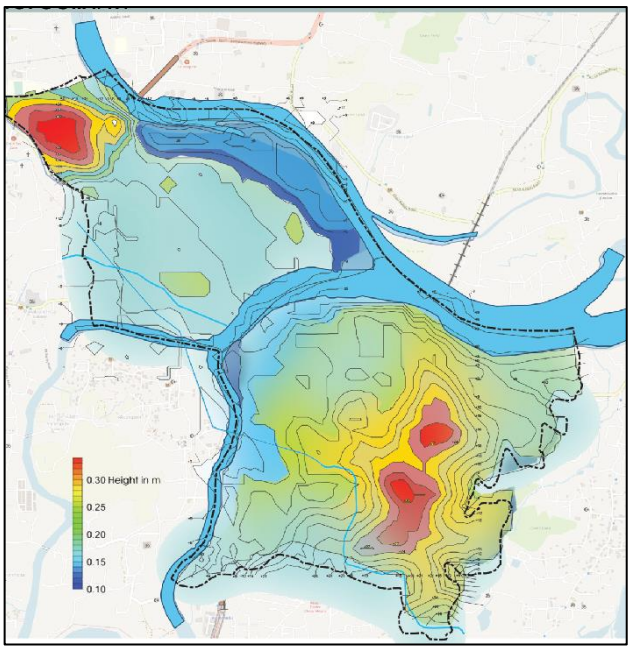


Figure 54: Contour map of Aluva Municipality

Source: Author generated using ArcGIS 2023

e) Flood map

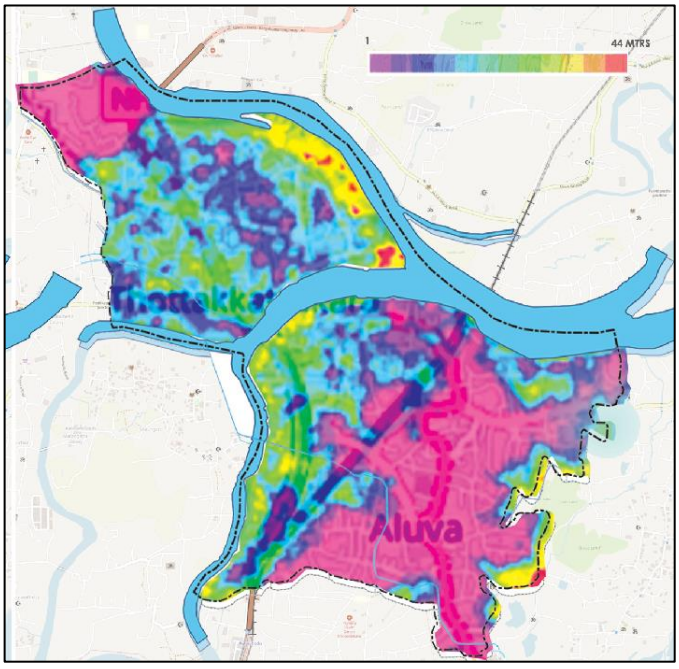


Figure 55:Flood map OfAluva municipality

Source: Author generated using retrieved data from flood map .net 2023

f) Watershed map of Periyar river

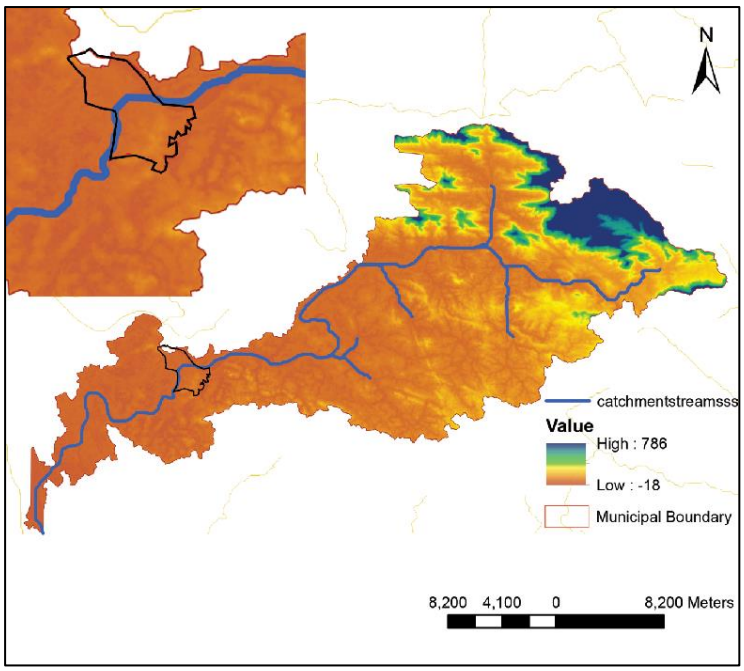


Figure 56: Watershed map of periyar river

Source: Author generated using ArcGIS 2023

g) Waterlogging and drainage pattern

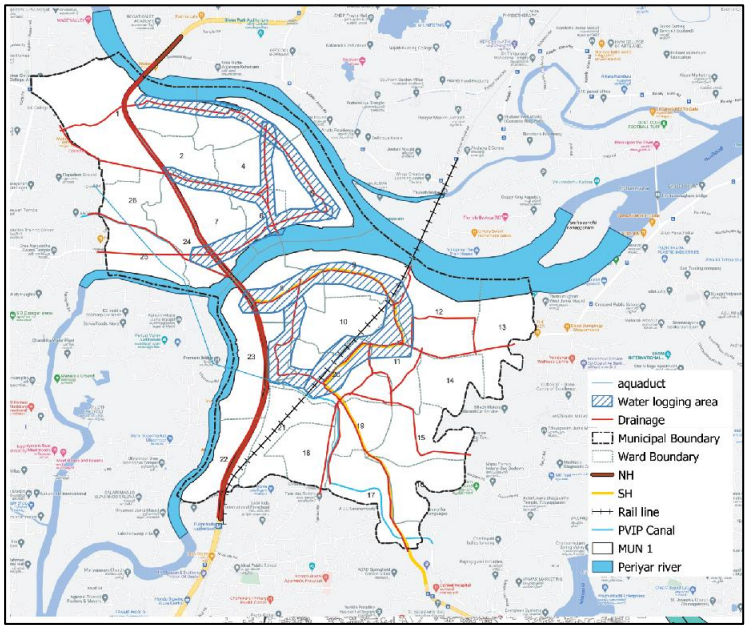


Figure 57:Water logging area and drainage

Source: Author generated using GIS 2023

h) Topography

Aluva has a vast planar char- acter except the high contour [30m+] areas at northern and 5 southern ends. The natural drainage is directed towards the Periyar passing through the central plateau.

i) Rainfall

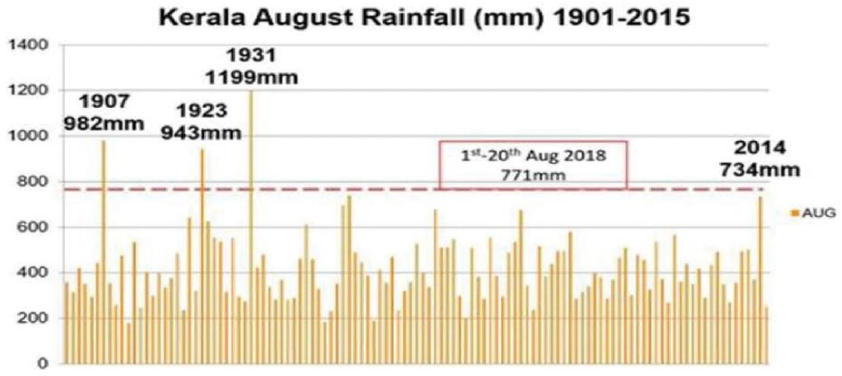


Figure 58: Rain fall

Source: Ernakulam weather information 2015

j) Natural slope

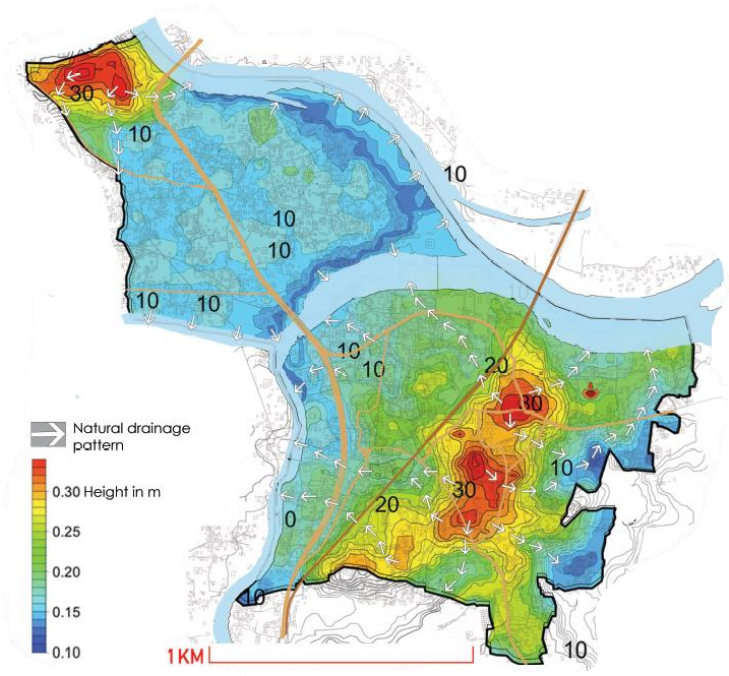
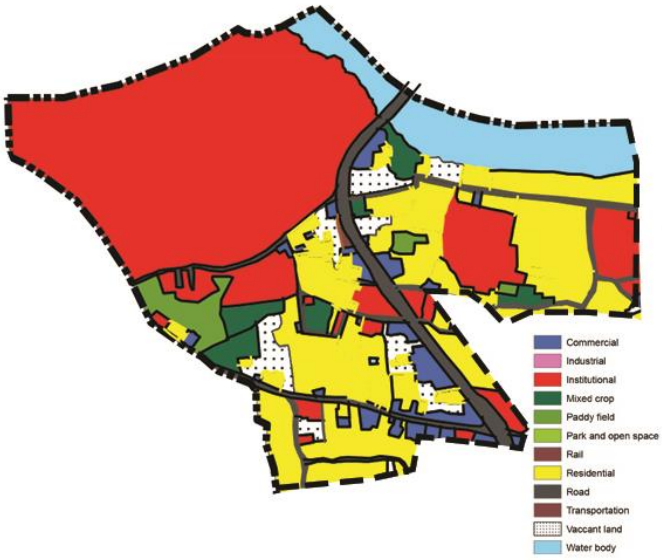


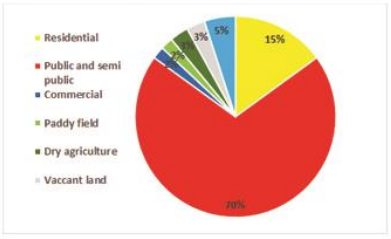
Figure 59:Contour map

Source: Author generated with respect to the report of Aluva municipality master plan batch of 2020-2021 TKMCE 2023

3.11 Land use analysis

3.11.1 Institutional area Land use analysis



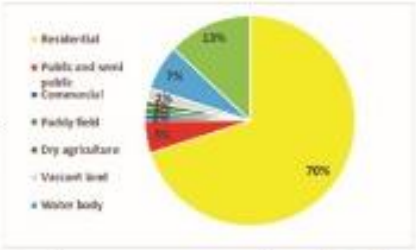


Total area	0.7 Sqkm
Surface sealing	38%
Population	809
Density	1,155
Imp/Per ratio	0.7
Roof /Per ratio	0.3
Average plot size	150000 Sq.ft
Average roof size	30000 Sq.ft
Average household size	4
Average water use	62 lpcd

Figure 60:Institutional area

Source: Author generated using ArcGIS 2023

3.11.2 Residential area Land use analysis

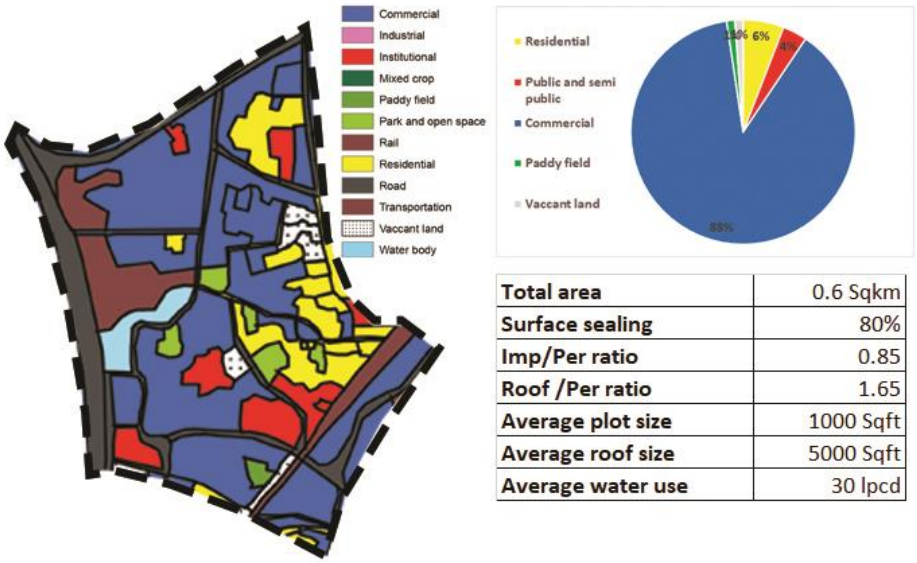


Total area	1.6 Sqkm
Surface sealing	48%
Population	3,367
Density	2,104
Imp/Per ratio	1.4
Roof /Per ratio	1.03
Average plot size	1000 sqft
Average roof size	800 Sqft
Average household size	4
Average water use	75 lpcd

Figure 61:Residential area

Source: Author generated using ArcGIS 2023

3.11.3 Commercial area Land use analysis



Total area	0.6 Sqkm
Surface sealing	80%
Imp/Per ratio	0.85
Roof /Per ratio	1.65
Average plot size	1000 Sqft
Average roof size	5000 Sqft
Average water use	30 lpcd

Figure 62:Commercial area

Source: Author generated using ArcGIS 2023

3.12 Land cover analysis

The selected study areas were divided into two zones. Impervious zone - consisting of roof areas, paved areas and roads. Pervious zone - consisting of open spaces and water bodies

3.12.1 Institutional area Land cover analysis

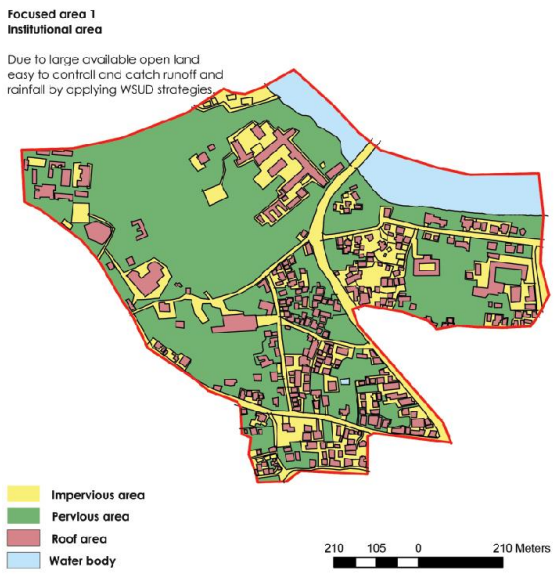


Figure 63: Map showing landcover of delineated focused study area in the municipality

Source: Author generated with reference to Google earth pro using ArcGIS 2023

3.12.2 Residential area Land cover analysis

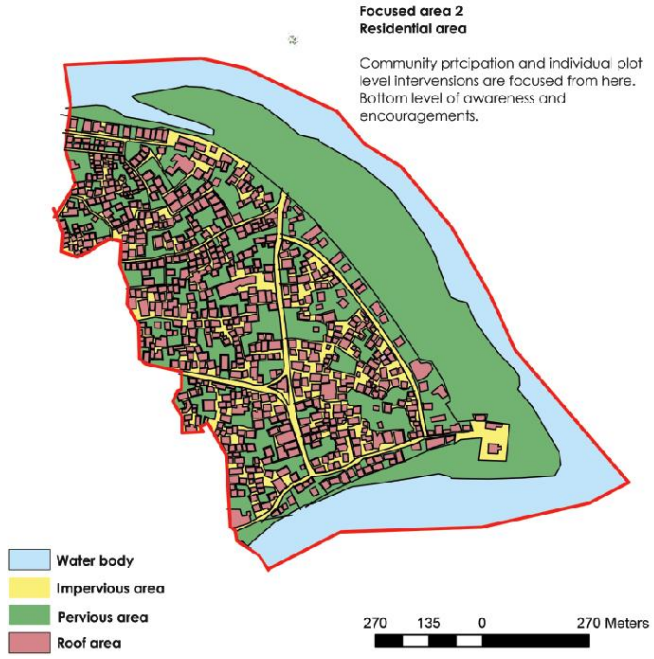


Figure 64: Map showing landcover of delineated focused study area in the municipality

Source: Author generated with reference to Google earth pro using ArcGIS 2023

3.12.3 Commercial area Land cover analysis

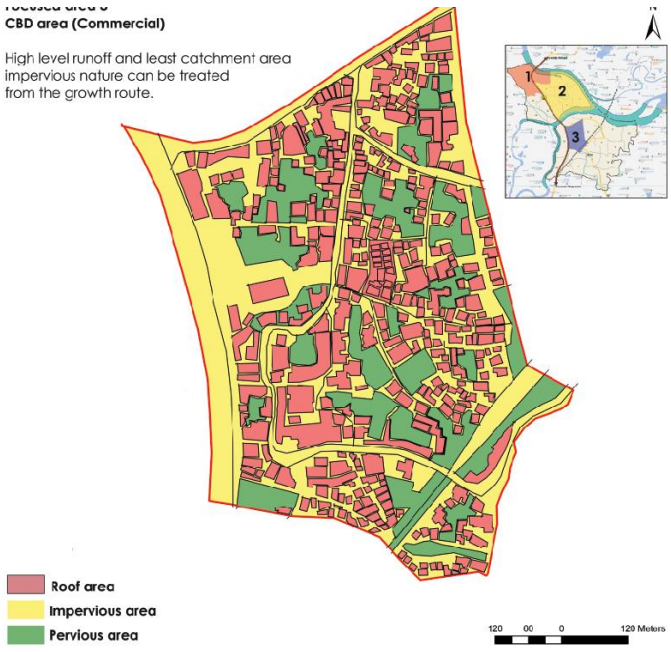


Figure 65: Map showing landcover of delineated focused study area in the municipality

Source: Author generated with reference to Google earth pro using ArcGIS 2023

3.12.4 Surface sealing analysis of different land use pattern

Table 6:Surface sealing and pervious impervious ratio

Location	Area in sq. km	% Roof	%Pervious	% Impervious (Road +Pavement)	Surface sealing	Imp/Perv	Roof/Perv
Institutional	0.7	17	53	21	38	0.7	0.3
Residential	1.51	34	33	14	48	1.4	1.03
Commercial	0.5	33	20	47	80	0.8	1.65

Source: Author generated 2023

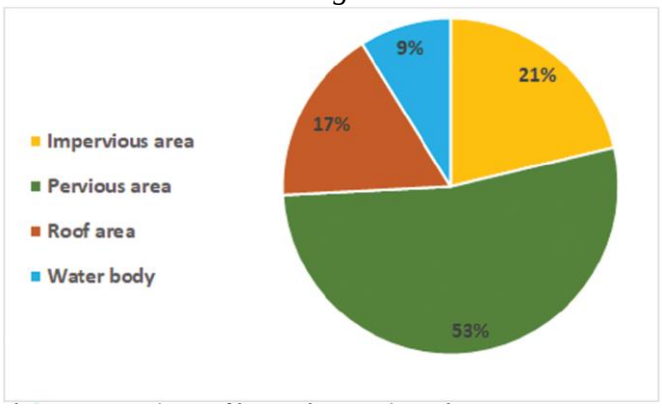


Figure 66:Percentage of impervious and pervious area of institutional area

Source: Author generated with reference to Google earth pro using ArcGIS 2023

Institutional area has 53 %of pervious area which is suitable for the water sensitive development and planning. Natural infiltration and rainfall catch will effectively work in these areas.

