THESIS REPORT
(2021-2022)

“FLOOD URBAN RESILIENCE IN ADDIS ABABA”
MASTERS THESIS IN SUSTAINABLE DESIGN

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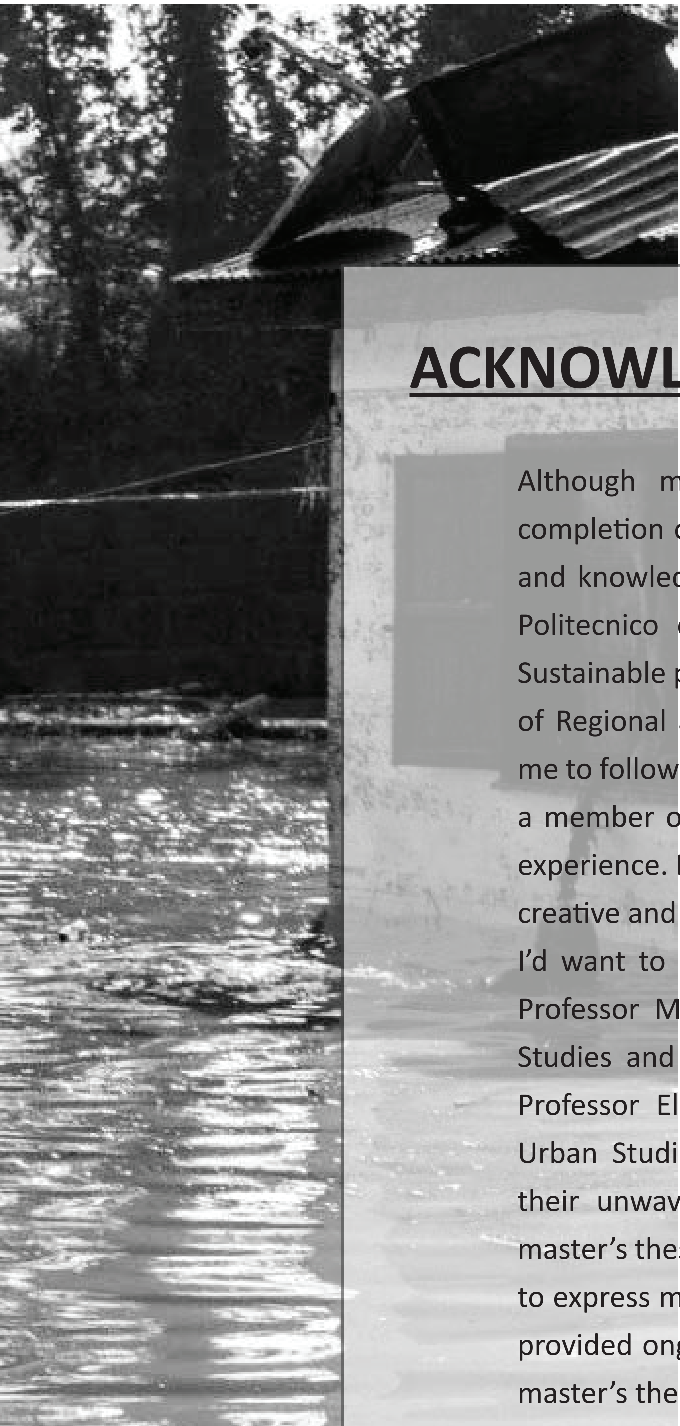
MASTER OF SCIENCE PROGRAM IN ARCHITECTURE FOR THE SUSTAINABLE PROJECTS

Figure 1: Damages caused by heavy rain on 18 August 2021 [1] [MEMO, n.d.]

[1] This image was published on Middle East Monitor, creating new perspective| page after an event of flash flood in Addis Ababa. Around 217 localities were at high risk due to this flooding in the Addis Ababa, according to concerned institution.



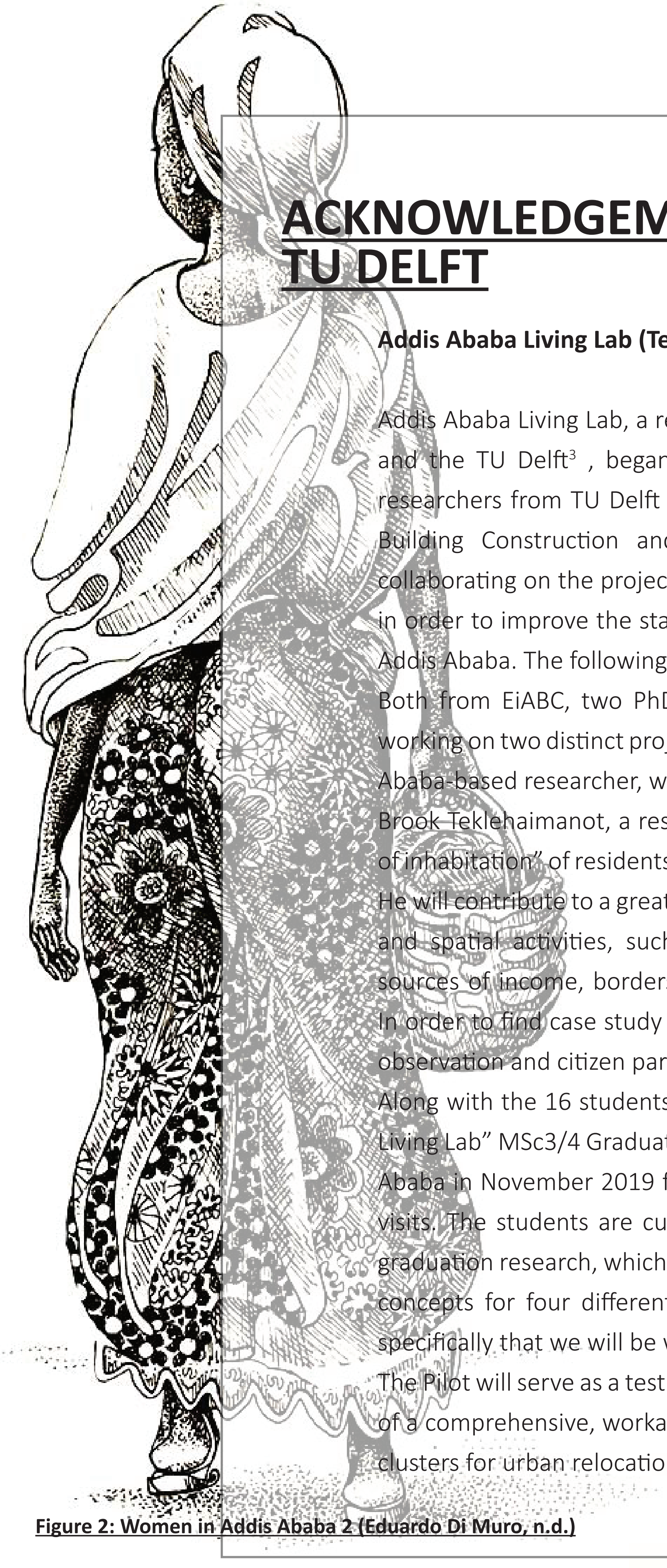
ACKNOWLEDGEMENT

Although my master's degree will be completed with the completion of my thesis, I hope that this lifelong path of wisdom and knowledge will continue. I owe a great debt of gratitude to Politecnico di Torino's Department of Architecture design for Sustainable projects (Department of Architecture and Department of Regional and Urban Studies and Planning (DIST)) for allowing me to follow my aspirations and improve my talents. For me, being a member of a multicultural institution has been a life-changing experience. During my time at Politecnico, I met some of the most creative and extraordinary people.

I'd want to express my heartfelt appreciation to my supervisor, Professor Mario Artuso of Department of Regional and Urban Studies and Planning (DIST) at Politecnico di Torino, and tutor, Professor Elena Camilla Pede of Department of Regional and Urban Studies and Planning (DIST) at Politecnico di Torino, for their unwavering support and encouragement throughout my master's thesis in this unprecedented epidemic. In addition, I want to express my gratitude to my close friend Bilal Ahmed, who have provided ongoing encouragement and motivation throughout my master's thesis and degree.

Lastly, I want to convey my heartfelt appreciation to my parents, and siblings, who have been an integral part of my life and have always supported me. This work is dedicated to them in particular.

ACKNOWLEDGEMENT TU DELFT



Addis Ababa Living Lab (Technische Universiteit Delft, n.d.)

Addis Ababa Living Lab, a research initiative financed by NWO-WOTRO[2] and the TU Delft[3] , began two years ago, in May 2019. A group of researchers from TU Delft and the Ethiopian Institute for Architecture Building Construction and City Development (EiABC)[4] have been collaborating on the project's initial research outputs for the past years in order to improve the standard of living for resettlement residents in Addis Ababa. The following few years will be devoted to this task.
Both from EiABC, two PhD candidates joined the project and began working on two distinct project components. Yonas Alemayehu, an Addis Ababa-based researcher, will examine historical and present urban.
Brook Teklehaimanot, a researcher at TU Delft, examines the "patterns of inhabitation" of residents in the various urban settings of Addis Ababa. He will contribute to a greater understanding of urban community social and spatial activities, such as habitation patterns, social structures, sources of income, borders, and construction methods and materials. In order to find case study locations and test ethnographic methods of observation and citizen participation, he did fieldwork in Addis Ababa.
Along with the 16 students from the associated TU Delft "Addis Ababa Living Lab" MSc3/4 Graduation Studio, the entire team traveled to Addis Ababa in November 2019 for intensive meetings, a workshop, and site visits. The students are currently working on the final stages of their graduation research, which will provide 16 different architectural design concepts for four different Addis Ababa locations. In which one site specifically that we will be working on is facing flood issues.
The Pilot will serve as a test case and feedback loop for the development of a comprehensive, workable framework for building resilient dwelling clusters for urban relocation in Addis Ababa.

Figure 2: Women in Addis Ababa 2 (Eduardo Di Muro, n.d.)

[2] WOTRO Science for Global Development, a cross-domain effort of NWO, plans, funds, and supports research for inclusive global development. The goal of the WOTRO research programs is to provide information and abilities that support long-term fixes for

Project partners

TU Delft, Faculty of Architecture and the Built Environment (TUD-BK, Prof.dr.ir. Marja Elsinga, PI), Ethiopian Institute for Architecture, Building Construction and City Development (EiABC, Dr. Elias Yitbarek), Federal Housing Corporation, Addis Ababa (Zekarias Sebsbie, Mahlet Yared), Mecanoo architecten, Delft (Prof.ir. Dick van Gameren), RAAS Architects, Addis Ababa (Rahel Shawl)

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User-committee

Senait Damtew, Timnit Eshetu (Addis Ababa City Government), Tsegaye Moshe (Ministry of Urban Development and Housing)

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Ir. Frederique van Andel (TUD-BK), Dr. Elias Yitbarek (EiABC)

social and ecological issues in low- and middle-income nations (LMICs).

[3] The oldest and largest public technical university in the Netherlands is Delft University of Technology (TU Delft), which is situated in Delft, the Netherlands.

[4] In Addis Abeba, Ethiopia, there is an institute for architecture and civil construction called the Ethiopian Institute of Architecture, Building Construction, and City Development (EiABC).

[5] This image was published on Middle East Monitor, creating new perspective| page after an event of flash flood in Addis Ababa. Around 217 localities were at high risk due to this flooding in the Addis Ababa, according to concerned institution.

ABSTRACT

In recent years natural disasters hit the globe especially serious flood events leading to deaths of living beings, displacing millions of people and affecting and damaging economic structure of around tens of billions of Euros. According to research[6] the effect of climate change in future and especially urban growth will result in flooding issues in some regions. It's not just pre or during disaster issue, Post disaster recovery process takes months or years to get back to equilibrium from damage caused by it.

As a result of this government organizations and policy makers and authorities in globe are diverted to work on flood resilient strategies and are forced to invest their resources for the improvement of their structural and nonstructural framework. This raises a question to think on what kind of proposed solutions the government is working on to build a resilient society, in overall world.

In case of Ethiopia, it is housing around 100 million people and as a country stands on second number in Africa related to population. It suffers from natural disasters like floods, droughts, wildfire, earthquakes, epidemics, landslides, and others conflicts etc.(Tesso, n.d.) The main reason of these natural disasters is increasing climatic issues to which floods are the deadliest one. The other reason specially for flooding is also rapid urbanization.

Our aim of this research is to study Addis Ababa, capital and one of the largest city of Ethiopia, which has been a victim of floods for many decades. This city faced severe damage

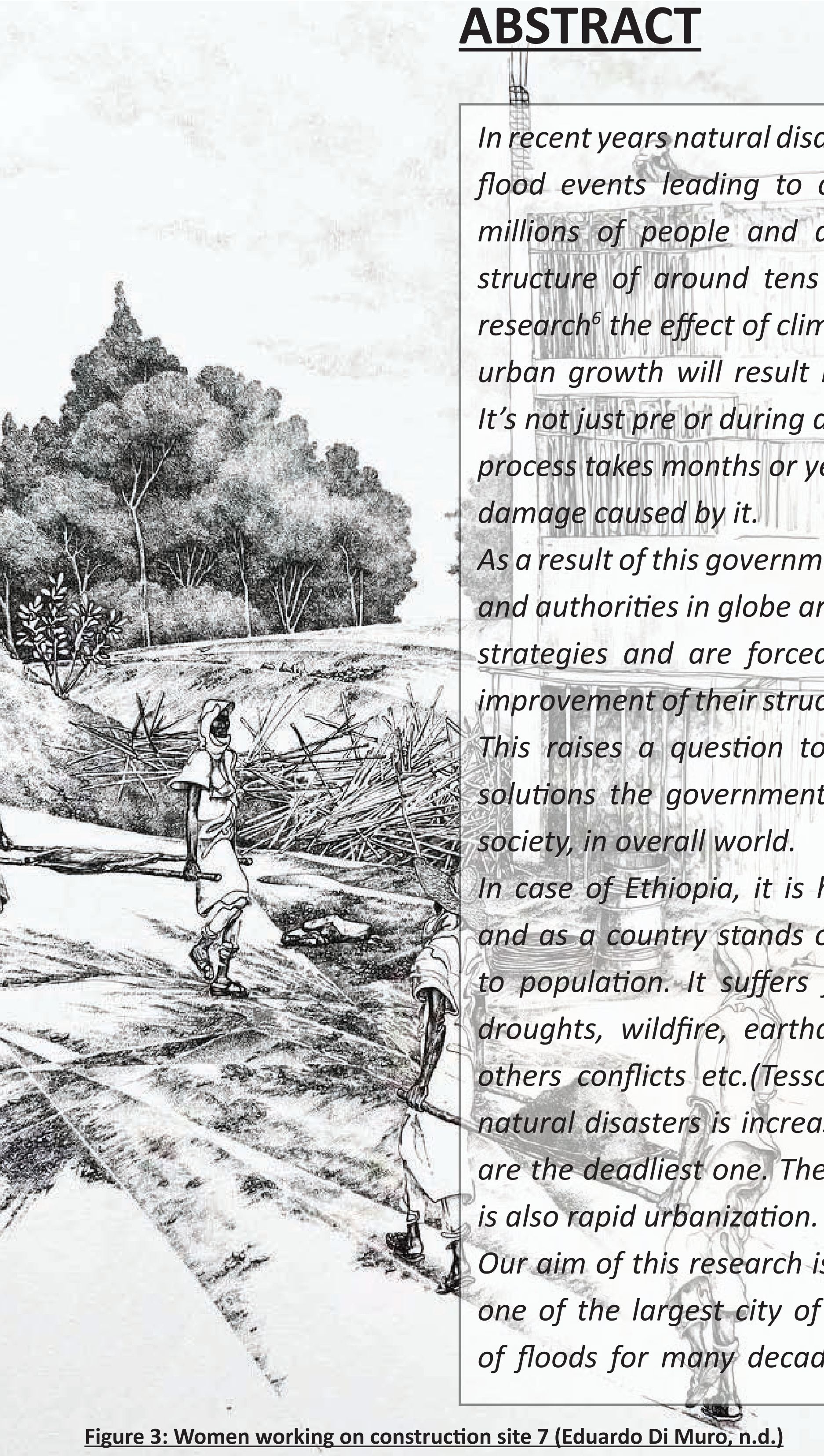


Figure 3: Women working on construction site 7 (Eduardo Di Muro, n.d.)

[6] According to papers (GIS based quantification and mapping of climate change vulnerability hotspots in Addis Ababa (written by Getnet Feyissa, Gete Zeleke, Ephrem Gebremariam, Woldeamlak Bewket), Historical flood events and hydrological extremes in Ethiopia (written by Surafel Mamo, Belete Berhanu and Assefa M.Melesse)) the flood events are rising.

*specially in 1988, 1996, 1998, 2006, 2010, 2012, and 2016, (**Extreme Hydrology and Climate Variability: Monitoring, Modelling, Adaptation and Mitigation**) resulting in loss of lives of inhabitants and their living style along with infrastructure. The rainfall pattern in recent years and the variation in temperature is adding to climate change and increasing flash flooding in urban areas.*

So, the main purpose of this research is to discuss in detail the issue of flooding and the reasons that make the area more prone to flooding disaster and the proposals and policies to deal with the floods by using architectural techniques and amphibious macro planning that absorbs these stresses, a sustainable solution for resilient architecture.

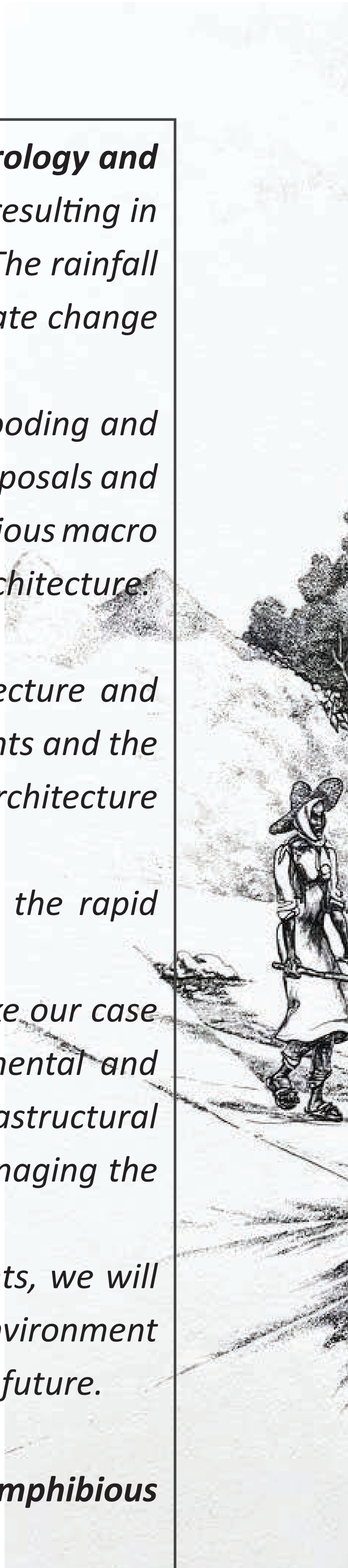
The design proposal will focus on resilience and regeneration of architecture and lives by considering these challenges and addressing the needs of inhabitants and the architecture of the people of Addis Ababa. A dialogue between nature and architecture that would be sustainable and last longer.

Apart from people and culture and their needs factor of economy and the rapid urbanization issue will be taken under consideration.

The idea of this research is to serve as a prototype for developing cities like our case study of Addis Ababa by comparing nonstructural actions like governmental and administrative policies and guidelines and structural actions in term of infrastructural techniques and spatial urban planning to maintain urban density and managing the natural disasters, used in developed countries.

However, respecting the local material and needs and spatial requirements, we will devise a solution to deal with natural disasters and changing needs of environment and inhabitants and making it resilient for every kind of shock in uncertain future.

*Keywords: **Resilient architecture, Sustainable solution, Prototypes, Amphibious planning, resilient urban planning***



[7] A book written by Eduardo Di Muro which illustrates the social character of urban capitals of Africa. He tried to explain the scenes of community, markets and streets and drew the culture through his drawings.

Figure 4: Typical cityscape of Ethiopian capital 8 (Eduardo Di Muro, n.d.)

[8] A book written by Eduardo Di Muro which illustrates the social character of urban capitals of Africa. He tried to explain the scenes of community, markets and streets and drew the culture through his drawings.

“In order to get a grip on it, one must be able to relate resilience to other properties that one has some means of ascertaining, through observation.”

City resilience framework | The Rockefeller Foundation

METHODOLOGY

In this thesis we will work on critical scientific research on the term RESILIENCE, and we will study the evolution of resilience from engineering resilience to ecological resilience. How the urban resilience work, we will do in depth study of scientific research of urban resilience and its relationship with urban flooding due to rapid urbanization and find out other causes of natural flooding.

It will be linear research, first the theoretical research which will include the UN sustainable goals that can be implemented for our case study of Addis Ababa and then exploring the critical discussion of resilience and urban resilience and its relationship with flooding and Addis Ababa.

Then we will do the Empirical research which will be exploring the nonstructural framework used by flood resilient cities that can be learned and implemented in our case to create strategical spatial planning and techniques used in architectural planning to deal with flooding issue.

Then we will do the design research, we will study different aspects of Addis Ababa, its climatic issues, how the urbanization is expanding in the city centers and how the load is affecting the city center and making it flood prone.

This study of ADDIS ABABA will help us understand the elements that are adding into the flooding issue and then we can relate our theoretical research, empirical research with design research in a framework to devise different guidelines and strategies that can be implemented in proposing solutions for Addis Ababa and then we will conclude our research in master planning by choosing potential site in Addis Ababa.

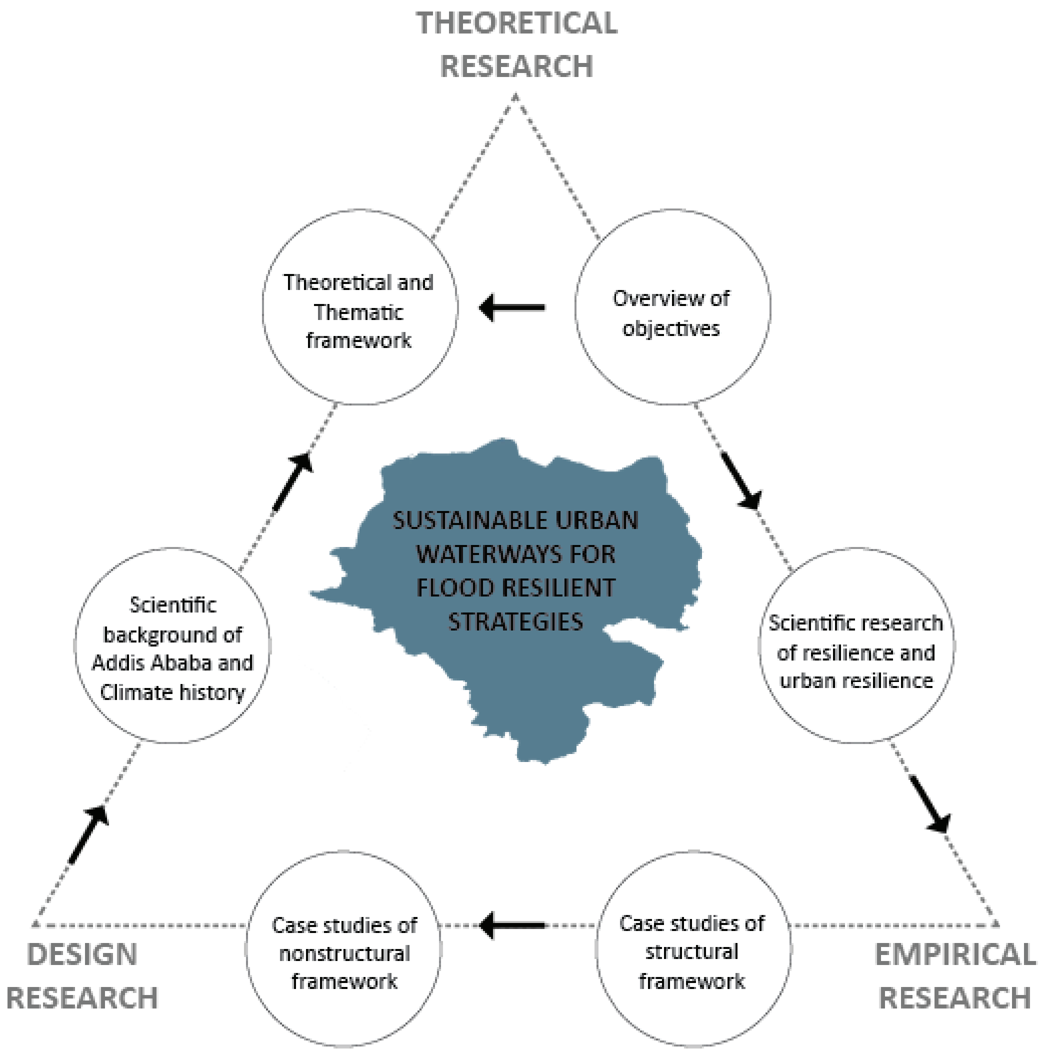


Figure 5: Methodology of research (by author)

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[9] A book written by Eduardo Di Muro which illustrates the social character of urban capitals of Africa. He tried to explain the scenes of community, markets and streets and drew the culture through his drawings.

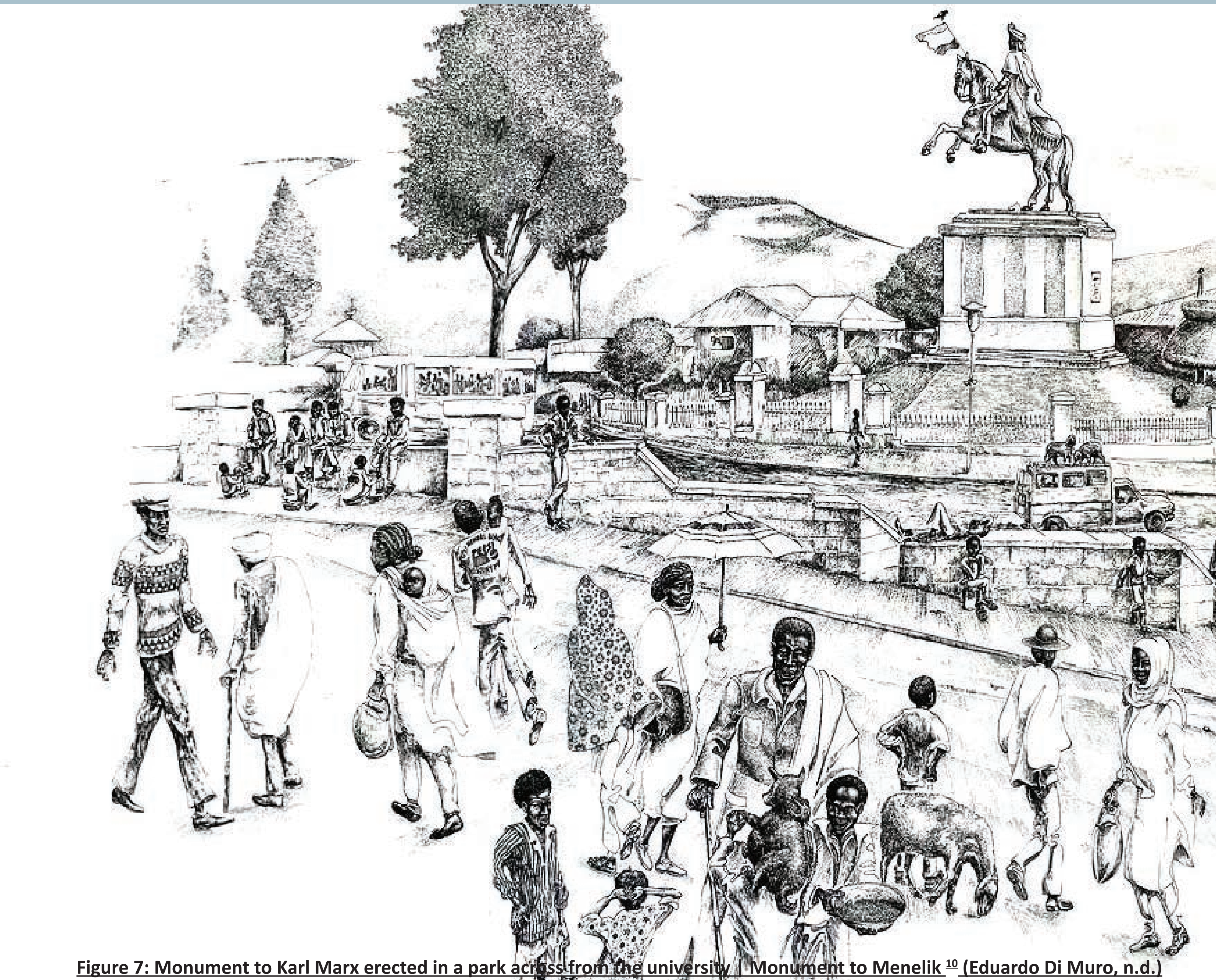

Figure 7: Monument to Karl Marx erected in a park across from the university | Monument to Menelik [10] (Eduardo Di Muro, n.d.)

|01

RESEARCH OVERVIEW

"The great migration of humans is manifesting itself in the creation of a special kind of urban place.
These transitional spaces - arrival cities - are the places where the next great economic and cultural boom will be born, or where the next great explosion of violence will occur. The difference depends on our ability to notice, and our willingness to engage."

-Doug Saunders

[10] A book written by Eduardo Di Muro which illustrates the social character of urban capitals of Africa. He tried to explain the scenes of community, markets and streets and drew the culture through his drawings.

1.1 - PREFACE

Ethiopia implemented the Millennium Development Goals (MDGs), integrating them into its national development framework and registering remarkable achievements in the period 2000 to 2015. The MDGs were implemented through effective government leadership and coordination of all stakeholders in an organized and structured manner throughout the country. The integration of MDGs into the national development frameworks enabled full access to the national budget allocated and human capital deployed for the implementation, coordination, monitoring and evaluation of the national development frameworks and avoided duplication of efforts. Ethiopia also had recent experience in evaluating and capturing best practices and identifying challenges because of the national review it conducted on the performance of the MDGs. Important lessons have been drawn at the national level, enabling Ethiopia to make significant contributions to the preparation of the 2030 Global Agenda for Sustainable Development.

Ethiopia has been pursuing pro-poor policies and implementing development plans and programs within global development frameworks, such as the MDGs, the Brussels Program of Action and its successor the Istanbul Program of Action for Least Developed Countries. There have been considerable achievements in economic growth, social development, and environmental management.

The world in which we live is rapidly changing. Every day is a new challenge. Due to environmental changes the threat of natural hazards is also increasing. In which floods has highest capability to destroy and negative impact on people in destructive way. If we see the global statistics the evidence shows that the greatest number of casualties are caused by floods.
(Shown in figure 8)

The rate of floods is rising over the year by alarming rate. (Shown in figure 9)

We need to move forward from the pattern of responding to post-disaster response only. Some actions and strategies must be worked through to break the chain and adopt inclusive approaches to manage the floods disasters. As flooding is not only consigned to least developed countries but it affects the same to developed countries, the only difference is recovering capacity of nations economically and strategically.

In developing countries, it wipes out the years of efforts and investments and left the nations crippled and leaving behind deaths and epidemics. With this the tragedy is post traumatic stresses which can only be evaded or can be reduced through proper planning and strategies

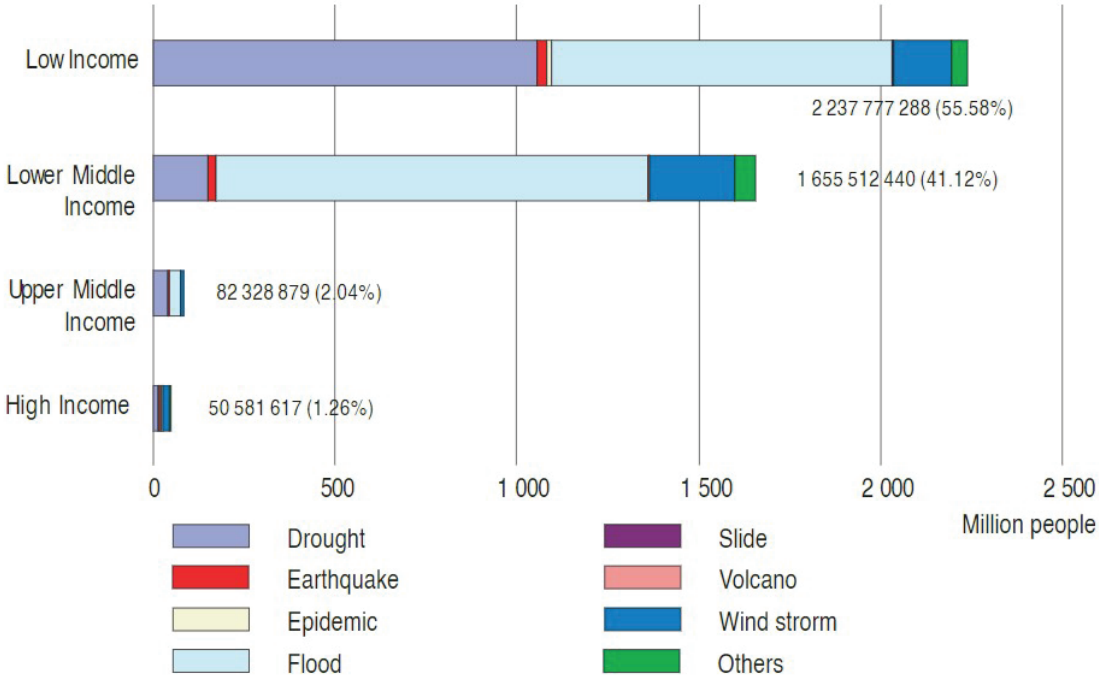

Figure 8: worldwide overview of people affected by category of natural hazards and income groups from 1975-2000 [11] [Nations and Gov, n.d.]

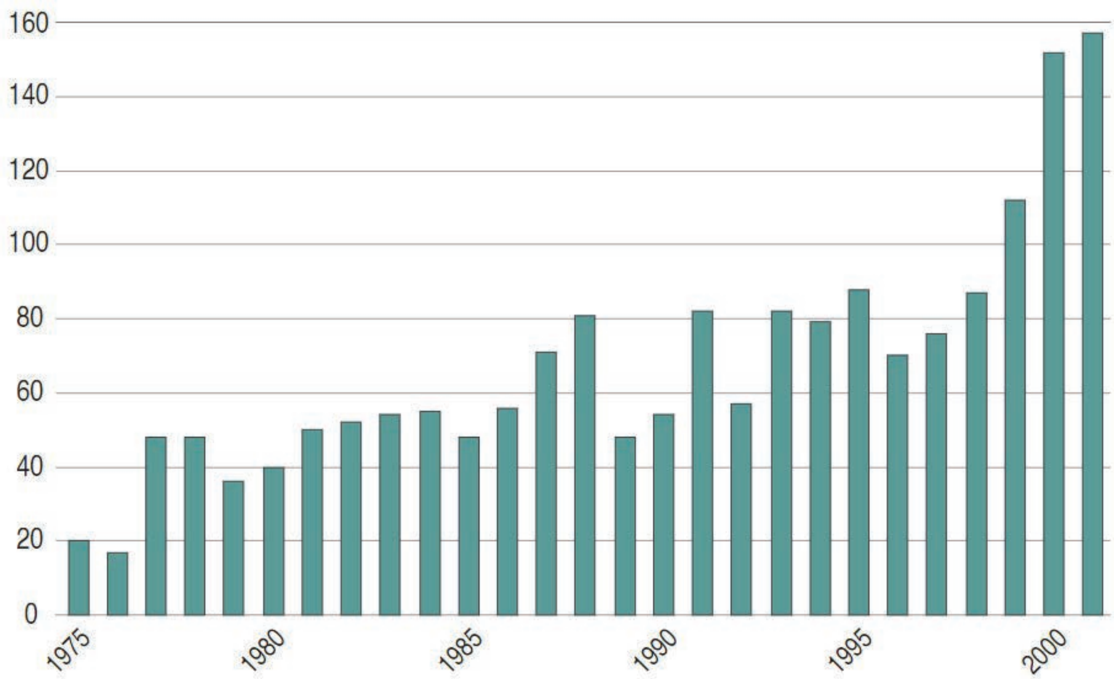

Figure 9: Flood disaster from 1975-2001 [12] [Nations and Gov, n.d.]

[11] [12] *Source: EM-DAT, CRED, University of Louvain, Belgium*

for pre-, during and post disaster water management. Devising new policies, effective and strategical spatial planning, monitoring, and forecasting and effective warning communications and then can only respond to such hazards.

UN Sustainable Development Goals (SDGs) has introduced 17 goals for the globe to achieve sustainable world by 2030. Ethiopia is significantly advancing the worldwide 2030 Agenda for Sustainable Development in this regard.

Ethiopia put the Millennium Development Goals (MDGs) into practice, incorporating goals into its national development framework and recording outstanding accomplishments from 2000 to 2015. Through strong government leadership and the organization and collaboration of all stakeholders across the nation, the MDGs were successfully implemented. The inclusion of the MDGs in national development frameworks prevented duplication of effort and allowed full access to the national budget and human resources deployed for their implementation, coordination, monitoring, and evaluation. Ethiopia's recent national evaluation of the MDGs' performance gave it expertise in reviewing and documenting successful practices as well as highlighting concerns. Nationally significant lessons have been learned, allowing Ethiopia to significantly contribute to the development of the 2030 Global Agenda for Sustainable Development. ("Government Commitments, National Ownership and Performance Trends Ethiopia 2017 Voluntary National Review on SDGs National Planning Commission Federal Democratic Republic of Ethiopia" 2017)

Ethiopia has been promoting pro-poor policies and carrying out development plans and programs. There have been significant advancements in environmental management, social development, and economic progress.

Considering all this I began my study by evaluating the 17 United Nations Sustainable Development. These objectives are blueprints for a healthier and more sustainable tomorrow for all emerging countries, allowing mankind to prosper within its capabilities. These objectives are centered on the worldwide difficulties that many communities confront, such as poverty, inequality, climate change, environmental degradation, peace, and justice.

1.2 - GLOBAL AWARENESS

The 17 Sustainable Development Goals also known as global goals that are adopted by United Nations in 2015 to be accomplished by 2030 are:(UNDP, n.d.)("Government Commitments, National Ownership and Performance Trends Ethiopia 2017 Voluntary National Review on SDGs National Planning Commission Federal Democratic Republic of Ethiopia" 2017)

Goal 1: End poverty in all its forms everywhere

Goal 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture

Goal 3: Ensure healthy lives and promote wellbeing for all at all ages

Goal 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all

Goal 5: Achieve gender equality and empower all women and girls

Goal 6: *Ensure availability and sustainable management of water and sanitation for all*

Goal 7: Ensure access to affordable, reliable, sustainable, and modern energy for all

Goal 8: Promote sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all

Goal 9: *Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation*

Goal 10: Reduce inequality within and among Countries

Goal 11: *Make cities and human settlements inclusive, safe, resilient and sustainable*

Goal 12: Ensure sustainable consumption and production patterns

Goal 13: *Take urgent action to combat climate change and its impacts*

Goal 14: Conserve and sustainably use the oceans, seas and marine resources for sustainable development

Goal 15: Protect, restore, and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss

Goal 16: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable, and inclusive institutions at all levels

Goal 17: Strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development.

1.3 - FOCUS GOAL POINTS

1.3.1 - Goal 6: Clean water and sanitation

Figure 10: Goal 6 - Clean water and sanitation[UNDP, n.d.]

Ensure availability and sustainable management of water and sanitation for all

In order to mitigate disaster susceptibility and improve community resilience to water-related hazards, sustainable water management is essential. Around 90% of catastrophe occurrences globally are caused by water-related phenomena, including floods, droughts, storms, storm surges, and landslides(Kull et al. 2016). Rising agricultural development on marginal lands and ongoing population expansion in flood-prone areas would increase exposure to and vulnerability to such threats. Water resource management that is robust and sustainable can greatly lessen the effects of water-related hazards and support attempts to integrate disaster risk reduction measures into water management.

TARGET 6.6 -

It will greatly improve a community's ability to withstand risks associated with water by protecting and restoring water-related ecosystems. This aim also presents an indirect opportunity to mainstream ecosystem-based disaster risk reduction strategies and to further emphasize their merit as a "win-win" and "no regrets" response to the rising disaster and climate hazards emphasized in the Sendai Framework. Incorporating disaster risk assessment, mapping, and management into rural development planning as well as managing rivers, coastal flood plains, drylands, wetlands, and all other areas vulnerable to drought and flooding are some of the approaches suggested by the Sendai Framework. This includes identifying areas that are safe for human settlement while also sustaining ecosystem functions that help reduce risks.

1.3.2 - Goal 9: Industry, innovation, and infrastructure

Figure 11: Goal 9 - Industry, innovation, and infrastructure [UNDP, n.d.]

Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation

A fundamental requirement of a competitive economy is infrastructure, such as road, power, communications, and water networks, as well as primary and secondary educational facilities ("From Shared Risk to Shared Value : The Business Case for Disaster Risk Reduction," n.d.). Infrastructure failures during catastrophic events can disrupt essential services and endanger both large and small enterprises' viability. For instance, electricity outages during hurricanes may affect water delivery and transportation. When a bridge is destroyed by a flash flood, a nearby smallholder farm, workshop, or restaurant may be cut off from markets and supplies for days. Due to a lack of cash flow or reserves to be resilient, some firms, especially small and medium-sized ones, may be at risk of bankruptcy.

By 2030, it is predicted that the yearly investment needs for infrastructure development will likely reach US$53 trillion, or an average of 2.5 percent of global GDP ("DISASTER RISK REDUCTION AND RESILIENCE IN THE 2030 AGENDA FOR SUSTAINABLE DEVELOPMENT 1," n.d.).

TARGET 9.1 and 9.a -

Infrastructure development needs to be robust and sustainable in order to protect both current and future infrastructure investments. Any economy must make sure that key infrastructure is resilient to the effects of catastrophe and climate threats given the current trend of rising disaster risk. Resilient infrastructure systems have the capacity to foresee, take in, adapt to, and/or quickly recover from a catastrophic hazardous occurrence. This comprises both structural and non-structural solutions such flood control systems, defensive embankments, seawall repair, building regulations, building retrofitting, risk-sensitive planning, hazard mapping, and disaster risk financing("Making Infrastructure Disaster-Resilient Learning Lessons Evaluation" 2013).

1.3.3 - GOAL 11: Sustainable cities and communities

Figure 12: Goal11 - Sustainable cities and Communities [UNDP, n.d.]

Make cities and human settlements inclusive, safe, resilient and sustainable

More than two-thirds of the world's population will live in cities by 2050, according to projections of population growth and urbanization. Risk may be created by increasing population density, particularly when urbanization is quick, poorly managed, and taking place amid a lot of poverty. Furthermore, it is observed that regions of high-risk exposure overlap with the expanding populations and economic activity in most cities.

According to projections, by 2050, investments in urban development are anticipated to rise from US$7.2 trillion in 2011 to US$12 trillion by 2020 ("From Shared Risk to Shared Value : The Business Case for Disaster Risk Reduction," n.d.). By the 2070s, metropolitan assets might be exposed to sea level rise and floods to the tune of US$35,000 billion, a tenfold increase from today's levels (Corfee-Morlot and Chateau 2007).

Urban growth presents an unrivaled opportunity to eliminate vulnerability to hazards in urban centers by reflecting resilience and disaster risk reduction in policy, planning, design, and investment decisions over future urban development, as well as to avoid mistakes made in previous development given that 60% of what will be urban in 2030 has yet to be built ("ISSUE BRIEF Reducing Disaster Risk in Urban Settings," n.d.).

TARGET 11.1, 11.3, 11.4, 11.5, 11.b and 11.c -

Focusing on improving urban slums, integrating urban planning, minimizing the social and economic effects of disaster risk, boosting the resilience of the urban poor, adopting and putting into practice urban policies in line with the Sendai Framework, and creating sustainable and resilient urban infrastructure are strategic opportunities to ensure increase support for cities, safeguard current and future development prospects, and construct safer, more resilient cities throughout the world.

1.3.4 - GOAL 13: Climate action

Figure 13: Goal 13 - Climate action [UNDP, n.d.]

Take urgent action to combat climate change and its impacts

Disaster costs and risk are both heightened by climate change. Global climate change is altering hazard levels and escalating disaster risks in various industries and nations through variations in temperatures, precipitation, and sea levels, among other variables. Since 1980, climate hazards have caused 61 percent (1.4 million) of all fatalities, 87 percent (18,200) of all recorded damages, and 74 percent (US$2.6 trillion) of all catastrophes. ("From Shared Risk to Shared Value : The Business Case for Disaster Risk Reduction," n.d.)

People now live in twice as many flood-prone and cyclone-prone places, and there are now three times as many weather-related dangers. It is anticipated that the tendency will persist. For instance, by 2050 ("From Shared Risk to Shared Value : The Business Case for Disaster Risk Reduction," n.d.), climate change would add an additional US$1.4 billion to estimated yearly losses in the Caribbean. Higher losses and consequences in the future are anticipated, which would undoubtedly damage present and future development efforts as risks are compounded further by growing climate unpredictability and change.

TARGET 13.1, 13.2, 13.3, 13.a, 13.b -

to develop sustainable environment in changing climatic conditions investment in strategies for risk disaster reduction is necessary. Need actions on strengthening the resilient technologies and infrastructure that can absorb stress and shocks. Integrating all these in policies and plans for near future. Early warnings and monitoring water management and protecting development paths at all levels. This target may also have an impact on the long-term finance for disaster and climate risk management that is required to improve implementation and effect radical change.

Figure 14: Damages caused by heavy rain on 18 August 2021 [13] [MEMO, n.d.]

[13] This image was published on Middle East Monitor, creating new perspective| page after an event of flash flood in Addis Ababa. Around 217 localities were at high risk due to this flooding in the Addis Ababa, according to concerned institution. A firefighter is standing next to deadbodies, accident caused by flood.

Currently there are 56 activities going on in Addis Ababa by united nations in collaboration with different partners to improve the living quality and to make it more resilient city. [“Locations of Our Key Initiatives Linked to This Sustainable Development Goal,” n.d.]

1.4 - STUDY MOTIVATION

One of the most dangerous natural disasters in the world, including Ethiopia, is flooding, which destroys infrastructure and harms the environment. Ethiopia is frequently subject to flooding incidents that vary in size, length, and the region they effect. Extreme hydrological events, such as peak water flows and accompanying floods, are brought on by heavy rainfall and altered by a variety of watershed processes and anthropogenic activities. As a result of several driving forces such changing land use and climate change, flooding is projected to get worse. As a result of recent constructions and habitations in flood-prone locations, the frequency and causes of flood dangers are occasionally growing. Ethiopia is one of the world's fastest-growing countries, not only on the African continent but also globally. The nation has a population of almost 110 million people, with only 20% of the population residing in cities and the remaining 80% in rural regions. Being one of the world's least urbanized nations, and it has hurdles in terms of general development. Due to this urbanization and climatic conditions the management of water and drainage system suffers and requires a certain investment.

Figure 15: Map of Ethiopia (By Author)

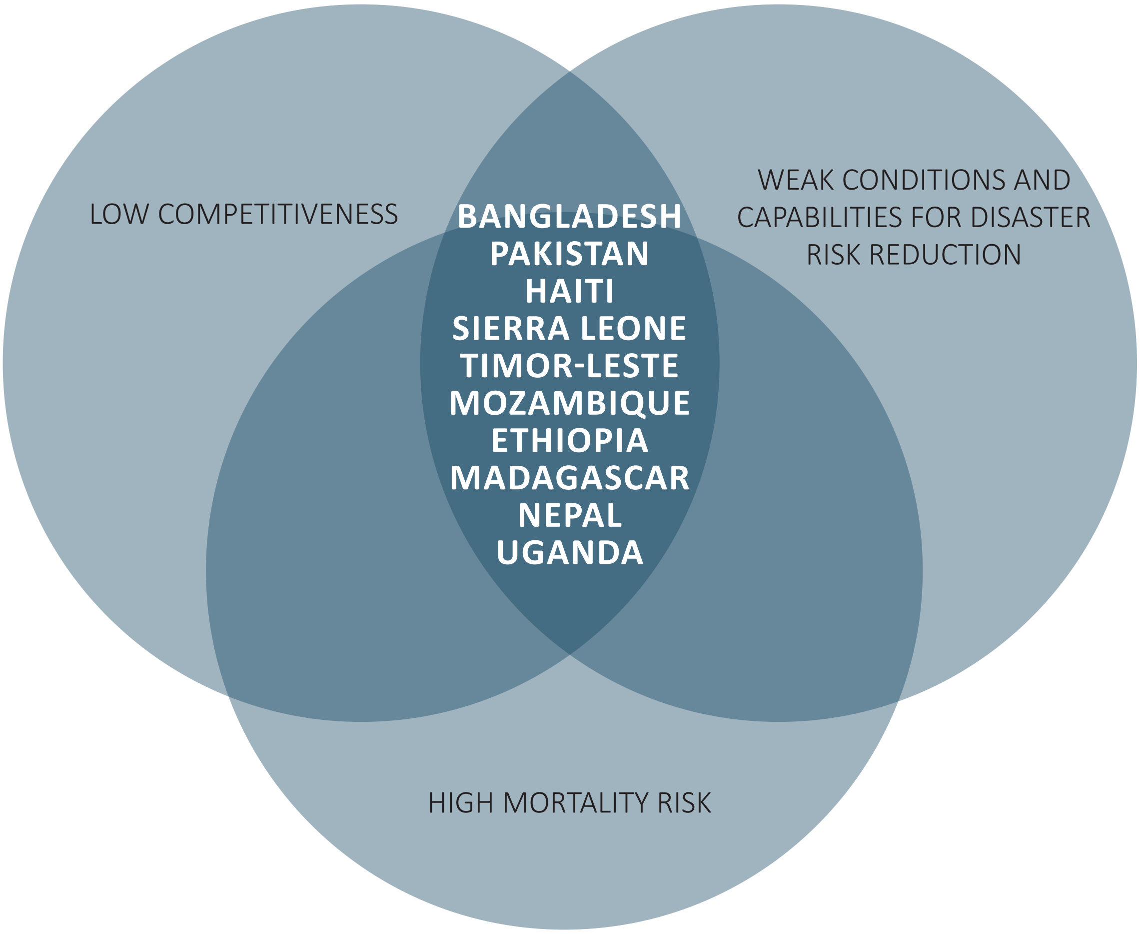

Figure 16: Countries with high mortality risk, low competitiveness and weak conditions and capabilities of risk reduction [14] (Redrawn by Author)
[“From Shared Risk to Shared Value : The Business Case for Disaster Risk Reduction,” n.d.)]

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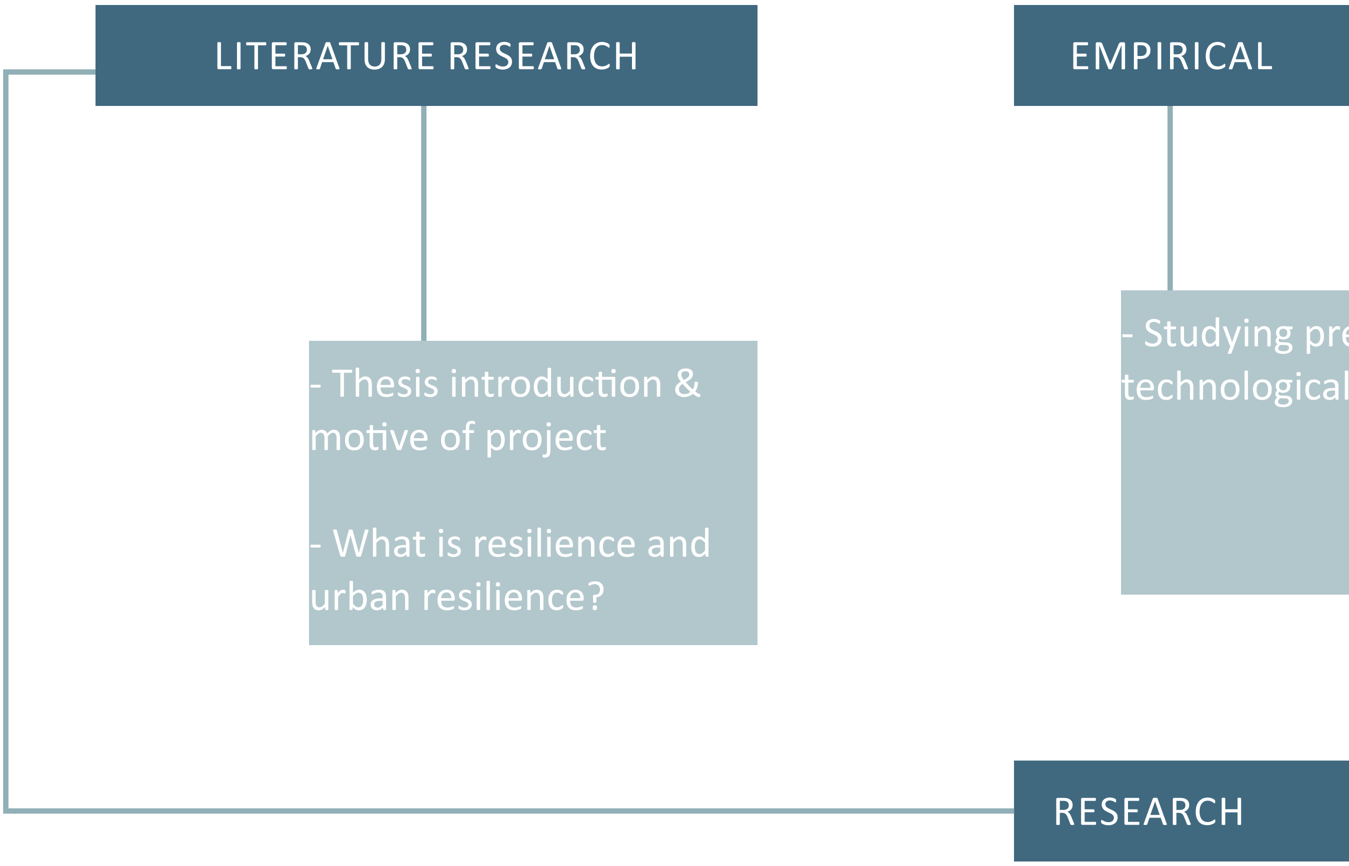
[14] *Source: UNISDR, based on the WEF Competitiveness Index 2011; GAR Mortality Risk Index; DARA Risk Reduction Index 2012*

1.5 - THESIS STRUCTURE

This thesis will discuss about those resilient programs that shaped the Addis Ababa until now and how we can improve the situation for future in term of livability for inhabitants and the reliance of city against the environment and the changing socio-economic paradigms.

The first part discusses the general literature, the main motive of the thesis. As the research site in located in Addis Ababa, Ethiopia; and we are doing research from Italy so we will define our limitations as well to rely on data that we will get from different sources but not directly from the stake holders.
Then the scientific background and preview of the topic, as a scientific background and research basis is necessary to understand the problem before starting to write this research.

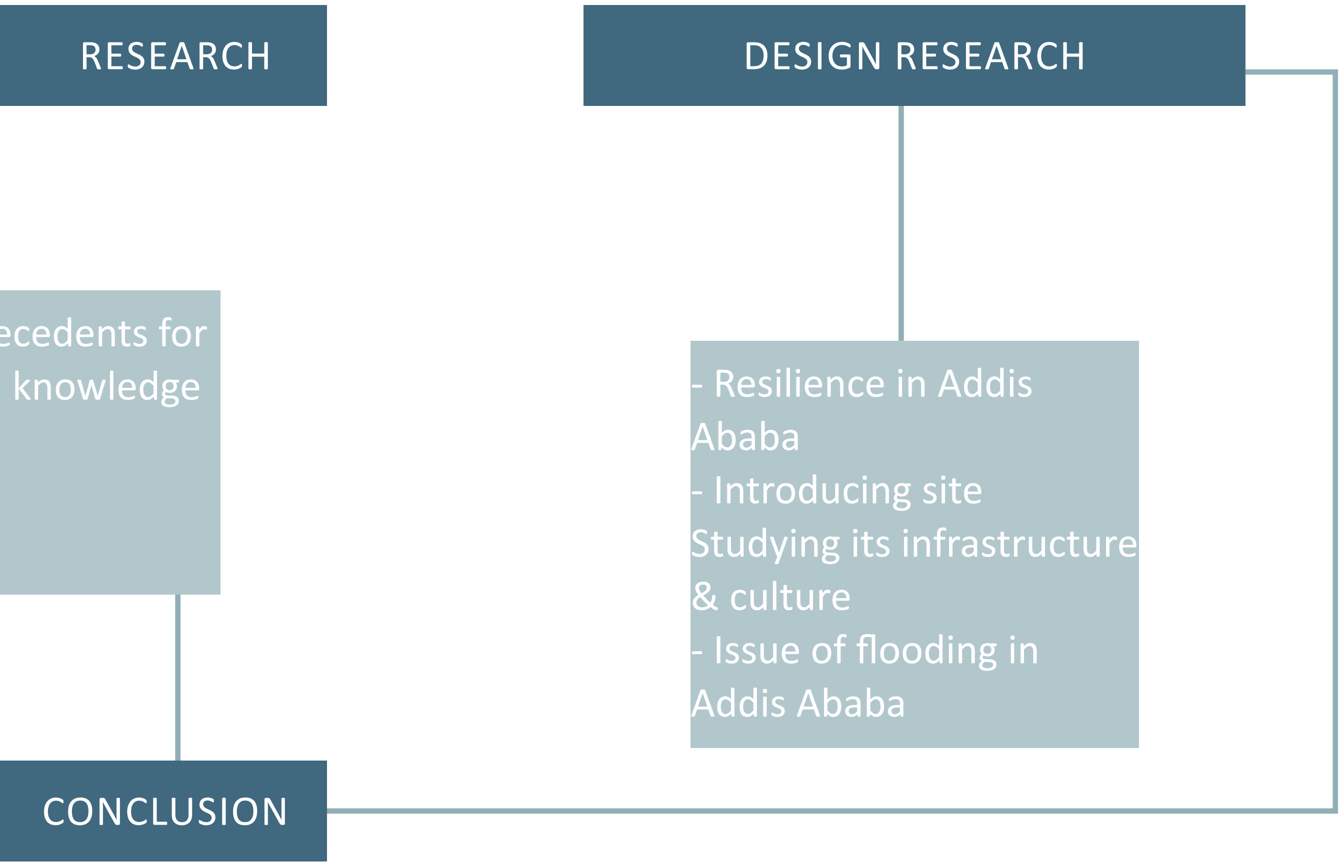
We will define the background of the research topic and discuss the definition of problem| the resilience.



As it is necessary to debate the word resilience as it is being discussed in different dimensions and aspect, so to define the main goal of our thesis we will explore the scientific background of resilience and then define urban resilience and its relationship with flooding and then we will sort out our direction according to our research.

In the second part we are doing empirical research. We selected some case studies at different levels and then we will study them in detail and understand the reason they were built and how they are responding to the environment they are in.

In the third part we will discuss the main site. We will introduce the urban resilience in Addis Ababa, and we will go in detail of the city focusing on mobility, society, their energy resources, the typology of living and place, the kind of climate geography they live in, their local materials as it will help in sustainable regeneration. Apart from that we will discuss the situation of WASH, their waste management and their production quantity and quality. And the impact of all those on society reshaping.



As flooding is the main topic, we will be working on so we will define the climatic patterns and the other main factors causing these issues. Then defining our problem statement and our research questions and agenda that will set our line straight to achieve our goal to get a resilient urban project.

We will define our methods and approach to identifying the problems and proposing a prototype that works well in field.

In the next phase of this part, we will discuss the research methodology. As to create a better place it's not just government and administration and higher authorities that create proposal and make a better place. But it also involves the bottom-up approach in which stake holders take part to give identity to the place and making their own place where they can live in together as a healthy society.

So, we will work on theoretical part of defining strategies for master planning and then the thematic order to get to the outcome of proposal.

1.6 - RESEARCH BACKGROUND AND PROBLEM FIELD

RESEARCH BACKGROUND

The city of Addis Ababa is facing a lot of changes in all aspects including climatic change, socio economic, and spatial manner. The administration has been applying different plans to reshape and reconstruct a resilient city in all dimensions. These scenarios are kept on shaping the future of Addis Ababa experiencing wide range of changes.

However, empirical researchers argue that despite remarkable achievements in restructuring of the city to make it more livable, there are several and complex urban downsides and bottlenecks. (Assefa 2018)

PROBLEM FIELD

In Africa the number of residents doubled the amount then the present figure through the period of next 20 years. (“World Population Prospects The 2008 Revision,” n.d.) this rise in population with this constant changing climatic conditions make the Ethiopia prone to natural disasters. Specially temperature-related risks have emerged as significant natural hazards of the twenty-first century, owing to greater changes in climate and weather linked with catastrophic occurrences of rainfalls specially resulting in flash flooding. Because of this an expected rise in the global average surface temperature by about 0.9 °C–1.3 °C for the period 2016 to 2035. (Revi et al., n.d.)(“Geography of Ethiopia,” n.d.)

In my case study Addis Ababa, since 1988, has been increasingly flooded. The city’s rapid economic growth has accelerated urbanization; also, an increase in summer season precipitation is expected, perhaps leading to flooding.

The area is vulnerable to riverine and flash floods because of extreme climatic events and upper catchment activities, and the susceptibility is worsened by an inadequate drainage system, rapid home expansion along riverbanks, and the use of unsuitable construction materials. (Birhanu et al. 2016a)

1.7 - RESEARCH QUESTIONS

This research will discuss following factors and the design proposal will answer those factors:

1- What are the possible aspects that make a city more resilient?

2- What are the strategies that can be opted to make a flood resilient city, accommodating climate changes and population density?

3- What kind of interventions can improve the quality of life that can have a dialogue with people and their cultures along with the environmental changes?

4- What kind of Strategical interventions can be introduced to make a resilient city?

1.8 - SCOPE & LIMITATION

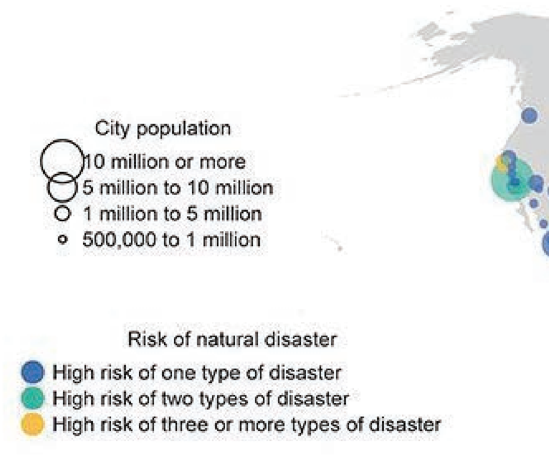
Specific areas or applications are highlighted when they indicate the usage of resilience thinking or are historically significant in the development of resilience concept.

Climate resilience and disaster resilience (in communities and other settings) have been deemphasized. Such a reduction in focus should not be seen as a dismissal of their relative relevance or historical and conceptual connections to the broader concepts of resilience presented here.

We need to provide proposal considering this rate of density in urban areas and also user need and incorporate different income groups and providing facilities.

For this user questionnaire and site survey is mandatory. But we are doing a desk job as visiting site is not possible. But to tackle the issue we tried to get data from workshop done by **TU DELFT ADDIS ABABA LIVING LAB**[15] . We took the images of Addis Ababa and the user need data that was useful for deriving some strategies.

So, for now we are relying on data we get from different sources on internet and based on that we will derive a hypothetical conclusion.



UNDESA

[15] *The project's objective is to enhance the standard of living for resettlement residents of Addis Ababa, and a group of academics from TU Delft and the Ethiopian Institute for Architecture Building Construction and City Development (EiABC) have been collaborating on the initial research outputs.*

1.9 - EXPECTED OUTCOME

This master's thesis will propose policies for flood-resistant home recovery and permanency in areas threatened by natural hazards because of climate change. Natural hazards or disasters are depicted in contemporary literature as the result of natural events that result in the loss of many lives and infrastructure, as well as the destruction of people's economies and lifestyles.

The factors of resilience that can work in the chosen place will be discussed. Some proposals will be hypothetical because they must be tested on the site, but others will be explored on a literature level and then implemented in the chosen site.

These implementations will consider techniques based on site and culture requirements, as well as lessons learned through our literature, case studies, and actual instances of projects executed by experts in various locations across the world. It will consider the needs of stakeholders and devise a plan to teach them how to fight, absorb, and survive in such situations.

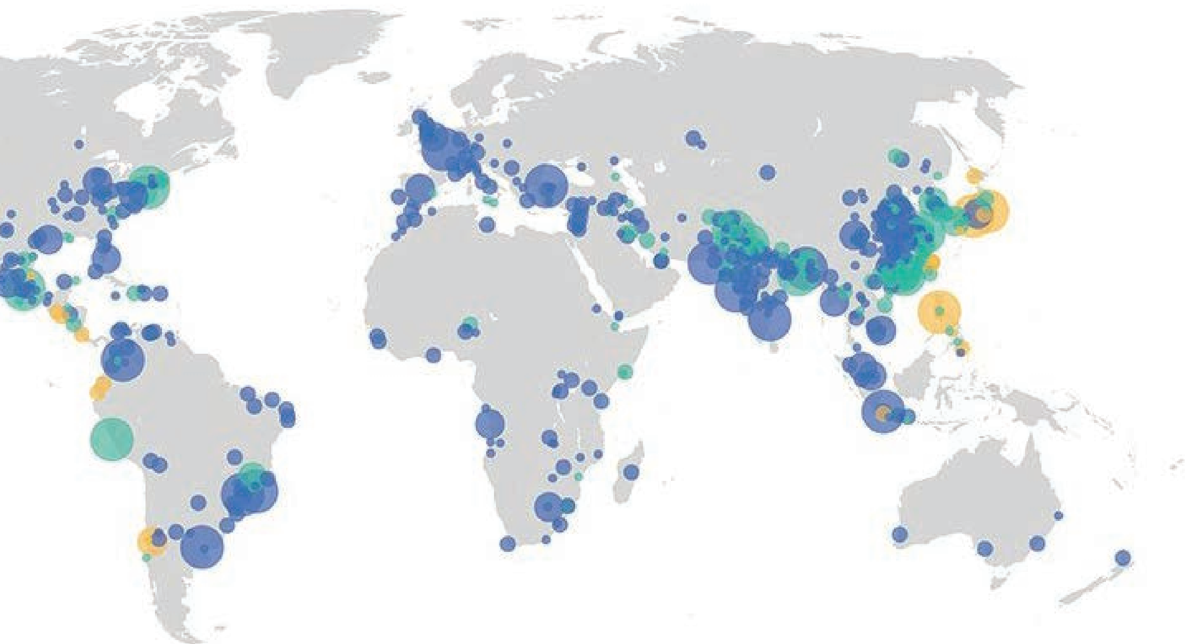


Figure 17: Cities risk of exposure of natural disasters ["The World's Cities in 2018," n.d.]

Figure 18: A big market of Addis Ababa [16] (Eduardo Di Muro, n.d.)

|02

RESILIENCE AND URBAN RESILIENCE

“The world breaks everyone and afterward many are strong at the broken places”

Ernest Hemingway, A farewell to Arms (1929)

[16] *A book written by Eduardo Di Muro which illustrates the social character of urban capitals of Africa. He tried to explain the scenes of community, markets and streets and drew the culture through his drawings.*

2.1 – OVERVIEW

In recent years, initiatives to increase resilience to natural disasters have occupied the forefront. To do this, it is necessary for more clarity to be provided regarding what measures should be taken, who is responsible, what is an appropriate strategy, and where to allocate scarce resources. This includes policy makers, planners, engineers, sociologists, and communities. We must understand the notion of resilience and how it relates to flooding to create this research project.

Resilience in its broad sense refers to the ability to adapt to changing conditions, and to maintain or recover functionality after a disruption (Michael Mehaffy and Nikos A. Salingaros 2013). Resilience caters for all walks of life. Mainly used in designing and engineering of systems to better adapt to changing environment and to maintain functionality in different scenarios, the word has caught on in other sectors as well. To provide a brief example resilience in engineering can refer to a lot of phenomena covering technical, economic, and organizational perspectives. Resilience can be further exemplified by robustness, redundancy, resourcefulness, and rapidity. Already a lot of publications have been cited to define the term. For example, a review performed by Dr Sara Meerow, and Dr Joshua Peter from the Arizona State University and University of Michigan respectively identified 25 definitions of urban resilience. (In Fig 19 and Table 1)

But the inconsistencies and vagueness in these definitions, as well as the publications in which they occur, demonstrate that urban resilience is a controversial notion. Given the difficulties in defining and describing “urban” and “resilience” separately, as well as the different disciplines involved in this field of research, multiple definitions and conceptual tensions are unsurprising. The following diagram exhibits the influential works of various scholars and professors in the field of architecture.