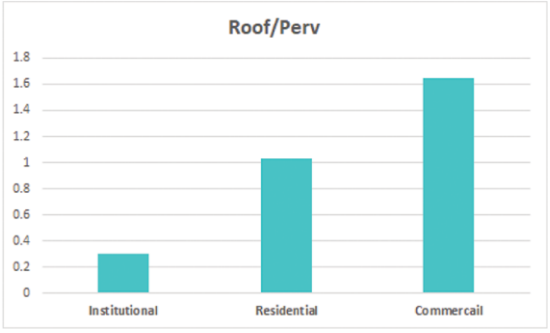


Figure 67:Graph showing Roof/Pervious of Different land use distribution

Source: Author generated with reference to map prepared with Google earth pro using ArcGIS 2023

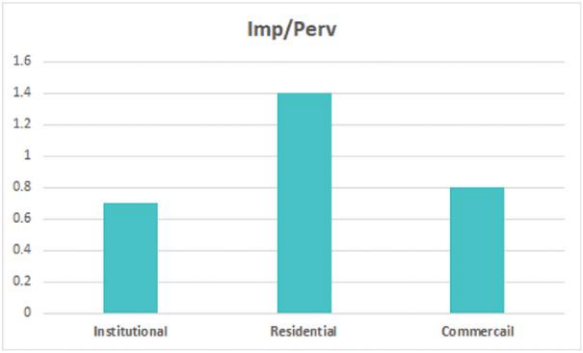


Figure 68:Graph showing impervious/pervious area of different land use distribution

Source: Author generated with reference to map prepared with Google earth pro using ArcGIS 2023

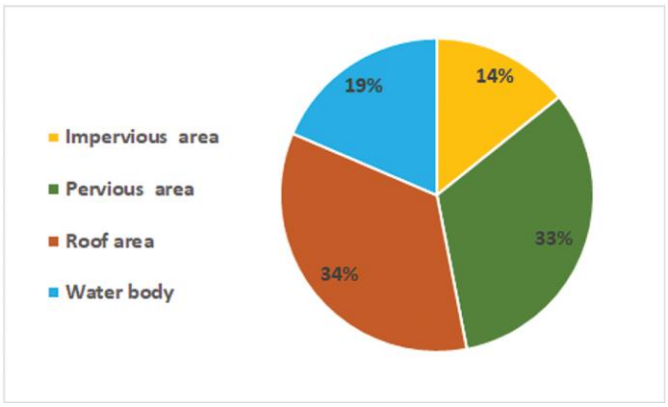


Figure 69:Percentage of impervious and pervious area residential area

Source: Author generated with reference to Google earth pro using ArcGIS 2023

Residential area has 14 % of Impervious area. is less than the previous area. While accounting the surface sealing which high than the institutional area.

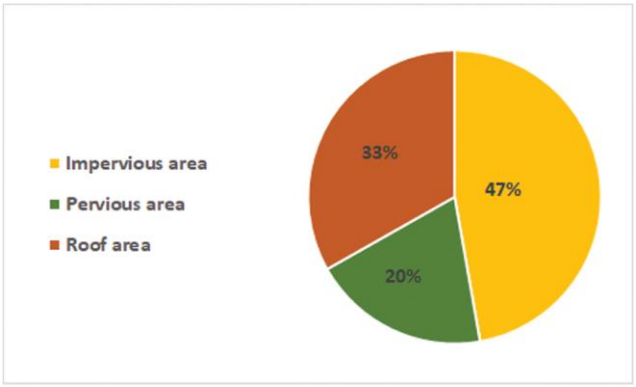


Figure 70:Percentage of impervious and pervious area

Source: Author generated with reference to Land cover map prepared with Google earth pro using ArcGIS 2023

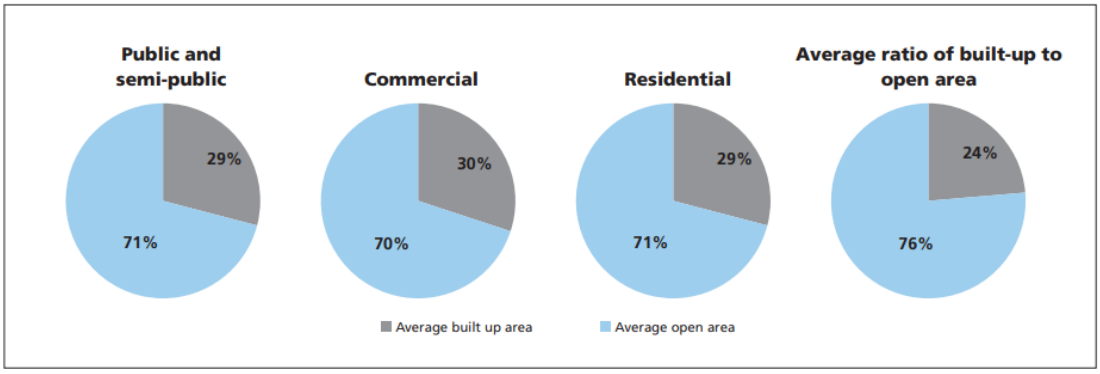


Figure 71:Ratio of built-up to open area in different land uses

Source: Urban and regional development plans formulation and implementation (URDPFI) guidelines (2014), ministry of urban development.

3.12.5 Inference

The amount of imperviousness or the surface sealing is highest in a commercial area and residential area. This corresponds the changes in percentages of built-up area and perviousness in the three study areas.

3.13 Ground water potential zone mapping

Ground water potential zone is identified using Analytic hierarchy process (AHP) Using ArcGIS. For the analysis combination of various spatial datasets can help to identify the GWPZ by overlaying.

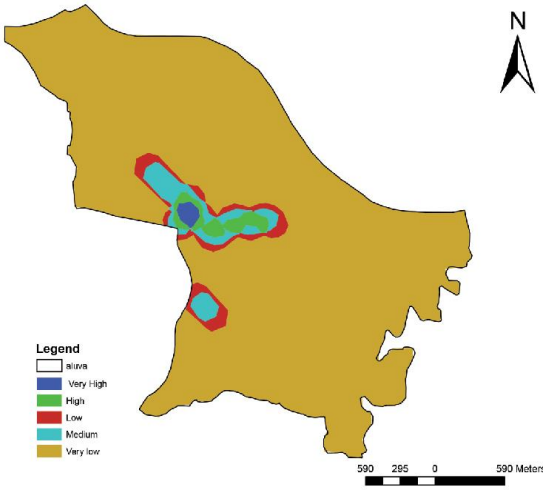


Figure 72:Drainage density

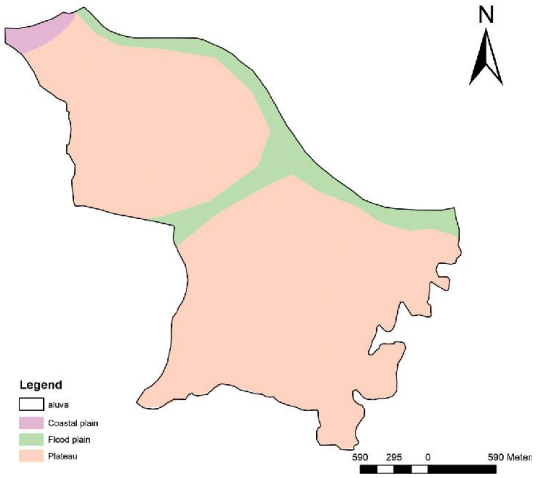


Figure 73:Geomorphology

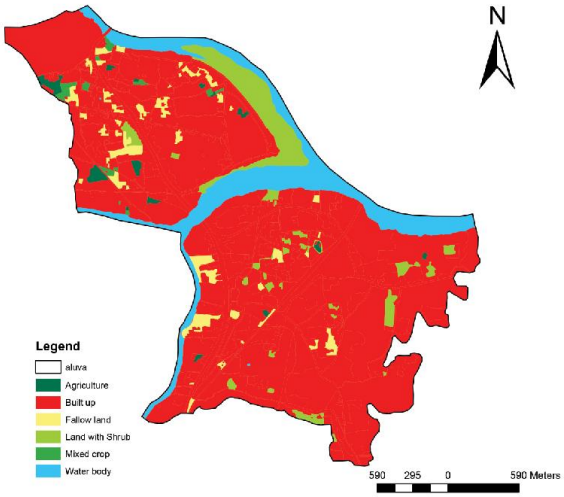


Figure 74:Landcover

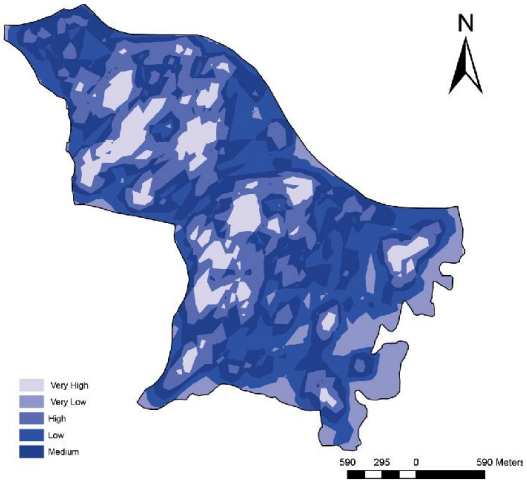


Figure 75:Lineament density

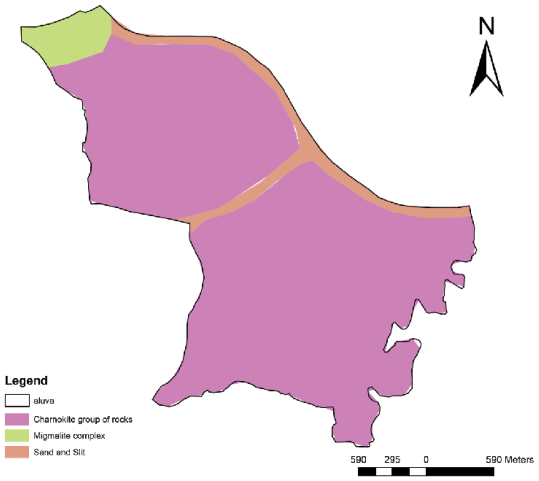


Figure 76:Lithology

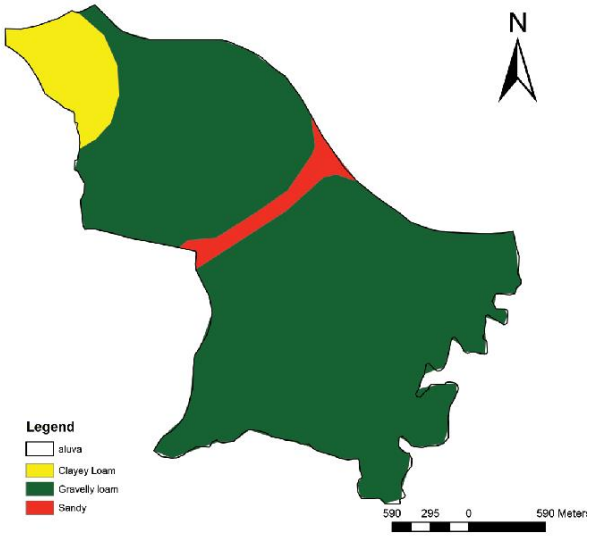


Figure 77:Soil type

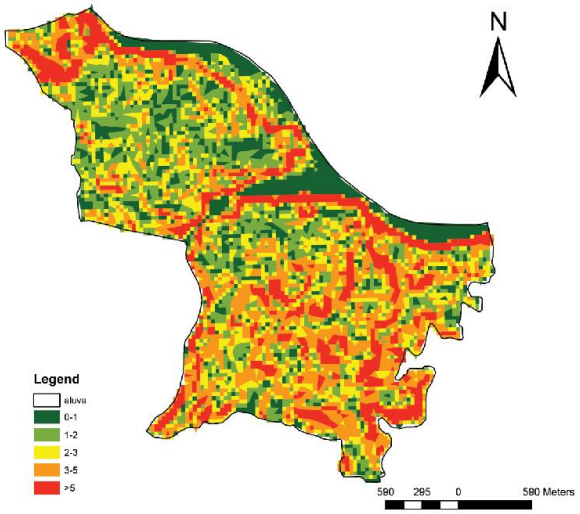


Figure 78:Slope

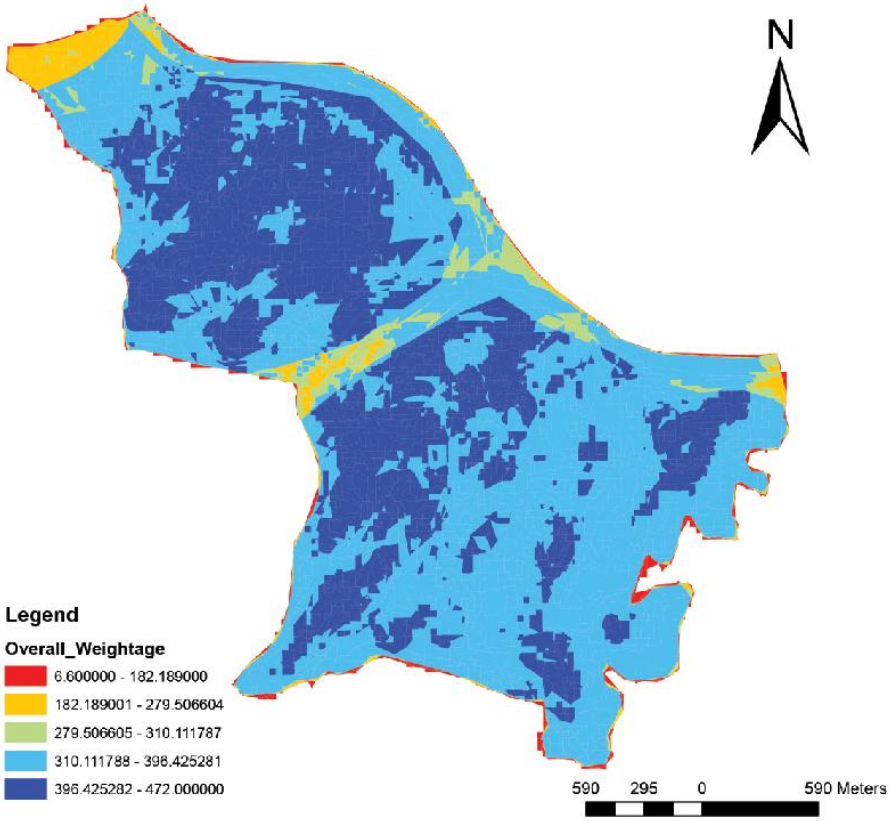


Figure 79:Ground water potential zone

Source: All maps are Author generated with reference to Landsat, National bureau of soil survey and land use planning, Geological map of Ernakulam district etc. using ArcGIS 2023

Table 7:Ground water potential zone analysis

Factors	Geomorphology	Lineament density	Lithology	Slope	Soil	LULC	Drainage density	Weight
Geomorphology	7	6	5	4	3	2	1	0.38
Lineament density	7/2	6/2	5/2	4/2	3/2	2/2	1/2	0.19
Lithology	7/3	6/3	5/3	4/3	3/3	2/3	1/3	0.12
Slope	7/4	6/4	5/4	4/4	3/4	2/4	1/4	0.10
Soil	7/5	6/5	5/5	4/5	3/5	2/5	1/5	0.08
LULC	7/6	6/6	5/6	4/6	3/6	2/6	1/6	0.066
Drainage density	7/7	6/7	5/7	4/7	3/7	2/7	1/7	0.064
Total								**1**

Source: Author generated using ArcGIS 2023

Table 8:Overall weightage and Ranking of Each spatial data

Factors	Weight	Rank	Overall
Geomorphology			
Plateau	38	5	190
Flood plain		3	114
Coastal plain		2	76
Lineament density			
Very High	19	5	95
High		4	76
Moderate		3	57
Low		2	38
Very low		1	19
Lithology			
Charnokite group of rocks	12	4	48
Sand and slit		3	36
Migmalite complex		2	24
Slope			
0-1	10	5	50
1-2		4	40
2-3		3	30
3-5		2	20
>5		1	10
Soil			
Gravelly Loam	8	3	24
Clayey Loam		1	8
Sandy soil		2	16
LULC			
Agriculture	6.6	3	19.8
Built up land		1	6.6
Fallow land		5	33
Land with shrub		5	33
Mixed crop		5	33
Water body		5	33
Drainage Density			
Very High	6.4	1	6.4
High		2	12.8
Moderate		3	19.2
Low		4	25.6
Very low		5	32

Source: Author generated using ArcGIS 2023

3.12.1Inference

Planning techniques that take into account the potential for ground water recharge can be implemented in these zones.so that the appropriate capturing measure may be put in the area.