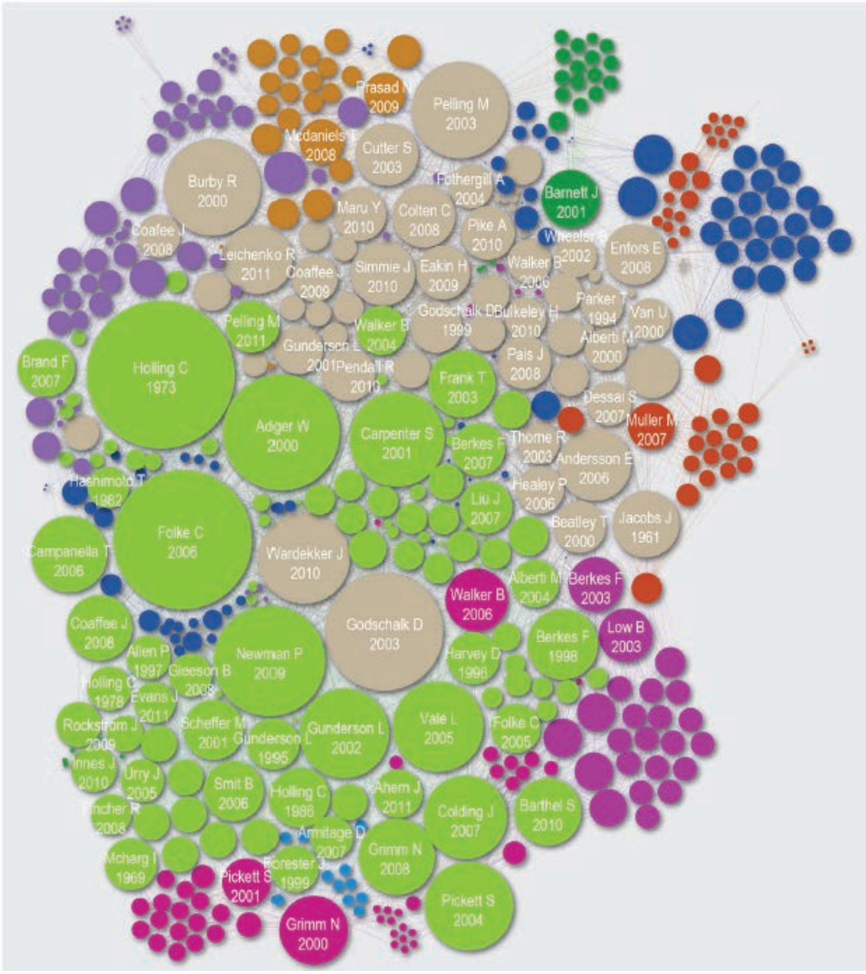


Figure 19: Influential publications in the urban resilience literature [Meerow, Newell, and Stults 2016a]

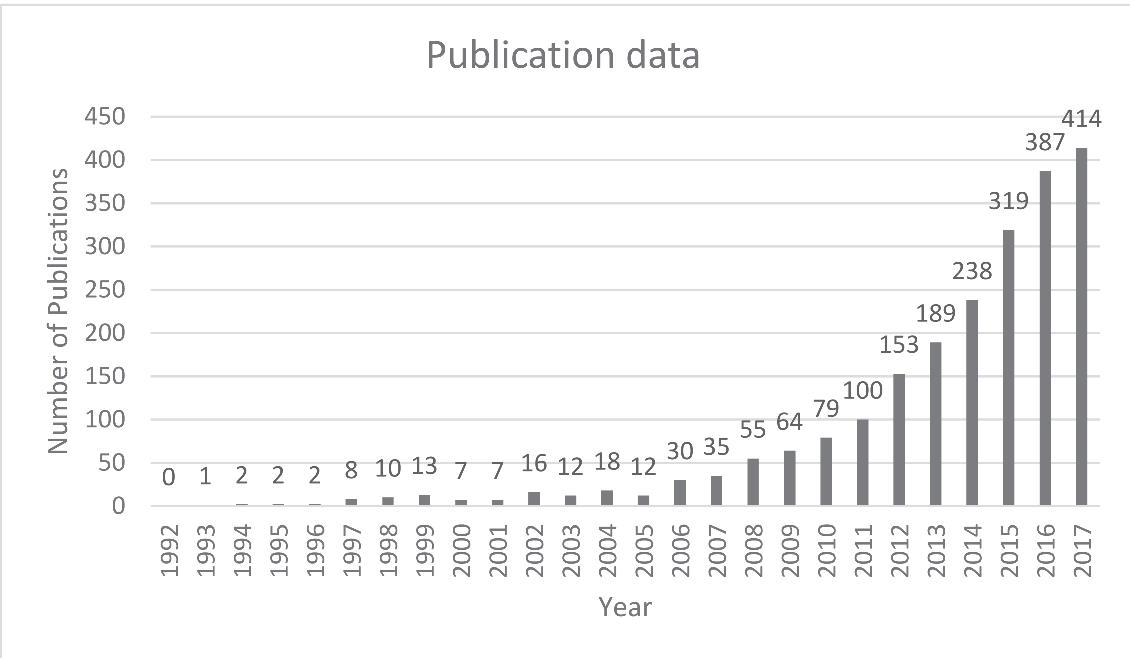


Figure 20: The rapid rise of urban resilience research (1992–2017) [17] [23]

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[17] *Source is from book Urban Resilience for risk and adaptation governance| Chapter 1 – The challenge of urban resilience operationalization*
Authors: Ombretta Caldarice, Grazia Brunetta, and Nicola Tollin
Authors' elaboration based on the Scopus database. The research query represents the number of publications for each year from 1992 (UN Conference on Environment & Development, Rio de Janeiro) to 2017 with the terms "urban resilience" in the title, abstract, or keywords)

To give a brief overview these 25 definitions of how resilience is being discussed by different authors for various subject areas are as follow.

No.	Authors (years)	Subject area	Definitions
1	**Alberti et al. (2003) [24]**	**Agricultural and biological sci-ences; envi-ronmental sci-ence**	**“. . . the degree to which cities tolerate a 1170).**
2	Godschalk (2003) [25]	Engineering	“. . . a sustainable network of physical sys
3	Pickett et al. (2004) [26]	Agricultural and biological sci-ences; envi-ronmental sci-ence	“. . . the ability of a system to adjust in th
4	**Ernstson et al. (2010) [27]**	**Environmental science; social sciences**	**“To sustain a certain dynamic regime, u change” (p. 533).**
5	Campanella (2006) [28]	Social sciences	**“. . . the capacity of a city to rebound fro**
6	Wardekker et al. (2010) [29]	Business man-agement and accounting; psychology	“. . . a system that can tolerate disturb-an by reducing or counteracting the damage disturbances” (p. 988).
7	**Ahern (2011) [30]**	**Environmental science**	**“. . . the capacity of systems to reorgan- systems that are “safe to fail” (p. 341).**
8	**Leichenko (2011) [31]**	**Environmental science; social sciences**	**“. . . the ability . . . to withstand a wide a**
9	Tyler and Moench (2012) [32]	Environmental science; social sciences	“. . . encourages practitioners to consid-e be predictable” (p. 312).
10	**Liao (2012) [33]**	**Environmental science**	**“. . . the capacity of the city to tolerate f occur, so as to prevent deaths and injuri**
11	Brown et al. (2012) [34]	Environmental science; social sciences	“. . . the capacity . . . to dynamically and e an acceptable level. This defini-tion inclu re-organize in order to es-tablish the nec thrive at best” (p. 534).
12	Lamond and Prov-erbs (2009) [35]	Engineering	“. . . encompasses the idea that towns ar
13	Lhomme et al. (2013) [36]	Earth and planetary sciences	“. . . the ability of a city to absorb dis-turb
14	**Wamsler et al. (2013) [37]**	**Business management and ac-counting; energy; engineering; environmental science**	**“A disaster resilient city can be under-st (b) reduce current and future susceptibi sponse; and (d) establish functioning m**

	Citations count
alteration before reorganizing around a new set of structures and processes" (p.	**212**
stems and human communities" (p. 137).	113
ne face of changing conditions" (p. 373).	101
rban governance also needs to build transformative capacity to face uncer-tainty and	**46**
om destruction" (p. 141).	44
nces (events and trends) through char-acteristics or measures that limit their impacts, e and disruption, and allow the system to respond, recover, and adapt quickly to such	30
ize and recover from change and dis-turbance without changing to other states . . .	**24**
array of shocks and stresses" (p. 164).	**20**
er innovation and change to aid recovery from stresses and shocks that may or may not	11
flooding and to reorganize should phys-ical damage and socioeconomic disrup-tion ies and maintain current socioeco-nomic identity" (p. 5).	**6**
effectively respond to shifting climate circumstances while continuing to func-tion at udes the ability to resist or with-stand impacts, as well as the ability to recover and cessary functionality to prevent catastrophic failure at a mini-mum and the ability to	5
nd cities should be able to recover quickly from major and minor disasters" (p. 63).	5
bance and recover its functions after a disturbance" (p. 222).	4
ood as a city that has managed. . . to: (a) reduce or avoid current and future hazards; ility to hazards; (c) establish functioning mechanisms and structures for disaster re- echanisms and structures for disaster recovery" (p. 71).	**3**

15	Chelleri (2012) [38]	Earth and planetary sciences; social sciences Brugmann (2012) [40]	". . . should be framed within the resili-er (system reconfiguration) views" (p. 287).
16	**Hamilton (2009) [39]**	**Engineering; social sciences**	**"ability to recover and continue to pro-v ering in the face of calamities and other**
17	Brugmann (2012) [40]	Environmental science; social sciences	"the ability of an urban asset, location ar rents and other cash flows – under a wid
18	**Coaffee (2013) [41]**	**Social sciences**	**". . . the capacity to withstand and re-bo**
19	Desouza and Flanery (2013) [42]	Business man-agement and accounting; social sciences	"ability to absorb, adapt and respond to
20	Lu and Stead (2013) [43]	Business man-agement and accounting; social sciences	". . . the ability of a city to absorb dis-turl
21	**Romero-Lankao and Gnatz (2013) [44]**	**Environmental science; social sciences**	**". . . a capacity of urban populations and**
22	Asprone and Latora (2013) [45]	Engineering	". . . capacity to adapt or respond to un-u
23	**Henstra (2012) [46]**	**Social sciences**	**"A climate-resilient city . . . has the ca-p hazards, and to recover quickly from res**
24	Thornbush et al. (2013) [47]	Energy; engi-neering; social sciences	". . . a general quality of the city's social,
25	Wagner and Breil (2013) [48]	Agricultural and biological sciences	". . . the general capacity and ability of a ter and rapidly move on" (p. 114).

Table 1: Definitions of resilience by different authors [Meerow, Newell, and Stults 2016b]

nce (system persistence), transition (system incremental change) and trans-formation	2
vide their main functions of living, commerce, industry, government and social gath- r hazards" (p. 109)	**2**
nd/or system to provide predictable performance – benefits and utility and associated le range of circumstances" (p. 217).	1
ound from disruptive challenges . . ." (p. 323).	**1**
changes in urban systems" (p. 89).	1
bance while maintaining its functions and structures" (p. 200).	1
d systems to endure a wide array of hazards and stresses" (p. 358).	**1**
usual often radically destructive events" (p. 4069).	0
acity to withstand climate change stresses, to respond effectively to cli-mate-related sidual negative impacts" (p. 178)	**0**
economic, and natural systems to be suf-ficiently future-proof" (p. 2).	0
community to withstand stress, survive, adapt and bounce back from a crisis or disas-	0

The definitions from the authors above discussed resilience in various aspects. We will discuss resilience further in detail with respect to its evolution in architecture and planning.

The following chapter provides the definition of word resilience its definitions in detail in engineering, ecology and socio ecological term and comparison between engineering resilience, a term which has been used for decades in the industry to define the ability of products to withstand harsh conditions and work ideally, while on the other side the ecological resilience, a term that focuses on multiple equilibria of ecological systems and their ability to return to the stable state. This will lead us to its evolution to architecture and planning.

Then we will discuss the urban resilience and definitions in different fields like environment, governance, and health etc.
Then we will provide a framework of its indicators and further elaborate it with Rockefeller foundations framework.
Then we will discuss the needs and challenges for improving resilience and later in chapter we will discuss resilience in term of flood risks resiliency.

Our project is "Urban resilience and Addis Ababa" so to build a solid base to understand the urban resilience and creating strategies for our case studies we need to develop a strong theoretical research frame for further better results.

2.2 - RESILIENCE | DEFINITION AND OVERVIEW

As many discussed the term resilience (discussed in above overview) so there are variety of definition in different aspects. All deal with system's capacity to resist and/ or recover from disruption, disturbance, or potentially dangerous events. Numerous definitions also address concepts like adaptability and flexibility, as well as early recognition and quick failure recovery. Some people make a distinction between an event's bounce "back" and bounce "forth." ("Disaster Resilience: A Bounce Back or Bounce Forward Ability?" 2011)

Then in 2011 a useful definition was introduced by NIU[18]: (Treasury 2011)

"The ability to withstand disruption, absorb disturbance, act effectively in a crisis, adapt to changing conditions, including climate change, and grow over time."

This evolved over the years, first from Hollings in 1973, Canadian theoretical ecologist Crawford Stanley Holling. Holling was the first person to actualize the term resilience in an ecological perspective by applying the concepts to not materials as in engineering, but rather ecosystems (Balducci 2020). According to his research, stability is one of the core aspects that help in actualizing the concept of resilience and he defines stability as:

"The ability of a system to return to an equilibrium state after a temporary disturbance [(Holling 1973a]."

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[18] NIU stands for National infrastructure unit, which access the situation and propose resilient strategies.

ENGINEERING RESILIENCE|

Before Holling's definition the term of resilience was just a linear logic. It was used for material's property to survive the pressure and shocks because each material has its own elastic strength. Depending on the strength and pressure applied, the ability of that material to withstand and resist the pressure and how fast it recovers define the resilience of material (Adger 2000). According to Davoudi factor of resilience increases with its capacity to come back to its original state. (Davoudi, Shaw, Haider, Quinlan, Peterson, Wilkinson, Fünfgeld, McEvoy, and Porter 2012)

ECOLOGICAL RESILIENCE|

In Holling's definition, he negates the theory of engineering resilience. He discussed that its nonlinear system in which the system will not be in one equilibrium but in multiple equilibrium; it's not like how the material resilience works. He discussed the term resilience with respect to system in which with some stresses and shocks, the system will absorb it or adapt it which is not like coming back to its original form but constantly developing and adapting to new situations which is constantly evolving.

Then holling's stated it as:

> **Resilience determines the persistence of relationships within a system and is a measure of the ability of these systems to absorb changes of state variables, driving variables, and parameters, and still persist. (p. 17) [Holling 1973b].**

This was termed as ecological resilience (Adger 2000) (Walker et al. 2004). Following a focus on ecological systems and disaster risk reduction (Walker et al. 2004) (L. H. Gunderson 2000)

> **"The capacity of a system to undergo disturbance and maintain its functions and controls" [59] [60]**

(Lance Gunderson and Holling 2003) (Lance Gunderson, Allen, and Holling 2010)
Or according to Folke the ability of the buffer zones to absorb and withstand the outside disruptions and constantly developing and evolving. (Folke 2006b)

2.2.1 - ENGINEERING RESILIENCE AND ECOLOGICAL RESILIENCE: A COMPARISON

This concept became known as ecological resilience in the literature. According to this stance and way of thinking, the phenomenon discards the presence of a single equilibrium system rather it evokes the concept of multiple equilibria. This can be thought of as a buffer capacity of a system to endure external disturbances (Folke 2006a). So, to summarize our discussion regarding the comparison of engineering resilience and ecological resilience, one can say that the former focuses on the efficiency of a system and its vicinity to an equilibrium state, while the latter focuses on the concept of multiple equilibria (Davoudi, Shaw, Haider, Quinlan, Peterson, Wilkinson, Fünfgeld, McEvoy, Porter, et al. 2012). Engineering resilience, on the other hand, is limited to the behavior of a linear system, in which resistance to change is handled in terms of recovery.

A more recent emphasis has been placed on the resilience of the built environment and infrastructure environment (Treasury 2011) (National library of Medicine, n.d.) (Bruneau et al. 2003) .

Summing it up we can define resilience in Holling views as the ability to absorb and adapt to a disturbance, not necessarily the ability to return to a previous steady state. In consequence, we can state that according to Holling, resilience is basically

"A property that determines the persistence of relationships within a system and is a measure of the ability of these systems to absorb changes of state variables, driving variables, and parameters, and still persist.(Balducci 2020)"

2.2.2 - RESILIENCE IN SOCIAL ECOLOGICAL SYSTEMS

Continuing the above definitions of stability of system through these stress and shocks, the definitions did not stay confine till there. With the time it was discussed in socio-ecological domain with reference to resilience. This system included social structure in ecosystem to make it socio ecological resilience. It is worth mentioning in this section the fact that pristine eco-systems exist (without human activity), and the main goal of the management committee should be to reduce the human interference to a minimum in order for the eco-systems to be restored in their true form was discarded by the resilience scholars who first studied the phenomenon.

Rather the fact is the opposite, most eco-systems have been manipulated by human activity. The formal shift to the social-ecological systems (SESs) was then introduced (F Berkes, Colding, and Folke 2003). To define SES, it's the combination of different elements including ecology, culture, political component, and economic and technological component. So, Multiple stable attractors (multiple system identities) and the adaptive cycle are then the two primary areas of resilience theory applications.

SOCIO-ECOLOGICAL RESILIENCE|

So defining the definition it is complex system which is adaptive and bound by spatial and functional edges.

Its definition is combination of Holling's (Engineering Within Ecological Constraints 1996) and Glaser's (Glaser et al. 2012) ("Human-Nature Interactions in the Anthropocene," n.d.) definitions. Its main points are:

1. *the evolutionary ecological approach, which emphasizes cycles of adaptive renewal in multi-scale, panarchical [19] structures.*

2. *the application of system knowledge to strategic planning and adaptive management, with a focus on non-linear dynamic systems.*

3. *the formal and quantitative methods.*

"social and ecological systems are themselves linked [...] to synergistic and co-evolutionary relationships" ["social and ecological systems are themselves linked [...] to synergistic and co-evolutionary relationships" (Adger 2000]

[19] *"A dancing supply chain" A panarchy is a system of adaptive cycles connected at various levels on time, space, and meaning scales. It serves as the foundation for transformational SCM and more accurately captures the intricacies of the world than reductionist and static theories ever could.[59]*

So, summing up socio-ecological resilience according to Folke (Folke 2006b) is:

1. Multiple equilibria: Complex systems typically have multiple metastable regimes rather than a single equilibrium point.

2. Disturbance:

> **"[..] the magnitude of disturbance that can be absorbed before the system changes its structure by changing the variable and process that control behavior"**
>
> **[Lance Gunderson and Holling 2003]**

3. Several unique scales with interactions across scales. Systems, according to Gunderson and Holling (Lance Gunderson and Holling 2003), generate a multilevel hierarchical structure with varying levels of self-organization.

2.2.3 - Evolution of resilience from socio-ecological field in term of architecture and planning

According to Davoudi, Planning has historically been receptive to incorporating fresh ideas into its theories and methods (Davoudi, Shaw, Haider, Quinlan, Peterson, Wilkinson, Fünfgeld, McEvoy, and Porter 2012).

Many terms, methods, and metaphors have been swiftly incorporated into planning theories and practices; some have strong foundations, while others have gained uncritical acceptance and resilience as well. The idea of resilience has broadened during the past ten years, as was stated in the previous section. It was created as a result of the integration of concepts from several multidisciplinary disciplines, including those related to ecology, engineering infrastructure, psychology, behavioral sciences, and disaster risk reduction. Due to resilience's ambiguous nature, a variety of concepts and research methodologies have been developed to address it. This combination leads to planning and architecture as it involves all these multi disciplines and resilience of all these components is necessary to create a resilient complex system.

Due to the essential significance of the human ecosystem framework at many scales, the metaphor of social-ecological resilience aids in synthesizing the connection between ecology and social sciences. Returning to planning, we can pinpoint three qualities that make it possible to apply the notion of social-ecological resilience to urban and territorial systems:

1. Humans are included in ecosystems.

"The models derived from the human ecosystem framework are not a matter of humans versus nature, but humans and ecological processes combined into a reciprocally interactive network" [Pickett, Cadenasso, and Grove 2004]

2. Territorial systems are intricate structures. They are the culmination of various interconnected subsystems.

3. An adaptive cycle defines a territorial system. The ongoing adjusting and self-organization of urban systems is made possible by ecological, social, and economic forces.

Resilience emphasizes the necessity for greater flexibility in the planning process as a result. It views change as commonplace and recognizes that dynamism plays a fundamental role in how systems behave. Because of this, there is a strong affinity between social learning, co-management, and participation theory and governance theory. A resilient city, according to Godschalk's 2003 argument, is a network of physically sound human communities. (Godschalk 2003)

As well as resilience is further evolved in different sectors of planning of communities.

Understanding of the variables that boost resilience in communities, the built environment, and infrastructure has improved as a result of recent studies on resilience measurement and assessment. There are many different opinions on this, but a few commonalities are beginning to emerge:

INFRASTRUCTURE RESILIENCE|

Robustness, redundancy, modularization, safe-to-fail, diversity, and adaptability are among the guiding principles (Hughes, Healy, and NZ Transport Agency, n.d.) (da Silva, Kernaghan, and Luque 2012).

ORGANIZATIONAL AND COMMUNITY RESILIENCE|

Change preparedness, robust networks, leadership and culture, situational awareness and reactivity are among the guiding principles (Lee, Vargo, and Seville 2013).

2.3 - RESILIENCE AND SUSTAINABILITY

There is a rising need to develop precise, integrated solutions to reduce infrastructure and system failure as well as the broader effects of hazards due to the increased reliance on interdependent infrastructure and technologies that can be affected by hazards like flooding. An equally wide range of institutions and entities are involved in the efforts to solve these difficult problems, which span a number of different fields. These include, among others: risk management, resilience, and civil defense and emergency management (CDEM), as well as social sciences, economics, and sustainable development. Disaster risk management is one of these.

Although attempts have been undertaken to integrate many of these fields together, the terminologies used are frequently unclear and overlap. Practitioners and scholars from each of these domains have established their own conceptual frameworks and distinct sets of terms, parameters, and definitions. Among these concepts are resilience, robustness, redundancy, sustainability, risk, hazard, vulnerability, sensitivity, and exposure, to name a few. The relationships between several of these phrases as well as the definitions of some of them are frequently ambiguous. In fact, as we stated in the concept of resilience in regard to ecology and engineering, terminology may have distinct meanings when applied within different disciplines of study.

But the link of resilience and sustainability is the need of today.

Sustainability | The sustainability of a system is a measure of its lifespan. Resilience is one measure of the potential sustainability of a system; so, resilience is to sustainability what, say, blood pressure is to health. Since resilience is a component of sustainability, the opportunity should exist to do both things simultaneously.

[McRoberts 2010]

In many diverse contexts, including green growth, urban design, and land-use planning, extensive study has been done on the connections between sustainability and resilience. A resilient community is one that attempts to comprehend and coexist with the physical and environmental factors existing at its place. In order to create resilient communities, the significance of sustainable urban design, land-use planning, and construction codes.

According to Godschalk,

“sustainable development must be robust to the inherent unpredictability of the planet”

as a fourth criterion to be added to the sustainability's economic, environmental protection, and social requirements. (Godschalk 2003)

It is obvious that unsustainable practices have led to many communities becoming non-resilient and vulnerable given the substantial and arguably unshakeable weight of evidence pointing to humanity's influence on global warming and climate patterns, as well as our ongoing modification and destruction of ecosystems and landscapes. The obvious solution of stopping or changing these unsustainable habits is known as mitigation. Despite being widely supported, mitigation has, up until this point, mostly failed for a variety of reasons. Since communities will continue to be vulnerable as a result of our unsustainable habits, adaptation has become more and more important. However, we can adapt and "engineer" communities to become more resilient.

The third method, which may be dubbed "transformation," entails reimagining and reshaping our communities in the context of a new functional regime. This method may be more difficult than mitigation. Figure 3's subsequent diagram seeks to tie these ideas together from the immediate (shock event) to the long-term (new shock or stress event). The "ball-in-cup" paradigm (Holling) (Holling et al. 2012) is used in this diagram, which also includes the resilience concept of "bounce forward" (Manyena) ("Disaster Resilience: A Bounce Back or Bounce Forward Ability?" 2011). Focusing on "robustness" and returning to the status quo would be a common resilience reaction to a short-term shock event.

This may increase the chance of being dependent on subpar, unresilient, or possibly unsustainable methods. Instead, it is proposed that a society or system could recover from a shock event and enter a new state or paradigm by planning and offering adaptable/flexible solutions. This new paradigm would be more flexible and resistant to stress and shock occurrences alike.

It has been hypothesized that this change will eventually resemble sustainability. Evidence supports the numerous advantages of green infrastructure (water sensitive urban design) in the context of flood prevention, including the ability to buffer flood events (increase resilience), as well as provide long-term stormwater quality/quantity improvement, urban heat island reduction, biodiversity and amenity enhancement, among other benefits.

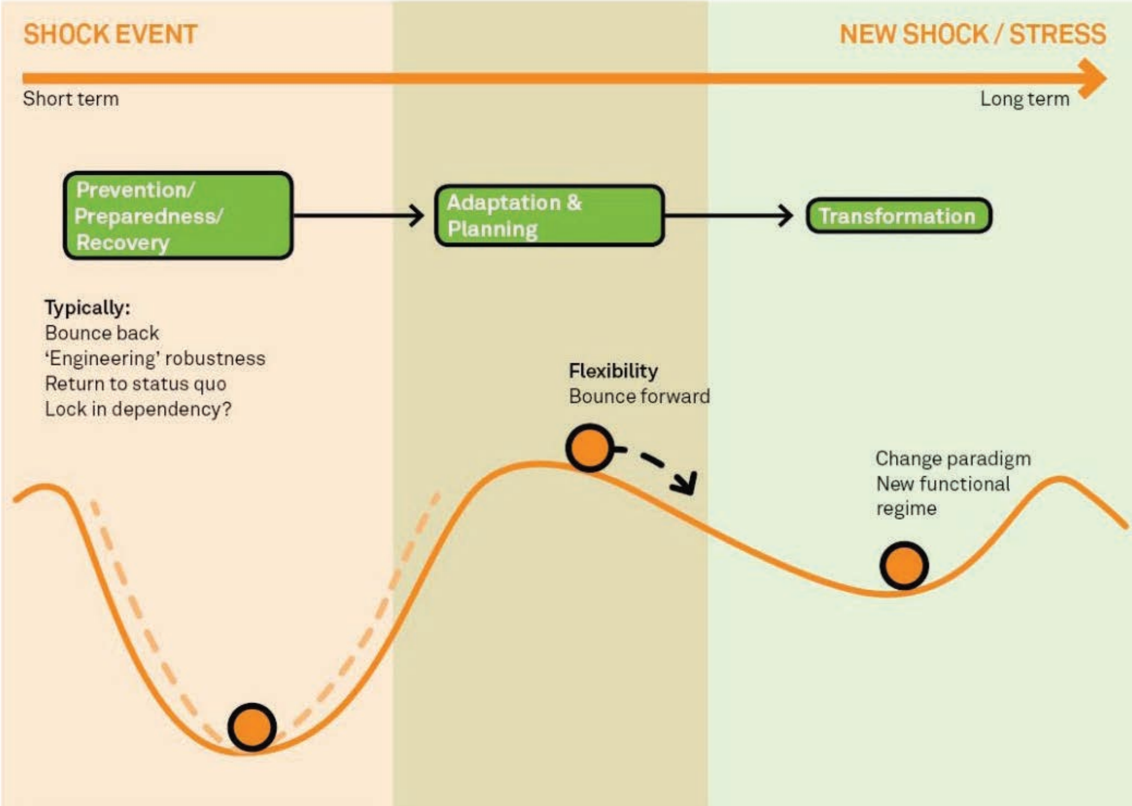


Figure 21: Temporal aspects of resilience (Todorovic et al. 2017)

In conclusion, it is apparent that resilience and sustainability are connected concepts. There are an increasing number of instances when increasing resilience has also improved sustainability. This is apparent, for instance, in the fields of decentralized infrastructure provision, green infrastructure design, and climate change mitigation (Ahern 2011) (Pickett, Cadenasso, and Grove 2004).

2.4 - URBAN RESILIENCE | DEFINITION AND OVERVIEW

Urban resilience refers to a city's ability to function such that its residents and workers, particularly the poor and vulnerable, may survive and thrive regardless of the stressors or shocks they face (Arup and The Rockefeller Foundation 2014).

In the 1970s, the science of ecology coined the term "resilience" to define a system's ability to sustain or restore functionality in the face of interruption or disturbance. Because cities are complex systems that are continually reacting to changing conditions, it is relevant to them. When chronic stressors or unexpected shocks threaten widespread disruption or the collapse of physical or social systems, the concept of a resilient metropolis becomes theoretically significant. The idea of resilience has a conceptual flaw in that it does not always account for the power dynamics that are inherent in how cities function and deal with disturbances (Arup and The Rockefeller Foundation 2014).

As previously stated, the systems ecologists' method is increasingly being used elsewhere; here, we discuss a proposed application of the idea to urban systems by Ernstson (Ernstson, van der Leeuw, et al. 2010) in his article in the journal of human environment (Ernstson, Leeuw, et al. 2010). The authors contend that (1) the rapid growth of the urban system is driven by the exponential growth (relative to population size) of social network connections between people of various backgrounds, which connections drive urban innovations, and (2) the "culturally biased" belief that the natural environment that supports an urban system is fundamentally different from it has limited the impact of these innovations on the built environment.

Focusing on "slow variables" rather than the quick changes that identify crucial events is key to managing for resilience (Walker, B., Carpenter, S., Anderies1b, J., Abel1b, N., Cumming, G., Janssen, M., Lebel, L., Norberg and Peterson, G., and Pritchard 2002). Slow factors dictate how a system, in this example an urban system, reacts to key occurrences. Humans can strengthen their resilience by successfully managing them (if desired). If they are poorly handled or, more often than not, neglected, their resilience will be harmed (if not desired). Slow variables refer to connections at a particular scale (diversity, network structure) as well as connections across scales (feedbacks and signaling).

Cities are big systems made up of smaller ones, such as utilities, buildings, weather, companies, open spaces, transportation networks, and financial markets. Politicians, planners, advocacy organizations, employees, kids, the jobless, destitute, and underprivileged are all included. Because

Ernstson (Ernstson, van der Leeuw, et al. 2010) are interested in urban-ecological interactions, they focus on those who have an impact on land development: planners, builders, politicians, social movements, and 'knowledge sources,' such as ecologists, local land-users, and finally, innovators of all stripes (who may, of course, include individuals who fall under one of the previous roles).

Ecologists can only examine some types of networks, such as food webs, at a single scale. Similar to energy distribution networks, social networks emerge when individuals interact, regardless of their role in another system (e.g., political); unlike energy distribution networks, social networks are dynamic: "a continuous recursive communication process that eventually allows people to understand each other, share values and beliefs, and generally work together to achieve their aims." Regardless of the role that such networks play in fostering diametrically opposed views and objectives, we can at least agree on the distinction between a static flow of information and the dynamic interaction of human actors that allows them to effect collective change.

One slow variable in complex adaptive systems is self-organization and novelty. Communities and people can show some degree of local organization to address the needs of its members in reaction to catastrophic crises, such as one that leads the government to collapse. This type of reaction is unique in that it cannot be planned or expected. However, some self-organization occurs on a regular basis, not simply in times of crisis or dramatic upheaval.

One of the concepts of managing complex adaptive systems, such as the urban system depicted here, is to encourage novelty so that systems may self-organize more effectively in the face of crises that break typical regulatory processes (L Gunderson, Peterson, and Holling 2008). Experimentation, learning, and invention are sources of novelty in human systems; they are the sources of novelty that allow self-organizing behaviour in response to crises (and, it should be noted, to take better advantage of sudden and unexpected beneficial changes.)

What causes urbanization—that is, why does the density of cities grow rather than the physical size of cities? While energy consumption per capita falls in dense metropolitan areas and the number of enterprises grows in a linear relationship with population, agent interactions expand exponentially. When the agents participating come from different backgrounds, these interactions generate novelty because the nodes of the urban social network (agents, persons) must have diverse attributes (skill sets, beliefs, traditions, information sources, and so on). In such a context, the potential for creativity is far larger than in a city with a similar population but lower density, or in a city with a stable population and more homogenous backgrounds.

We've just looked at the system structure within cities so far. Cities, on the other hand, are huge users of resources from outside of them; they are not closed or self-contained systems, but rather open systems that interact in both directions with systems located geographically outside of them. Ecosystems are critical in supplying energy, food, and water to cities. According to the urbanization driver, innovation may frequently increase the use of, and harm to, ecosystems, putting additional demand on resources.

Ernstson (Ernstson, van der Leeuw, et al. 2010) (Ernstson, Leeuw, et al. 2010) attribute this to the innovator's restricted understanding of the urban system, rather than to innovation itself. Cities are frequently seen as separate from the (typically rural) settings in which the resources that supply them are situated (farms, dams, power plants). Although such beliefs restrict the goals of social innovation, they may help urban systems to be more resilient to internal upheavals.

At various scales and across sectors, the challenge is to harness urban innovation for sustainability and learning. This necessitates developing discourses that deconstruct the artificial and culturally biased notion that society and cities are separate from nature and countryside, and instead see cities as reciprocal parts of regional ecosystems and dynamic landscapes, composed of social-ecological processes from ecosystems all over the world (Ernstson, Leeuw, et al. 2010).

The figure below summarizes how a holistic approach to urban resilience would have to include every aspect of the urban environment. Each niche has its own field of expertise, with numerous attributes and signs put forth by various authors. In the next section categories of resilience, we will discuss these four parameters in detail. (In fig 22)

The Rockefeller foundation worked on urban resilience and to mention Jane Jacobs who wrote "The Death and Life of Great American Cities" they all discussed the 4 aspects of urban resilience as mentioned in above diagram. But they created a framework of resilience and then they further explained all these categories in all aspects.