3.13. Swot analysis

Strength	Weakness
a) Efficient water supply and related infrastructure facilities. b) New proposals for WTP And STP cater the future demand. c) Grow as transportation hub.	d) Availability of park and green open space is less ss per URDPFI Guideline its doesn't meet the standards -A medium town need 18%of Park and open space, but Aluva has only 2% of land
Opportunities	**Threat**
b) Available public and semi-public land areas can be used in cooperate to sensitive developments.	c) Climate impacts d) Flood events

CHAPTER 4 LITERATURE CASE STUDY

This chapter discuss about various case studies that have incorporated WSP in their planning aspects as strategies, adaption techniques mitigating water related issues. Include national and international level case studies such as WSP of Melbourne's Fisherman's bend and another is in Chennai India. The case study of Chennai city is a driving methodology adopting for the study area which have a guideline to follow for an urban area.

4.1 Chennai city

4.1.1 Selection criteria for case studies

Selection criteria based on highly water stressed cities in India and how they tackled those issues leads to study. In this case Studies, I review and analyzed city level approaches and initiatives for water sensitive planning and its future considerations.

4.1.2 Water sensitive planning of Chennai city

According to a World Bank study, of the 27 Asian cities with populations of over 1,000,000, Chennai and Delhi are ranked as the worst performing metropolitan cities in terms of hours of water availability per day, while Mumbai is ranked as second worst performer and Calcutta fourth worst.

WATER CONSUMPTION IN INDIAN CITIES	
Town	**Consumption litres per capita per day**
Bangalore	140
Mumbai	260
Delhi	270
Chennai city	**90**
Pune	220

Figure 80:Water consumption in Indian cities

Source: Prof. Soamnth Sen and P Divya 2008

Figure 81:Location of Chennai city

Source: Prof. Soamnth Sen and P Divya 2008

4.1.3 Need for the water sensitive planning

Chennai, is the only metropolitan city without a perennial source of drinking water, is now in the grip of acute water scarcity.

The rapid growth of the Chennai city's population and the development activities over the years has adversely affected the ground water regime.

Even though Chennai gets an average rainfall of 1260 mm, the residents of Chennai allow the rainwater to flow through the city roads and join the Bay of Bengal. Thus, the infiltration rate is very less. The emergence of the availability, quality, and sustainability of drinking water in Chennai is a serious concern for policy makers.

Therefore, there is a need for sensitive planning of water for effective management of this vital and scarce resource.

4.1.4 Aim for the water sensitive planning

To determine the feasibility of minimizing the adverse effects of urbanization on hydrological parameters through appropriate water sensitive planning, by integrating water supply, storm water and waste water management.

4.1.5Objectives

To research and examine the connection between runoff, precipitation, and imperviousness across various locations.

To investigate if rainwater collection may help certain communities with their demand for potable water.

To discover different technologies for reducing the negative impacts of urban growth on the volume of ground water

4.1.6 Population growth

Sl. No.		Population (in lakhs)				Annual Rate of growth (in percent)			Area	Density per
		1971	1981	1991	2001	1971-81	1981-91	1991-01	in Sq.km.	Hect.in 2001
1	Chennai City	26.42	32.85	38.43	**43.44**	2.2	1.58	1.23	176	**247**
2	Municipalities	4.84	8.14	11.84	**15.81**	5.24	3.8	2.91	240	**66**
3	Town	1.11	1.64	2.71	**3.86**	4.43	4.94	3.62	156	**25**
	Panchayats									
4	Panchayat Unions	2.67	3.38	5.2	**7.31**	2.4	4.38	3.58	617	**12**
5	CMA Total	35.04	46.01	58.18	70.41	2.76	2.37	1.93	1189	59

Figure 82:Population change

Source: Prof. Soamnth Sen and P Divya 2008

4.1.7Climate

Due to its location near the ocean and proximity to the thermal equator, Chennai has little seasonal temperature variance. The majority of the year is hot and muggy.1,260 millimeters of rain fall on average every year (51 inches). From mid-September to mid-December, the north-east monsoon winds bring the majority of the city's annual precipitation

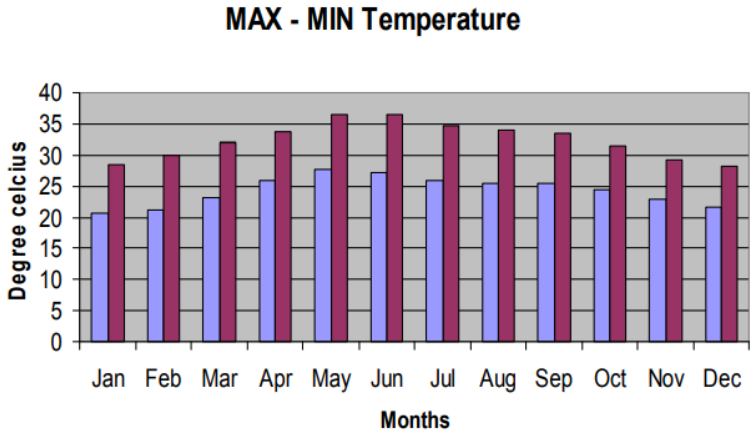


Figure 83:Temperature

Source: Prof. Soamnth Sen and P Divya 2008

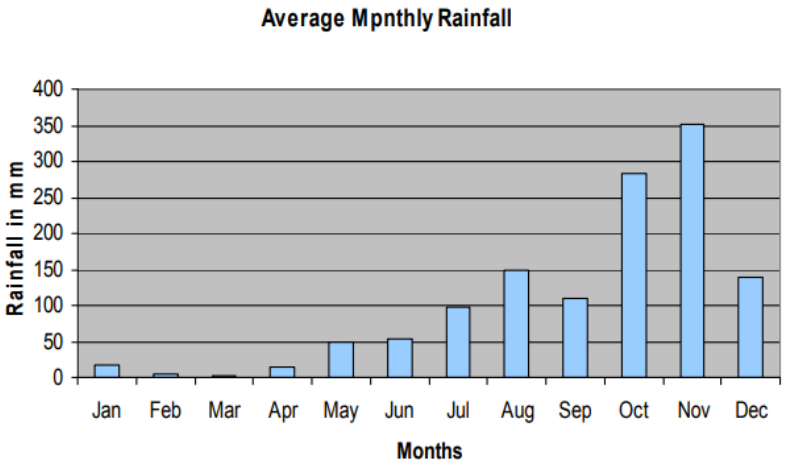


Figure 84:Annual rainfall

Source: Prof. Soamnth Sen and P Divya 2008

4.1.8Land use

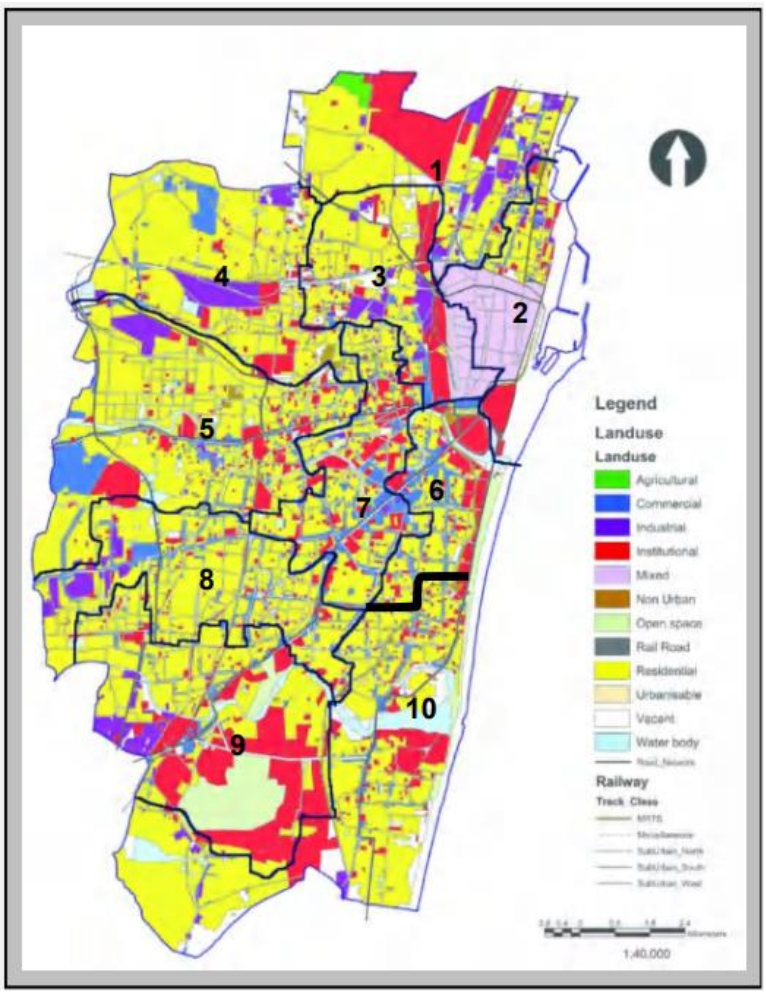


Figure 85:Land use

Source: CMDA Chennai 2008

Land Use	1991	2001
	%	%
Residential	48.57	52.94
Commercial	5.85	7.05
Industrial	6.66	5.07
Institutional	16.51	18.11
Open space and Recreational	14.55	2.07
Agricultural/Vacant	2.86	2.56
Non Urban		12.2

Figure 86:Land use breakup

Source: CMDA Chennai 2008

In Chennai City, residential use is predominant covering 52.94 % of the total area. The percentage of open spaces and recreational areas has sharply declined from 14.55% in 1991 to nearly 2.07% in 2001, which represents the threatening eco-system.

4.1.9 Source of water supply

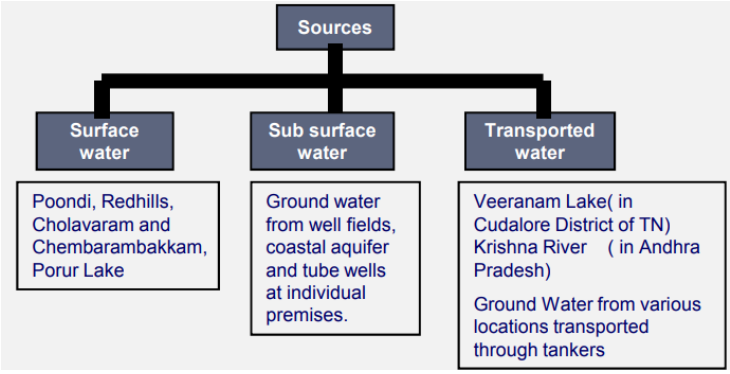


Figure 87:Chart of water supply

Source: Prof. Soamnth Sen and P Divya 2008

4.1.10 Supply Levels

•The average water supply in Chennai city is 90 lpcd.

•The current water supply from all the sources is of the order of 550 MLD.

•However, during the summer season, in times of reduced storage, the supply levels would be as low as 300 MLD

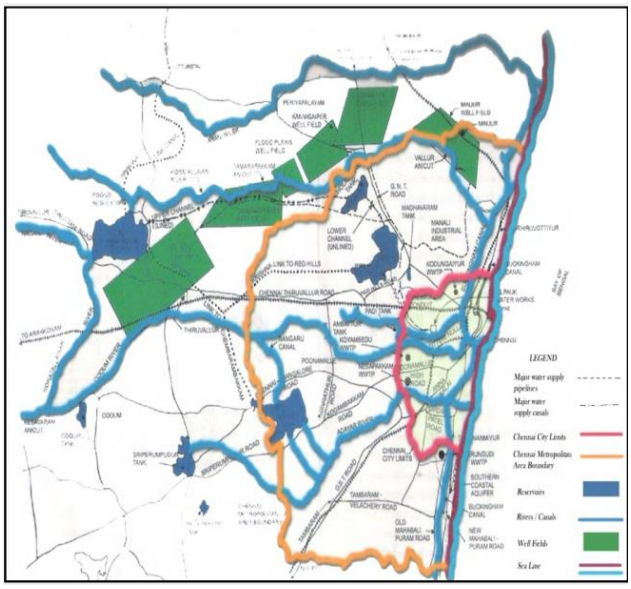


Figure 88:Available water sources in city level

Source: Prof. Soamnth Sen and P Divya 2008

Year	Population	Water availability	Water Demand	Deficit
	in lakhs	in MLD	in MLD	in MLD
2001	43.4	550	911	361
2011	49.5	730	1049	319
2021	55.4	850	1163	313

Figure 89:Supply and demand analysis

(Source: Prof. Soamnth Sen and P Divya 2008)

The projections indicate that the overall water demand for the city of Chennai for the year 2021 is of the order of 1163 MLD as against the full potential of the existing and presently ongoing source works totaling to 850 MLD, thus leaving a deficit of 313 MLD.

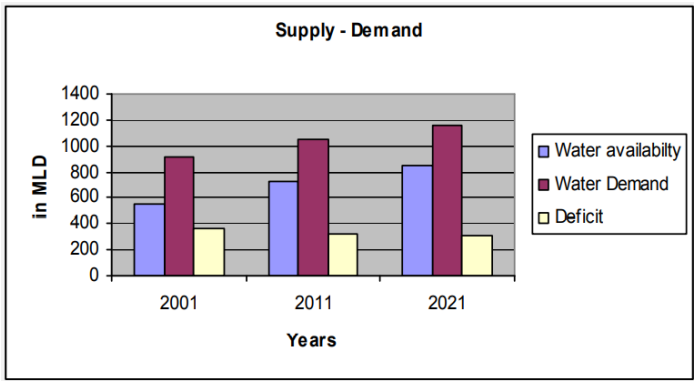


Figure 90:Supply and demand analysis chart

Source: Prof. Soamnth Sen and P Divya 2008

4.1.11 Selected sites for the detailed study

Three types of area are selected for the study which includes Residential, Commercial, Institutional

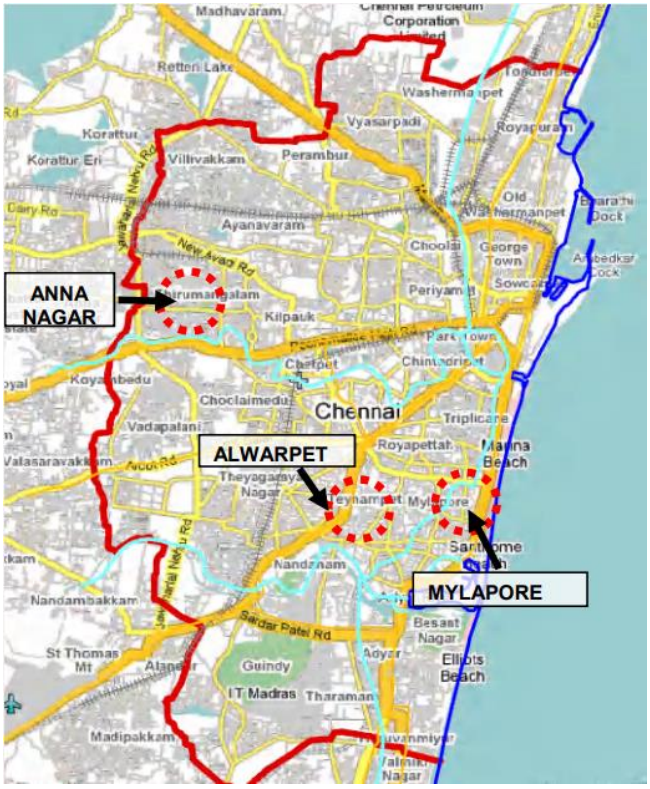


Figure 91:Selected sites

Source: Prof. Soamnth Sen and P Divya 2008

The selection of the pilot areas was based on the following criteria:

•Predominant land use/ land cover characteristic

•Plot size and coverage

•Ground water levels

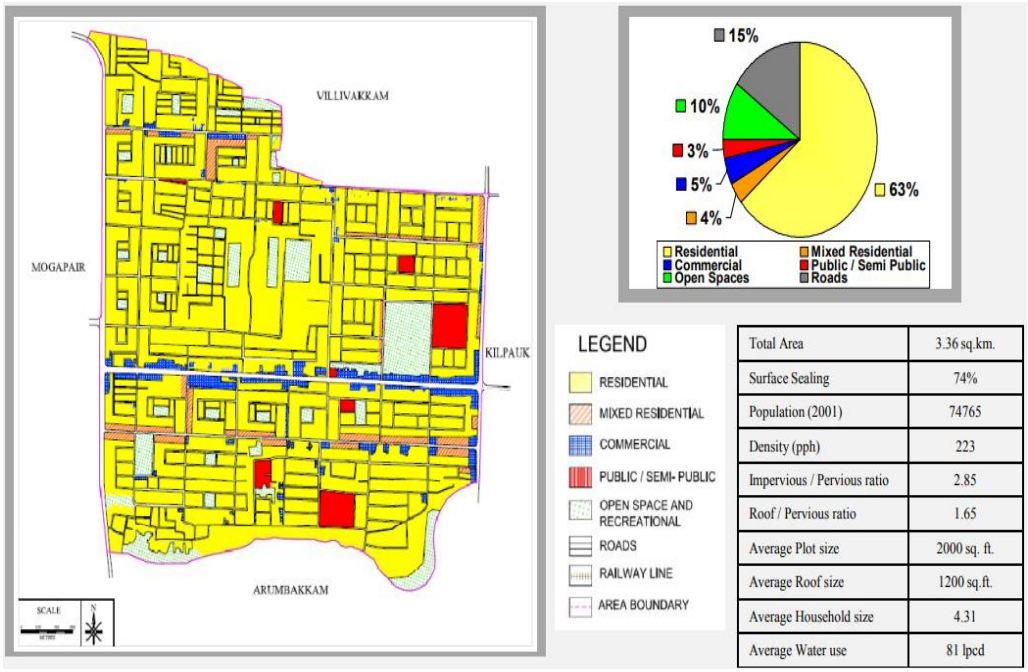
The selected pilot study areas are

Residential Area of Anna Nagar in ward numbers 66 and 67 in Chennai.

Commercial Area of Alwarpet in ward numbers 115 and 116 in Chennai.

Institutional Area of Mylapore in ward numbers 146 and 147 in Chennai.

4.1.12 Land use plan of Anna Nagar – Residential area



Total Area	3.36 sq.km.
Surface Sealing	74%
Population (2001)	74765
Density (pph)	223
Impervious / Pervious ratio	2.85
Roof / Pervious ratio	1.65
Average Plot size	2000 sq. ft.
Average Roof size	1200 sq.ft.
Average Household size	4.31
Average Water use	81 lpcd

Figure 92:Land sue and breakups analysis

Source: Prof. Soamnth Sen and P Divya 2008

Anna Nagar is a predominantly residential area with 63% of the area under residential use, located in the west of Chennai.

Ground water level-180' to 200'

Capacity

Average OHT size - 3000 liters (ranging from 500 liters to 8000 liters)

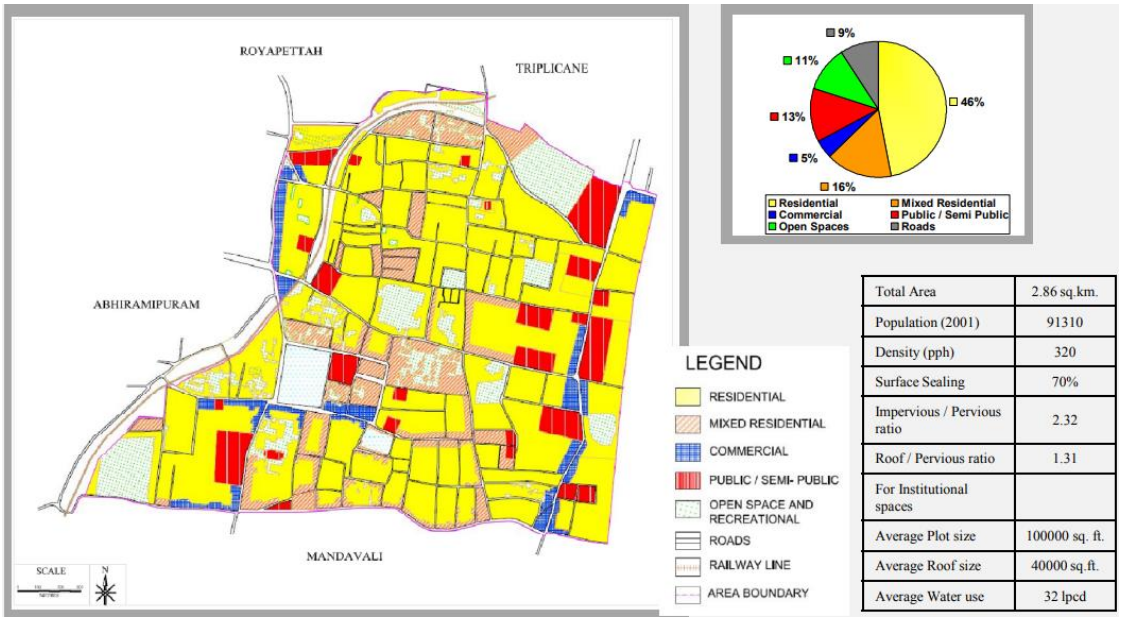
Average sump size - 6000 liters (ranging from 1000 liters to 10000 liters

Supply Duration - 2 to 3 hours on daily basis

Alternative sources -Metro water tankers, Metro water storage points

Water scarcity period - April, May.

4.1.13 Land use plan of Mylapoor –Institutional area



Total Area	2.86 sq.km.
Population (2001)	91310
Density (pph)	320
Surface Sealing	70%
Impervious / Pervious ratio	2.32
Roof / Pervious ratio	1.31
For Institutional spaces	
Average Plot size	100000 sq. ft.
Average Roof size	40000 sq.ft.
Average Water use	32 lpcd

Figure 93:Land use and breakups analysis

Source: Prof. Soamnth Sen and P Divya 2008

Mylapore is located a few kilometers to the south of Chennai city. It is one of the oldest parts of the city and home of temples and educational institutions.

Ground water level - 180' to 200'

Supply Duration - 2 to 3 hours on daily basis

Alternative sources -Metro water tankers

Water scarcity period - March, April, May

Capacity

Average OHT size - 15000litres (ranging from 6000 liters to 25000 liters)

Average sump size - 30000 liters (ranging from 20000 liters to 40000 liters)

4.1 14 Land use plan of Alwarpet –Commercial area

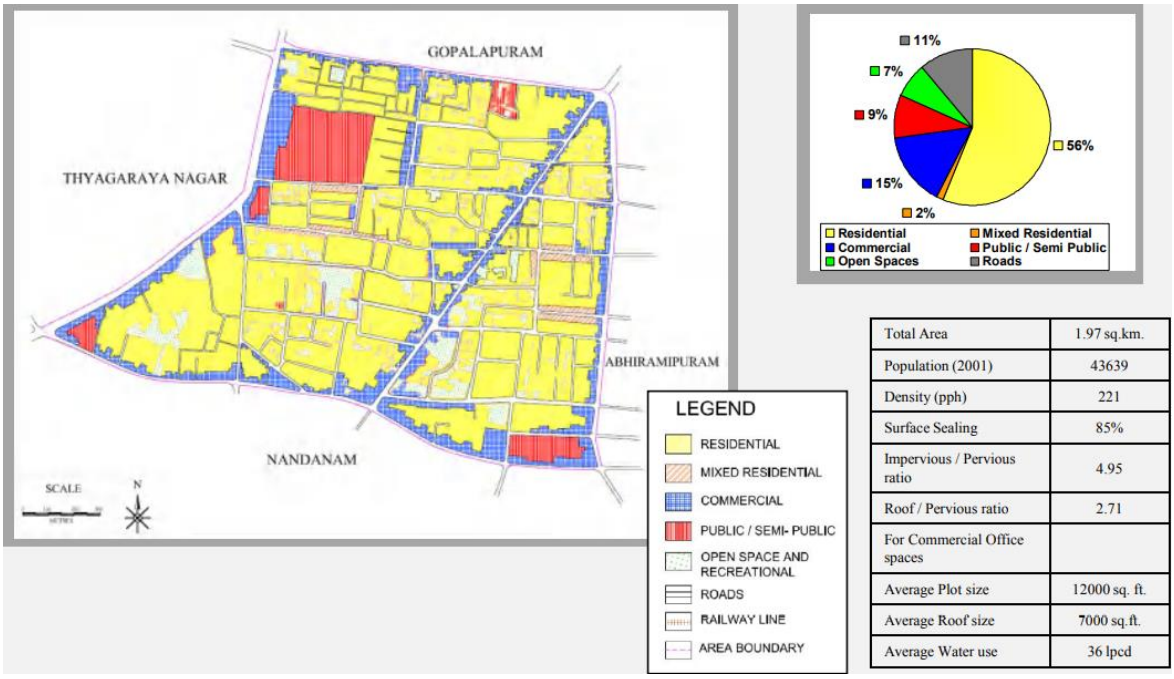


Figure 94:Land use and land use breakup analysis

Source: Prof. Soamnth Sen and P Divya 2008

Alwarpet is located in central Chennai and it mostly comprises of commercial establishments which mostly includes office complexes. It has 15% of the area under commercial use.

Ground water level -170’ to 180

Supply duration -2 to 3 hours on daily basis

Capacity -Average sump size- 25000 Liters (Ranging from 20000 liters to 300000 Average OHT size -20000 Liters (ranging from 15000 liters to 25000 liters)

Alternative sources -Metro water tankers.

Water scarcity period -April, May

4.1 15 Land cover analysis

The selected study areas were divided into two zones -Impervious zone - consisting of roof areas, paved areas and roads. Pervious zone - consisting of open spaces and water bodies.

4.1.16 Land Cover characteristics of study area

Location	Area in sq.km	% Road	% Roof	% Paved	% Pervious	Surface sealing (Roof+Paved+Road)	Imp/Perv Ratio	Roof /Perv Ratio
AnnaNagar (R)	3.36	15.4	42.7	15.8	26.0	74.0	2.85	1.65
Alwarpet (C)	1.97	11.3	45.6	26.3	16.8	83.2	4.95	2.71
Mylapore (I)	2.86	9.2	39.4	21.3	30.1	69.9	2.32	1.31

Figure 95:Land cover analysis details

Source: Prof. Soamnth Sen and P Divya 2008

The amount of imperviousness or the surface sealing is highest in a commercial area and it is much lesser in a residential area and least in an institutional area. This corresponds directly to the changes in percentages of built-up area and perviousness in the three study areas.

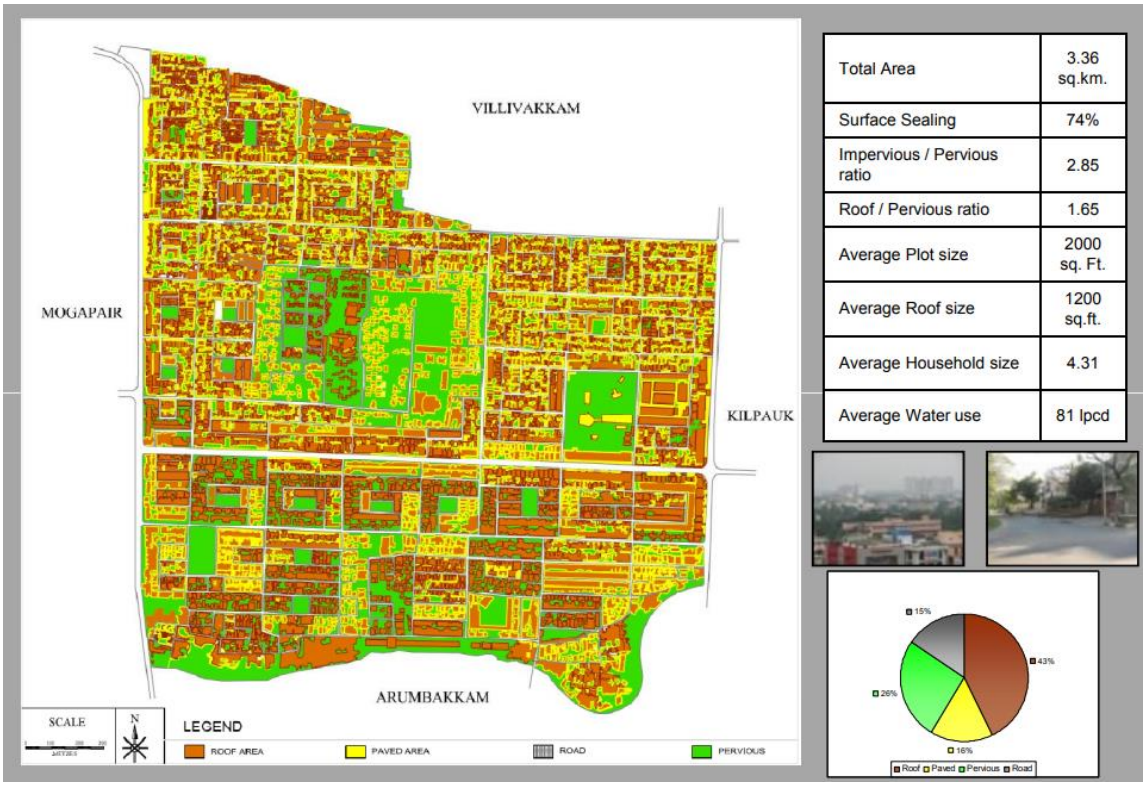


Figure 96:Land cover of Anna nagar

Source: Prof. Soamnth Sen and P Divya 2008

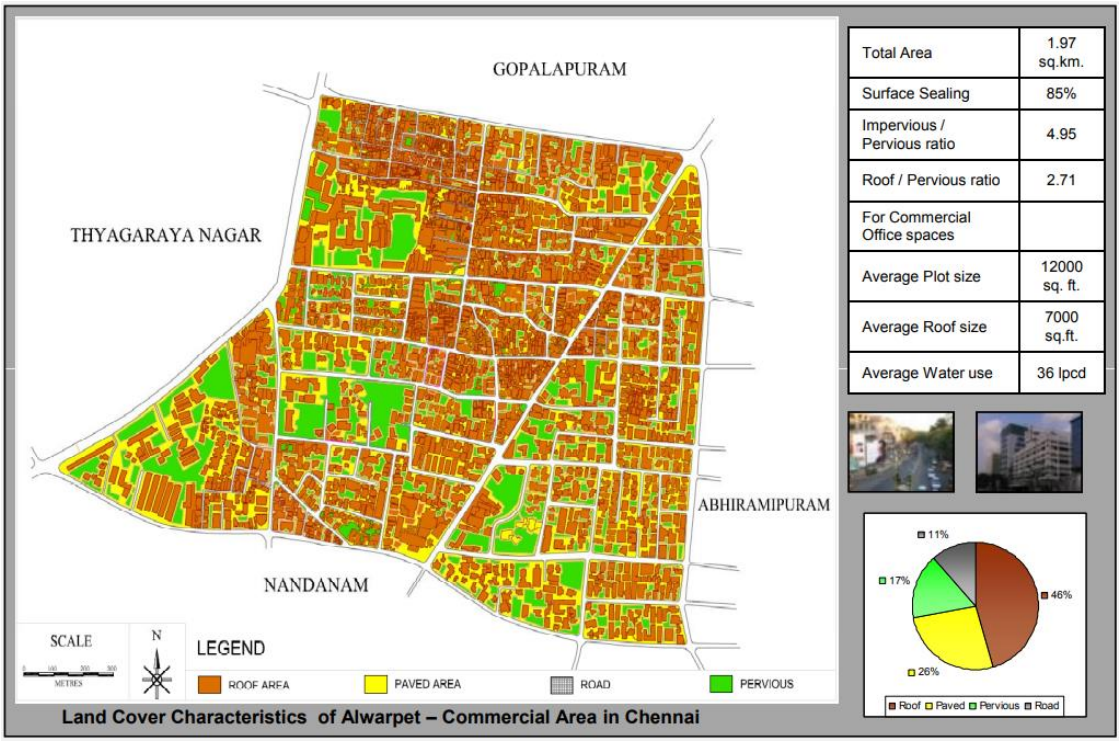


Figure 97 : Land cover of Alwarpet - Commercial area

Source: Prof. Soamnth Sen and P Divya 2008

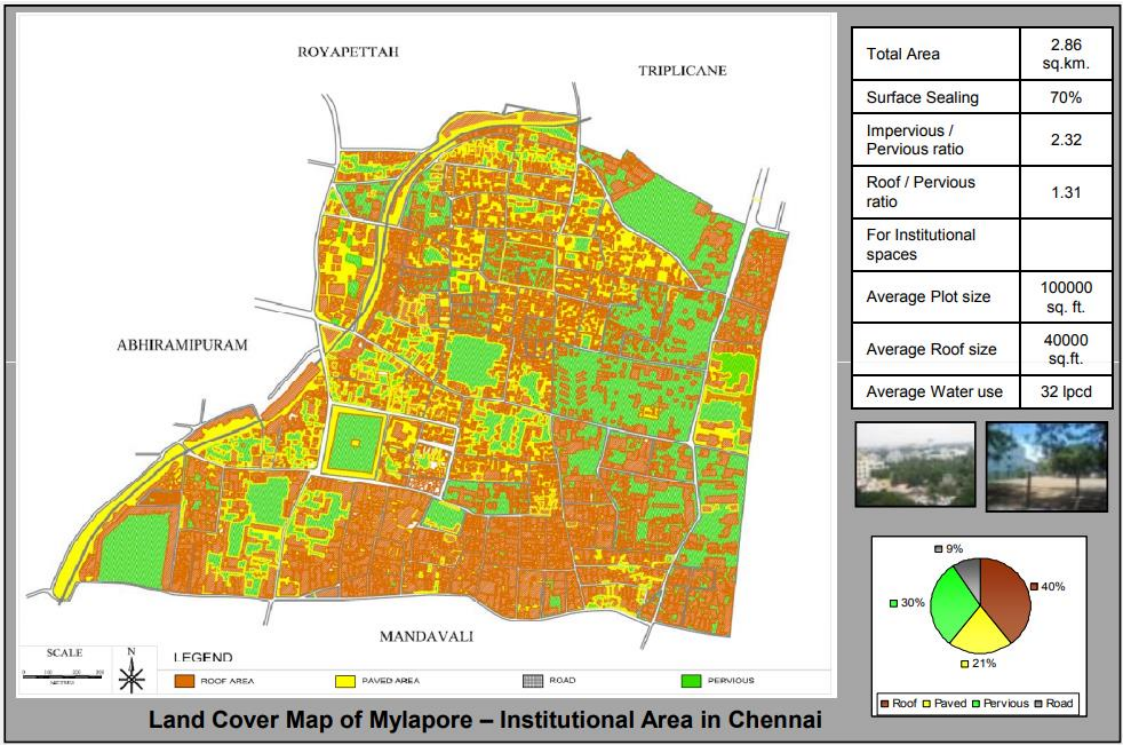


Figure 98:Land cover Mylapore- Institutional area

Source: Prof. Soamnth Sen and P Divya 2008

•The runoff from a commercial area is more than that of the residential and institutional area only due to the variations in percentage of Imperviousness.

• For the different rain years, the corresponding runoff in the commercial area varies from 76% to 91% and that in the residential area varies from 68% to 88% and the runoff in the institutional area varies from 52% to 81%

4.1.17 Different levels of planning

a) Plot level -Individual houses, Apartments, Commercial complex

At individual building allotment or plot level the Water sensitive techniques can be incorporated as a source control measure. The various techniques include Rainwater tanks, infiltration trenches including percolation pits and recharge wells, permeable pavements, grey water recycling systems including vegetation filter strips and planter beds.