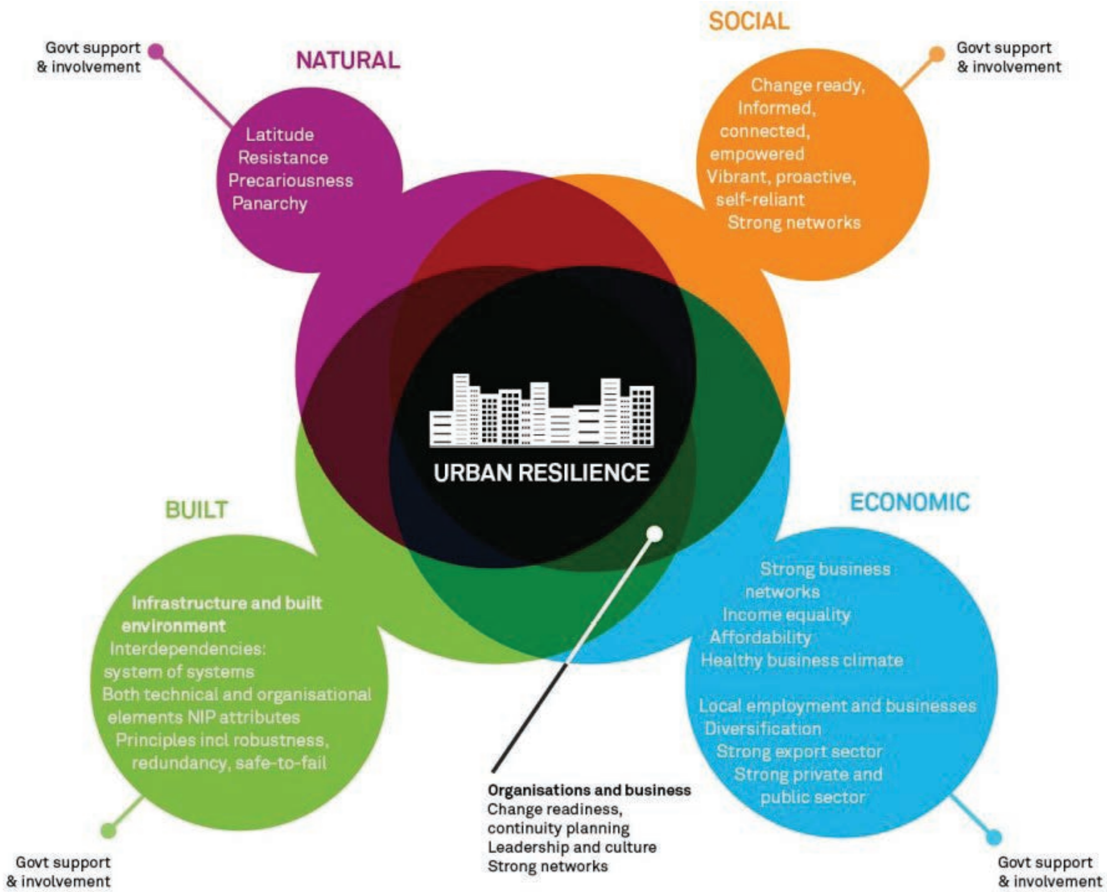


Figure 22: Urban resilience schematics((Todorovic et al. 2017) [20]

[20] *This is adapted by Chelleri et al, 2012*

2.5 - RESILIENCE IN DIFFERENT FIELDS AND ITS INDICATORS

2.5.1 - FRAMEWORK

Every city is distinct. In different parts of the world, resilience presents itself in different ways. The City Resilience Framework provides a prism through which to comprehend the complexity of cities and the myriad aspects that contribute to a city's resilience. It is made up of 12 main indicators that describe the essential characteristics of a resilient city. The following diagram perfectly depicts the sub-division framework, indicators and qualities connected to the discussion of urban resilience.

URBAN RESILIENCE FRAMEWORK

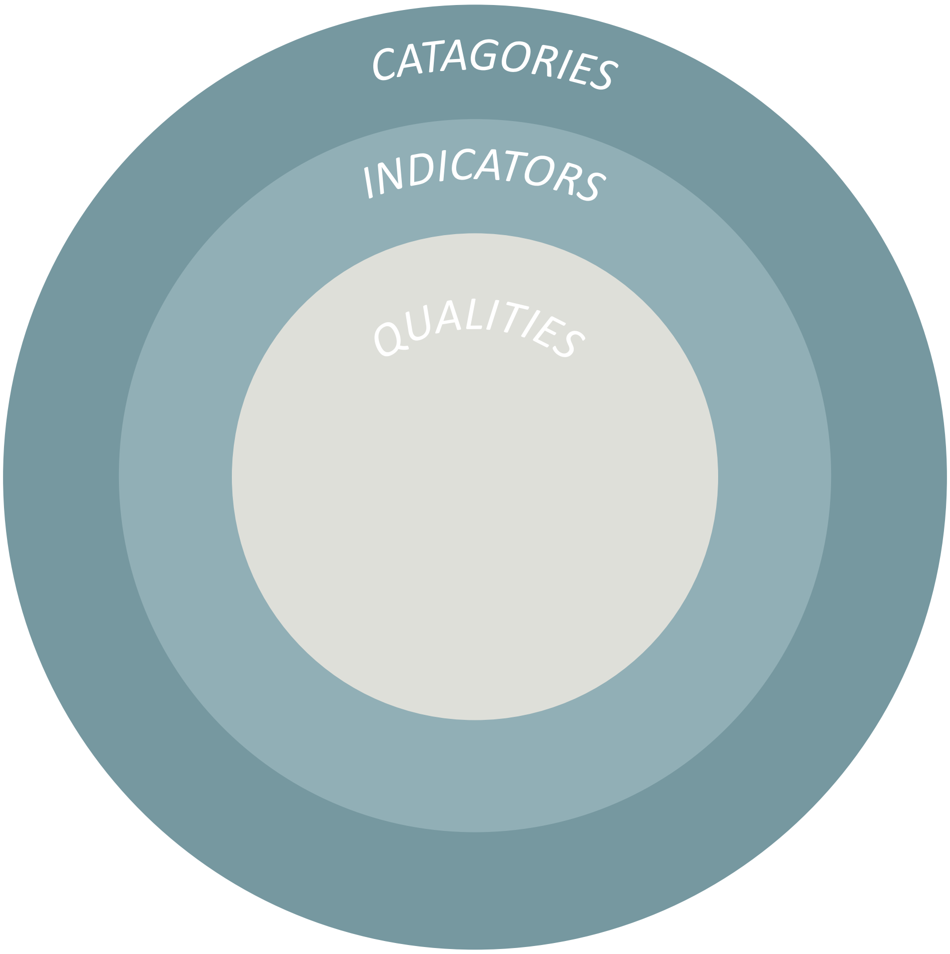


Figure 23 : Explanation of framework for categories, indicators, and qualities (By Author)

The following portion discusses the indicators for city/urban resilience.

2.5.2 - INDICATORS

*1. **Minimum Human Vulnerability:** Referring to the extent to which basic needs of the population are met.*

*2. **Diverse livelihoods and employment**: Access to money, the capacity to save, skill training, business support, and social welfare all help.*

*3. **Adequate safe guards for human life and health:** Reliable social services which include health facilities and services including emergency services.*

*4. **Social Stability and security:** The indicator refers to law enforcement, crime prevention, justice, and emergency management.*

*5. **Collective Identity and mutual support:** Includes strong social networks and social integration.*

*6. **Availability of financial resources and contingency funds:** Sound financial management, a variety of revenue streams, the capacity to attract corporate investment, enough investment, and emergency savings are all factors to consider.*

*7. **Reduce Physical exposure and vulnerability:** Environmental stewardship, adequate infrastructure, competent land use planning, and the implementation of planning standards are all indicators.*

*8. **Continuity of critical services:** Diverse provision and active management; ecosystem and infrastructure upkeep; and contingency preparation are all indicators.*

*9. **Reliable communications and mobility:** Diverse and cheap multimodal transportation systems and information and communication technology (ICT) networks, as well as contingency planning, are all indicators.*

*10. **Effective leadership and management**: multi-stakeholder consultation; and evidence-based decision-making including government, industry, and civil society, as suggested by trustworthy persons.*

*11. **Empowered Stakeholders:** Education for all, as well as access to up-to-date information and knowledge, are indicators that people and organizations are taking proper action.*

*12. **Integrated Development planning:** A municipal vision, an integrated development strategy, and plans that are evaluated and revised on a regular basis by cross-departmental working groups are all indicators.*

2.5.3 - QUALITIES OF URBAN RESILIENCE

After providing a detailed overview about urban resilience, let us repeat the qualities of the urban system.

NO.	QUALITIES
1	Reflective
2	Robust
3	Redundant
4	Flexible
5	Resourceful
6	Inclusive
7	Integrated

Table 2: Explanation of framework for categories, indicators, and qualities (By Author)

1. Reflective

In today's environment, reflective systems acknowledge the underlying and ever-increasing unpredictability and change. They have systems in place to change over time, and instead of pursuing permanent answers based on the current system, they will adjust standards or norms depending on new facts. As an outcome, people and organizations analyze and learn from their previous experiences in a methodical way and use that knowledge to influence future decision-making.

2. Robust

Robust systems are made up of well-designed, built, and maintained physical assets that can survive the effects of hazard occurrences without sustaining severe damage or losing functionality. Robust design foresees system failures and makes provisions to guarantee that collapse is anticipated, secure, and proportional to the cause. Over-reliance on a single component, cascade failure, and design thresholds that, if surpassed, might result in catastrophic failure are all carefully avoided.

3. Redundant

Redundancy is the intentional creation of spare capacity inside systems to absorb disruptions, harsh pressures, or demand spikes. It involves variety: the existence of numerous options to meet a certain *requirement or perform a specific function. Distributed infrastructure networks and resource reserves are two examples. Redundancies should be planned, cost-effective, and prioritized at a city-wide level, rather than being an unintended consequence of inefficient design.*

4. Flexible

Flexibility refers to a system's ability to modify, evolve, and adapt to changing conditions. This may favor decentralized and modular infrastructure and ecosystem management techniques. As needed, flexibility may be done by introducing new knowledge and technology. It also entails rethinking and adopting traditional or indigenous knowledge and practices.

5. Resourceful

During a shock or while under stress, resourcefulness means that people and organizations may quickly come up with new ways to accomplish their objectives or meet their requirements. Investing in ability to predict future situations, define objectives, and respond, for example, by mobilizing and coordinating larger human, financial, and physical resources, is one example. Resourcefulness is crucial to a city's capacity to restore key system operation, even in the face of severe constraints.

6. Inclusive

Inclusion emphasizes the need of wide community dialogue and involvement, particularly the most disadvantaged populations. Addressing the shocks or pressures that one industry, place, or community is experiencing in isolation from others is antithetical to the concept of resilience. To enhance city resilience, an inclusive strategy adds to a culture of collective ownership or a shared vision.

7. Integrated

Integrating and aligning city systems enhances uniformity in decision-making and guarantees that all investments work together to achieve a unified goal. Within and within robust systems, as well as across various levels of operation, there is evidence of integration. Through shorter feedback mechanisms across the city, information exchange between systems allows them to work together and respond quickly.

2.5.4 - CATEGORIES OF URBAN RESILIENCE

The above mentioned 12 indicators can be fit into 4 categories that further help us to plan for urban resilience. The four categories can be regarded as the following:

1. Health and wellbeing of individuals (People)
2. Urban systems and services (Place)
3. Economy and society (Organization)
4. Leadership and strategy (Knowledge)

For each, a best-case scenario that depicts a resilient city and a worst-case scenario that amounts to breakdown or collapse may be imagined. Poverty, social unrest, bad infrastructure, and poor governance are not characteristics of a resilient city. This is notably visible in Port au Prince, Haiti, where rehabilitation from the damage wrought by an earthquake on January 12, 2010, has been exceptionally difficult (Arup and The Rockefeller Foundation 2014).

The categories may be used to describe New York City's resiliency in the aftermath of Superstorm Sandy in 2012, as well as the terrorist attacks of 9/11 in 2001. This was owing to the city's relative affluence, as well as a strong sense of community and good leadership. People were eager to support one another and unify around the shared objective of restoring the city back to normal as soon as possible as a result of these causes. There were emergency measures in place to ensure that urban systems and services were quickly restored, and that civil order was maintained.

Wealthier cities are not always more resilient, as seen by the downfall of Detroit, Michigan, which grew unduly reliant on a single sector, or the floods that brought Bangkok, Thailand, to a halt in 2010, disrupting global supply lines. Cities that are relatively impoverished, on the other hand, can make decisions that strengthen their resilience.

In response to yearly waterlogging in the city's poorest areas, Gorakhpur, India, is striving to establish resilience at the ward level. The city has reduced the frequencies of illnesses like malaria and Japanese encephalitis, which are carried by vectors that nest in waterlogged regions, by improving solid waste management procedures to unclog drains and enhancing drainage of waterlogged areas.

In this regard Alan, P and Bryant, M provided a definition of resilience in their work named Resilience as a framework for urbanism and recovery in the journal of landscape and architecture in 2011. The definition is as follows:

"Resilience is based on the shifting relationship between scales, and between autonomy on the one hand and connectivity on the other."
(Allan and Bryant 2011)

The following figure further on helps in understanding the subdivision of categories, indicators, and qualities. The categories envisage the indicators and then the qualities are found in the inner most level of the diagram.

Figure 24: Different layers of urban resilience
[Arup and The Rockefeller Foundation 2014]

Following is a brief description of the categories and their indicators.

HEALTH AND WELLBEING:

a. Minimal human vulnerability:
Individuals and households can reach a level of living that goes beyond simple survival by reducing fundamental human weaknesses. People with a fundamental sense of well-being can also cope with unanticipated events. This will only be feasible if their physiological demands have been satisfied in terms of food, water, cleanliness, energy, and shelter.

b. Diverse Livelihoods and employment:
Citizens may adapt proactively to changing conditions in their city by diversifying their livelihood possibilities and support systems without jeopardizing their well-being. Individuals with access to financing, skills training, and business support can explore a variety of choices to obtain the vital assets they need to satisfy their fundamental requirements. Long-term, stable employment allows people to accumulate personal funds that will help them develop as well as survive in times of distress.

c. Adequate safeguards to human life and health:
Health systems are essential for preventing sickness and the transmission of disease on a daily basis, as well as safeguarding the people during catastrophes. They are a collection of behaviours and structures that aid in the maintenance of public health and the treatment of chronic and acute health disorders.
Education, sanitation, epidemiological surveillance, immunization, and the provision of healthcare services are all examples of health services. These are aimed at maintaining both physical and emotional well-being. A successful city health system must provide daily individual healthcare that is both accessible and cheap, as well as appropriate population-based treatments (i.e., aimed at the community or city level).

ECONOMY AND SOCIETY:

d. Collective identity and mutual support:
Communities that are engaged, well-supported by the city administration, and well-connected to one another help to build a city with a strong identity and culture from the ground up. Individuals, communities, and the local government may all trust and support one another, allowing them to handle unanticipated crises without civil unrest or bloodshed. The social and physical components of creating integrated cities are intertwined. Individual relationships are strengthened when local

identity and culture are reinforced, as is their collective power to change the environment in which people live, work, create, and play. A variety of actions, such as social networks and community organizations, creative expression, and the preservation of cultural heritage, such as religion, language, and customs, sustain these relationships. These activities should, in theory, be supported by spatial interventions that shape the locations where communities grow and connect. Community amenities, public areas, and physical accessibility can all contribute to build community cohesiveness and prevent isolation.

e. Social stability and security:

The reduction and prevention of crime and corruption in a city is facilitated by a comprehensive and contextually relevant strategy to law enforcement. Cities may protect the rule of law and foster citizenship in everyday life by establishing a transparent judicial system founded on ethical values. These rules are essential for preserving order in stressful situations. By decreasing crime-related injury, mortality, and stress, well-planned and resourced law enforcement allows calm rehabilitation and guarantees a healthy population.

f. Availability of financial resources and contingency funds:

A strong economic system is essential for sustaining the investment that a city requires to maintain its infrastructure and provide for its people. It assists in the establishment of contingency funds that may be used by both the commercial and governmental sectors to respond to catastrophes and unanticipated disasters. Cities are thus better prepared to adapt to shifting economic conditions and pursue long-term development as a consequence. A sustainable city economy is created by matching government budgetary policies with the private sector's ability to function in the face of shocks and strains. The availability of cash to consistently invest in infrastructure and respond to crises will be considered in the careful construction of local budgets. This is aided by the city's capacity to attract inbound investment, as well as a strong income base.

URBAN SYSTEMS AND SERVICES:

g. Reduced physical exposure and vulnerability:

Ecosystems provide natural protection to cities, which may be preserved through conserving environmental assets. This might involve tidal surge absorption by coastal wetlands or river floods absorption by upstream woods, among other things. Infrastructure's protective role is dependent on proper design and construction. This is as true for everyday infrastructure like houses, workplaces, and other buildings *as it is for particular defences like flood barriers. Both natural and man-made assets work together to provide protection against harsh circumstances, reducing the risk of injury, damage, or loss. Ecosystems and constructed infrastructure that are developed as interconnected urban systems help to reduce physical vulnerability and exposure. River basins, woods, drains, and sewers, for example, all help to protect communities against floods. In coastal locations, for example, utilizing natural wetlands and man-made dykes as part of an integrated response to coastal flooding can improve resilience.*

h. Continuity of critical services:

Both ecosystems and infrastructure provide essential services to urban residents. These services, on the other hand, rely on more than simply the availability of assets; quality and performance can only be maintained by proactive management. Some ecosystem services and infrastructure become critical to the city's functioning during times of stress. Systems that are well-maintained are better equipped to meet atypical demand, resist unusual stresses, and continue to function. Infrastructure managers are better equipped to restore disrupted services because to well-established management methods that increase their understanding of system components. Communities and businesses must be educated to ensure that ecosystem services that are important to urban populations, such as natural drainage capacity and flood defences, remain robust and are not jeopardized by careless or unwise actions, such as natural resource extraction or the destruction of coastal dunes and mangroves. The management of man-made infrastructure comprises continuous monitoring as well as upgrade and renewal plans. Demand management is essential for the continued availability of important services, ensuring that neither constructed nor natural systems are overburdened, and that adequate redundancy is available to absorb demand spikes. A resilient city also executes continuity plans to guarantee that infrastructure managers are prepared to sustain service and avoid interruption in the event of a disaster.

i. Reliable communications and mobility:

Daily connectedness between locations, people, and services is enabled through reliable communications and mobility. This promotes a healthy working and living environment, strengthens social cohesiveness, and allows for speedy mass evacuation and extensive communication in the event of an emergency. In today's cities, connection requires a combination of transportation and information technology. Physical mobility is enabled through transportation links, which should *have a wide coverage of the city, as well as high service quality and price. The capacity, safety, and efficiency of infrastructure are critical for the efficient functioning of transportation networks. The importance of business logistics and freight infrastructure in supporting the city's economic operation cannot be overstated.*

LEADERSHIP AND STRATEGY:

j. Effective leadership and management:

Trust, solidarity, and a common sense of a city's direction are all enhanced by clear and purposeful leadership. Leadership is a crucial component in motivating individuals and communities to take action during difficult circumstances. A dedicated municipal administration that makes choices based on facts allows a city to grow on a daily basis and adjust to shocks and challenges.

k. Empowered Stakeholders:

Trust, solidarity, and a common sense of a city's direction are all enhanced by clear and purposeful leadership. Leadership is a crucial component in motivating individuals and communities to take action during difficult circumstances. A dedicated municipal administration that makes choices based on facts allows a city to grow on a daily basis and adjust to shocks and challenges.

l. Integrated development planning:

Cities utilize development plans and land use rules to coordinate and manage urban growth and direct future expenditures. Individual projects and programs are coordinated and adequately manage uncertainty thanks to the establishment and implementation of plans and rules. Integrated plans establish a formalized framework for addressing interdisciplinary challenges including climate change, catastrophe risk reduction, and emergency response. The presence of a city vision is a vital part of creating a complete development and planning framework. Understanding and alignment between the objectives of diverse stakeholders participating in creating and implementing initiatives in the city is required for the establishment of a common and integrated city vision.

This, in turn, necessitates constant communication and coordination activities at all levels of the planning process. A vision should be based on sound facts and the acceptance of ambiguity, and it should be communicated through policies and laws. Land use plans should be strictly enforced and modified on a regular basis. Plan preparation necessitates the collection of current and relevant data, as well as continual monitoring of urban developments.

2.6 - IMPORTANCE AND CHALLENGES TO IMPROVE RESILIENCE

IMPORTANCE |

We live in a world where the risks we face—both known and unknown—are occurring more frequently, and where the costs of rebuilding after significant shock events are severely straining governments, owners of infrastructure, and societies alike. Natural disaster-related deaths have been proven to have declined globally, yet since 2000, capital losses have topped US$2.5T.

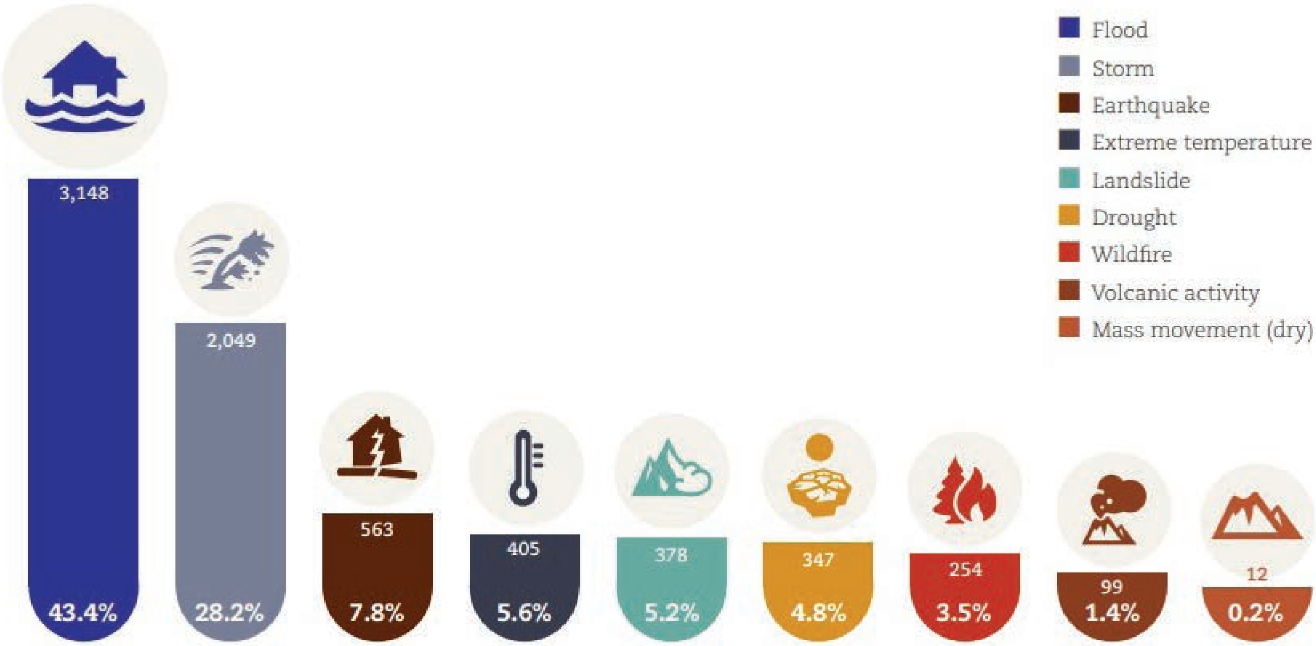


Figure 25: The natural disasters damage to economic data from 1998 – 2017 [“Economic” 1998]

Building resilient societies and making sure our vital infrastructure is robust are becoming more and more crucial. Basic infrastructure not only meets societal demands for the seamless continuation of daily operations, but also serves as the foundation upon which society is based (Croope 2010). Godshalk (Godschalk 2003) cites the following two arguments for the significance of resilience:

1. The ability to adapt to change without catastrophic failure during disasters is essential since the fragility of technological, natural, and social systems cannot be predicted.

2. When calamities strike, people and property do better in resilient cities. There are fewer building collapses, power outages, businesses at risk, and fatalities and injuries.

We must contend with longer-term, “corrosive” stress events in addition to the *frequently unanticipated shock events, such as widespread infrastructure damage or coastal erosion brought on by sea level rise.*

Further still, we face broader issues like resource depletion, overuse, and urban sprawl that create critical issues with how we approach sustainable development in our cities and society. There is a rising understanding of the need to:

1. Provide effective, integrated solutions to these complicated problems given our growing reliance on interconnected infrastructure and technology and our steadfast expectation for 24/7 service delivery.

2. Offer evidence to support any interventions and the necessary expenditures.

Disasters caused by flooding have had a significant socio - economic impact recently all over the world. More people are impacted by floods than any other sort of disaster globally (Keating et al., n.d.). Because of climate change, there is a good chance that there will be more instances of excessive rainfall. Like any other natural hazard, flooding has a negative impact on development and diverts resources away from more beneficial applications. Given the dense populations in metropolitan areas, floods can significantly affect families, communities, livelihoods, and individuals. Building flood resistance is essential as a result.

CHALLENGES |

Dealing with complexity is a requirement for increasing resilience. Decision-making can be time-consuming because to the uncertainty around threats, competing goals in the short and long term, limited resources, and they have to take into account the opinions of many different stakeholders. Organizations are under pressure to "optimize" their expenditures and ultimately achieve a "return on investment" due to the necessity for thorough financial business case evaluations and discounting of future benefits. Investments that reduce the risk of hazard occurrences that are yet to occur require a shared knowledge of risk and agreement from all parties involved. Naturally, it can be challenging to accomplish this. Therefore, it is essential to provide a framework or strategy to aid in prioritizing investments and assessing resilience.

Many of the concepts that are frequently linked to resilience also seem to be in opposition to one another. These include robustness and safe-to-fail, diversity and interdependence, redundancy and efficiency, autonomy, and collaboration, planning and flexibility, and diversity and interdependence referring to figure below. It is crucial to develop precise definitions and distinctions between these potential

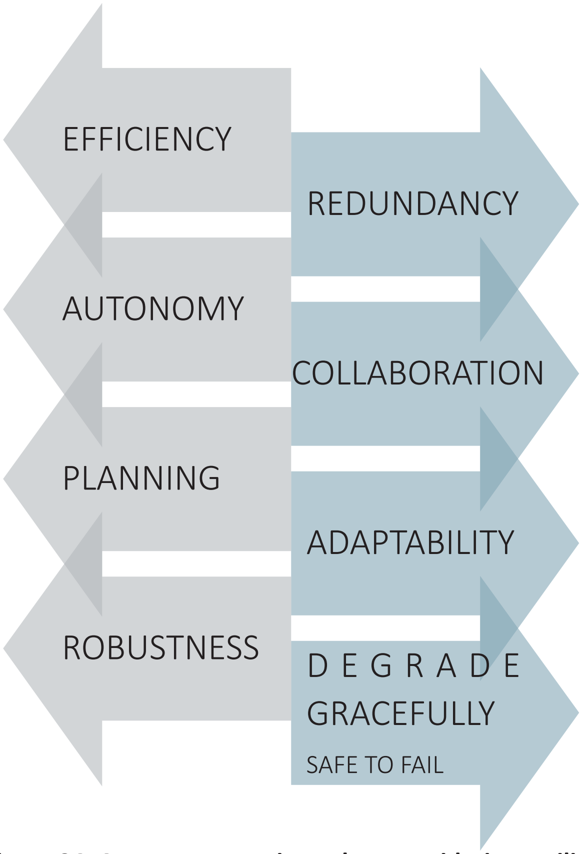


Figure 24: Apparent opposites when considering resilience

outcomes. Below is a list of some other difficulties:

1- Behavioral factors at work and in communities that favor response and recovery above risk mitigation and preparedness.

2- Uncertain future circumstances: Making plans and decisions is challenging due to the inherent (and significant) uncertainty surrounding the likelihood and severity of hazard events, as well as the repercussions that go along with them. Risk analysis and resilience-based strategies are both viable possibilities, but in the face of extreme ambiguity, "soft" choices—also referred to as "low-regret solutions"—that increase a system's adaptability and flexibility are given more weight (Fankhauser, Smith, and Tol 1999) (Dokken, n.d.).

3- A comprehensive comprehension of community well-being and disaster risk. Keating (Keating et al., n.d.) advise placing a considerably higher emphasis on bridging the gaps between centrally planned catastrophe risk management and community-led responses. Too frequently, planned reactions fall short or are not put into action.

4- Finding connections between resilience to natural disasters and longer-term sustainability, ensuring that co-benefits are discovered, and systemic changes are taken into consideration.

2.7 - URBAN RESILIENCE AND FLOODING

2.7.1 - FLOOD HAZARDS AND ITS IMPACTS

FLOOD HAZARDS AND UNCERTAINTY

Recent occurrences around the world have brought attention to:

1. *The difficulty in foreseeing extreme events, including floods, and their effects*

2. *The complexity of the systems* that are affected by hazards and the wide spectrum of failure possibilities.

Flood dangers are unusual in that their occurrence may be predicted using rather complex techniques, albeit with limited advance notice, and their potential flood extents can be modelled (computer modelling). However, the techniques and models employed only offer approximations of flood sizes and areas. There are a wide variety of presumptions, restrictions, and unknowns regarding the rainfall data utilized as well as how rainfall intensities may change as a result of climate change, how runoff is converted into water, and how water is transported through drainage systems to an outfall.

As pointed out by Reese (Reese 2006)

"Urban hydrology is a compromise between accuracy and data availability. And as Murphy would have it, a densely populated urban setting is the one place a designer would most want to be accurate in flooding predictions and is also the one place where accuracy is often least possible to attain."

According to Schnoor (Schnoor 2008), significant uncertainty in river management result from:

1. The stochastic nature of hydroclimatic forcing is intrinsic

2. In such forcing, nonstationary (e.g., land use and land cover changes, precipitation changes, and climate change; additional infrastructure changes)

3. Long-term records are insufficient to accurately forecast the occurrence of extreme weather events, such as 100-year or 500-year events.

This is said by engineers and planners who are aware of the delicate nature of:

1. Relating modeling outputs to assumptions and inputs

2. More effectively and in a way that facilitates informed decision-making. on-the-ground flood thresholds to modifications in those inputs and hypotheses

FLOODS IMPACT ON INFRASTRUCTURE AND POVERTY

Wide-ranging effects on important infrastructure and property can result from flooding. There are two types of effects: direct (such flooded homes) and indirect (failure through interdependent infrastructure linkages). In general, our knowledge of how failures can spread and intensify inside and among complex systems is lacking. Risks can develop as a result of interactions between internal system components and outside variables or events that are both linear (cascade) and non-linear. In the latter scenario, problems typically don't manifest until after they've already happened. It is critical to take into account the pertinent interdependencies with, for instance, other utility services and the variety of potential failure modes when evaluating an asset's resilience to risks like flooding.

2.7.2 - URBAN RESILIENCE FOR FLOODING:

The capability of a city to suffer flooding and reorganize in the case of physical damage and socioeconomic disruption is described as the ability to prevent fatalities and injuries while maintaining present socioeconomic identity. It stems from the city's experience with frequent floods as a means of learning how to prepare for more severe floods (K.-H. Liao, n.d.).

The notion of urban flood resilience contradicts the traditional understanding that cities cannot exist without flood management, eroding resilience in the process. To put the theory into reality, a proxy metric for gauging flood resilience in cities is developed: the percent floodable area. Flood adaptation is promoted as a replacement for flood control in order to permit natural floodplain processes to improve urban resilience to floods.

The capacity to absorb recurring hazard impacts and reorganize while experiencing change has been applied to community resilience, highlighting the ability to sustain core structures, processes, identity, and feedbacks. Similarly, urban flood resilience is described as a city's ability to withstand flooding and reorganize in the case of physical damage and socioeconomic disruption, in order to avoid fatalities and injuries and retain present socioeconomic identity. It may be thought of as the ability to maintain a desired state in the face of a deluge. A set of variables indicating elements such as livelihood security, economic performance, and mobility that combined comprise the city's socioeconomic identity define the optimal regime (Lance Gunderson 2010). The flood magnitude that a city can withstand until it hits a threshold and transitions to an undesirable regime is used to assess its resistance to floods.

A regime, unlike biophysical systems, is defined socially rather than scientifically. The preferred regime represents the city's tolerance range of socioeconomic state changes, which is important for flood resistance. A wider range indicates that the city considers a higher degree of socioeconomic fluctuations to be normal, resulting in a larger/deeper basin of attraction; whereas a narrow range indicates that the city considers a lower degree of socioeconomic fluctuations to be normal, resulting in a smaller/shallow basin of attraction, making a regime shift easier (Zhao 2018).

Essentially, flood resilience in cities refers to the ability to prevent calamity in the event of a flood. The city's flood ability, which is defined here as the physical ability to accommodate—not resist—flooding, would be crucial in preventing physical damage and economic disruption. If there has been damage and disturbance, staying in the system ensures reorganization—the restoration of socioeconomic order. While a restoration to pre-flood conditions is unimportant, the speed with which the city is reorganized is critical since protracted socioeconomic disruption might lead to an undesirable regime. Overall, flood ability and rearrangement determine urban flood resilience, not flood resistance and recovery, as engineering resilience would indicate.

2.7.3 - RESILIENCE BASED FLOOD HAZARD MANAGEMENT

In complex adaptive systems, improving resistance to one disturbance sometimes generates vulnerabilities to others. Flood control overlooks complexity and unpredictability, resulting in increased flood risk and ecological calamities. Many cities nowadays are not flood-proof because they are built on the artificial environmental stability imposed by flood-control technology and can only sustain minor socioeconomic fluctuations. Control as a management paradigm must be abandoned. Cities must transition to resilience-based flood hazard management in order to ensure long-term flood safety.

2.7.4 - LIVING WITH FLOODS

Resilience is the ability to cope with adversity (Folke et al. 2010). Studies have indicated that societies that have adapted to disturbances, rather than being impervious to them, have a longer lifespan. Building urban flood resilience is fundamentally an adaptation process—rather than battling the river, cities live with it on a regular basis, allowing floodwaters to enter the city and learn from them in order to become more robust to major floods. The management objective has shifted from “safety against floods” to “safety at floods,” signaling a paradigm change from resistant to resilient cities. Working with the river rather than against it is a philosophy that has long been advocated for in terms of urban flood resistance. It also harkens back to the ancient notion of “living with floods,” which is still practiced in rural areas of Bangladesh, Cambodia, and Egypt today (Fikret Berkes 2007). Identifying the differences between benign regular floods and destructive rare floods, these people adjust their lives and built environments to river dynamics, taking advantage of post-flood production gains in fisheries and agriculture.