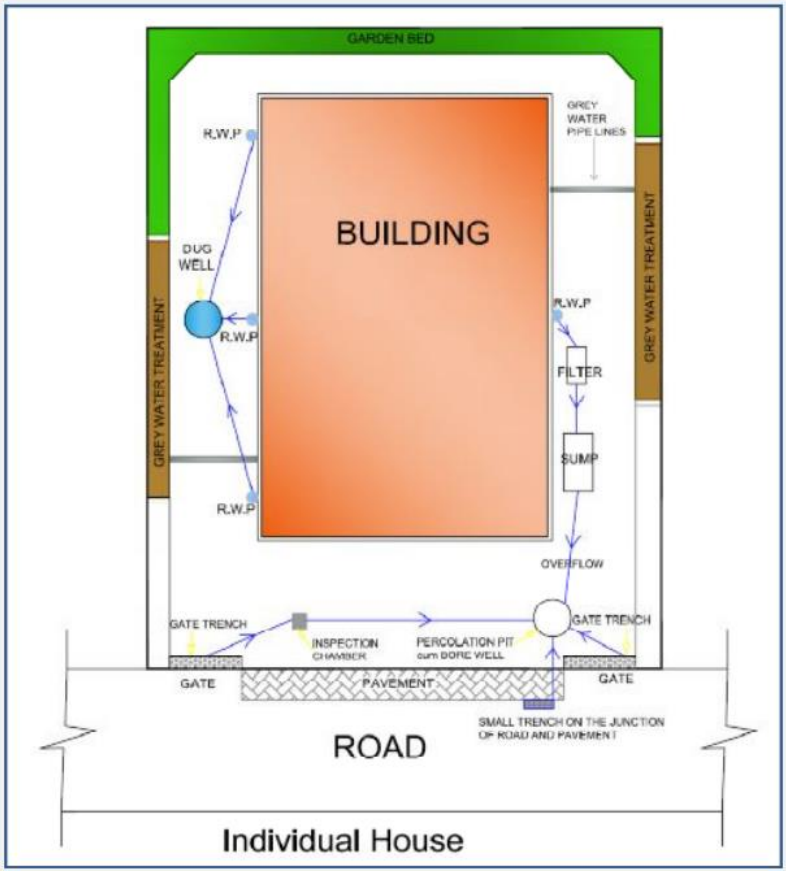


Figure 99:Conceptual proposal for integrated water management systems at Residential level
Source: Prof. Soamnth Sen and P Divya 2008

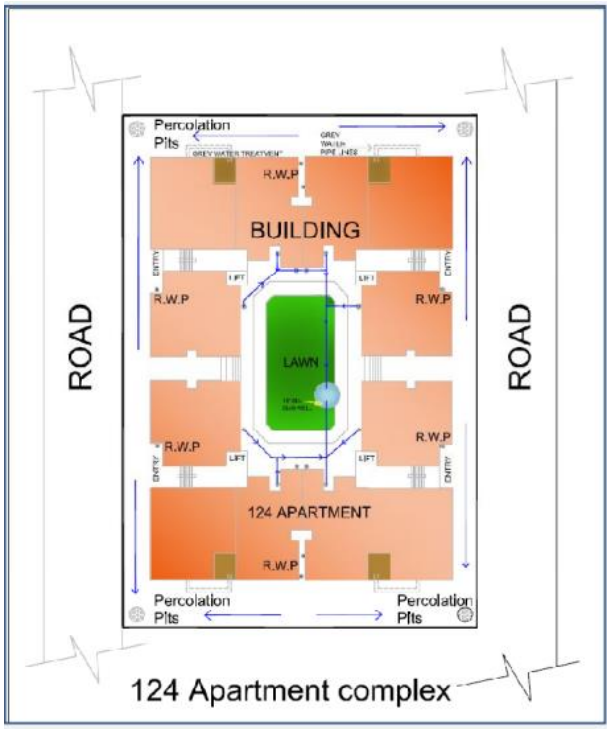
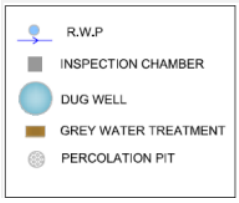


Figure 100:Appartments

Source: Prof. Soamnth Sen and P Divya 2008



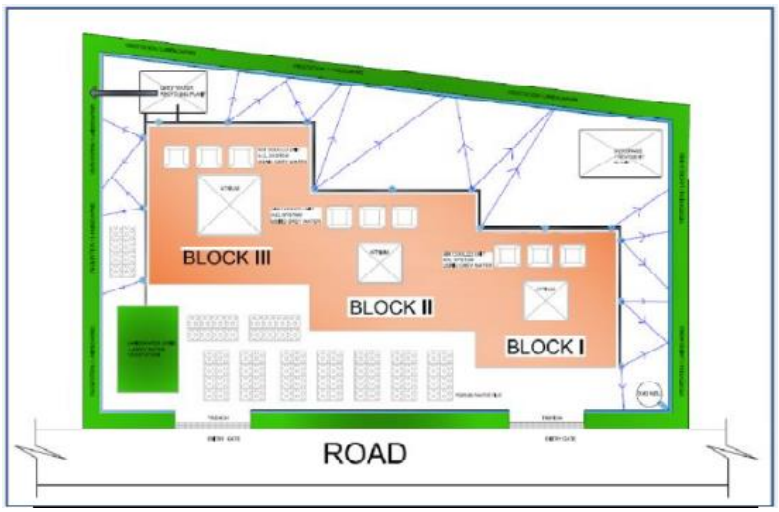


Figure 101:Commercial complex

Source: Prof. Soamnth Sen and P Divya 2008

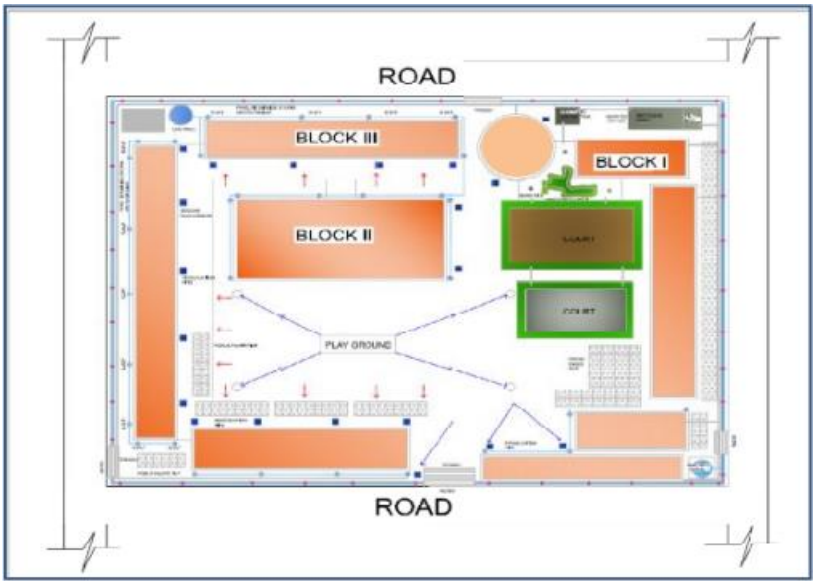


Figure 102:Institutional level

Source: Prof. Soamnth Sen and P Divya 2008

b) Street level

Water-sensitive practices increase the potential for passive storm water treatment, lessen the need for traditional, expensive water treatment facilities, and lower long-term maintenance costs.

In order to decrease runoff and enhance recharge, different water sensitive treatments, such as vegetated swales, infiltration devices, and porous pavement materials, can be incorporated into the design at the street level.

Swales are naturally occurring, vegetated depressions that are utilized to transport storm water runoff from impermeable surfaces.

Figure 103:Vegetated swales

Source: Prof. Soamnth Sen and P Divya 2008

Infiltration planter

Infiltration planters are structural landscaped reservoirs used to collect, filter, and infiltrate storm water runoff, allowing pollutants to settle and filter out as the water percolates through the planter soil and infiltrates into the ground.

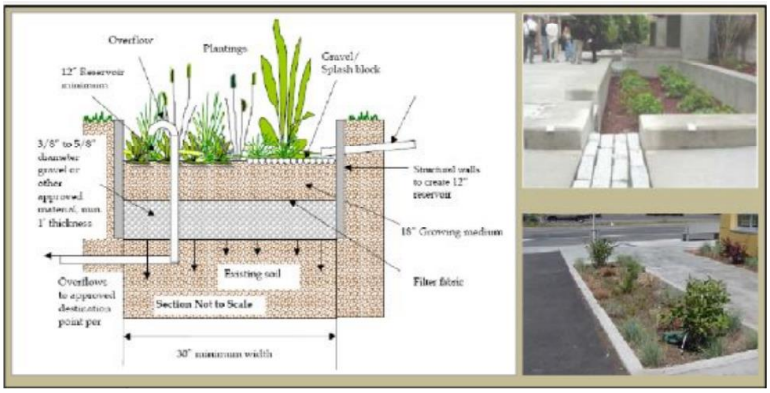


Figure 104:Infiltration planter

Source: Prof. Soamnth Sen and P Divya 2008

Permeable pavements

which is an alternative to typical impermeable pavements, allow runoff to percolate through hard surfaces to an underlying granular sub-base reservoir for temporary storage

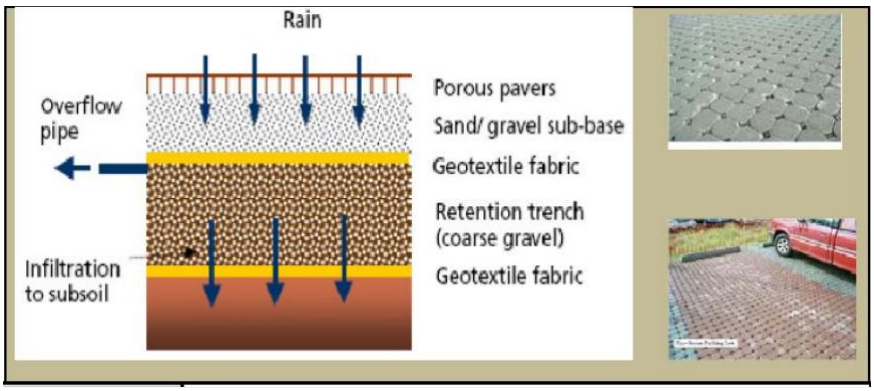


Figure 105:Permeable pavement

Source: Prof. Soamnth Sen and P Divya 2008

Street recharges

These include percolation pits which are placed at the point where the road level is lowest Percolation pits may be dug in the pedestrian pavement area on either side of the road. The rainwater tending to stagnate in the street will flow into these percolation pits and enrich the water table in that street.

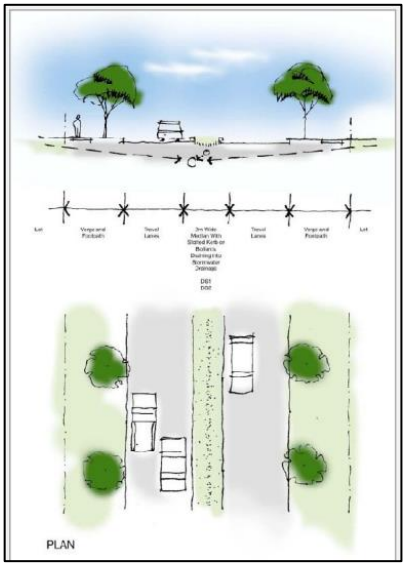


Figure 106:Street with 2m wide median

Source: Prof. Soamnth Sen and P Divya 2008

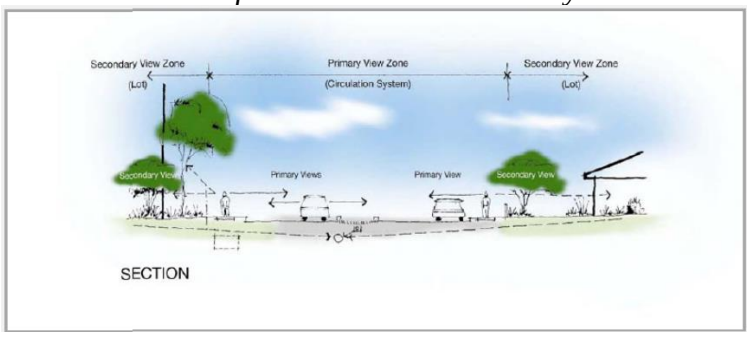


Figure 107:Street with both sides development

Source: Prof. Soamnth Sen and P Divya 2008

c) Community level

Vegetated infiltration basin

Vegetated infiltration basins are shallow landscaped depressions used to collect and hold storm water runoff, allowing pollutants to settle and filter out as the water infiltrates into the ground.

Infiltration / Retention basins

Infiltration basins are either sited in natural or excavated open areas, designed to temporarily hold storm water runoff prior to infiltrating through the basin floor.

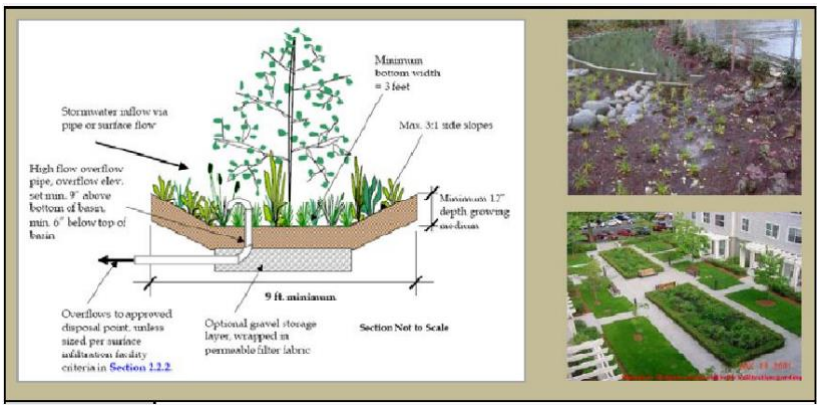


Figure 108:Vegetated infiltration basin

Source: Prof. Soamnth Sen and P Divya 2008

4.1.18 Proposed dimensions and planning

a) Anna Nagar – Residential area

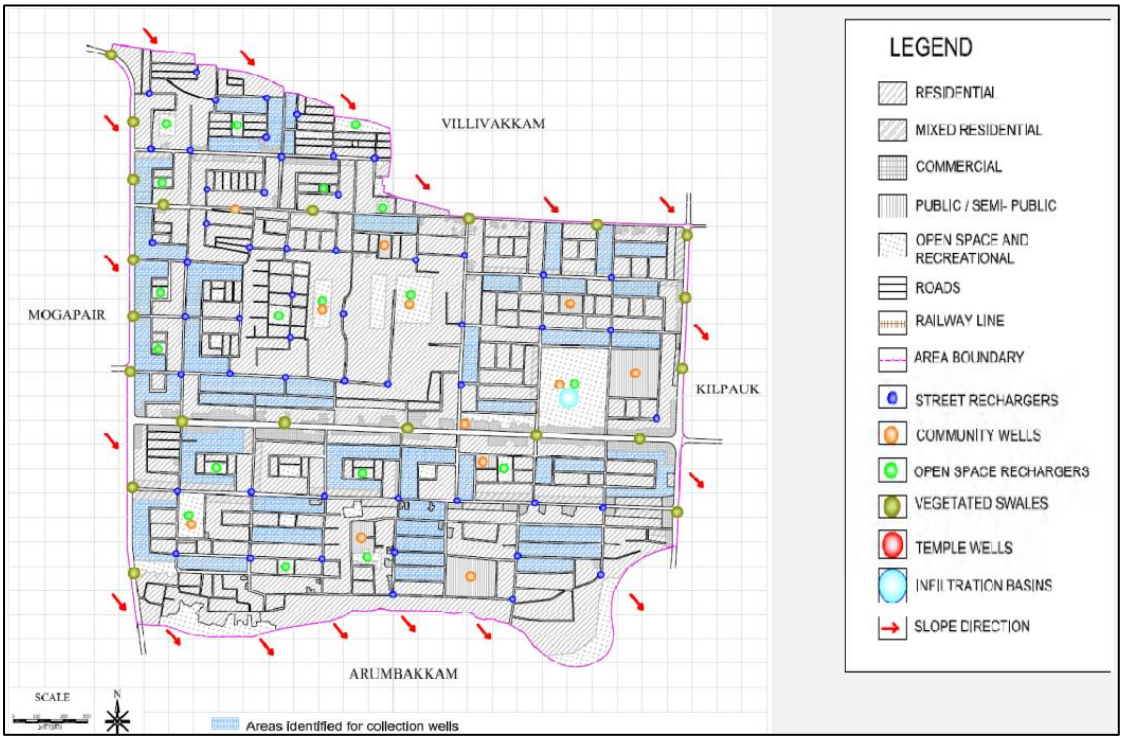


Figure 109:Planning interventions

Source: Prof. Soamnth Sen and P Divya 2008

b) Alwarpet – Commercial area

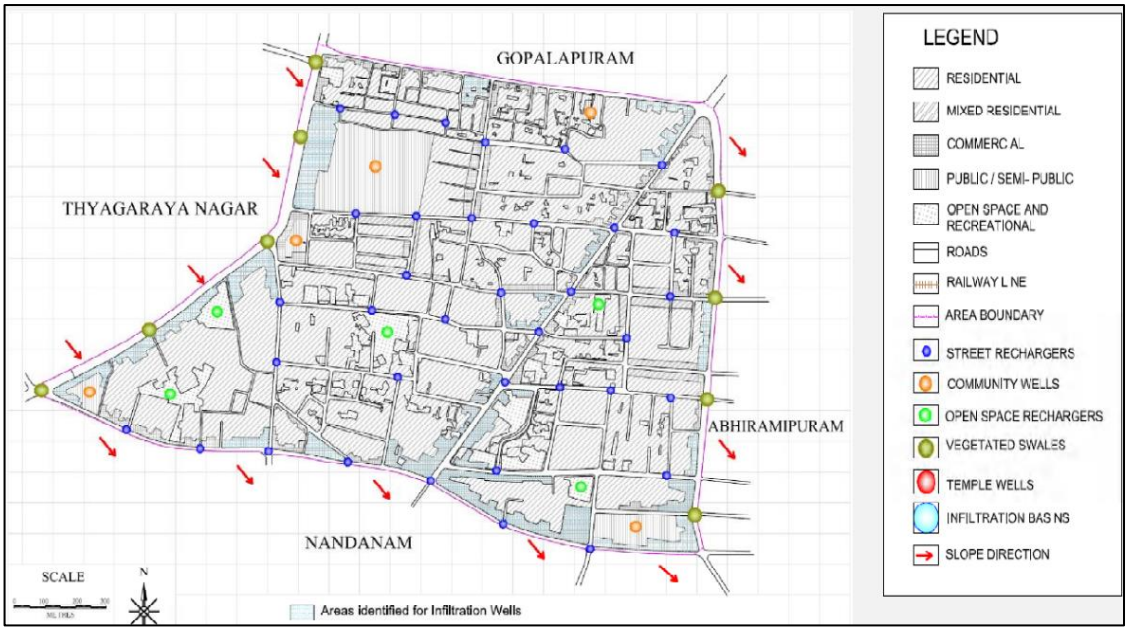


Figure 110: Planning interventions of Commercial

Source: Prof. Soamnth Sen and P Divya 2008

c) Mylapore – Commercial area

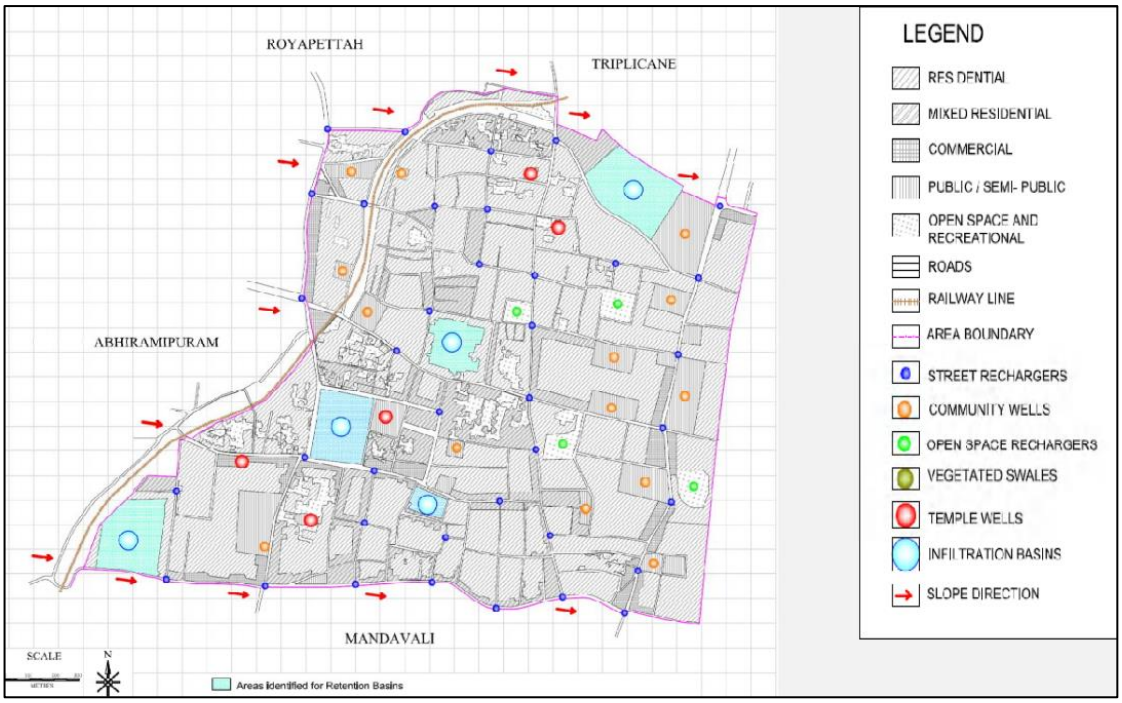


Figure 111;Planning intervention for institutional area

Source: Prof. Soamnth Sen and P Divya 2008

4.1.19 Based on the components of urban planning, the recommendations for new developments are given at two levels

At the Land Use Planning Level

a) Impervious control.
b) Building Compact Communities.
c) Distribution of open (pervious) spaces over the area.
d) Sub-division of the area into small 'micro' catchments.