2.7.5 - FLOOD ADAPTATION

The argument that cities and floods cannot coexist demonstrates a lack of imagination, which is the result of being too acclimated to a constructed environment that is not designed to withstand floods. Cities may gradually phase out flood-control equipment and live with floods by upgrading the built environment and providing redundancy, variety, and flexibility to every subsystem with a shift in mindset and innovative planning and design. During wet seasons, open spaces can be used to transmit and store floodwater. Infrastructure may be reconfigured as a collection of functional parts that can be operated in a variety of ways (Fiering 1982). (Buildings can be raised, floatable, or wet-proofed through remodeling.

It would necessitate a shift in city planning. The effort “Water Sensitive Cities is integrating water management into urban planning and architecture to improve climate change resilience, with Rotterdam serving as a noteworthy example of flood adaptation. However, a paradigm shift in city planning is required—it should be based on dynamism rather than assumed environmental stability. Floodplains are continually shifting, rearranging themselves not just as a result of flooding but also as a result of channel migration, in which land can become the location of a flowing river and vice versa. Building structures that are adaptable, detachable, and temporary, rather than permanent constructions, is the most practical method to live on floodplains.

Flood adaptation as a mitigation strategy would address a number of issues caused by flood control. First, unlike levees and channelization, which reduce floodplain retention and increase river velocity to enhance downstream flooding, and flood-control dams, which submerge upstream regions to displace people, it would not move the city's own issue elsewhere. Second, there would be no increase in long-term flood risk because there would be no chance of flood-control infrastructure failure, which would result in more catastrophic damages from greater floods than if there were no flood-control infrastructure (Tobin 1995). Third, by enabling biologically important periodic floods to reunite the channel and floodplain, it would not compete with, but rather may complement, ecological preservation and restoration of urban rivers.

Part 2|
EMPIRICAL RESEARCH

Figure 27: The Arat Kilo District (reference copied) [21] (Eduardo Di Muro, n.d.)

[21] *A book written by Eduardo Di Muro which illustrates the social character of urban capitals of Africa. He tried to explain the scenes of community, markets and streets and drew the culture through his drawings.*

Figure 28: The Kababna district with its Eucalyptus trees [22] (Eduardo Di Muro, n.d.)

|03

LEARNING FROM LITERATURE, CASE STUDIES AND EXISTING STRATEGIES IN URBAN AREAS

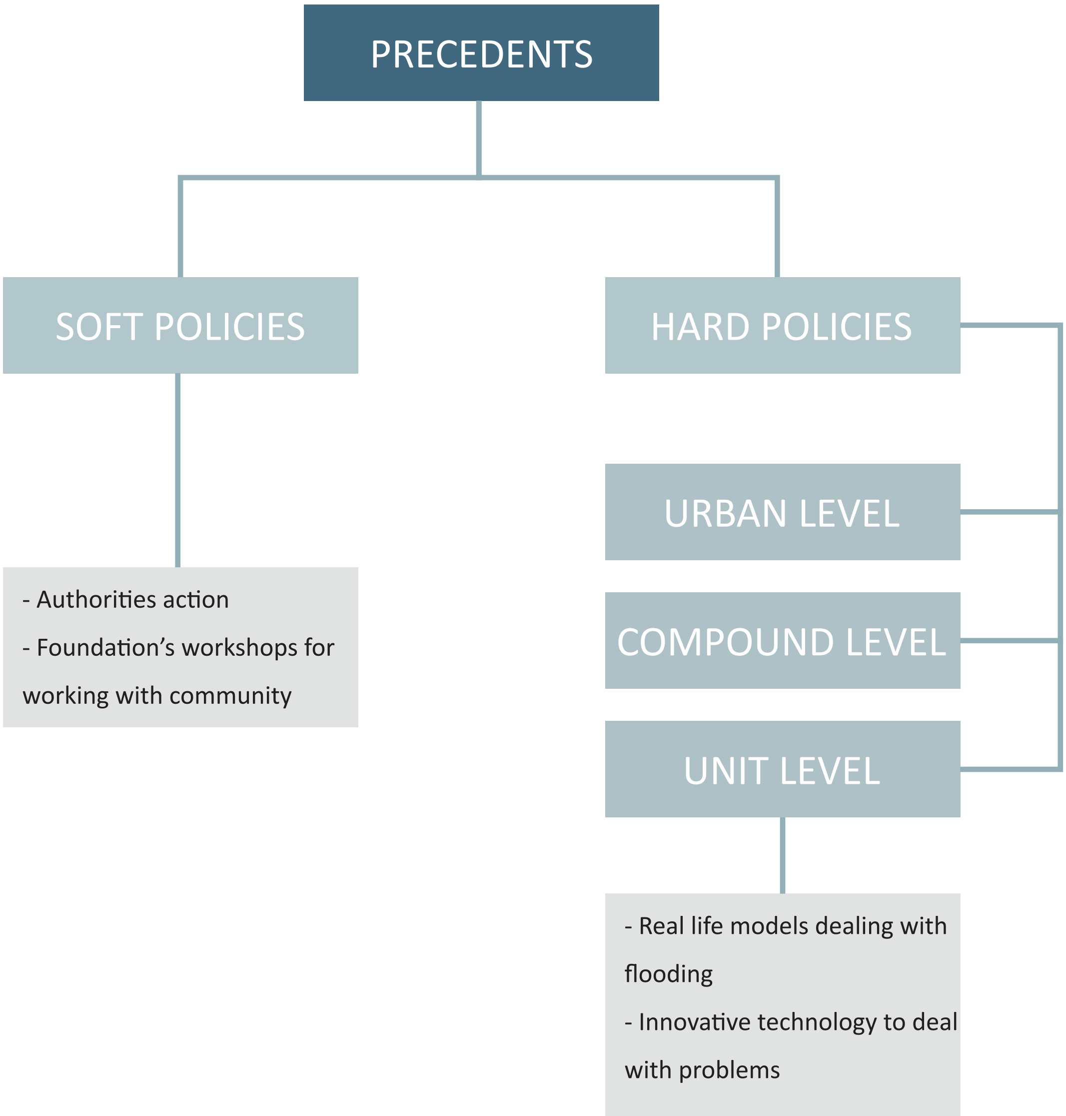
[22] A book written by Eduardo Di Muro which illustrates the social character of urban capitals of Africa. He tried to explain the scenes of community, markets and streets and drew the culture through his drawings.

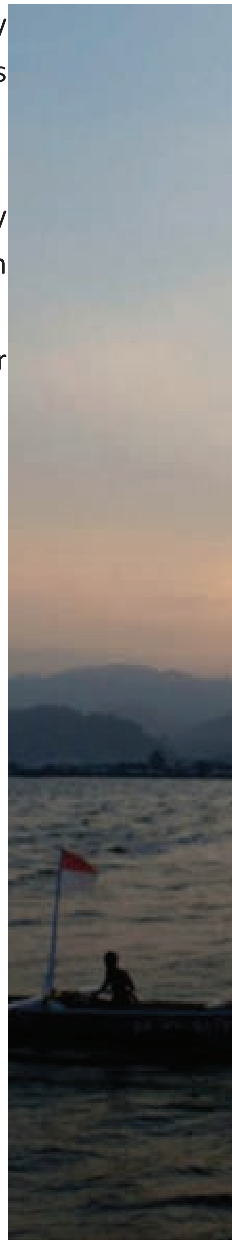
3.1 – INTRODUCTION

In this chapter we will do empirical research and will discuss different case studies at different level.

It will be divided in two categories: soft policies which will discuss the actions taken by government and different institutions as a top to bottom approach and then the actions taken by people or residents as bottom-up approach.

In the next category Hard policies, we will learn infrastructural technologies proposed by experts for the flood resilient structure. This part will be divided in three sections from macro to micro scale.
The purpose to study this is to learn from the existing examples and devise similar solutions or more advanced solution that can fit well in our case study of Addis Ababa.





3.2 – SOFT POLICIES

3.2.1 - SEMARANG, INDONESIA

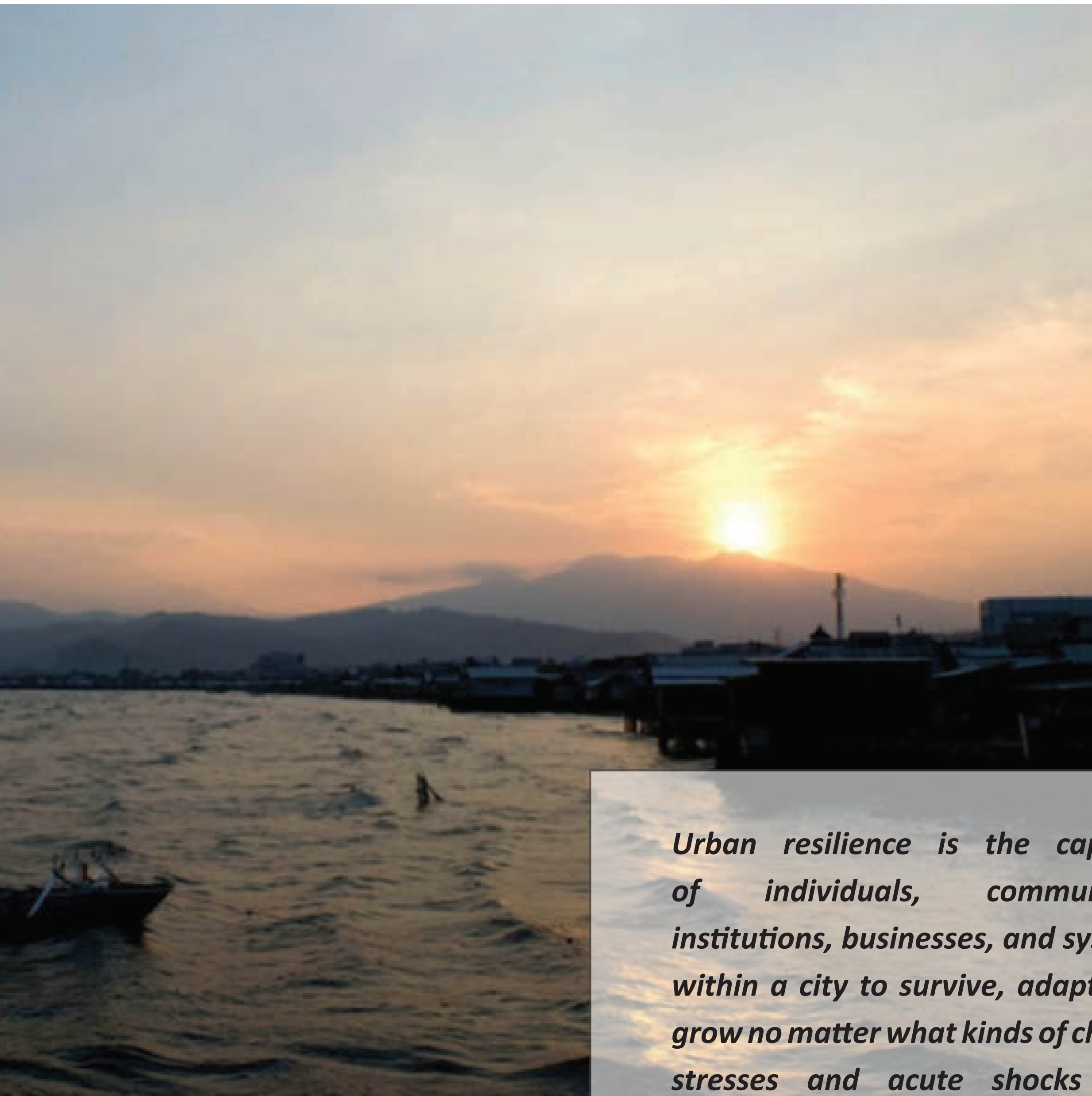


Figure 29: Semarang waterfront [“City Resilience Framework City Resilience Index” 2014]

Urban resilience is the capacity of individuals, communities, institutions, businesses, and systems within a city to survive, adapt, and grow no matter what kinds of chronic stresses and acute shocks they experience. We believe in building our capacity to better strengthen our city resilience.(“RESILIENT SEMARANG Moving Together Towards a Resilient Semarang,” n.d.)

INTRODUCTION

Figure 30: Location of Semarang [“RESILIENT SEMARANG Moving Together Towards a Resilient Semarang,” n.d.]

Semarang is a coastal town that is now dealing with serious issues such tidal flooding, flooding, and coastal erosion. Semarang was selected as one of the 100 resilience city initiatives supported by the Rockefeller Foundation due to several significant issues. The City of Semarang is anticipated to be able to develop plans to address these issues. The north shore of Semarang has been threatened by the tidal flood phenomenon since the 1980s. (Hadi 2017)

ISSUES

Semarang is frequently flooded and landslide prone. Sea level rise causes tidal flooding, which is aggravated by land subsidence. The extraction of groundwater and the density of built-up areas are the main causes of land subsidence.

These problems are exacerbated by the lack of essential amenities supplied to certain households, when PDAM (the local water corporation) isn't working, people may readily use groundwater

Figure 31: View of street of Semarang [“RESILIENT SEMARANG Moving Together Towards a Resilient Semarang,” n.d.]

and artesian wells as an alternate water supply. This is an illustration of how stressors interact with one another, causing further issues.

Residents in Semarang's coastal areas are frequently impacted by water shortages, considering their proximity to water. They frequently buy water from formal or informal sellers of uncertain quality. Wells are another option for groups or people who are unable to access water from the mains. However, wells along the shore are getting salinised, while reservoirs in other sections of the city are drying up during peak demand periods.

Land sinking is exacerbated by urban development. Due to soil subsidence, flooded regions get sea water. According to some estimations, land subsidence occurs at a rate of up to 10cm per year because of groundwater extraction. By reducing the city's ground level, this ecological process has enhanced the city's vulnerability to floods. Tidal overflow, which happens on a regular basis in some areas, has serious consequences for coastal towns. Homes, stores,

Figure 32: View of street of Semarang [“RESILIENT SEMARANG Moving Together Towards a Resilient Semarang,” n.d.]

and highways are often flooded, and fishpond farmers' fish stocks have been driven out to sea, posing a threat to their livelihood. During the rainy season, the region that has been inundated gets worse.(Hadi 2017)

Figure 33: Change in coastal line over the time due to urbanization23
[“RESILIENT SEMARANG Moving Together Towards a Resilient Semarang,” n.d.]

[23] *Source: Research and Development, SANITATION AND LANDSCAPING OFFICE, UNDIP, IPB, 2009*

ADDRESSING THE PROBLEM:

Government policies (top to bottom approach)

The government constructed the Polder System, which includes the Bulu Drain System, Kemijen, and Ampong Tawang Drain Systems, to deal with tidal flooding. One of the systems used to regulate flooding along the Semarang shore, which includes the Kampongs of Panggung Lor, Panggung Kidul, and Bulu Lor, is the Bulu Drain system. Retention tank, pumping station, and flood gate make up the polder system. The amount of tidal flood and flood is temporarily reduced thanks to a retention tank in Tawang, Semarang. While Kemijen's Polder is still being built.

A pumping station has been constructed, and locals have a plan to voluntarily administer the Polder System by gathering dues from community members to cover the costs of operation and maintenance. The government donated seed money for the construction of a coastal belt in Mangunhardjo and Mangkang Wetan in order to address coastal erosion. The government has plans to normalize the river by paying people's land downstream as a response to the flooding in Mangunhardjo

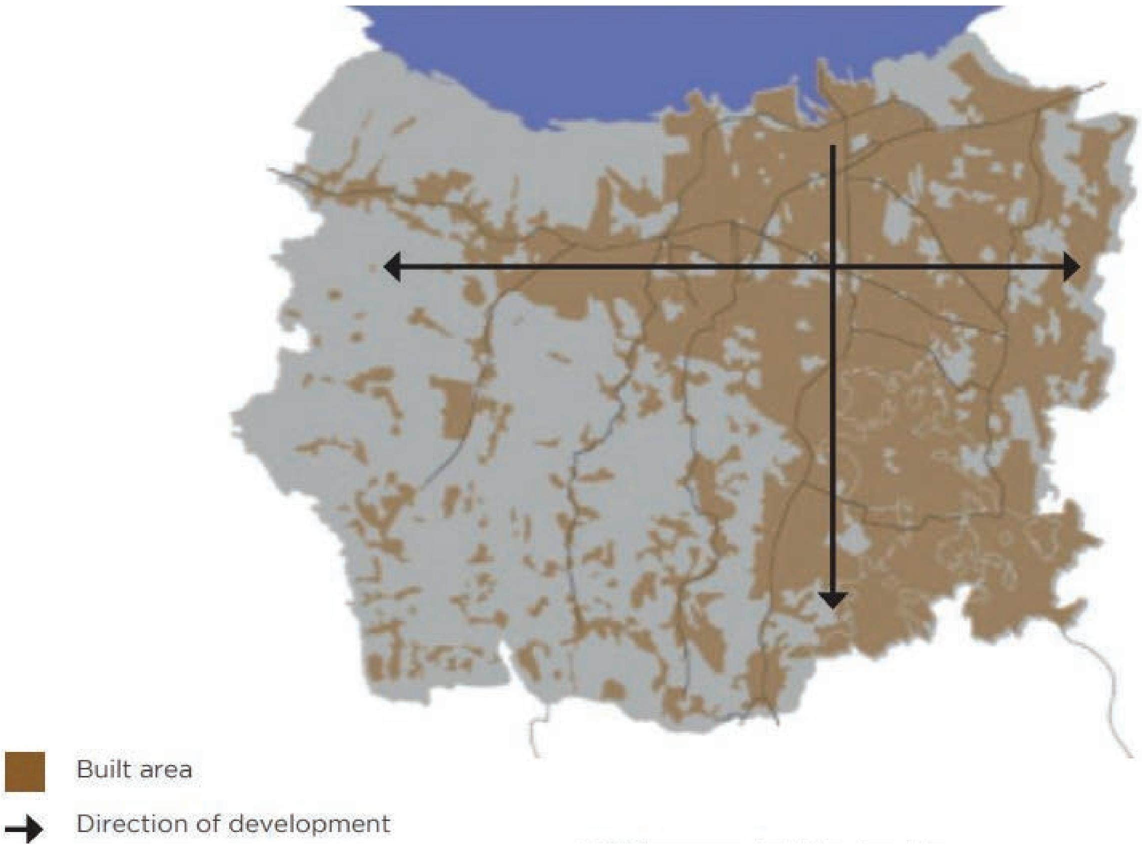


Figure 34: Urban expansion direction
["RESILIENT SEMARANG Moving Together Towards a Resilient Semarang," n.d.]

and Mangkang Wetan.

The local government is now raising the Beringin River embankment during the wet season. According to the authorities, sedimentation-induced constriction of the Beringin River is the primary cause of this flood. Since the 1980s, there has been a significant shift in land use in the Mijen District, which has caused runoff and flow to the Beringin River, and this is where the majority of the flood's contribution originates from.(Hadi 2017)

Actions by people

The affected people's response to these catastrophes has included both individual and group action. Miladan (Miladan, n.d.) discovered that each household in Kampong Tambaklorok independently rebuilt their homes to lessen the effects of tidal flood. Every five years, people raise the foundations of their homes. They are aware that this is merely a short-term solution, but there is no other way to solve the issue. The process of rebuilding a house involves raising the floor with cement, sand, or dirt piles, remodeling the terrace, and raising the roof and yard.

Additionally, as a collaborative effort, residents have been cleaning up garbage and silt, repairing local drainage systems and dikes, reconstructing neighborhood roadways, and maintaining the government-built pump system in order to lessen the effects of tidal floods. The goal of the rehabilitation work is to improve the local streets. To add 30 to 50 cm, they pile such materials on the nearby streets.

Miladan (Miladan, n.d.) goes on to say that at Tanah Mas Estate, residents have taken individual mitigation measures to lessen the effects of tidal floods by raising their homes and streets. Every single household built small walls around their homes, particularly entrances that enclose the houses. These attempts were simply short-term fixes, and their community was really submerged throughout the tidal flood events.

Paguyuban Pengendali Air Pasang Panggung Lor (Association of Controlling and Handling of Rob (tidal flood) Risk in Panggung Lor Sub District) was established as a community collaborative effort in 1996. People believe that the pumping system project was an acceptable response since flooding discharge could be pumped while the Asin River's water surface was higher than the settlement's surface water. People are cognizant of the social and geographic issues raised by local road and housing heights. With help from the Central Javan government, residents of Mangunhardjo and Mangkang Wetan worked together to establish a coastal

Figure 35: Flooding in Semarang streets [“City Resilience Framework City Resilience Index” 2014]

belt. 3,2 km of the 3,5 km of deteriorated shoreline have had their coastal belt completed as of yet. They also received financing from other organizations, including the Ministry of Fisheries and Marine. Locals planted mangrove trees parallel to the coastal belt to fortify it. Mangroves have the ability to restore decrepit fishponds. In reality, a fishpond with mangroves may be replanted with shrimp and milkfish. The coastal belt serves as a sediment trap to restore the damaged shoreline in addition to preventing wave abrasion. (Hadi 2017)

3.3 – HARD POLICIES

For flooding there are many case studies from macro level to micro level, which includes infrastructural policies for urban level to the unit level. So, in this research we have divided it in to three categories.

1. *Macro level (urban scale case studies)*

2. *Medium level (For neighborhood level case studies)*

3. *Micro level (Buildings case studies)*

3.3.1 – MACRO LEVEL CASE STUDIES

ROTTERDAM WATERPLAN 2, ROTTERDAM, NETHERLAND

CONCEPT OF THE DESIGN

Using water as a chance to improve a city's allure by developing and implementing more modern stormwater storage options in a crowded urban environment using an integrated method.

DESIGN APPROACH

Rotterdam is the second-largest city in the Netherlands, behind Amsterdam. It has the largest port in Europe and was the busiest port in the world until Shanghai overtook it in 2004. The port development has a significant impact on Rotterdam's urban environment. Due to Rotterdam's location 2 meters below sea level, the city is surrounded by dikes and has a sophisticated pumping system that prevents floods. Until date, water management techniques have mostly seen water as an invading hazard, focusing on concerns with safety, quantity, and quality. This changed in 2007 when it became more clear that Rotterdam will be significantly impacted by climate change (higher water levels due to rising ocean levels; floods brought on by increased precipitation) [98]. In the meantime, Rotterdam was confronting difficulties including the rebuilding of ancient waterfront districts as well as population decline, particularly among working people. As a result, Rotterdam developed Waterplan 2, a thorough combined strategy for spatial planning and water management.

With the second water design, Rotterdam embraces water as an opportunity,

concentrating on management solutions that offer safety while enhancing the cityscape and promoting contact with water. As a delta city, Rotterdam has always seen water as one of its main attractions. The major purpose is to make the following goals a reality throughout the city while also developing a comprehensive plan known as Rotterdam Watercity 2030.

Figure 36: Vision of Rotterdam water city 2030
[“Municipality of Rotterdam Hollandse Delta Water Board. Waterplan. Rotterdam - KIPDF.COM,” n.d.]

PROJECT GOALS

1- Protection: The project is for resilience against flooding on both sides of barriers.

2- Clean Water: It guarantees to reach the quality of water required by standards of European structure mandate to improve the urban areas feature.

3- Attractive City: Apart from technical features it adds into the urban spatial planning along with the water management and act as attractive urban element.

4- Sewers: Reorganize stormwater flow using decentralized creative solutions that perfectly sync the local region.

DESIGN OUTCOME

By implementing innovative water management strategies that also enhance urban quality, such as green roofs, water squares, water gardens, and creative detainment zones, these aims can be achieved. The water square is one of the City of Rotterdam's most inventive installations (otherwise called water court). This design, which was created by **De Urbanisten and Studio Marco Vermeulen**, improves the open space's natural attributes while using stormwater management systems. The square is used as an open area during dry spells, and during periods of intense rain, it is used to store temporary water. To identify problems and strengthen the concept, a pilot water square type has been developed and will be implemented. 2011 is when execution is expected to start in two different locations. A play area and a gaming field are features of the water square's pilot version of its design.

The space is surrounded on all sides by stairs where people can sit and observe, and it is located about 1 meter below the level of the surrounding ground. The playing surface is divided into a number of zones with varying heights. 90% of the year, the area is dry and used for entertainment. The space changes its capacity just amid substantial rain: Then water streams flow visibly into the square starting at the playground area, filling the carefully arranged hollows in the ground and gradually creates streams, brooks, and small ponds. In the event that the rain endures longer, the games field tops off too. At the point when completely filled, the water square can hold a most extreme of 1,000 cubic meters. After the rain closes, the water will remain for a couple of hours and afterward is gradually released to Rotterdam's sewer frameworks ("Rotterdam Sewers," n.d.).

WATER SENSITIVE DESIGN

When it rains heavily, the space's capacity only changes little. Then, beginning at the playground area, water streams flow dramatically into the square, filling the thoughtfully placed voids in the ground, and eventually produce streams, brooks, and tiny ponds. The games field tops off as well if the rain lasts longer. The water square can store a maximum of 1,000 cubic meters when it is fully filled. The water will linger after the rain stops for a few hours before being gradually discharged into Rotterdam's sewer systems.("Rotterdam Sewers," n.d.)

Figure 37: From left to the right|
1- Square during dry season
2- During mid rainy season functions as water play ground
3- During heaving rain serves as buffer zone to store water
[Hoyer 2011]

Figure 38: View from above of the pilot water square in dry, medium, and heavy weather (left to right)
[Hoyer 2011]

INTEGRATION IN SURROUNDING AREA

A concerted effort involving many planners, agencies, and water boards resulted in the steps that are suggested by Waterplan 2. The main goal was to develop site-appropriate methods for diverse city locations. While development in Rotterdam Zuid focuses on connecting waterways and increasing the part of current surface water bodies for water governance and recreation, proposals for the local locations of Rotterdam Nord use water squares, green rooftops, as well as, water gardens to improve the appeal and connectedness of the areas. The city also started looking at novel architectural alternatives for storing water in denser urban areas during the planning stage: water squares of 50 different sizes and shapes, water avenues, underground cisterns, green roofs, and blue rooftops.

FUNCTIONAL DESIGN SOLUTION

Height estimates, flow off models, and water detention capabilities were calculated to identify the regions that are appropriate for creating water squares. The planners commissioned design studies to show potential layouts for the water squares in the interim. Additionally, they looked at the entire cityscape to determine which buildings would look best with green and blue rooftops added later. Pilot projects also provide information for future endeavors, such as an open underground parking structure at the Rotterdam Museum Park with a maintenance reservoir that retains water after heavy rain.

APPROPRIATE USABILTY

Every suggestion made in Rotterdam's Waterplan 2 aims to increase open space accessibility for water capacity while also enhancing its convenience. For instance, the water squares are designed in such a way that they are enticing places to play, relax, and wait. Planners came up with ideas for how these areas may be used as water playgrounds or even for boats, despite the fact that before and after rain, water is kept in the squares. The same holds true for other stormwater infrastructure that the agreement suggests, such as green rooftops, which serve their function of holding water while also providing room for wildlife. For around 90% of the year, water boulevards serve as regular open recreation areas and may store water during heavy downpours. Overall, Rotterdam has had the most impact on ideas for varied urban space usage.

INTEGRATIVE PLANNING

This size of city improvement is unquestionably a mind-boggling endeavor. The Waterplan 2 of Rotterdam refers to a comprehensive list of demands made for a city’s improvement. From the outset of Waterplan 2, water management and planning were mutually established and later required for the advancement of objectives and processes. There were created expensive city-wide networks that were also divided by region and then by specific communities. The all-inclusive strategy is then mirrored by specific arrangements, which also respond to specific group requirements. Additionally, arrangements were created with future development goals in mind and typically serve as public parks or group gardens.

3.3.2 – MEDIUM LEVEL CASE STUDIES

COPENHAGEN CLOUDBURST MANAGEMENT PLAN

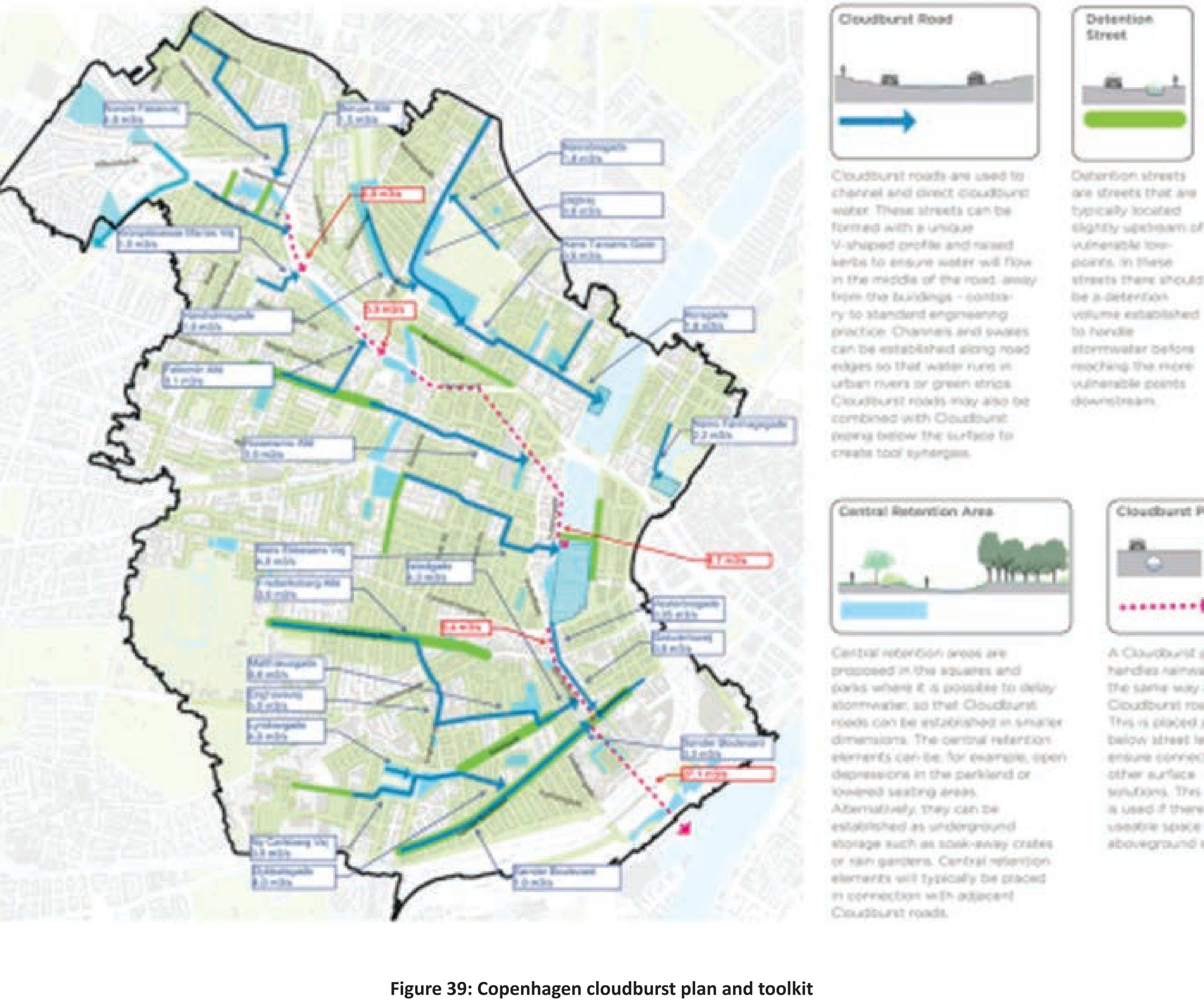


Figure 39: Copenhagen cloudburst plan and toolkit
[“Cloudburst Management Plan, Copenhagan,” n.d.]

INTRODUCTION

During 2012 a project of cloudburst management program was implemented in Copenhagen, Denmark by the ***city of Copenhagen & Ramboll*** [24]. The strategy was developed in response to a terrible string of storms that struck the city between 2010 and 2011, causing damages totaling 3.8 billion Danish Kroner.

Figure 40: Flood in Copenhagen
[“Cloudburst Management Plan, Copenhagan,” n.d.]

CONCEPT OF DESIGN

By regulating precipitation at the surface, Copenhagen’s Cloudburst Management Plan employs adaptive methods that reduce pluvial floods while also making the city greener and blue.

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[24] *A multinational engineering, architecture, and consulting firm called Ramboll was established in Denmark in 1945. For 75 years, Ramboll has been a crucial part of the city’s growth.*
Copenhagen consistently ranks first in the world for being livable, sustainable, and intelligent. Numerous open spaces, swimming areas along the harbor, a network of bike lanes across the entire city, and a low-carbon energy system all serve to draw people to the area.

PROJECT GOALS

The city will be ready for storm events 100 times more frequent thanks to the projects carried out as an outcome of the plan than the current sewer system, which can only handle storm events 10 times more frequent.

The objective is to prepare for and make investments in measures that will both safeguard the city from severe flooding occurrences and reduce strain on the sewage system during frequent rain events. Urban flood adaptation strategies should ideally include methods for draining surface-level precipitation, which will make the city greener and bluer.

The expense of damages from the aforementioned disasters is expected to be 5–6 billion Danish Kroner, but provided that, ***“recommendations lead to using the resources on preventing floods instead of on restorations once the harm has been done”***

Future storms of similar size and frequency are anticipated to occur more frequently in Copenhagen due to climate change. A severe rain event, according to the Danish Meteorological Institute, is one that produces 15 mm of rain in less than 30 minutes.

Copenhagen must deal with the possibility of rising seas as a coastal city. These two scenarios together pose significant difficulties, and the solutions intended to address them will need to differ from region to region in context-specific modifications. The Cloudburst Management Plan serves as the foundation for both specific mitigation actions and overall city

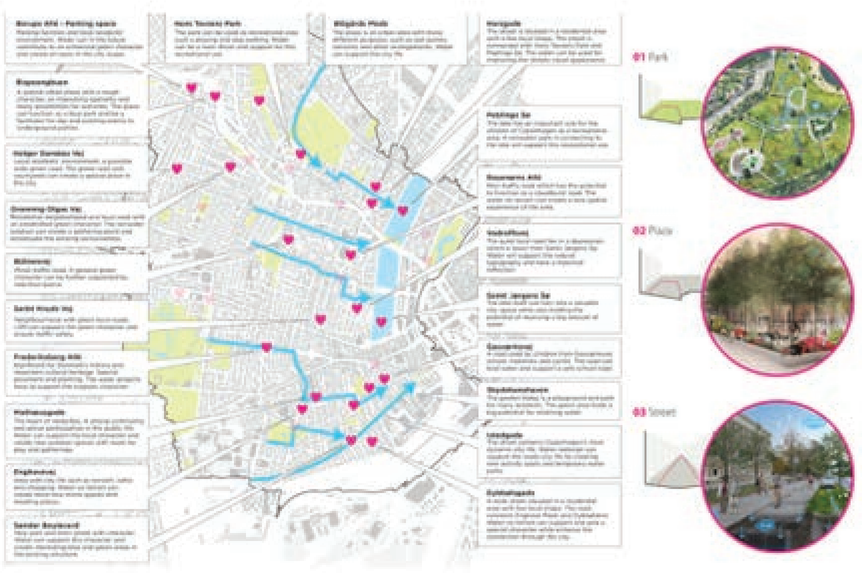


Figure 41: Cloudburst management masterplan, Copenhagen [“Cloudburst Management Plan, Copenhagan,” n.d.]

administrative planning and is based on thorough flood mapping and risk studies. For implementation to be effective, a collaborative strategy involving the public, utility companies, and city administration is needed.

Although it is preferable to choose surface solutions that can trigger many advantages, this is not always possible in Copenhagen. Subterranean tunnel solutions will be used if there are no options for surface-level water storage.

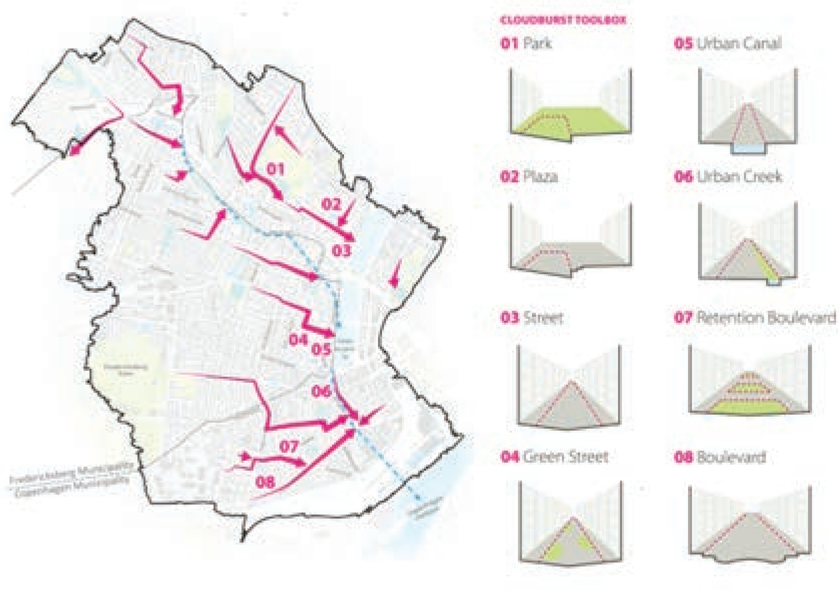


Figure 42: Directing the flow of flood water for flood protection [“Cloudburst Management Plan, Copenhagan,” n.d.]

When the plan was first put forth, it was suggested that rainwater be evacuated by discharging it to areas where flooding would cause the least amount of disruption, such as parks, sports fields, and open spaces, with the concept that these floodable areas would conserve water until the drainage system had managed to recover capacity to receive these flows.

However, calculations and future significant rain events have conclusively demonstrated that this strategy is insufficient to stop pluvial flooding in several parts of the city. According to recent studies, mitigating measures should also include methods for directing water out to sea through underground tunnels, canals, and urban waterways. The possible environmental effects of this strategy, however, have not been investigated.

Both flood risk and the possibility for synergies with other projects, such as road restoration, new urban growth, etc., were taken into consideration while prioritizing flood mitigation measures and municipal districts. Areas with a high risk of flooding, areas where adaptation measures would be simple to put into place, and areas where pluvial flood waters can be diverted

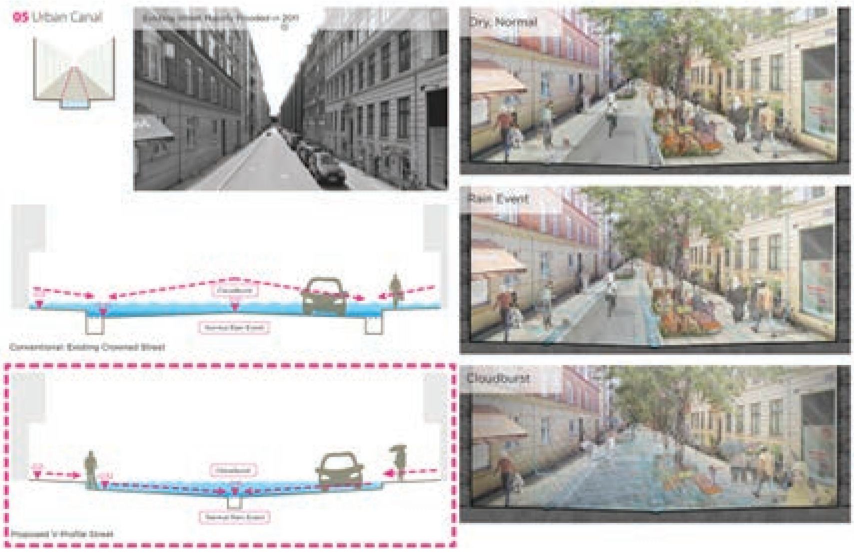


Figure 43: Street planning to help during time of floods
["Cloudburst Management Plan, Copenhagan," n.d.]

to locations where they won't cause harm, like next to the harbor, are all important considerations.

Along with potential locations for synergistic impacts, ongoing construction or renovation projects that may be carried out alongside flood adaptation measures were also taken into account. The city was separated into water catchment areas, prioritized, and then each area's risk, implementation potential, compatibility with active urban development projects, and synergistic effect were evaluated. Each basin was given a weighted score, with preference given to options that allow for multipurpose spaces with green recreational space. There have been identified more than 300 citywide pilot programs.

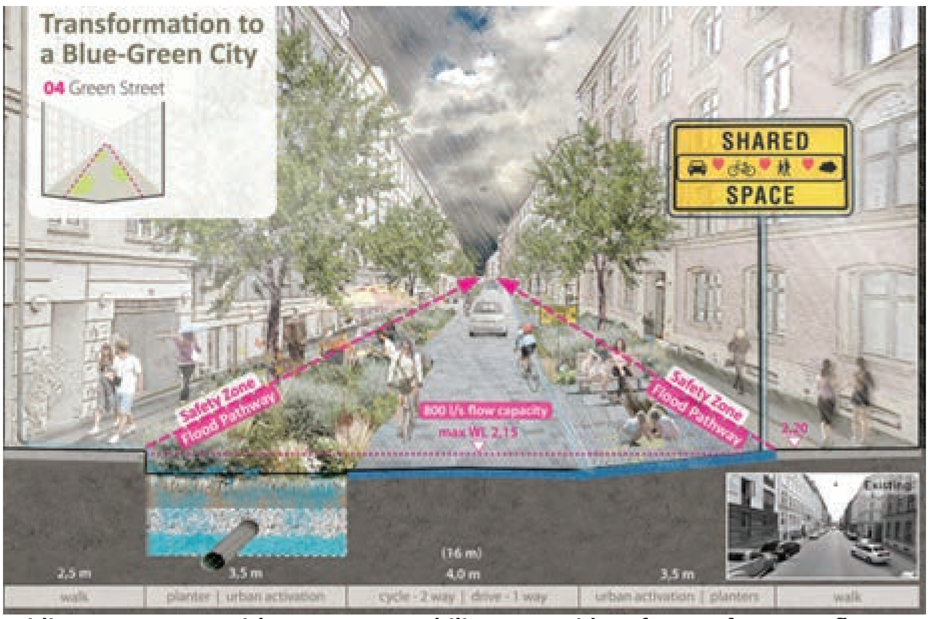


Figure 44: Providing green areas with water permeability to provide safe zone for water flow
["Cloudburst Management Plan, Copenhagan," n.d.]

DESIGN APPROACH

1. Green streets|

are suggested to connect all Cloudburst roads upstream. The stormwater planters or permeable paving should be used in conjunction with small scale channels to create the green streets. The Cloudburst roadways should receive stormwater that has been collected, held back, and then sent there.

2. Retention streets|

that are a little bit upstream of weak points are known as retention streets. To treat rainwater before it reaches the more vulnerable sites downstream, a retention volume should be set up in these streets.

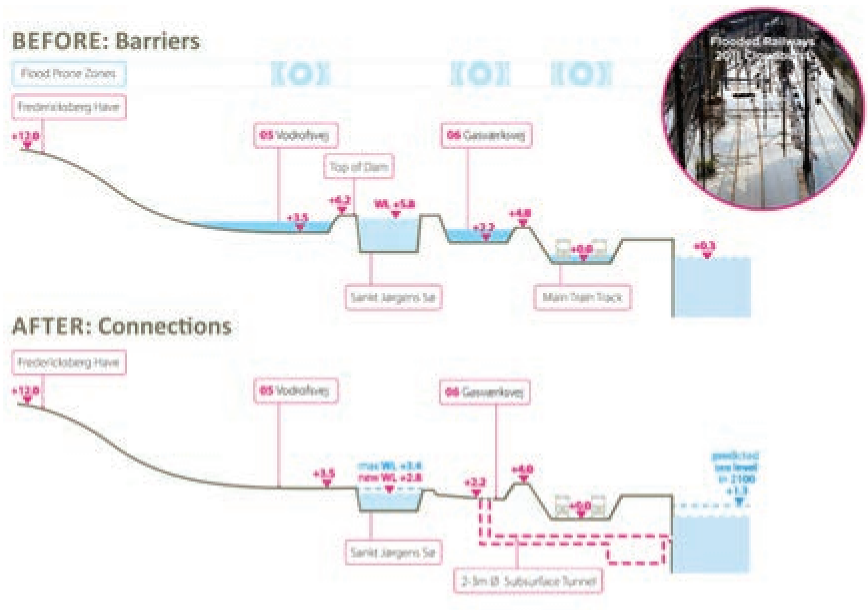


Figure 45: Section showing flood water management ("Cloudburst Management Plan, Copenhagan," n.d.)

3. Cloudburst roads|

cloudburst water is channeled and directed using cloudburst roadways. Contrary to conventional engineering practice, these streets might be designed with a distinctive V-shaped profile and higher *curbs to ensure that water will flow in the center of the road, away from houses. It is possible to create swales and channels along roadsides to direct water into green spaces or urban rivers.*

To generate tool synergies, Cloudburst roadways can also be connected to Cloudburst pipework underground.

4. Cloudburst pipes|

Like Cloudburst roads, Cloudburst pipes manage rainwater. To assure connection to other surface solutions, these are positioned just below street level. If there is no space that can be used for aboveground solutions, this solution is adopted.

Figure 46: Section showing flood water management ("Cloudburst Management Plan, Copenhagen," n.d.)

5. Central retention|

Areas in the parks and squares where stormwater might be delayed are suggested so that Cloudburst roads can be built in lesser sizes. For instance, open recessions in parklands or sunken seating areas might serve as the focal points. Typically, central retention components will be positioned beside nearby Cloudburst roads.

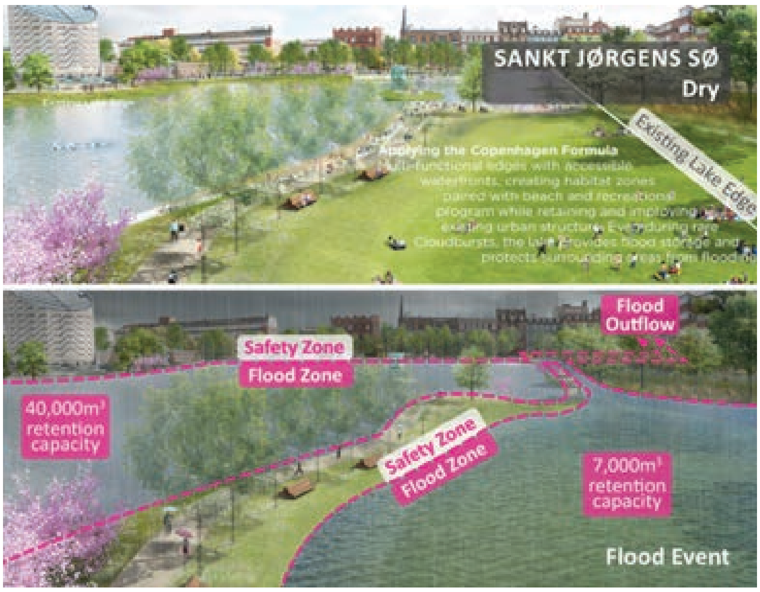


Figure 47: Retention zones for flooding period [“Cloudburst Management Plan, Copenhagen,” n.d.]

DESIGN OUTCOMES

1. *Reduced flooding*

2. *Increase water storage by increasing permeability*

3. *Less load on the drainage and sewerage systems*

4. *Improvement in quality of environment and city ambiance by providing blue and green infrastructure*

5. *Good quality life for biodiversity*

Figure 48: New master plan for resilient city
[“Cloudburst Management Plan, Copenhagan,” n.d.]

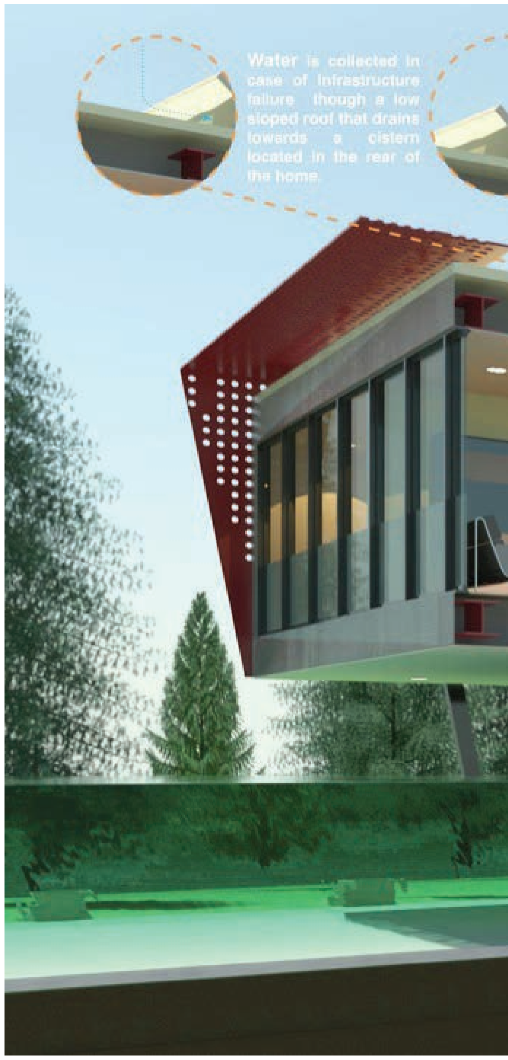
3.3.3 - MICRO LEVEL CASE STUDIES

For unit level we have selected residential category. Case studies are:

- ***Flood house***
- ***Amphibious house***

1- FLOOD HOUSE

The project was designed by the team F9 production. The idea originated by lance cayko and alex gore after their personal experience of living in the region of Fargo that is flood prone region. They thought of the disaster that can ruin the living being there they proposed a solution of resilient house. They designed a house that can survive the stresses and shocks of extreme conditions caused by flooding.



SOLUTION

They raised the building for creating a space for flooding season and provided living amenities on first floor and from the ground floor there is main entrance, parking, and the basic amenities.

On one side the architects provided emergency exit for extreme flooding season by creating a sun deck to approach the boat which also helps for getting basic supply delivery.

Figure 49: Section perspective of Flood house
[“Flood House _ F9 Productions _ ArchDaily,” n.d.]

Figure 50: Floor plan main level
[“Flood House _ F9 Productions _ ArchDaily,” n.d.]

LEGEND:

1- In order to combat the winter cold, cars are protected beneath the main living level and heated by automated starters.

2- The entrance is reached through a concrete pathway.

3- To guard against any slight flooding, the washer/dryer and all electrical outlets are raised above the ground.

4- The entrance acts as the primary entrance to the house.

5- On the ground floor are storage areas for toys, tools, and legal supplies.

6- optional room for growth.

7- The master suite and all other bedrooms are raised off the ground, protecting priceless possessions from floods.

8- Both residents and visitors of the house have access to two bathrooms.

9- The home’s primary storage wall, which is in the middle, has room for emergency supplies, books, blankets, dishes, and other things.

10- A secondary heating source for the house is the fireplace.

11- There is space for entertaining in a cozy living/dining configuration.

12- The living room and rear sun terrace are also visible from the kitchen, which has a full-height pantry.

13- A fire pit, cozy chairs, a bar, and a dining table can be found on the sun deck.

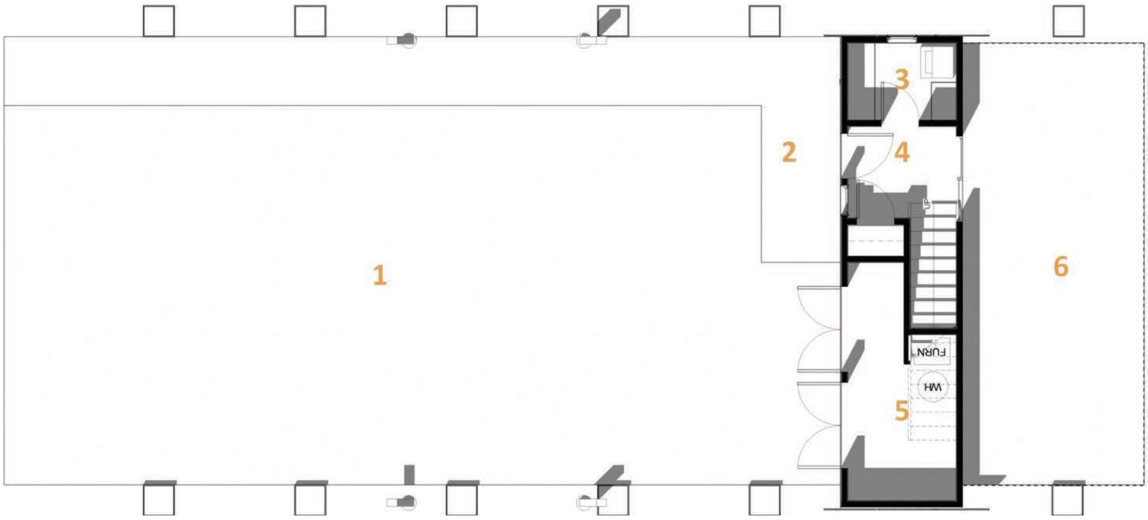


Figure 51: Floor plan entry level
[“Flood House _ F9 Productions _ ArchDaily,” n.d.]

Figure 52: Exterior view
[“Flood House _ F9 Productions _ ArchDaily,” n.d.]

Figure 53: Interior view
[“Flood House _ F9 Productions _ ArchDaily,” n.d.]

2- AMPHIBIOUS HOUSE

The first amphibious house in the UK.

In south Buckinghamshire, there are 15 buildings on a tiny island in the River Thames. Most of them were constructed in 1950s, to protect them from floods they raised most of them on timber pillars, 1 meter above the ground level. But they were not enough for catastrophic flooding. So, to deal with that problem the Baca Architects worked on proposal of amphibious house.

Figure 54: Plan | house during normal days [Baca Architects, n.d.]

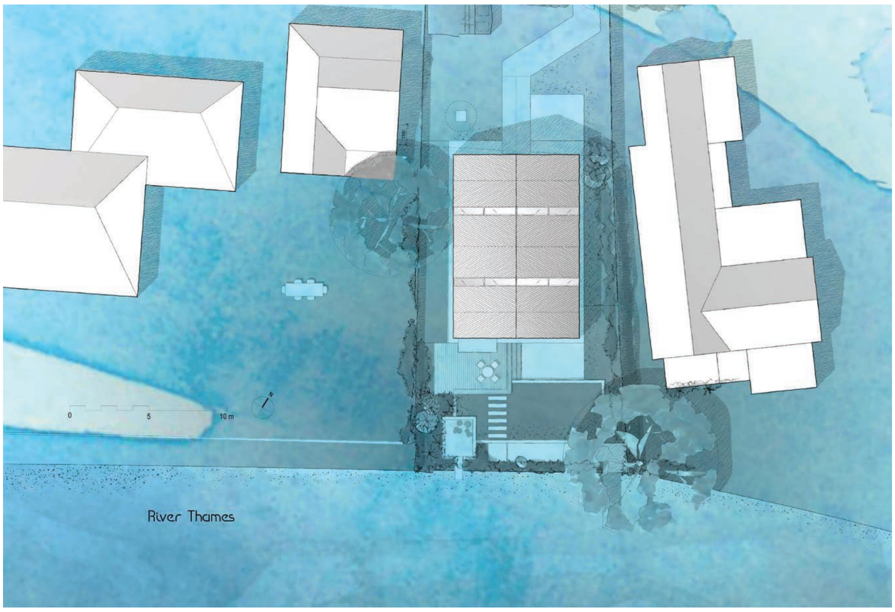


Figure 55: Plan | house during flooding [Baca Architects, n.d.]

SOLUTION

The answer was an amphibious home, a structure that floats during a flood but raises in its dock when it’s dry and sits on the surface when it’s not. The floating base is hardly apparent from the outside of the home, which is rooted in the ground. The house’s ground floor is elevated by less than 1 m above the ground as opposed to about 2 m as would be necessary if it weren’t amphibious. By using this method, it was possible to build a three-story, 225m2 three-bedroom home instead of a single-story, 90m2 home without greatly raising the ridge height.

The location of the property is in the Thames River’s central catchment area. The river is broad and accessible, and it takes a significant amount of rain for it to crest. A flood can be predicted two more days in advance thanks to flow gauges that have been erected along the river. So, when site does flood, it may do so for a number of days.

Figure 56: Image of Buoyant house by Baca architects [Baca Architects, n.d.]

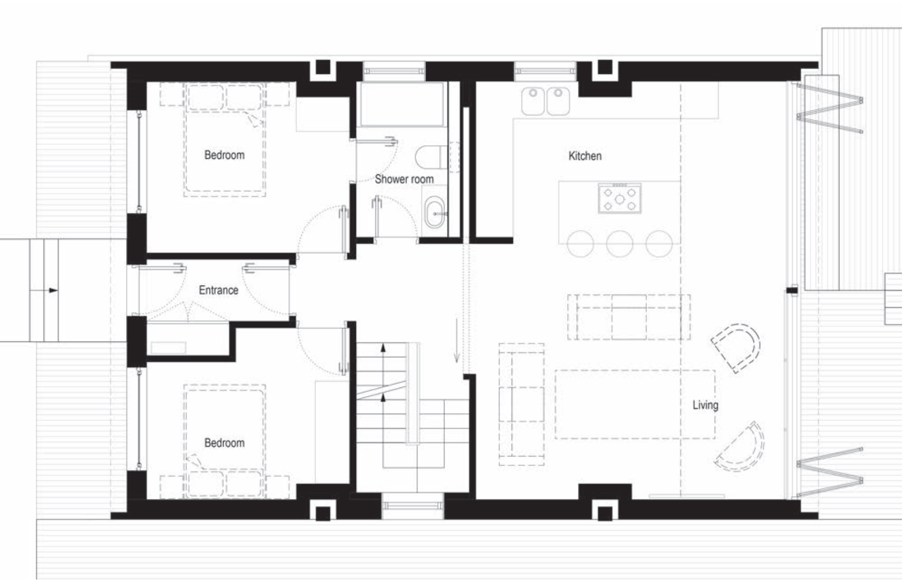


Figure 57: Ground floor plan of Buoyant house by Baca architects [Jessica Mairs, n.d.]

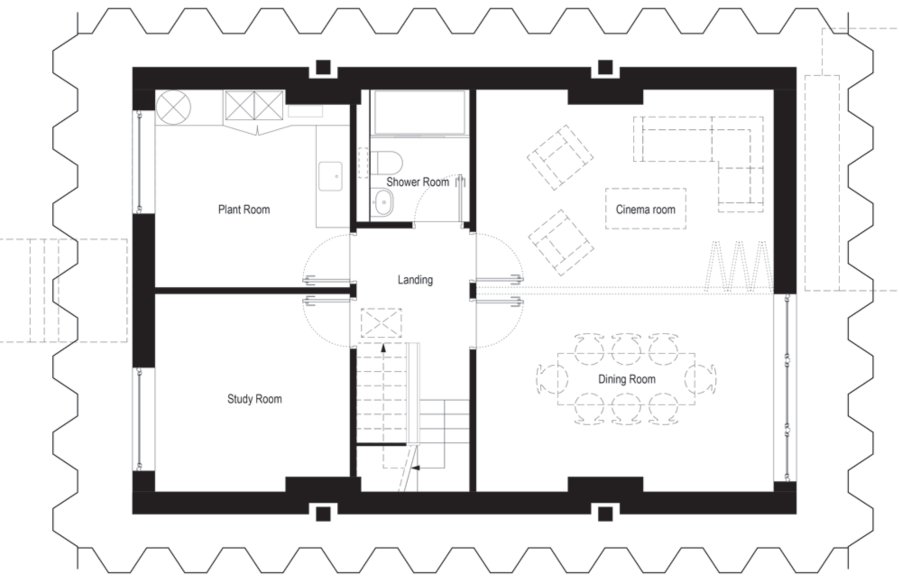


Figure 58: First floor plan of Buoyant house by Baca architects [Jessica Mairs, n.d.]

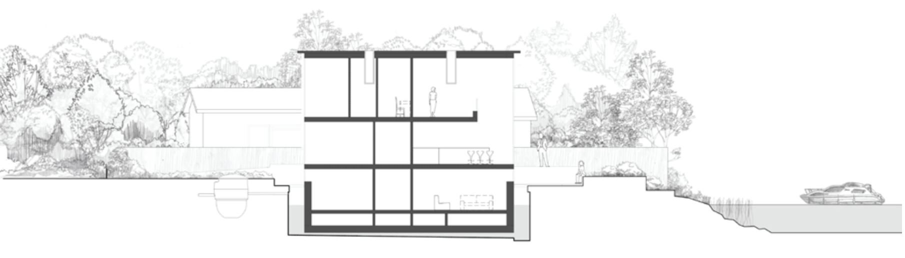


Figure 59: Section of Buoyant house by Baca architects [Jessica Mairs, n.d.]

Hydroscapes|

A thoughtfully designed garden serves as a built-in flood warning system. At Baca Architects, we refer to this as an “intuitive landscape”; terraces placed at various elevations are intended to flood gradually and warn the residents long before the flood water hits a worrisome level. Reeds and other plants and bushes are grown on the terrace with the lowest elevation. The terrace is situated at the highest point, just under the living room, while the lawn is situated one level above. Terraced levels aid in recovery by providing dry patches when water levels fall and by preventing the dock from becoming salted.

Elephant cabling connects the amphibious home to its utilities. All the services can continue to be clean and functional throughout any flooding incident thanks to these flexible service pipes, which may stretch up to 3m. Importantly, this maximizes the continuity of the residents' everyday life by enabling them to return to the property right away after a flood.
During construction, a float test was performed by elevating the house by half a meter by its own buoyancy while the wet dock was filled with water. Once the steel structure was finished and the house was furnished, the house underwent another test.

The United Kingdom had significant

winter floods between November 2019 and February 2020. The proprietors of the #AmphibiousHouse, which was featured on Channel 4's Grand Design series, said that during this time the River Thames grew and that "the home keeps rising and falling without interference." (Jessica Mairs, n.d.)(Baca Architects, n.d.)

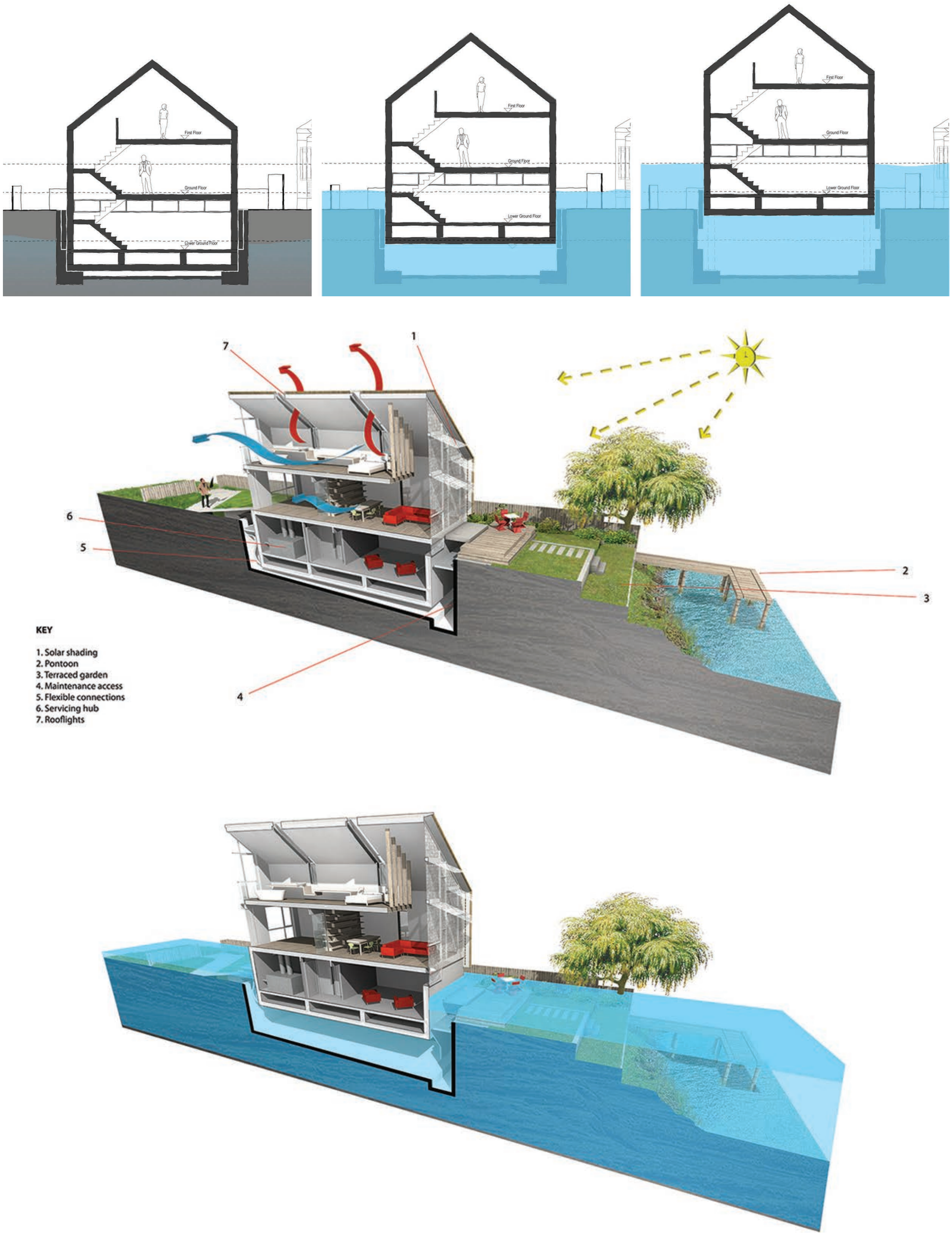


Figure 60: Sections of Buoyant house Showing before and after flooding phenomenon of house [Baca Architects, n.d.]

3.4 - PRECEDENTS SUMMARY

SOFT POLICIES	HARD POLICIES	HARD POLICIES
SEMARANG	**ROTTERDAM WATERPLAN 2**	**COPENHAGEN CLOUDBURST MANAGEMENT PLAN**
MACRO LEVEL	MACRO LEVEL	MEDIUM LEVEL

SEMARANG

- Floating floors
- elevating floors to avoid flooding
- Using nets in ponds and additionally anchoring with rocks to avoid loss because of flood
- Private companies use automated pumping system
- Construction of new road near port and elevate it 50 cm higher than old one

ROTTERDAM WATERPLAN 2

- Protection from flood by creating buffer zones- public space as water management space during flood
- Blue green infrastructure for flood management and beautifying city
- Clean sewers

COPENHAGEN CLOUDBURST MANAGEMENT PLAN

- Creating retention streets
- Channeling water, as we cannot stop water flow but can give it safe directions to avoid damage
- Creating public spaces as central retention points
- Less load on drainage and sewers
- Blue green infrastructure

3.4 - PRECEDENTS SUMMARY

HARD POLICIES

FLOOD HOUSE

UNIT LEVEL

- Elevating the living part of floor to avoid flooding
- Approaching sustainable materials
- Solar panels to produce electricity

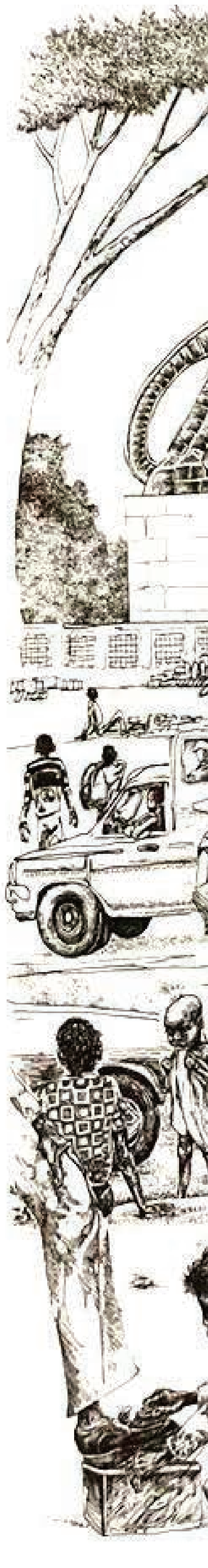
HARD POLICIES

AMPHIBIOUS HOUSE

UNIT LEVEL

- Using principle of Buoyancy
- Modular house

Part 3| ADDIS ABABA AND FLOODING: OVERVIEW AND DESIGN SURVEY RESEARCH



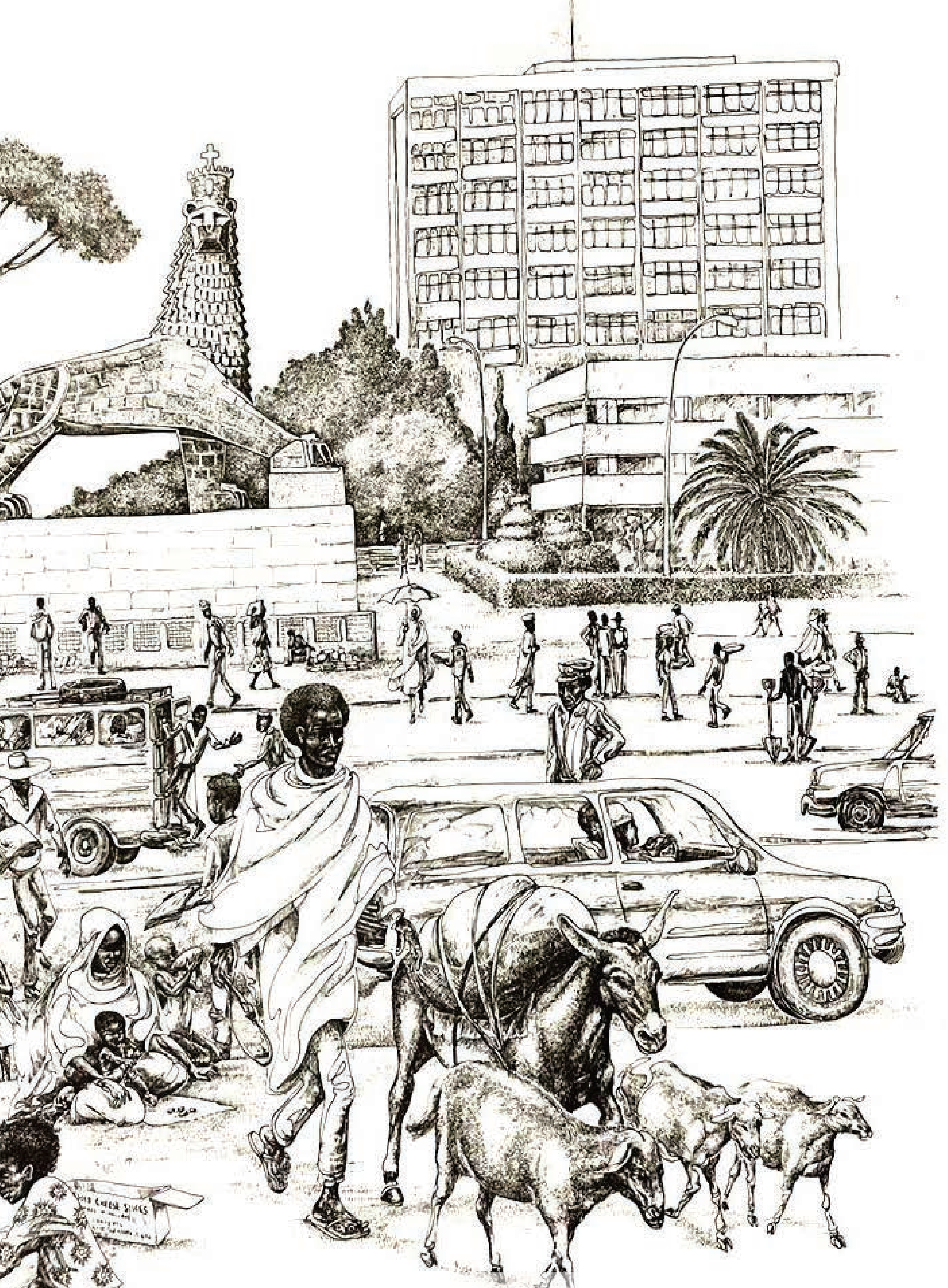


Figure 61: Monument of Lion of Juda [25] (Eduardo Di Muro, n.d.)