At the Site Design Level

There are a number of site design practices that can reduce impervious coverage for a wide range of land uses, which includes:

e) Reducing building footprints.
f) Reducing road coverage.
g) Limiting the Amount of Surface Parking
h) Use of Porous paving materials.

4.1.20 Distribution of pervious spaces over the area and building compact communities

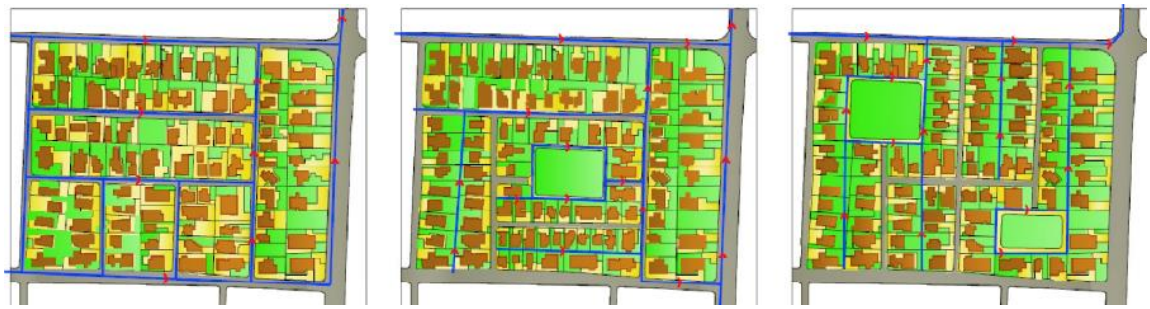


Figure 112:Residential layout model

Source: Prof. Soamnth Sen and P Divya 2008

4.1.21 Policy recommendations: Planning level

a) Guidelines for the future developments

All new future development in urban areas should follow the guidelines of water sensitive planning to incorporate the water resource issues early in the land use planning process.

a) Due consideration should be given to the characteristics of the site to be developed which includes parameters like rainfall, soil conditions, water table, impervious/pervious ratio.

b) Wherever possible, rainwater should be captured on site, before it flows and becomes polluted; special attention should be paid to using individual plots as micro catchments.

c) The impervious/ pervious ratio should range from 2.3 to 3 for all the plots in the future and the corresponding built-up area will range from 45% to 60% in order to maintain as much as possible the pre-urban development levels.

d) All new buildings with roof areas more than 80sq.m for residential, 400sq.m for commercial and 3000sq.m for institutional must provide rainwater harvesting structures in order to get approval of the building plans by the corresponding authorities.

e) In case of ordinary buildings (ground-plus-one residential buildings), the grey water should be used for groundwater recharge after a simple organic filtration. In case of multi-storied apartments, commercial office complexes and educational institutions and other public buildings, grey water should be recycled and used for non-potable purposes like toilet flushing and gardening.

f) At the street level various water sensitive treatments like vegetated swales, infiltration devices and porous paving materials can be integrated in the design depending on the local conditions so that it minimizes runoff and maximizes recharge.

g) At the community level the open spaces like parks and playgrounds, temple tanks, can act as recharge structures in order to mitigate urban flooding.

h) Policy changes in the building bye-laws has to be made to limit the extent of paved area in a plot and introduce a system of development incentives in terms of increased Floor Area Ratio (FAR) or a rebate on property tax for installing rainwater harvesting systems. This will encourage vertical expansion rather than horizontal expansion

i) Water metering and appropriate tariff structures should be introduced that allows a progressive rate of incentives for effective use of rainwater harvesting systems and treated waste water for non- potable use thereby reducing the potable water demand.

b) Inference

3 levels of planning consider the micro and macro level needs and uses their ability for resource management, planning interventions in land use management and built-up area management are strictly promoting the water sensitive elements in design and planning level. These element and consideration must help to restore their urban rivers and sustainable river front development keeps the livable

4.2 Fisherman's Bend Water Sensitive City Strategy

4.2.1 Selection criteria

Fisherman's bend Low lying area and near to the Yara river experience flood events eventually. Due to climate impacts WSP interventions are like input for planning as green community.

The Fisherman's Bend Water Sensitive City Strategy is the largest water sensitive urban project in Australia. This is significant to Fisherman's Bend given its location adjacent to the Yara River and Port Phillip Bay. Fisherman's Bend is planned to be Australia's largest Green Star Community, setting a benchmark for sustainable and resilient urban transformation.

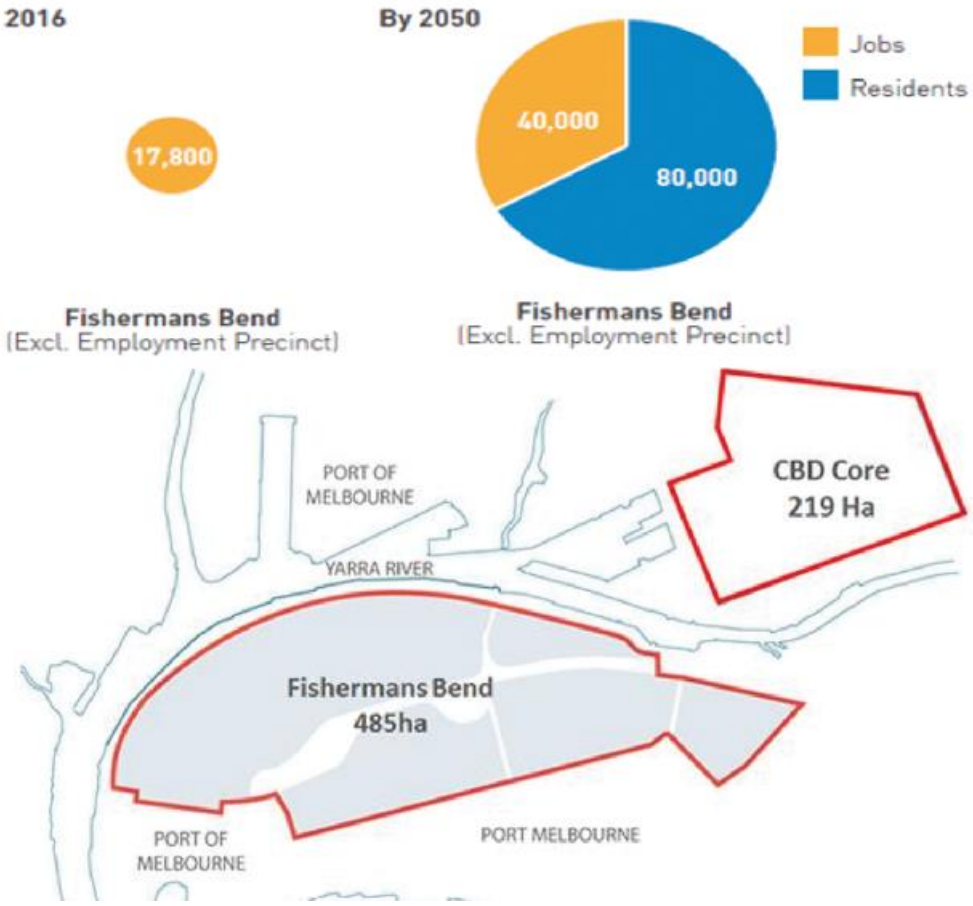


Figure 113:Fishermans bend

Source: Sam Innes GHD Port city Philip 2018

4.2.2 Topography

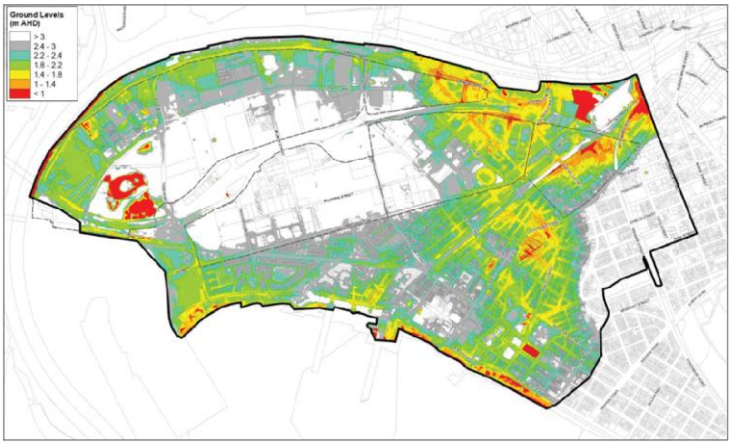


Figure 114:Topography

Source: Sam Innes GHD Port city Philip 2018

Fisherman's Bend is a precinct within the City of Port Phillip and the City of Melbourne. It is located on the south of the Yara River in the suburb of Port Melbourne and opposite Coode Island, close to the Melbourne central business district. Australia's largest urban renewal area. It offers an unparalleled opportunity to create a world leading, sustainable, mixed-use place to live, work, visit and invest.

Water has always played a significant role in Fisherman's Bend history, from creation stories as a rich food source for Aboriginal people through to the effects of flooding in the low-lying areas affecting residents and businesses. Fisherman's Bend faces significant challenges in the years ahead from climate change with stormwater, riverine and coastal flooding, coupled with Victoria's climate becoming drier and warmer, leading to water scarcity.

To ensure that Fisherman's Bend addresses the current and projected impacts of climate change, a bold, collaborative water plan is required. To achieve this, a Water Sensitive City Strategy is proposed. The Water Sensitive City Strategy builds on three overarching pillars;

1. Flood Management,
2. Climate Resilient Water System
3. Urban Ecology underpinned by water sensitive priorities to create a healthy, green environment that offers social, environmental and economic benefits. Water sensitive city strategy aims to create A healthy, green environment that offers range of social, environmental and economic benefits. Specific aims to protect Fishermen's bend from storm

and flood events, Reduce the water footprint and provide water security through efficient use of locally available water resources.

4.2.3 What is causing flooding?

In the context of the Fisherman's Bend Plan, there are two main causes of flooding. Water from upstream catchments and Port Phillip Bay (fluvial flooding) as well as rain falling directly on the Site (pluvial flooding). Often, these individual components occur simultaneously to compound flood levels at the Site.

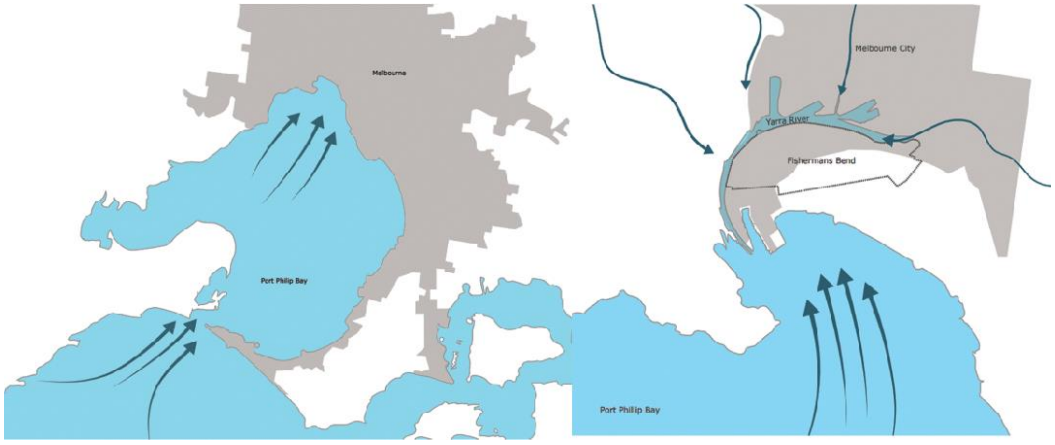


Figure 115:Cause of flooding

Source: Sam Innes GHD Port city Philip 2018

4.2.4 Flood risk and climate change

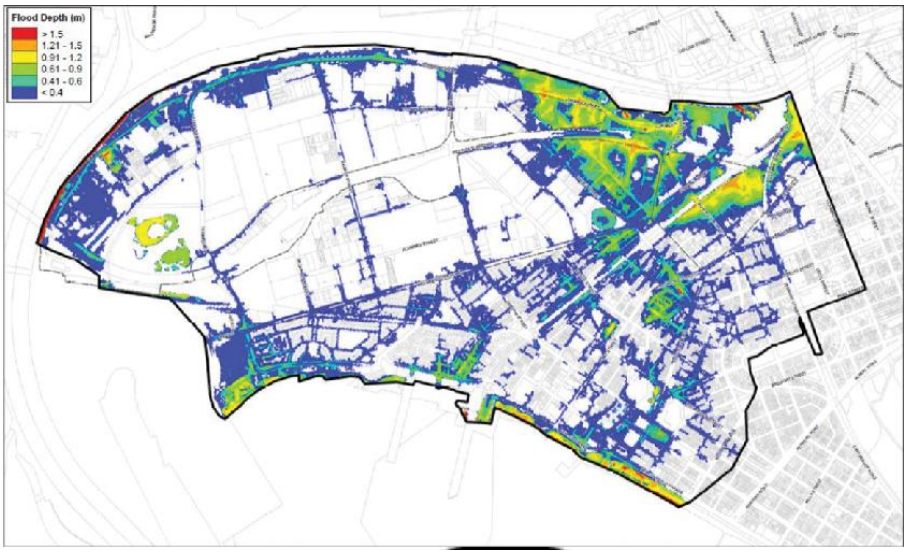


Figure 116:Flood risk

Source: Sam Innes GHD Port city Philip 2018

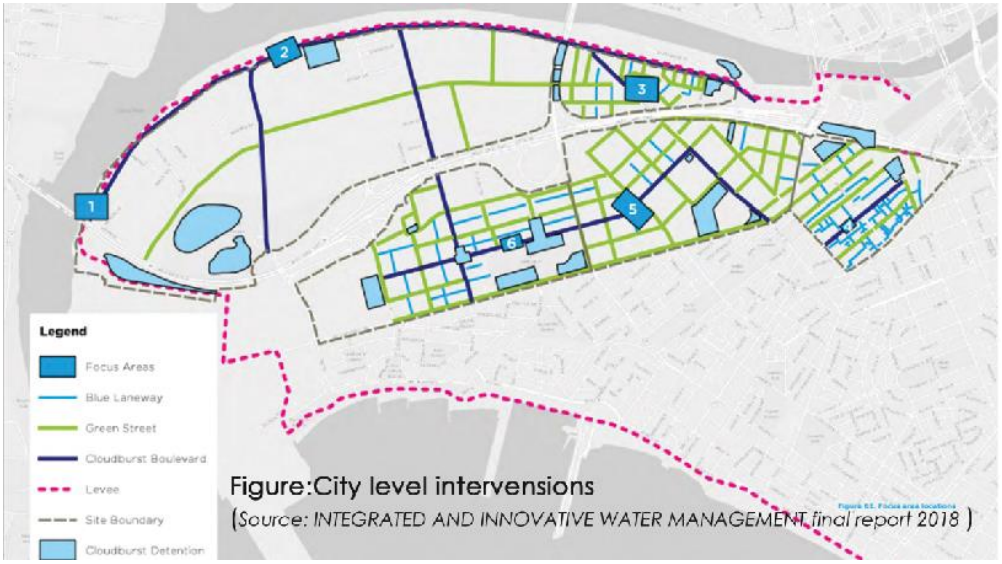


Figure 117:WS Planning

Source: Sam Innes GHD Port city Philip 2018

Water sensitive city strategy aims to create A healthy, green environment that offers range of social, environmental and economic benefits. Specific aims to protect Fishermen's bend from storm and flood events, Reduce the water footprint and provide water security through efficient use of locally available water resources. Transform private, public places and buildings to collect clean convey and reuse of storm water this will reduce nutrient and pollutant discharges, thereby protecting the health of the Yara river estuary and port Philip Bay. To achieve these goals interventions area required at the building, Street and the whole precincts scale. At the building scale green roof green wall and rain gardens will absorb filter and clean storm water. Evaporation will be promoted, there by cooling surrounded air.

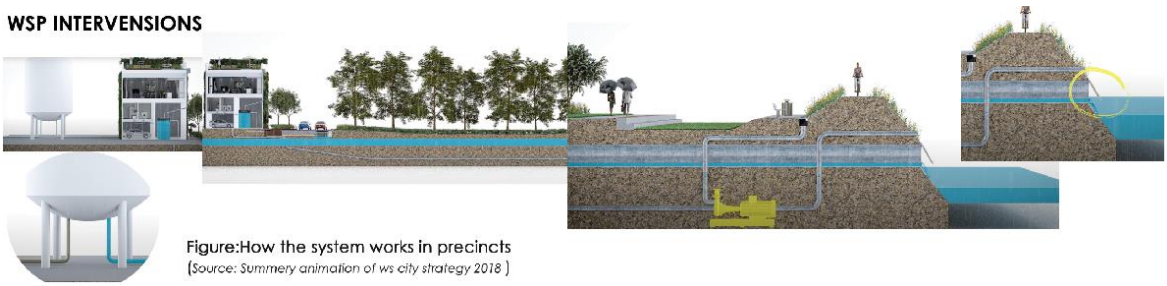


Figure 118:Intervension in Fishermans bend

Source: Sam Innes GHD Port city Philip 2018

Rain water tank will be serving multiple functions supply water to laundry, toilets, open spaces and storage of storm water during flooding events with use of smart communication. The rainwater tanks will communicate with bureau of metrology weather forecasts. when a storm event is forecast the tank will be activated to release any water, they have in storage this water will then drain to the Yara river via the underground piped drainage network. When a storm event comes the tanks will then able to store rainwater, thus reducing flooding in the fishermen's bend precinct. At the streets-scale, Rain gardens will and trees pits will feature similarly to the green roof and walls at the building scale retaining water passively irrigates and greens the urban landscapes clean and filter storm water and reduce urban heat island effect. The capture of water through human scale water sensitive urban design will allow the residents to appreciate the relationship between themselves and the natural environment, and celebrate the importance of water in the landscape in the occasion of an extreme storm events the rain gardens a tree pit can also use to temporarily store storm water. Some streets, parklands and other open spaces areas will also serve this role in addition to rain water tanks, water will be supplied by the state-of-the-art water cycling plant. This will be built within the employment precincts and be operational by 2030.The plant will mine the city's sewage and treat it to class A standard. The water will be used across the precincts for a drought resilient supply of water for flushing, washing and irrigation of both private and public places. A levee adjacent to the northern boundary of fishermen's bend will provide protection from flood waters from the Yara river and the port Philip Bay. The levee will be integrated into the urban form it will not be obvious flood barrier to the untrained eye taking the form of roads, public open space and buildings. When the waters of the Yara rise flap gates on the pipes draining fisherman's bend will close thus preventing water back flowing from the Yara into the precincts. Upon flap gates closing, pumps will be activated to transfer stormwater from fisherman's bend into the Yara river. Up to the seven pump stations will be required. The existing piped drainage network at fisherman's bend will be augmented with new pipes. Some of these will duplicate or upgrade pipes already there, others will be entirely new sections. All will connect with the existing drainage network. Without the pumps, flap gated and new pipes the development would be compromised. Notably, The Montague and Lorimer precincts would regularly flood, for any given year there would be a 1% chance that flooding depths could reach as high as 1 meter without a levee to protect against sea level rise, the depths would be as much as 1.5 Meters. Such an

outcome would fail to comply with state government guidelines for flooding safety presenting unacceptable risks to residents and users of the area. Furthermore, it would compromise the viability of shops and commercial premises to occupy lower levels of the building. In summery-It Works at multiple scale to achieve multiple outcomes. Green roofs, green walls and rainwater tanks in the private realm work with raingardens and tree pies at the street scale, which work with a water recycling plant and traditional civil engineering infrastructures of pipes pumps and levees to deliver on water security, flood protection, urban cooling, and greening outcomes.

CHAPTER 5 PROPOSAL

This chapter discussing about how WSP can be incorporated and attain sensitive planning in an urban area to keep natural water cycle of Aluva municipality using various proposals and strategies at micro and macro level. With the base of analyzed problems and potentials of the study area.

5.1 Vision

Managing water as a resource and supporting sustainable urban development to mitigate the effects of climate change impacts and offers various social, ecological, and economic benefits.

5.2 Mission

a) To facilitate sustainable development, improve climate resilience, boost biodiversity and urban ecology through sensitive practices.

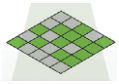
b) To make the city green and vibrant to enhance the quality of life for the present and future.

c) The protection and preservation of environmentally rich sources as valuable resources.

d) To catch every drop of water to maintain and complete the natural water cycle.

5.3 Goals

Table 9:Goals

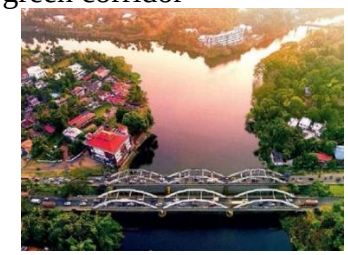
	To lessen impervious surface
	Control runoff, capture maximum rainfall
	Promote green infrastructure
	Promote water sensitive community
	Reduction in flood risk

Source: Author generated 2023

5.4 Proposals and strategies at macro level

Proposal 1- Whole municipality as a catchment area

Table 10:Macro level Strategies

Tourism strategy	Cultural strategy	Agriculture strategy
WS-Riverfront development-Buffer zone along the river side using native plants and trees, Existing Park enhancement (Haritha Vanam). Boating services, Pedestrian walkways etc. can be modified and activated accordingly. 	**Heritage walk** Connecting Manappuram Temple precincts, Adwaita asramam, Aluva palace etc.  There is huge scope for developing as heritage zone along the river side. Which promote people experience the presence of river and its calmness and beauty	**Sensitive agriculture practices.** Intensive pesticides and fertilizers applied agriculture runoff can be reduced by sensitive practice.
Infrastructural strategy	**Ecological strategy**	**Educational strategy**
Integration of new proposals such as STP and WTP to the WSP of Aluva municipality.  **Inclusion of institutional land for green corridor development.**	**Constructed wet land,** (Central marine fisheries research institute -Ward 25, Periyar aqua project) **Riverfront development, Park and open area preservation and enhancement.** Connecting green patches with one other to develop a green corridor 	**Spread the awareness of WSP and its benefit.** Community participation. Water efficient building practices. Strom water collection and reuse. And social awareness about the opportunities.

Source: Author generated 2023

Strategy 1: Developing water sensitive zones and corridor

By including existing road network transportation facilities and (Permanent impervious area) the available parks and open spaces connecting with existing water body.

a) Increased opportunity for stormwater to infiltrate soils to support trees and streetscapes.

b) Expanded access to recycled water sources for streetscape irrigation systems. Higher proportion of canopy cover across the Municipality.

c) Increased volume of catchment runoff is treated before discharging to natural waterways.

d) Create wetland features in key locations that capture, clean and release high quality stormwater into waterways.

e) Restore aquatic habitat, manage pests and increase biodiversity in the river side to support healthy ecosystem functions by creating riparian buffer zones.

f) New parks can be in cooperated in municipality.

g) Mixed and high-rise developments can be in cooperated

h) Collecting maximum storm water to infiltrate into GRWPZ

Strategy 2: Inclusion of institutional level area

a) The municipality has high institutional land availability this can be add to the sensitive corridor planning.

b) Demonstrate innovative greening ideas using alternative water sources on Institutional buildings and developments. Ideas using alternative water sources.

Proposal 2- Green developments for CBD area Meso level

Strategy 1: Water sensitive green infrastructures

a) More recycled water is used in buildings, public facilities and for council operations. Green streets and open spaces.

b) Building should promote efficient water use and its recycling Introduction of more green space. Encourage site infiltration.

c) Reduce impervious areas

Proposal 3 - Water sensitive community Micro level

Strategy 1: Community participation

a) Individual plot level WSUD Interventions. Awareness programmed at different level (Individual plot, City level, regional level)
Biodiversity enhancing, Buffer zone creation and protection.

b) Efficient use of water and it recycle, Storm water collection (Retention and detention tanks or pond).

c) Artificial wetlands Irrigation and Community Garden.

d) Encourage residents and the community to use alterative water sources for irrigation and greening.

e) Strategically deploy water sensitive urban design features to maximize use of stormwater runoff from city t streets.

Proposal 3 - Walk by the river

Strategy 1: Riverfront development with sensitive practices

a) Riparian zone.

b) Levee along the river side for flood risk reduction

WSUD Strategies

Water sensitive design strategies include green network, Sediment basins Swales and Buffer Strips Bio-retention areas, Wetlands, Infiltration Trenches, Permeable Pavements Retention ponds, Detention ponds, Green Roofs, Soak ways, Gross pollutant traps, Bio-retention, Basic Sand Filters.

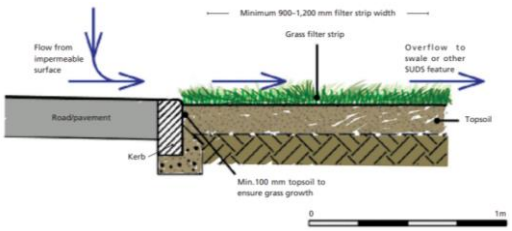


Figure 119:Filter strips

Source: WSUDP Practitioners guide 2018

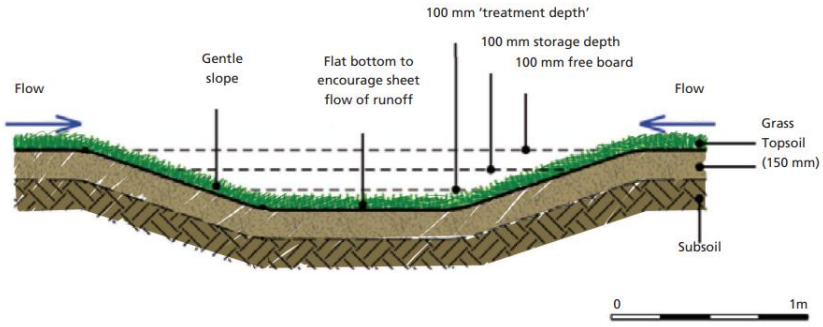


Figure 120:Bio swale

Source: WSUDP Practitioners guide 2018.

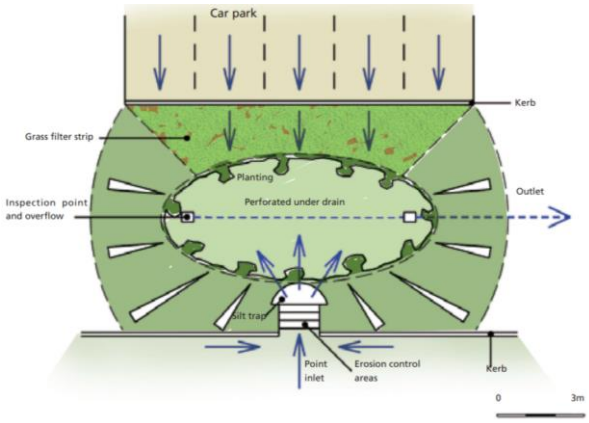


Figure 121:Bio retention and rain garden

Source: WSUDP Practitioners guide 2018.

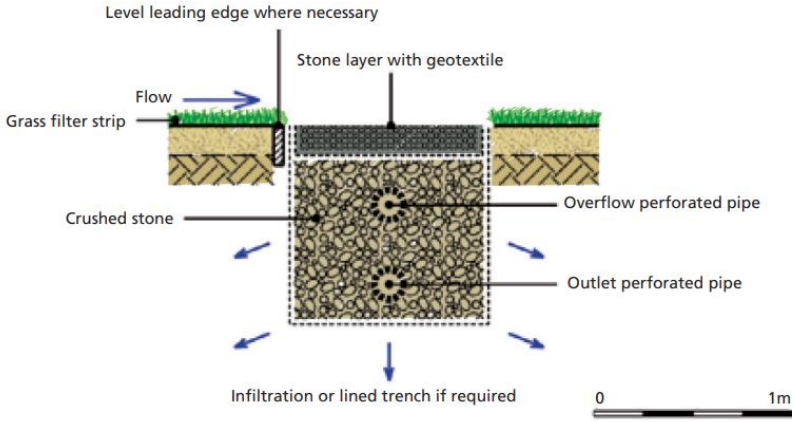


Figure 122:Filter drains and trenches

Source: WSUDP Practitioners guide 2018

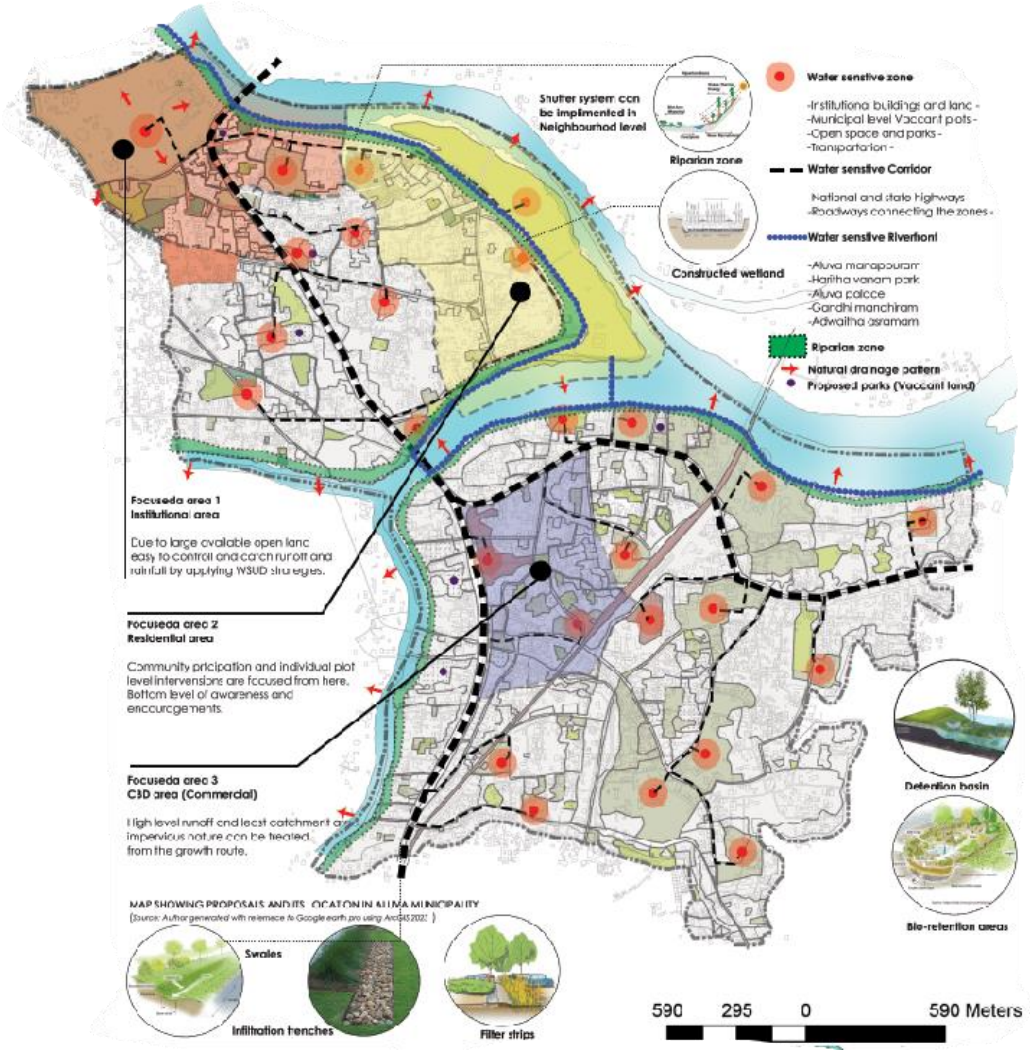


Figure 123:map showing proposals and its location in aluva municipality

Source: Author generated with reference to Google earth pro using ArcGIS 2023

5.4.1 WSP for Institutional area (Meso level)

Storm-water management at public and semipublic places, including open areas in cities through elements of landscape design (e.g., vegetated swales and buffer strips, bio-retention systems). The bio-retention areas can be located after identifying low-lying areas within the institutional area, surrounded by vegetation nodes. Trench with filter strips and swales can be located along the footpath. A small rain-garden can be incorporate with provision of overflow;

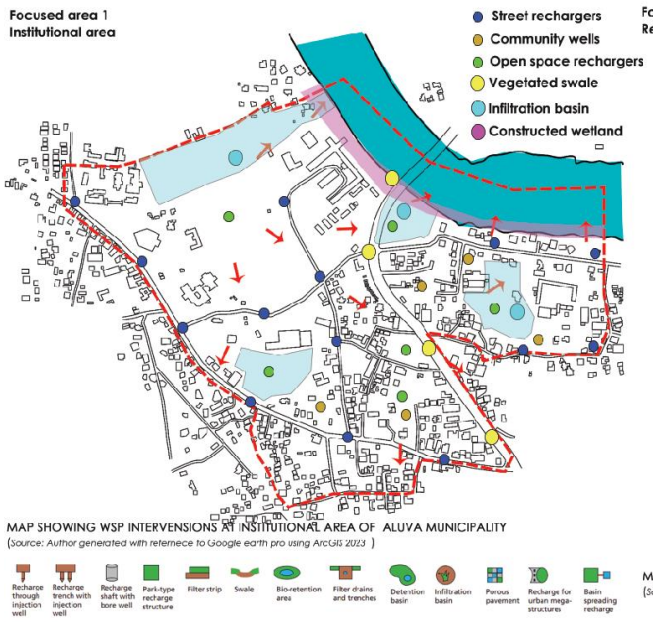


Figure 124:Map showing wsp intervensions at institutional area of aluva municipality

Source: Author generated with reference to Google earth pro using ArcGIS 2023

5.4.2 WSP for Residential area

Community participation can be motivated in each individual plot level's interventions can be implemented with the help of resident people.ie RWH, SWH etc. Community garden, Farming, other irrigation at residential level can be included in this level.

Figure 125:Map showing wsp intervensions at residential area of aluva municipality

Source: Author generated with reference to Google earth pro using ArcGIS 2023

5.4.3 WSP for CBD area (Commercial)

Green Growth means fostering economic growth and development, while ensuring that natural assets continue to provide the resources and environmental services on which our well-being relies. In water sensitive planning it promotes green developments to catch treat water and preserve it for future. While we analyzing the 2031 proposed master plan this area is marked as a central business district. So, the future economic activities may concentrate to this area. Thus, this area become a driving engine of Aluva municipality. As a commercial center of municipality this area possess high percentage of pervious area. So, the water sensitive planning and design intervention may help to reduce the future vulnerabilities and can keep the area as an example of green development and sensitive practices.