[25] A book written by Eduardo Di Muro which illustrates the social character of urban capitals of Africa. He tried to explain the scenes of community, markets and streets and drew the culture through his drawings.

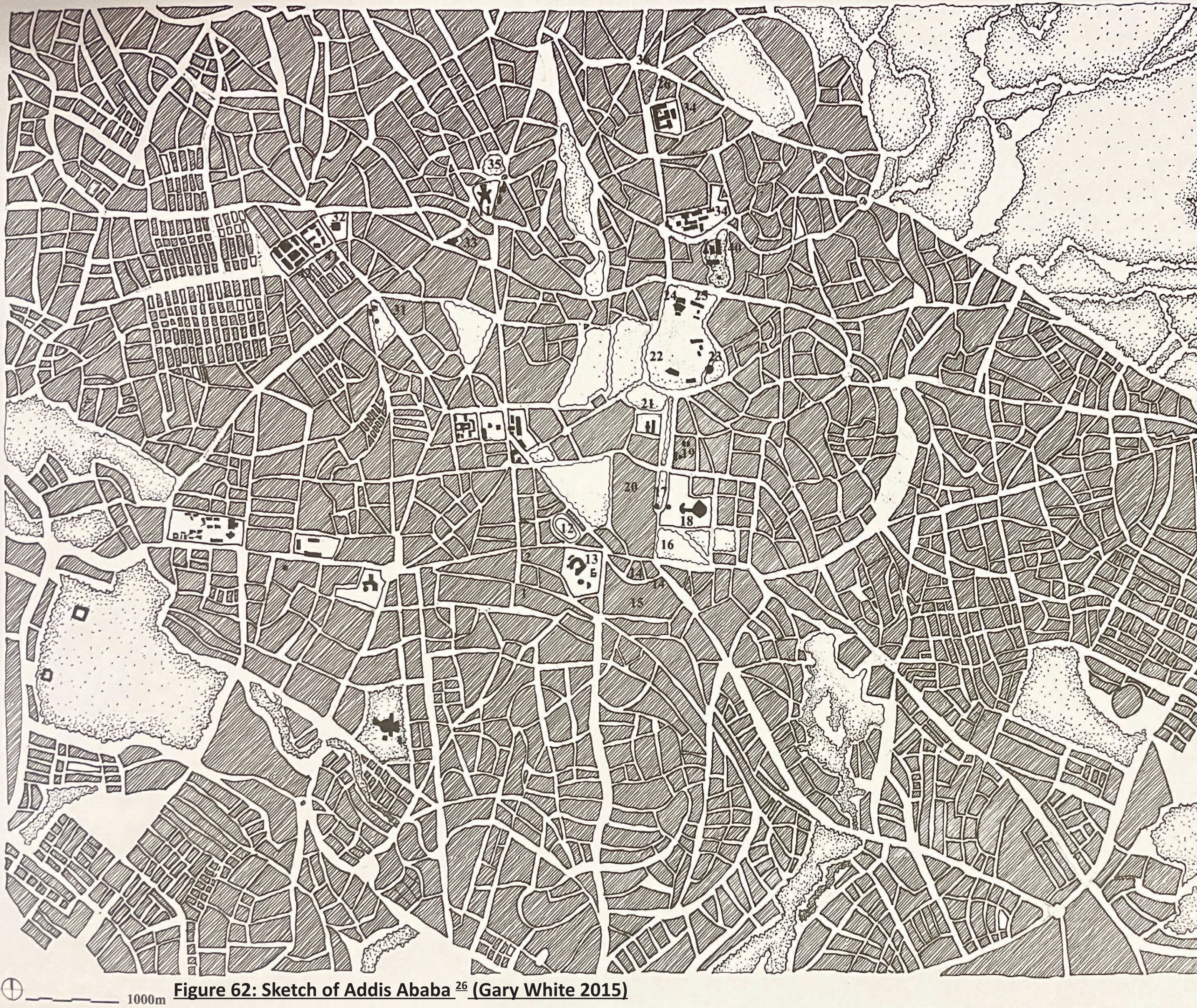


Figure 62: Sketch of Addis Ababa [26] (Gary White 2015)

|04

CONTEXTUAL ANALYSIS| INTRODUCTION TO ADDIS ABABA AND FLOODIING

ADDIS ABABA IN "AFRICA DRAWN - one hundred cities"

Addis Ababa means "new flower" | Evolution of city was originally urban settlements around hot springs. The settlements organically developed around the king's palace. The infrastructure and streets were not developed initially as the city was not planned properly. That's why the connections between the camps around the king's palace were widened like footpaths. Which later developed in organic fabric.

According to Baumeister and Knebel (2009) (Bakker, n.d.) state that as the city continued to expand, a street network was created by joining the dots of the original encampment. New and contemporary urban functions including stores, hotels, theaters, offices, workshops, etc. evolved here. There are several sizable sections with primarily traditional building constructions interspersed between these linear linkages with modern elements, such as street liners.

In Addis Ababa rather than planning one centralized building for market, there were small suppliers along one street. The outdoor open spaces were used for display and informal markets.[26]

[26] Book by Bouwer Serfontein, Gary White, and Marguerite Pienaar | Africa is unquestionably more than just a continent with isolated villages in the savannah and bush. African cities and metropolitan areas are among the fastest developing in the world, and the continent is rapidly becoming more urbanized. One hundred of the most connected and significant cities on the continent are shown in Africa Drawn. The goal of this book is to map the urban shape and structure of African cities, as well as to explain and provide examples of how these various locations were created.

4.1 - GEOGRAPHICAL LOCATION

Ethiopia is the world's most populated landlocked country, bordered to the north by Eritrea, to the north-east by Djibouti, to the east by Somalia, to the south by Kenya, and to the west by South Sudan and Sudan. At a height of around 1,800 meters, Lake Tana is Ethiopia's biggest inland lake and the major reservoir for the Blue Nile River. ("Geography of Ethiopia," n.d.)

Ethiopia is home to a variety of climate zones, ranging from equatorial desert to humid subtropical climate.

Addis Ababa, the 527-square-kilometer metropolis is in the heart of the country on a well-watered plateau at an elevation of roughly 2324 meters, surrounded by hills and mountains.

Addis Ababa is a grassland biome situated at 9°1'48''N 38°44'24''E, at a height of 2,355 meters (7,726 feet). The city is located at the foot of Mount Entoto, in the Awash River's watershed. Addis Ababa climbs to almost 3,000 meters (9,800 feet) in the Entoto Mountains to the north, from its lowest point around Bole International Airport at 2,326 meters (7,631 feet) above sea level on the southern fringe. There are two seasons in Addis Ababa: a rainy summer and a dry winter.

Ethiopia, being a developing country,

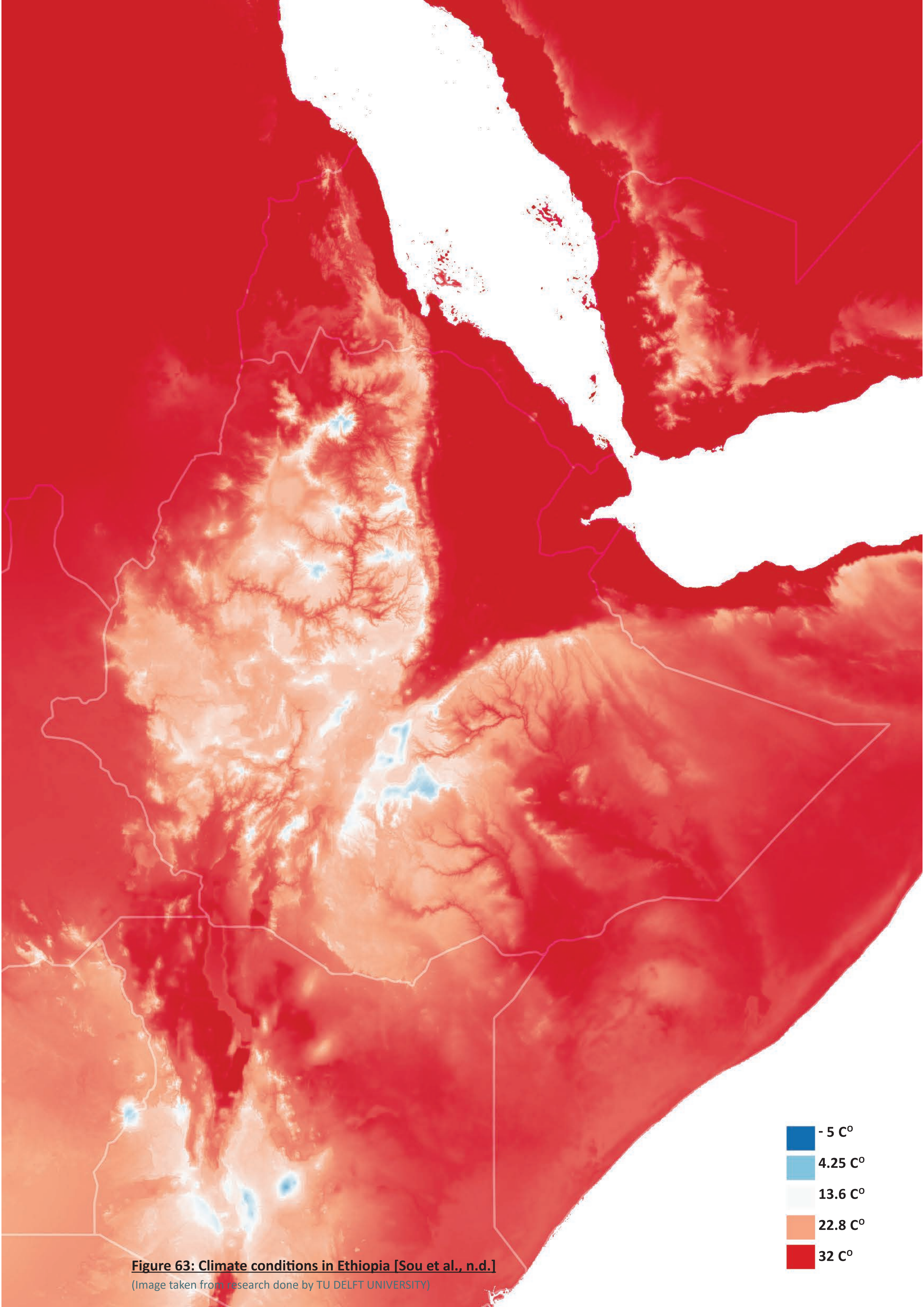


Figure 63: Climate conditions in Ethiopia [Sou et al., n.d.]

(Image taken from research done by TU DELFT UNIVERSITY)

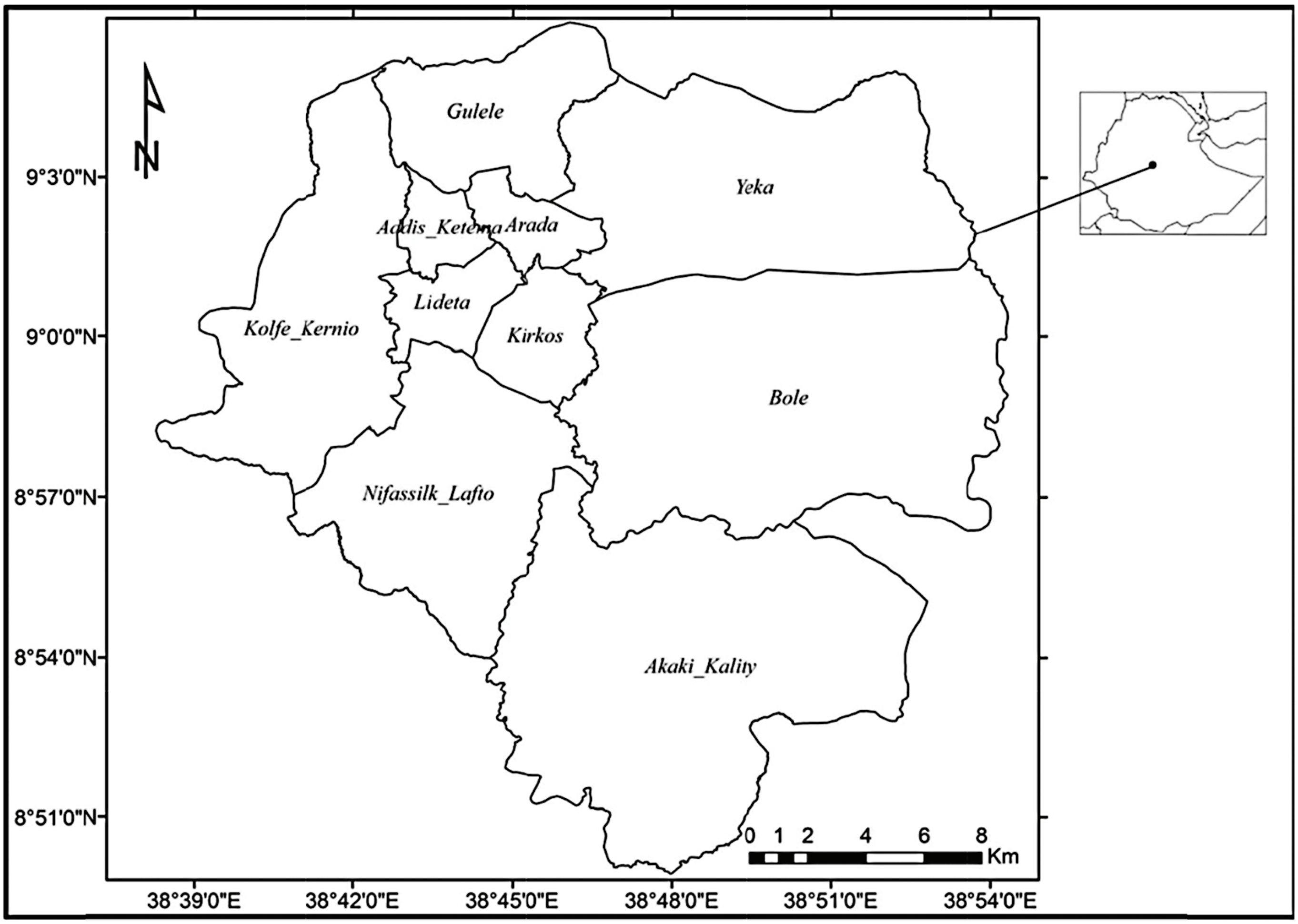


Figure 64: Addis Ababa by sub- cities [27] [Worku 2017]

nonetheless has a lot of natural resources. However, as the world's population grows, so does demand for farmland, commercial agriculture (coffee plantations), firewood, and construction materials, making deforestation an unavoidable environmental hazard. Furthermore, as the earth is less capable of storing water to the subsurface, the loss in forest area will increase the likelihood of drought.

[27] (Worku H. Integrating climate change adaptation strategies in urban planning and landscape design of Addis Ababa City, 2017)

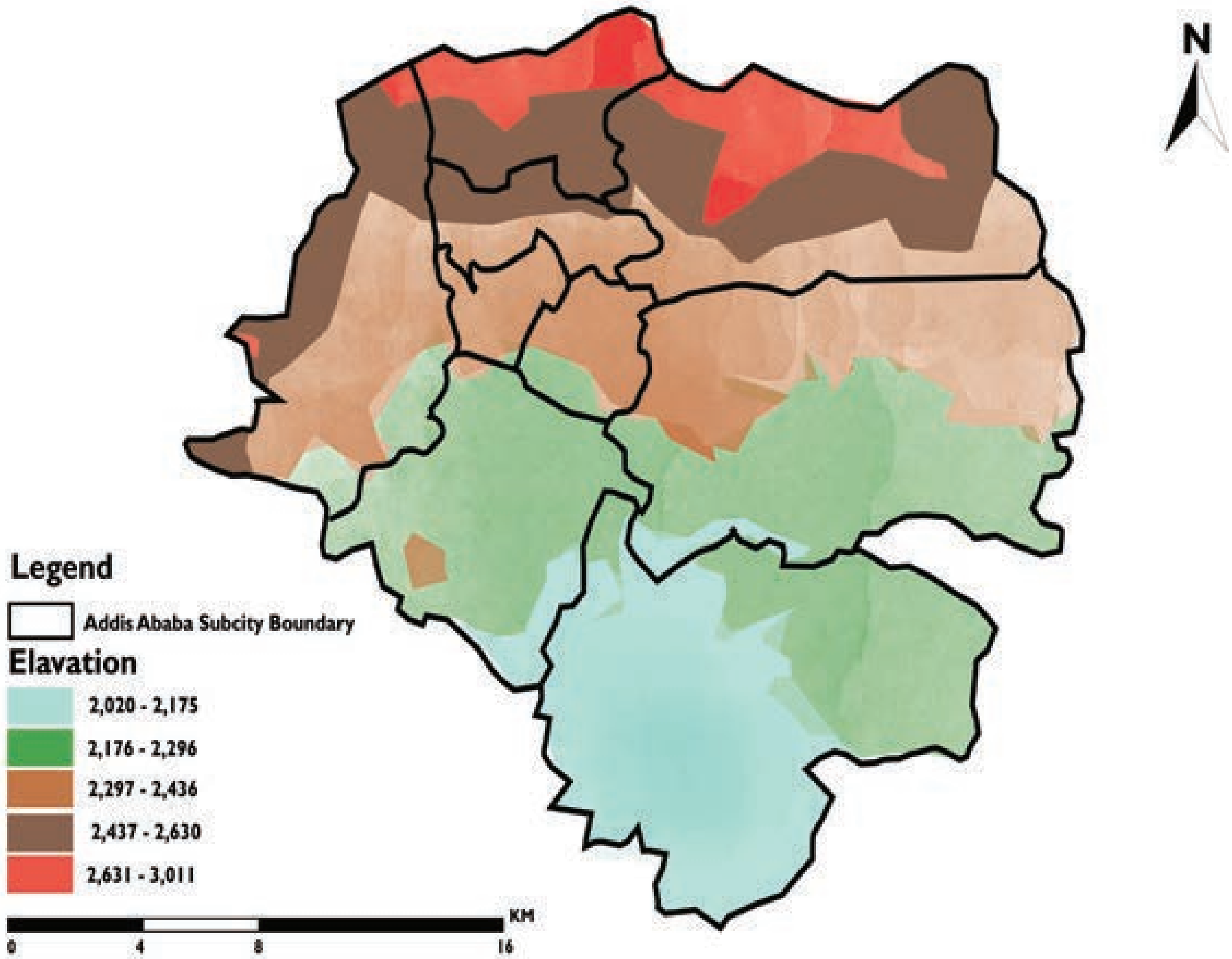


Figure 65: Different altitudes of Addis Ababa [Worku 2017]

4.2 - HISTORICAL BACKGROUND

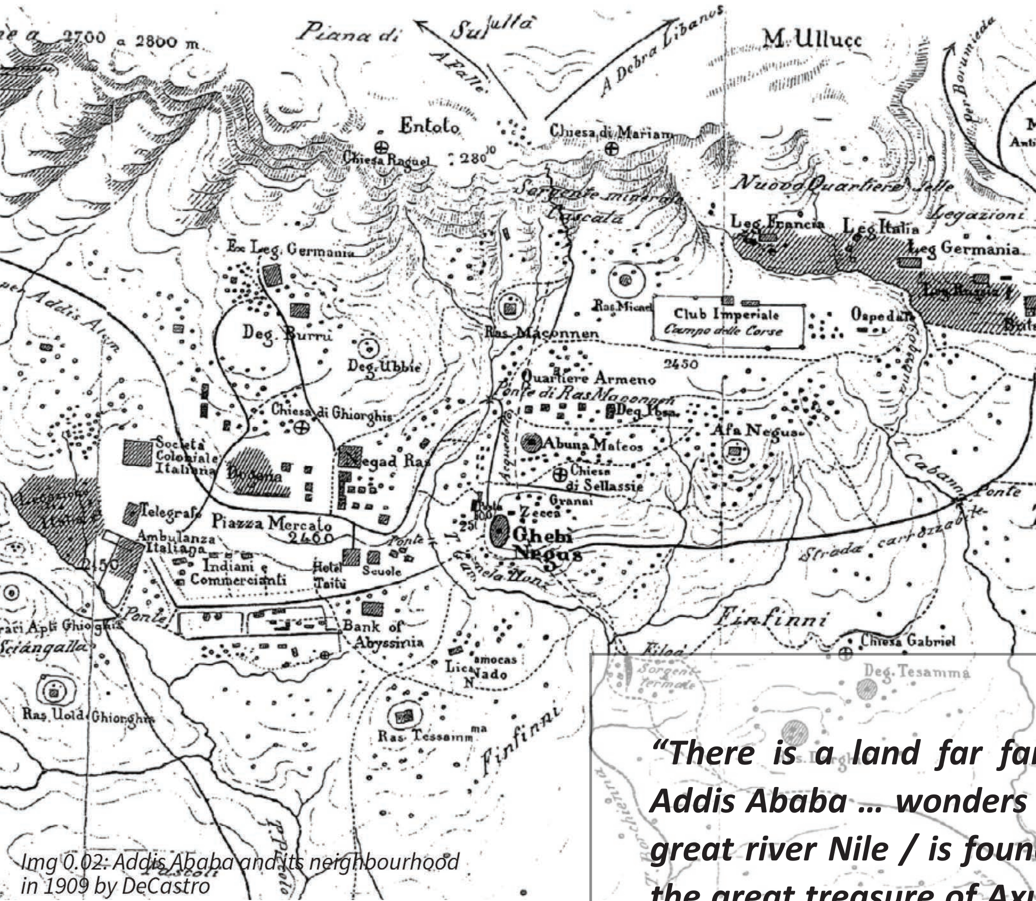


Figure 66: Addis Ababa and its neighborhood in 1909 by DeCastro [Subačiūtė, de Graaf, and Zhou 1962]

"There is a land far far away it's called Addis Ababa … wonders of the world / the great river Nile / is found there in Africa / the great treasure of Axum / Axum of Zion / is found there in Africa"
ADDIS ABABA (BY CULTURE)
[Addis Ababa - Culture, n.d.]

Figure 68: Addis Ababa & Entoto [Subačiūtė, de Graaf, and Zhou 1962]

Addis Ababa is Ethiopia's largest city, and it was named capital in 1887 due to its warmer climate than Entoto, the former capital. In the history of Ethiopia, the capitals kept on changing. According to the author **Ronald J. Horvath of the book "The wandering capitals of Ethiopia"** [Horvath 1969] we can find out the capitals with their timeline in following order:

1. *Axum and neighborhood: Before Christ – 12th cent. A.D.*
2. *Lasts capitals (Lalibela): 12th cent. -1268*
3. *Teguelat: 1268 – ca. 1412*
4. *Roving capitals: 1412 – 1636*
5. *Gondar: 1636 – ca. 1755*
6. *Regional capitals: 1755 – 1855*
7. *Magdella: 1855 – 1868*
8. *Mekele: 1886-1889*
9. *Addis Ababa: 1890 – present*

The two main factor of this moving capitals was the military considerations and burnout of resources mainly food and wood.

(Image taken from research done by TU DELFT UNIVERSITY)

Figure 68: Addis Ababa & Entoto [Subačiūtė, de Graaf, and Zhou 1962]

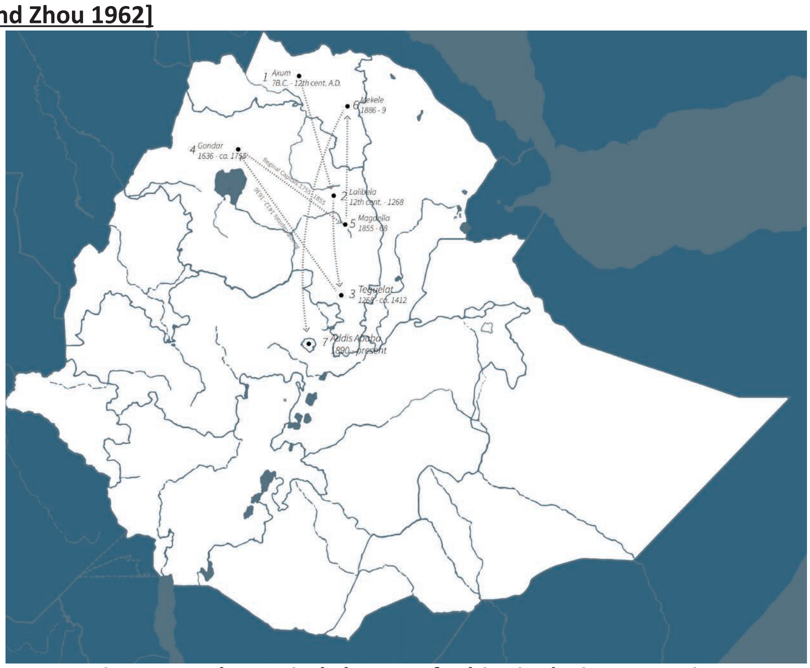


Figure 69: The capital change of Ethiopia during centuries [Subačiūtė, de Graaf, and Zhou 1962]

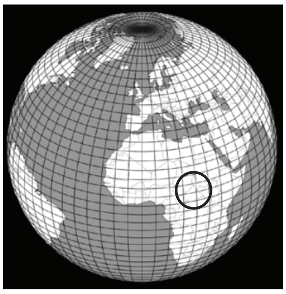
(Image taken from research done by TU DELFT UNIVERSITY)

4.3 – LAND

The altitude varies in different regions of the city due to its topographical structure. The city's altitude ranges from a low of 2020 meters in the south to a high of 3011 meters in the north. (Arsiso, Mengistu Tsidu, and Stoffberg 2018a)

Different types of landscapes and land uses exist at various altitudes. From a climatic standpoint, surveys from 2011 investigated the presence and distribution of natural spaces in Addis Ababa. We can see four primary zones dedicated to diverse uses on the map below:

- *-agriculture (a large percentage)*
- *-vegetation (a large percentage)*
- *-bare land (a medium percentage)*
- *-minerals (very low percentage)*



Latitude: 8°58'N
Longitude: 38°47'E

Figure 70: Land location (By Author)

All the empty spaces are committed to the residential sector, industry and commerce, and transportation.

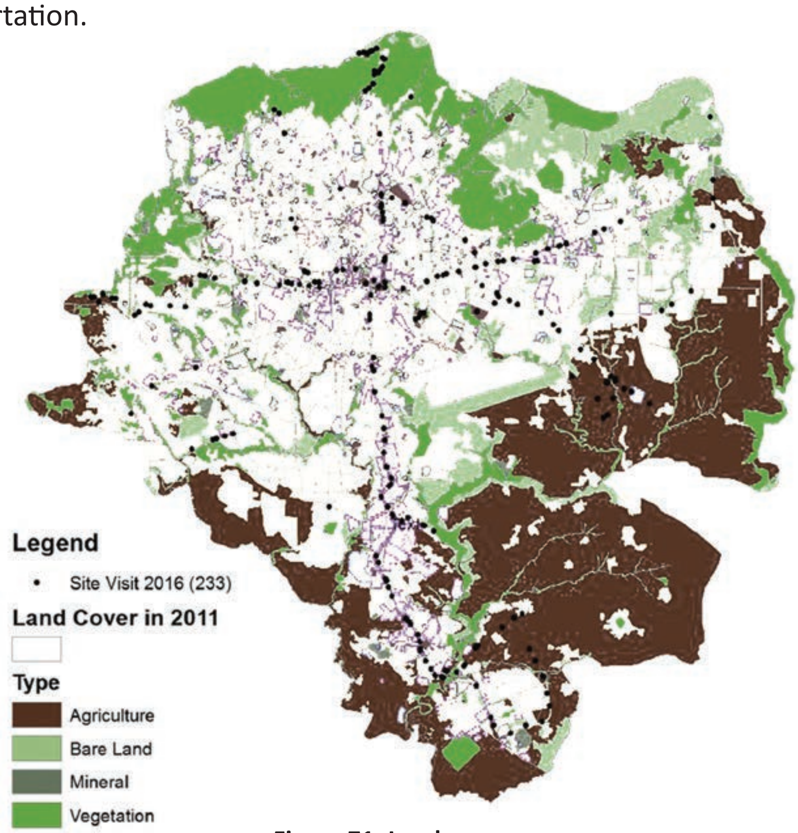


Figure 71: Land use map
("Land Cover Mapping and Watershed Planning in Addis Ababa Ethiopia," n.d.)

4.4 – ADDIS ABABA AND FLOODS

Large-scale atmospheric characteristics in the area are altered by variations in vegetation, hydrology, and dust transport from land surfaces to the atmosphere, all of which have the potential to affect climate variability. Despite this, every model currently in use consistently shows that, on a continental scale, climate change is significantly altering the spatial distribution patterns, frequency, and intensity of weather-induced hazards.

A qualitative illustration of how dangers will likely evolve as a result of climate change is shown below:

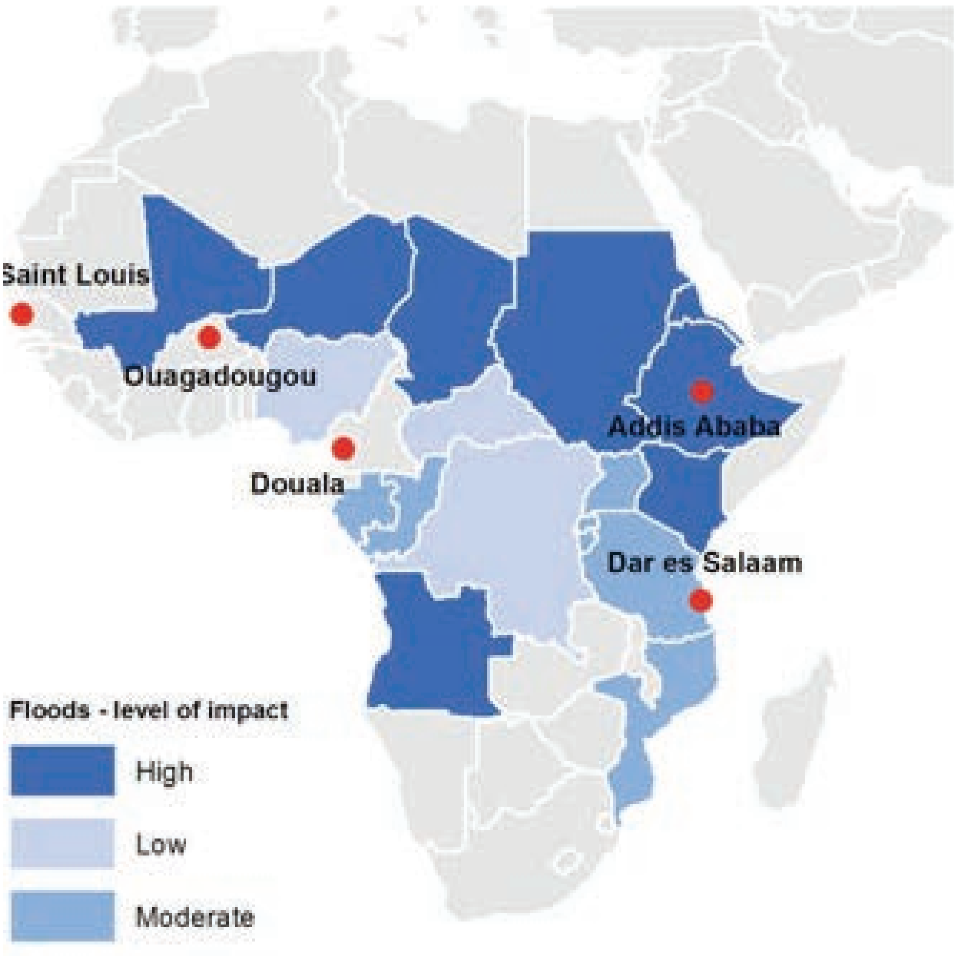


Figure 72: Exposure of CLUVA case study cities to climate change hazards [Pauleit et al., n.d.]