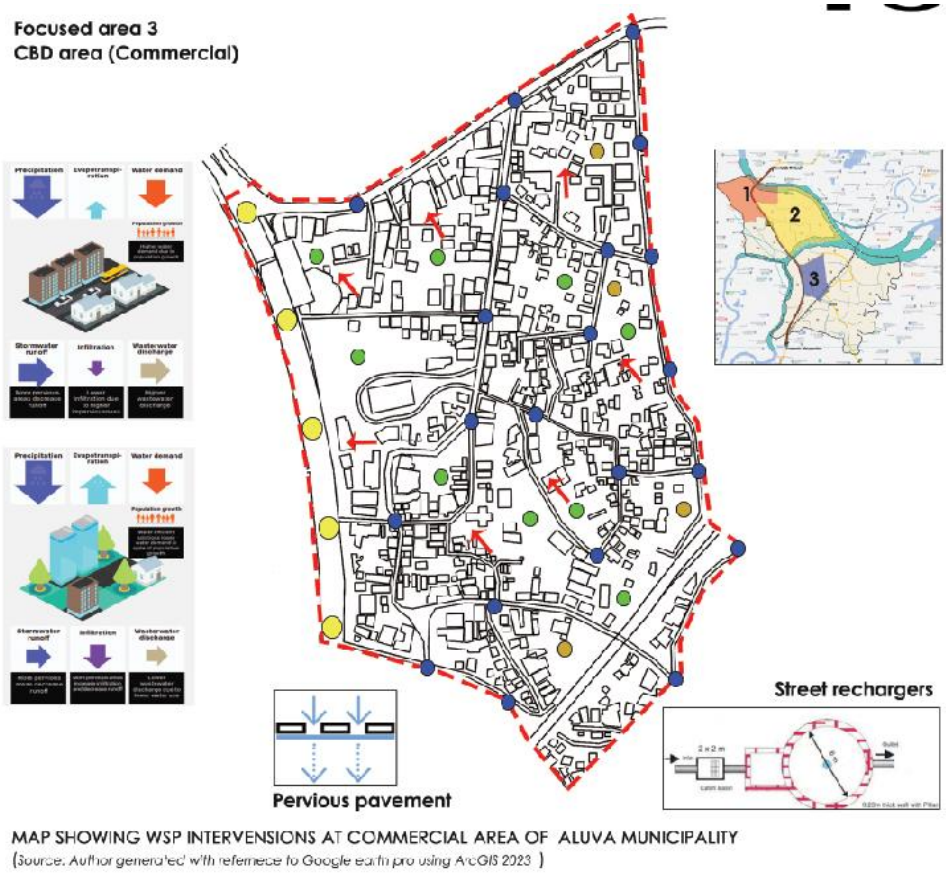


Figure 126:Map showing wsp intervensions at commercial area of aluva municipality
Source: Author generated with reference to Google earth pro using ArcGIS 2023

5.4.4 Water sensitive plan for Aluva municipality (Macro level)

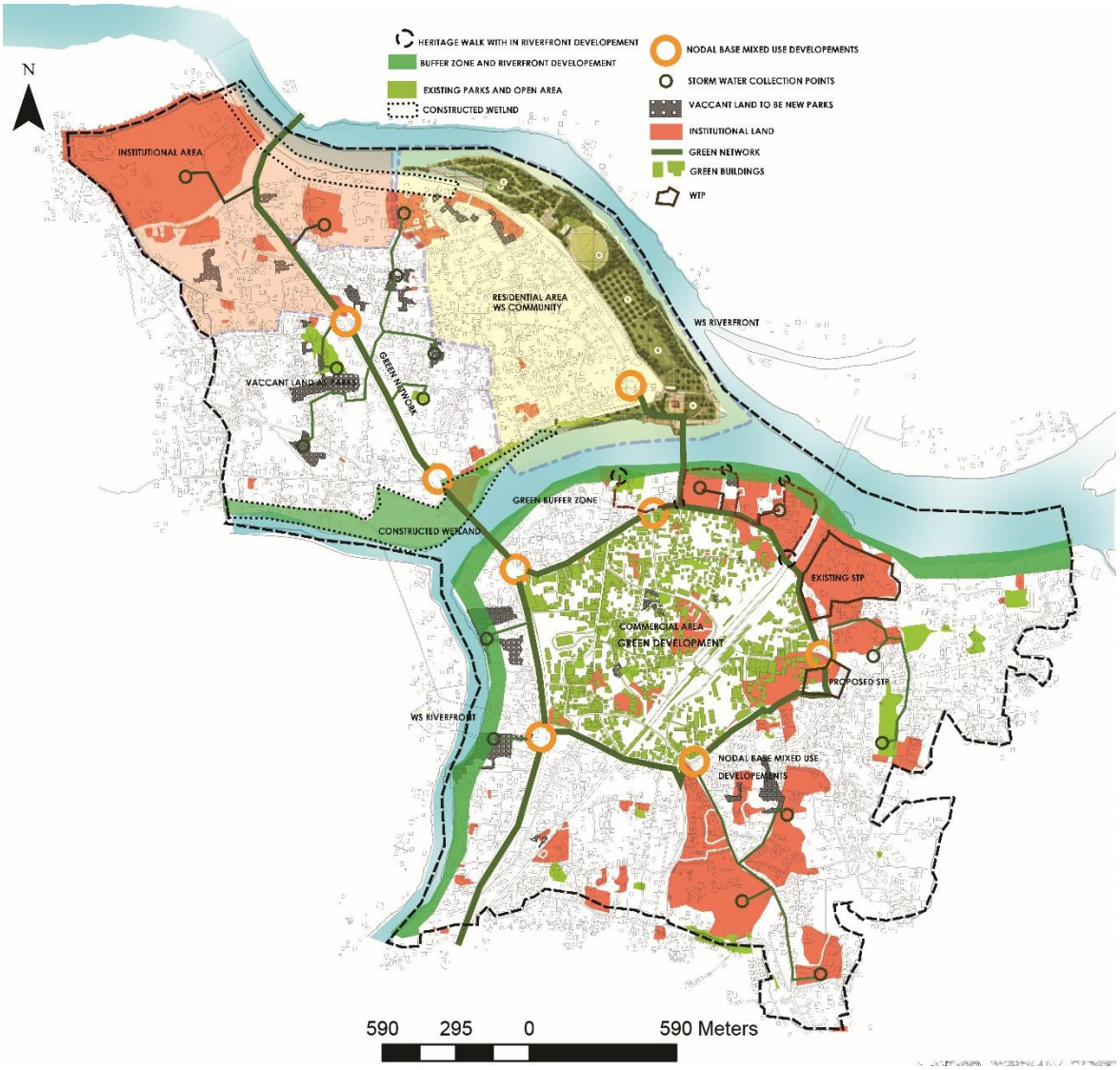


Figure 127:WSP For Aluva municipality

Source: Author generated 2023

a) Green development- Green infrastructure and public spaces.

Streetscapes, Transportation hub

Aluva is a significant transportation hub and a commercial hub for areas around. As a result, the city's center is home to a concentration of transit options, which causes the city's neighborhoods to be dispersed. The NH47 includes the Marathandaverma Bridge, which spans the river. To the right of the NH47 in the southern portion is where the bus stop and metro station are situated. The southern portion, to the west of the NH47, is where the

principal market district is situated. The southern half's center is roughly where you'll find the main train station. Potential to enhance the built environment and the standard of public space, particularly to service a growing migrant population. Potential to enhance the built environment and the standard of public space, particularly to service a growing migrant population. Creation of new typologies to address specialized problems and requirements, and to demonstrate sustainable development and a variety of land uses in light of the elevated FSI inside the designated CBD.

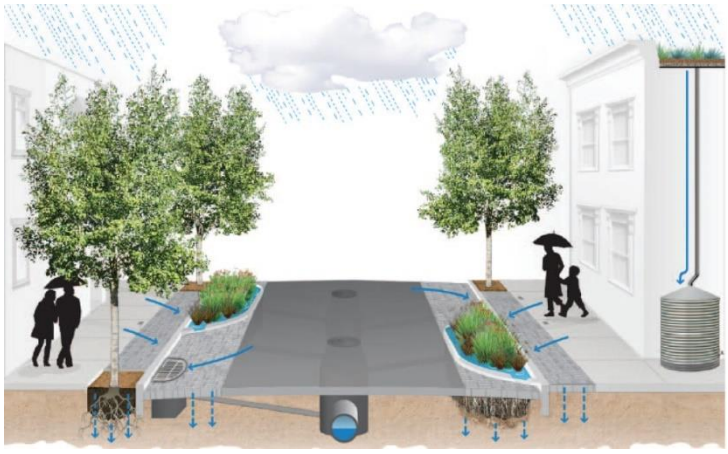


Figure 128:Water sensitive buildings and precincts

Source: Science direct.com 2018

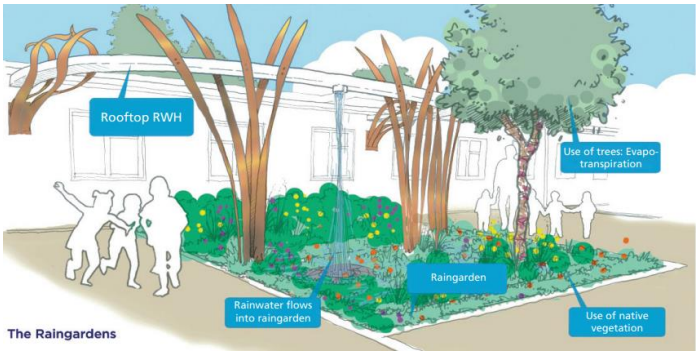


Figure 129:Rain gardens

Source: WSUDP Practitioners guide 2018

b) Challenges

Dense built fabric, rising land costs and largely private ownership of land leads to challenges in land acquisition for new development. Unavailability of vacant land for new development or public open spaces.

5.5 Recommendations and policies for WSP

1) The proportion of impervious versus pervious land cover in common building Patterns

Policy-1: Future buildings should have low ground coverage with vertical development to reduce building footprints.

2) The distribution of open (pervious) spaces over the area

Policy -2: Introduce green spaces for more infiltration of runoff.

3) Sub-division of the area into small 'micro' catchments.

Policy-3: Encourage on site infiltration.

4) Incorporation into the urban fabric of facilities designed to intercept, detain and infiltrate water from precipitation.

Policy 4: Incorporate infiltration facilities at all levels of planning - from an individual lot to a large urban area.

5) Pervious paving materials

Policy-5: Reduction of imperviousness even in hard surfaces.

Based on the components of urban planning, the recommendations for new developments are given at two levels.

At the Land Use Planning Level

Impervious control, Building Compact Communities, Distribution of open (pervious) spaces over the area Sub-division of the area into small micro' catchments

At the Site Design Level

There are a number of site design practices that can reduce impervious coverage for a wide range of land uses, which includes: Reducing building footprints, Reducing Road coverage Limiting the Amount of Surface Parking, Use of Porous paving materials.

5.6 Proposed Timeline

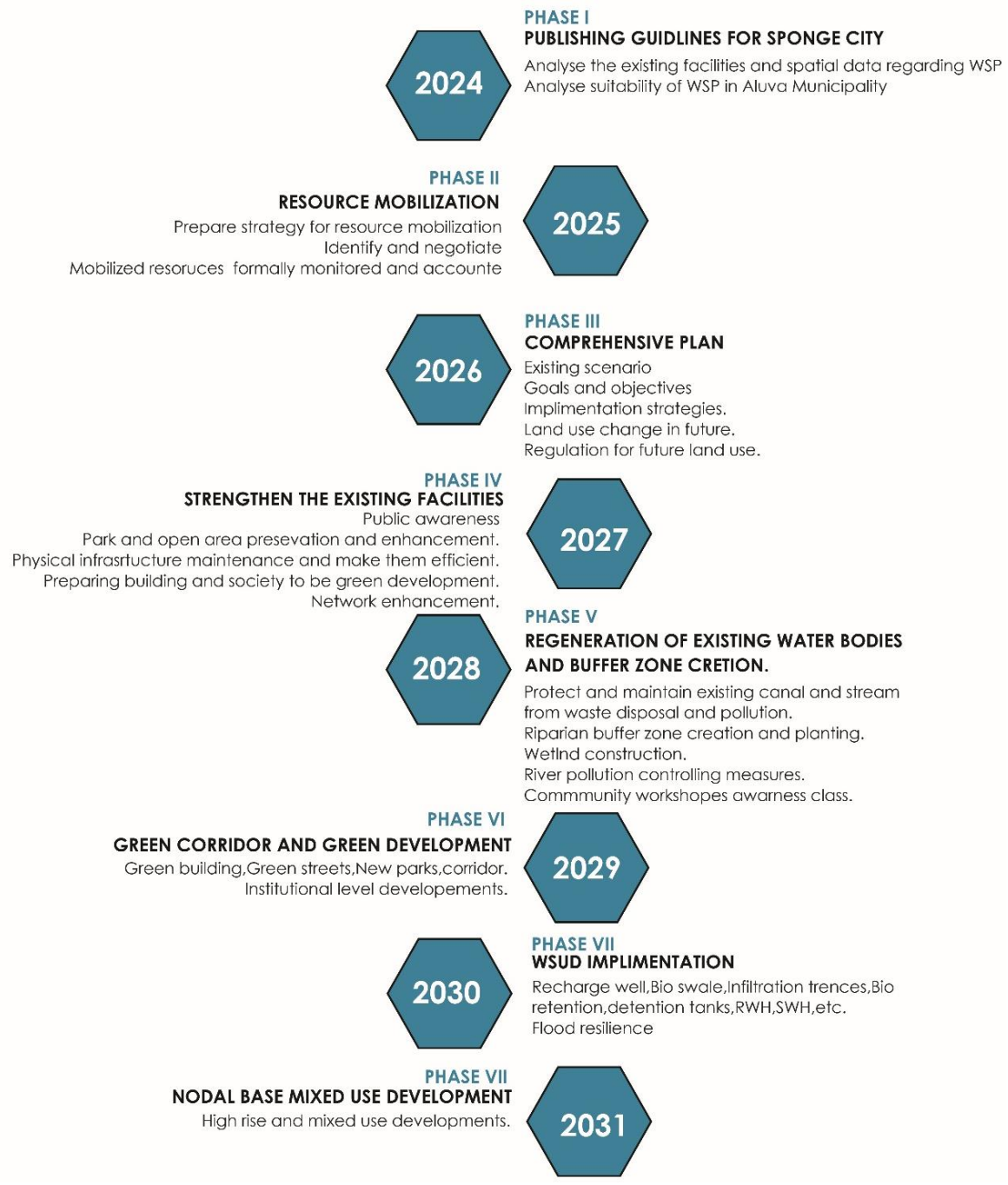


Figure 130:Implementation phases

Source: Author generated 2023

CHAPTER 6 CONCLUSION

The project intends to provide a water-sensitive plan for Aluva Municipality to deal with climate change challenges. As a growing urban center Water-sensitive planning of Aluva municipality can conserve water resources while offering numerous benefits by way of improving the urban environment, reducing the danger of flooding, increasing opportunities for recreation and leisure activities, and reducing flooding damage and cost of drainage systems. This was accomplished by analyzing the literature and case study's planning-related components. Moreover, a methodology for examining the distributions of land use should be adopted, and ArcGIS's Analytic Hierarchy Process should be used to find the possible zones for groundwater. In order to determine the surface sealing and water usage of certain land use, the water cycle-influenced factors of an urban region were researched and examined. Water usage is analyzed based on the primary survey of selected land use distribution. Moreover, it identified the region's problems and potential. Creating strategies and proposals to establish a water-sensitive municipality based on the findings.

Solutions where derived using strategies at micro, meso, and macro level. It is suggested that for reducing imperviousness and protection existing green cover is need to be carried out at macro level, i.e., as saturated development the municipality must have an eye on the green and open space. Because the high runoff due the impervious area is reduced or controlled only via through these sensitive area preservation and enhancement. By incorporating high open land concentrations observed in the institutional areas and, leisure zones can be built on the identified vacant land and then connect it to a green network such away creating a green corridor and catchment for the entire town, is helpful for creating more retention, detention and infiltration areas to fulfil the water sensitive planning strategies. Urban flooding losses can be also reduced and water logging is considerably managed using these sensitive approaches. Riverfront development and buffer zone along the river side and canal is also need to be connected using sensitive practices. At meso and micro level, Creating WSP for selected land use distribution as model for implementing Water sensitive urban design elements to achieve the planning interventions. The green development of proposed CBD area will be sustainable face of the town and nurture the future developments also. At the community level participation will be thorough RWH, SWH installation and its effective use at individual building level i.e. making water efficient buildings. Promoting people for

community garden and farming with the use of collected and treated storm water and at different land use level for the landscaping and other purposes. A closed water cycle loop can be established for an effective, water-sensitive municipality with the aid of the proposed sewage and water treatment facility.

Water sensitive planning can have the ability to control the climate change impacts like urban heat island, water cycle maintaining, flood risk management etc. due to urban development. Any open space designed according to water-sensitive planning principles provides recreational and visual amenities while filtering runoff that infiltrates to replenish groundwater. Maximize use of open spaces to rejuvenate the lost water cycle. Planning for new areas requires allocating land uses according to hydro-geographic layout. The placement of open spaces recreational areas, roads etc. plays a major role in complying with the water-sensitive planning.

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APPENDIX

1. Ward number:

2. Migrated population: Yes ☐ No ☐ If yes year of migration:

3. Reason for migration:

4. Economic status: LIG ☐ MIG ☐ HIG ☐

5. Occupation:

6. Ownership: Owned ☐ Rented ☐ Other ☐

7. Residence Type: Apartment ☐ Row house ☐ Squatter settlement ☐ independent ☐ house

8. If it is an independent house's Total area of the plot and built-up area:

9. Category of building: Pucca ☐ Kutcha ☐ Semi pucca

10. Flood affected: Yes ☐ No ☐ If Yes Level of water and losses:

11. During flood what is the maximum water level rise experienced in your ward?

(Mention in feet):

12. The number of stories:

13. Water supply: Well ☐ Pipeline ☐ Bore Well ☐ Other ☐

14. Quality of water: Good ☐ Contaminated ☐ Sometimes ☐

16. RWH installed or not: If not are you interested to install:

15. Condition of nearest water body (Rive, Lake, Pond, etc):

Poor ☐ Fair ☐ Excellent ☐ Detailed explanations:

16. Access Road width and its condition (Mention Impervious or not):

17. Availability of nearby vacant plot:

18. Nearby Open areas parks:

19. Condition of these open areas and parks and their maintenance:

Is any water harvesting methods implemented?

20. Are you satisfied with the present greenery and its experience?

21. How frequently do you visit parks? Are you satisfied?

☐ Hardly use

☐ A couple of times a week

☐ A couple of times a month

☐ Almost every day

☐ Other

22. What kind of infrastructure development do you need in this need in this neighbourhood?.....

23. Drainage condition and waterlogging: …….

24. Mention the name of the road where water gets logged during heavy rainfall……

24. Source of pollution in the nearest water bodies in your ward

☐ Hospital waste

☐ Industry

☐ Strom water runoff

☐ Agriculture

☐ Heavy runoff from residential areas

25. Causes of Environmental depletion identified in your ward?

How it can be maintained (Suggestions)

26. Have you experienced soil erosion? If yes how severe?

27. Have you experienced water scarcity? If yes how severe?

28. Have Any sensitive practices already been installed in your ward that you are aware of?

Permeable pavements ☐

Rainwater harvesting tanks ☐

Street trees ☐

Green roof, green wall ☐

Wetland construction and conservation ☐

Stormwater management ☐

None of the above ☐

29. How severely are you affected by climatic impacts in your ward?

30 Water body depletion if noticed?

31. Have you heard about green blue networks and their benefits?

32. Daily uses of water? And the quantity (L)?

Drinking -

Washing -

Bathing -

Cooking -

Cleaning -

Landscaping -

Toilet -

Other -