4.4.1 - MAJOR RIVERS OF ETHIOPIA

Nine significant rivers and twelve large lakes make up Ethiopia's vast water resources. Be several rivers flow off of its high tableland, it is frequently referred to as the "water tower" of eastern Africa. The three largest rivers in the nation are the Blue Nile, Awash, and Shebelle. In Ethiopia, the Awash River is a significant river. Approximately 100 kilometers (60 or 70 miles) from the head of the Gulf of Tadjoura, its flow empties into a series of linked lakes that start with Lake Gargori and terminate with Lake Abbe on the border with Djibouti. It serves as the mainstream for an endorheic drainage basin that drains portions of the Afar Region, the Oromia Region, the Somali Region, and the Amhara Region. Beginning in the highlands of Ethiopia, the Shebelle River, also known as the Webi Shabeelle River, runs southeast into Somalia in the direction of Mogadishu. It makes a sudden bend to the southwest, following the coast, close to Mogadishu. The river turns into a seasonal river below Mogadishu. The Jubba River's mouth is where the river often dries up, however during years with significant rains, the river reaches the Jubba and eventually the Indian Ocean. ("Major Rivers of Ethiopia," n.d.)

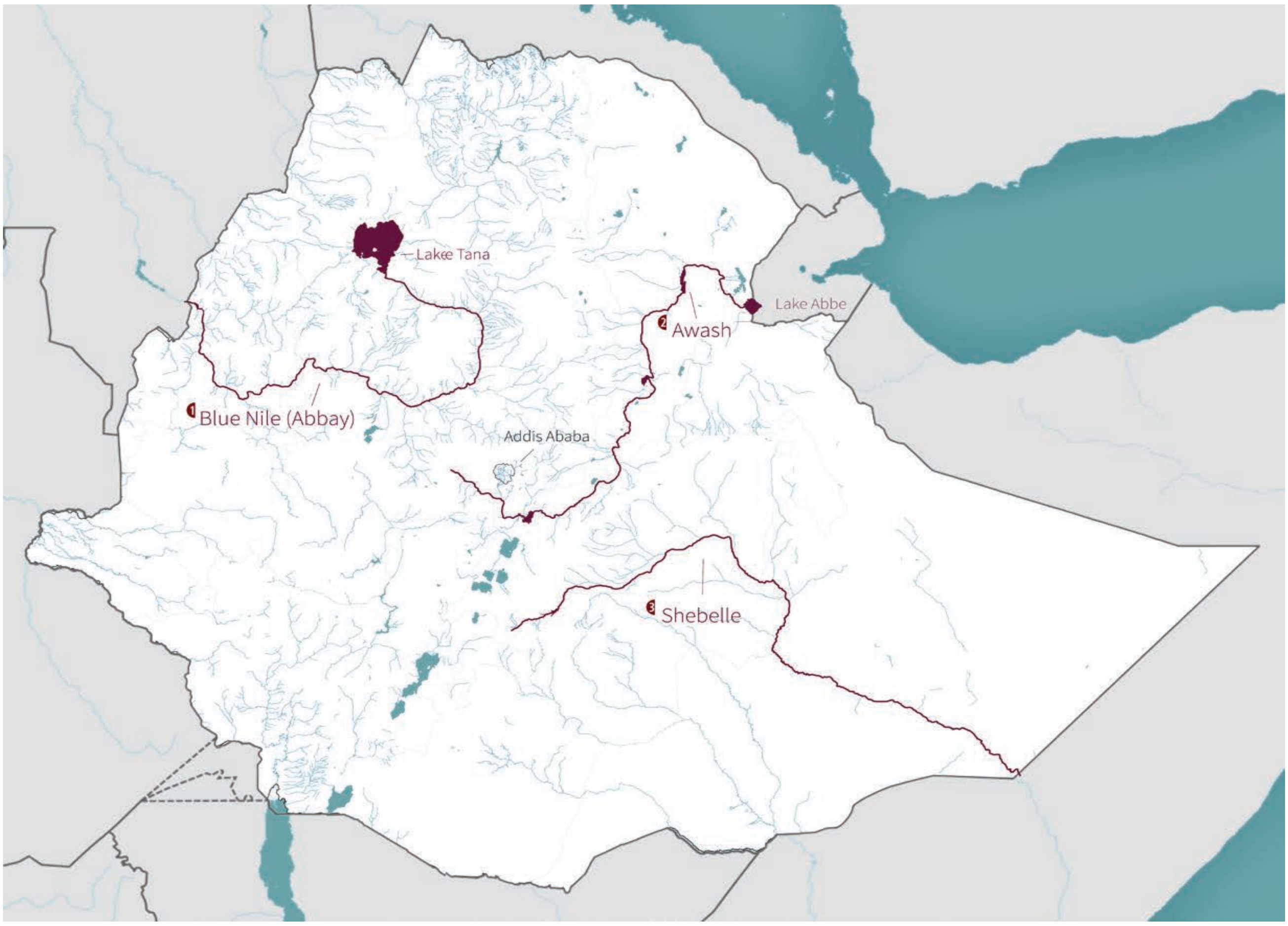


Figure 73: Major rivers of Ethiopia [Subačiūtė, de Graaf, and Zhou 1962]
(Image taken from research done by TU DELFT UNIVERSITY)

4.4.2 - FLOOD STATISTICS AND FACTORS

To get the flood statistics we cannot obtain the data only from average rainfalls and precipitation (which we will discuss in detail in the next subtopics) but the by using different data from different layers.

The layers have been divided into four sublayers [Feyissa et al. 2018]

1- Land cover layers|

for 2017 were derived from those layers. Built-up areas, bare ground, open land, vegetation cover, and agricultural land are the five land cover classifications that make up the land cover layer. (Discussed in detail in heading LAND)

2- Slope layers:

There are five classes of slope, from 0 to 2 percent to 2 to 8 percent to 15 to 30 percent to greater than 31 percent. According to FAO, the slope layer is categorized, with the highest slope value associated with fewer floods and the lowest with a higher likelihood of experiencing flooding.

3- Drainage density layers:

Addis Ababa's 30 m Digital Elevation Model (DEM) is used to obtain the drainage information. For the analysis, up to six stream orders have been taken into account. There are five different drainage classes: 0-0.5 km/km2, 0.5-1 km/km2, 1-1.5 km/km2, 1.5-2 km/km2, and > 2 km/km2. Flooding and drainage density are positively correlated.

4- The soil layers:

to check the porosity of layers. Because the soil that has higher level of permeability cause less damage during floods.

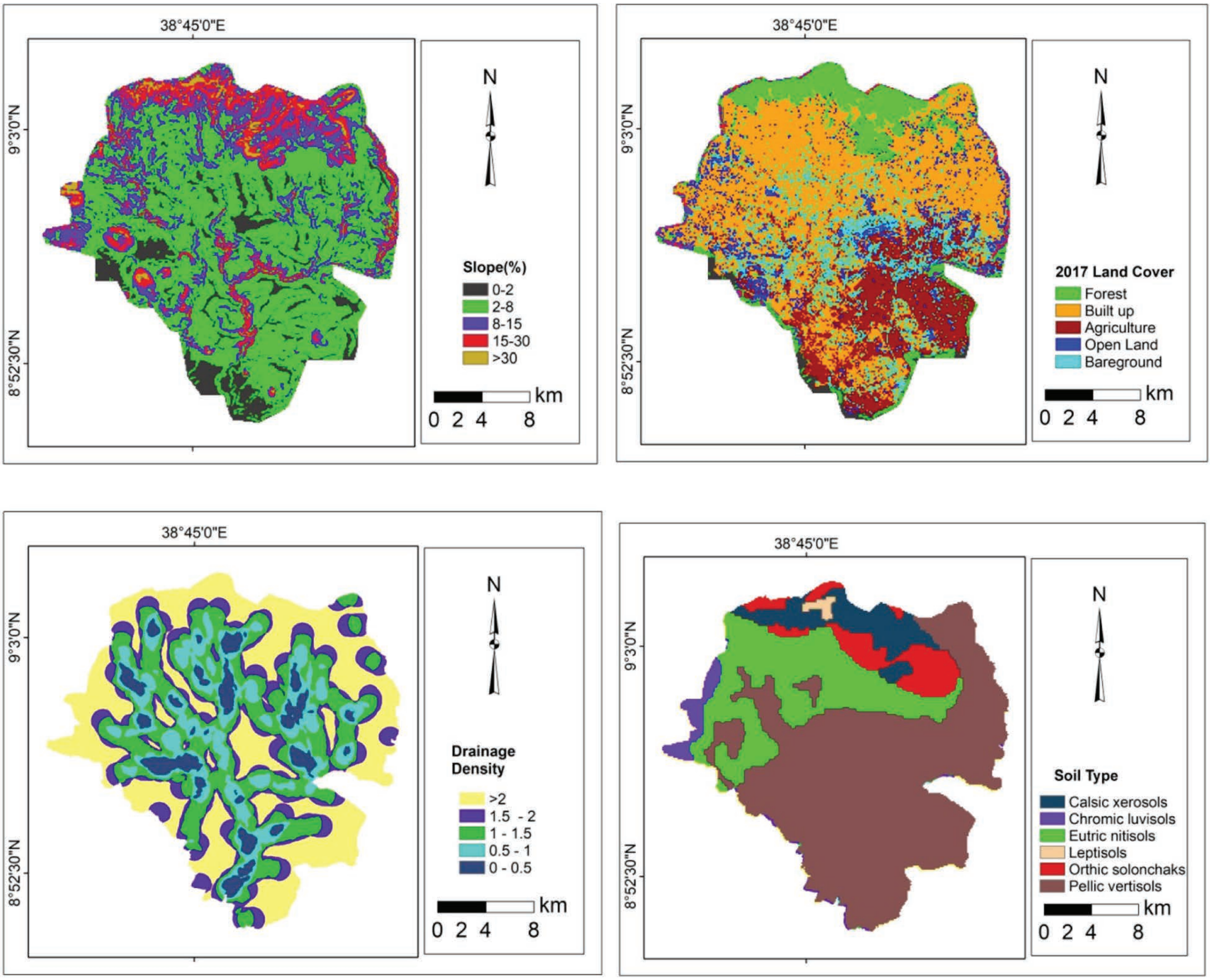


Figure 74: Flood risk layers [Feyissa et al. 2018]

So, collecting the whole data the flood risk map was made:

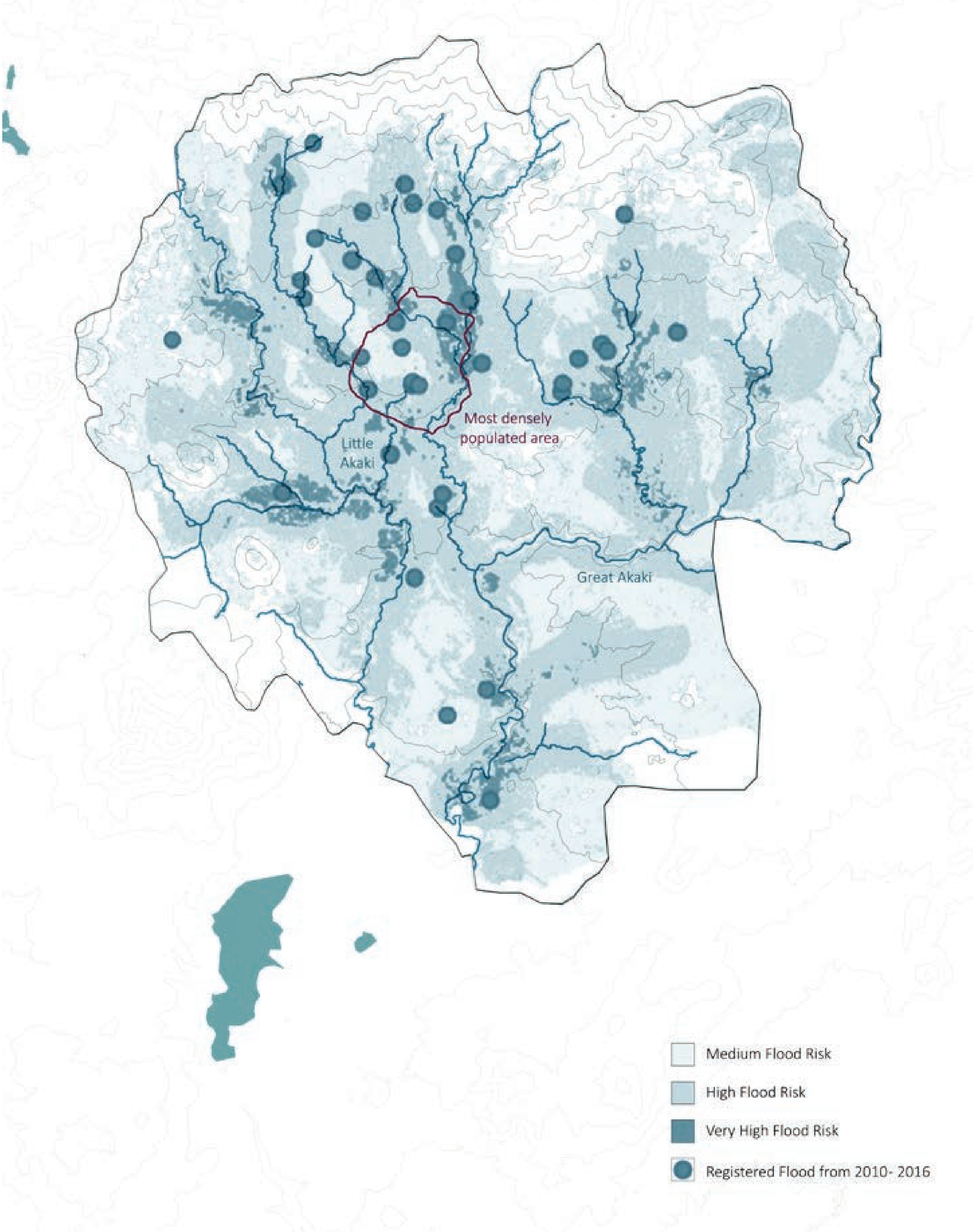


Figure 75: Flood risk map of Addis Ababa
[Subačiūtė, de Graaf, and Zhou 1962] [Feyissa et al. 2018]

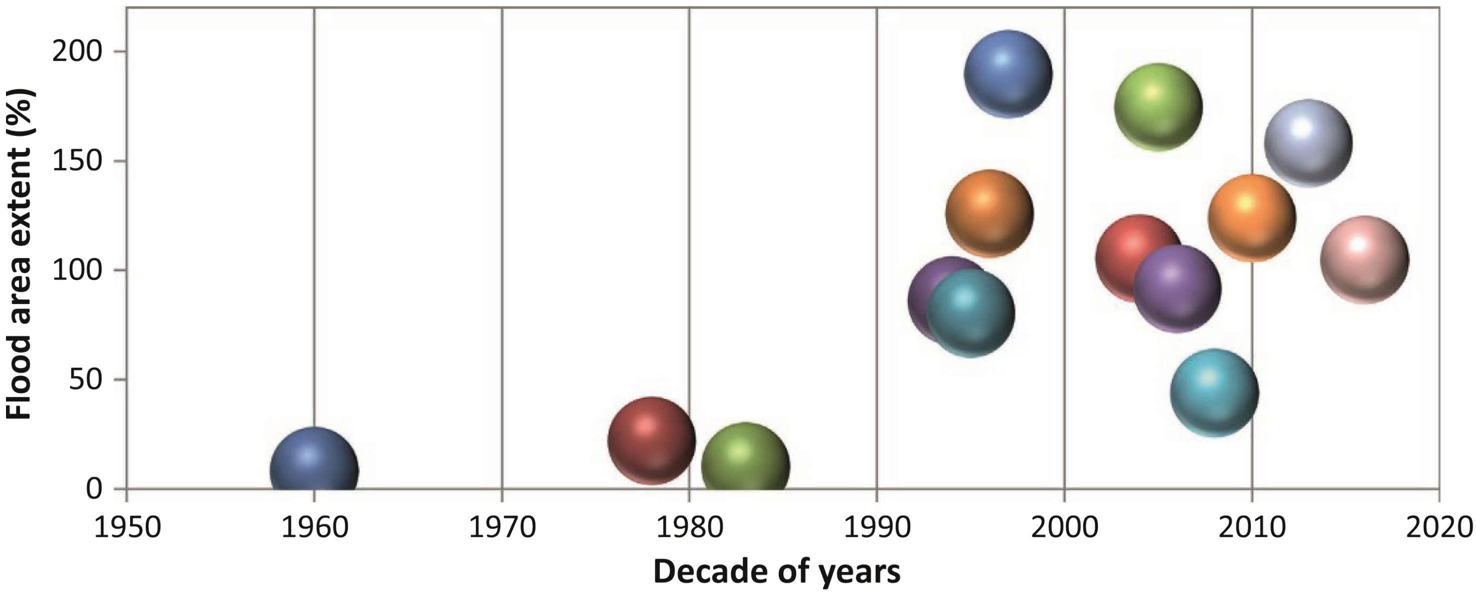


Figure 76: Flood statistics (Mamo, Berhanu, and Melesse 2019)

Ethiopia has vast experience with both riverine and flash floods. Since the 1960s until the present, the history of flood episodes and their geographic ranges have been assessed. Flooding during the past six decades has varied in frequency and size due to both spatial and temporal factors. From decades to decades, the country saw an increase in the frequency of floods. The decade from 2001 to 2010 is known for having the most floods, with five of the ten years seeing at least one flood. With four or three flood years, respectively, it followed the decade of 1991–2000 and is currently following the decade of 2011–20. (Mamo, Berhanu, and Melesse 2019)

The graph is shown above.

Addis Ababa experience two types of floods (Mamo, Berhanu, and Melesse 2019)

1- Flash floods | *Flooding that starts within six hours of the heavy rain, and frequently within three hours (or other cause). There are many different things that might create flash floods, but thunderstorms' unusually high rainfall is the main culprit.*

2- Riverine floods/ *fluvial floods | When the water level in a river, lake, or stream rises and overflows onto the adjacent land, it causes a fluvial flood.*

FACTORS OF FLOODS IN ADDIS ABABA

Due to Addis Ababa's fast urbanization, relative deforestation, poor urban planning, and inadequate road and urban drainage infrastructure, flooding has become an increasingly serious problem. Due to the Entoto mountain's elevation in the north and the city's location on a low-lying plain, which is frequently inside the basin of the Big and Small Akaki rivers, Addis Ababa is prone to flooding. The issue is made worse by the Kiremt rainy season's excessive precipitation, which lasts from June to September for three months. The villages along the streams sustain property damage each year as a result of floods. Given that Addis Ababa's rivers have been exploited as dumps for trash, their hygienic status is also subpar, with negative health effects on the city's inhabitants. ("Story Map Journal," n.d.)

1. *Anatomy of water bodies*
2. *Climatic and ecological implications*
3. *Environmental implications*
4. *Urban development implications*
5. *Infrastructural implications*

1 - ANATOMY OF WATER BODIES

AWASH RIVER BASIN

Most of Ethiopia is prone to flooding. However, lowland areas and communities located near water are the only places where flooding occurs on a significant scale. The Awash Valley, one of the nation's rivers with a drainage area of 110,000 square kilometers, is responsible for the worst flooding issues. Unfortunately, Addis Ababa is situated in the upper Awash River Basin. The city experiences flood every year. ("Story Map Journal," n.d.)

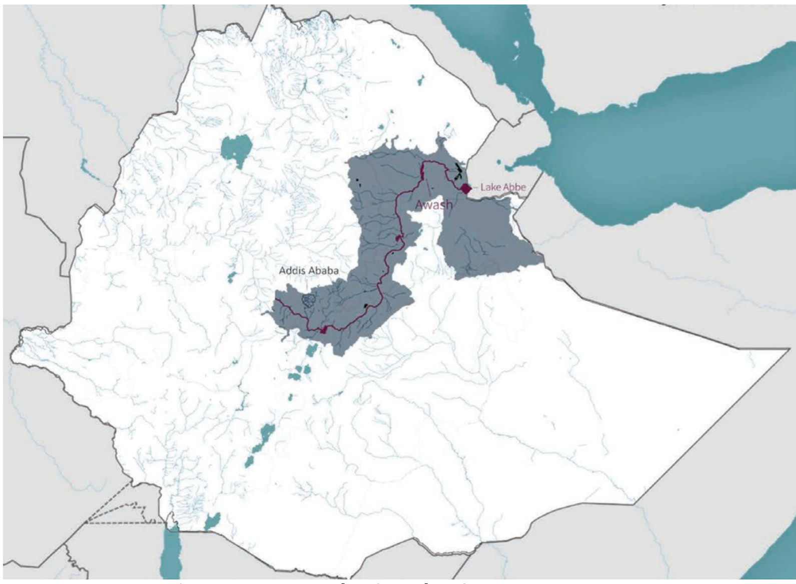


Figure 77: Awash River basin [Subačiūtė, de Graaf, and Zhou 1962]

2- CLIMATIC AND ECOLOGICAL IMPLICATIONS

CLIMATE

IIn Köppen-Geiger classification the location of Addis Ababa is defined as Cwb: Oceanic Subtropical Highland Climate.

The climate is warm and moderate. During summers there is heavier rain as compared to winters. So, if we see the average annual temperatures I Addis Ababa is 15.6°C and the precipitation is 1874 mm.(“CLIMATE: ADDIS ABABA,” n.d.)

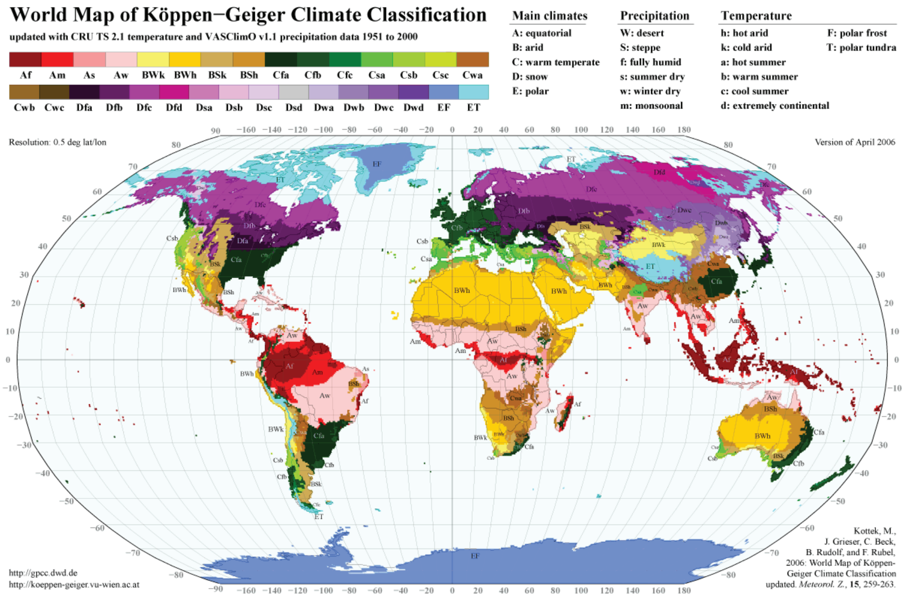


Figure 78: WORLD MAPS OF KÖPPEN-GEIGER CLIMATE CLASSIFICATION [“WORLD MAPS OF KÖPPEN-GEIGER CLIMATE CLASSIFICATION,” n.d.]

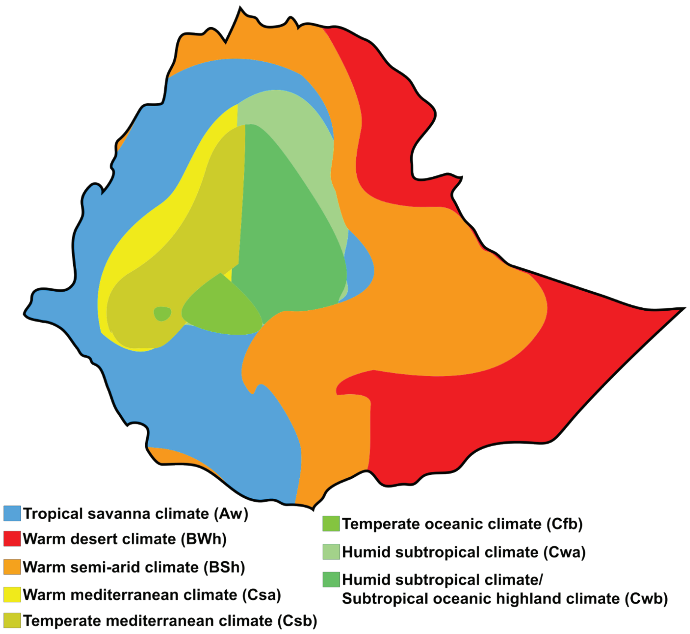


Figure 79: Köppen climate classification map of Ethiopia [“Köppen Climate Classification Map of Ethiopia,” n.d.]

RAINFALL

There are 3 seasons in Addis Ababa. Locally known as Bega, Belg and kiremt.
They are divided according to weather in months.

Bega – it is from October to January
This is the dry season and usually the trend of hot dry days and cold nights follow these months. In the morning the weather is usually frosty and last occasionally over most of the highlands. The average temperature during day can rise to 25 °C.

Belg – In this period, small rainy phase follows in most of the parts of Ethiopia except southern and southeaster lowlands. March, April and may are the hottest months. (Korecha and Barnston 2007)
Maximum temperatures and rainfall during the season vary according to space and time.(National Meteorological Agency (NMA) of Ethiopia., n.d.)

Kiremt – This the heaviest rainy season of all. Around 85% to 95% food crops are grown during this period.("Applied_Hydrology," n.d.) the frequent rains and homogenous temperature stays during the period of July and august. As compared to other seasons this term has higher magnitude of rainfall. (National Meteorological Agency (NMA) of Ethiopia., n.d.) the rain falling during day can go from 6mm to the extent of 50mm in a day. During 2012 during this season the rain fell was around 762mm.

In Köppen-Geiger classification the location of Addis Ababa is defined as Cwb: Oceanic Subtropical Highland Climate.
The climate is warm and moderate. During summers there is heavier rain as compared to winters. So, if we see the average annual temperatures I Addis Ababa is 15.6°C and the precipitation is 1874 mm.["Köppen Climate Classification Map of Ethiopia," n.d.]

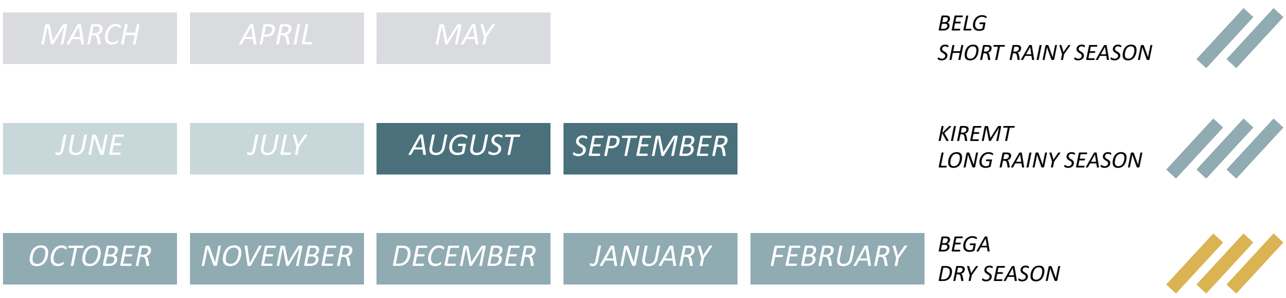


Figure 80: Seasons division in Addis Ababa [By Author]

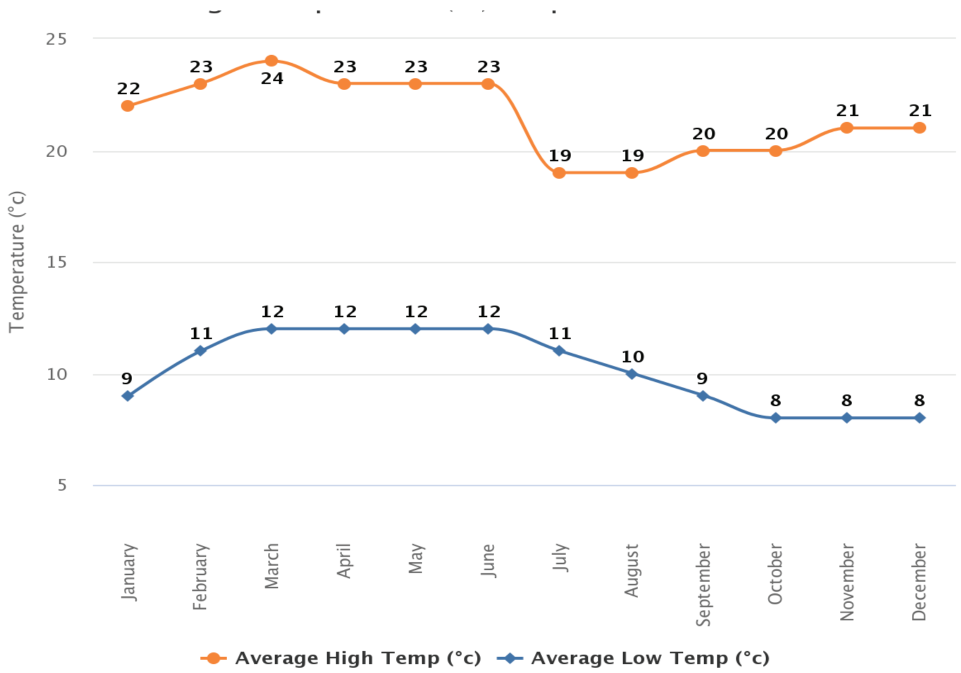


Figure 81: Average temperature per year and its values [“Addis Ababa Climate Weather Averages,” n.d.]

The above chart shows the annual average temperature, average higher temperature, and average lower temperature.

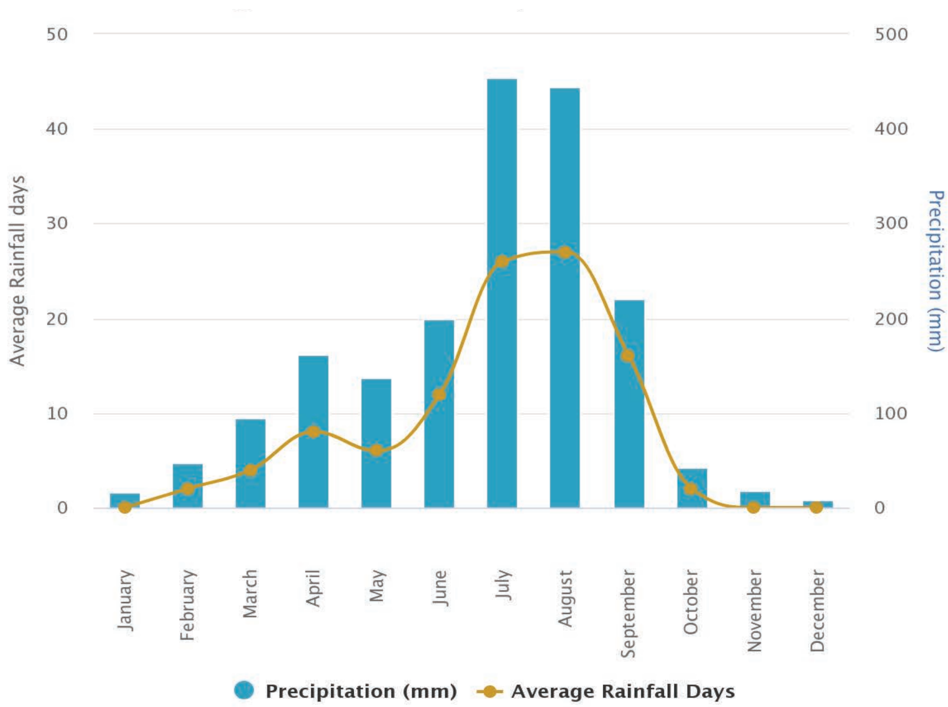


Figure 82: Average rainfall per year and its values [“Addis Ababa Climate Weather Averages,” n.d.]

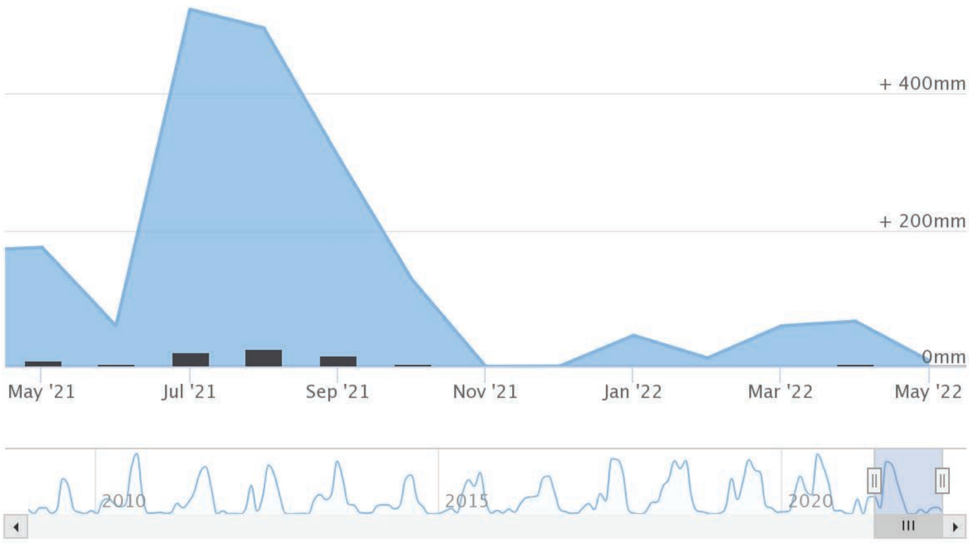


Figure 83: Average rainfall amount and rainy days
[“Addis Ababa Climate Weather Averages,” n.d.]

The above chart proves the fact that during June to September the rainfall is at its maximum value which is kiremt season.

From September through April, the percentage of relative humidity is quite low, with a peak that follows the precipitation pattern. In reality, RH hits 82 and 80 percent in July and August, respectively; also the clouding hit higher on the chart in these months.

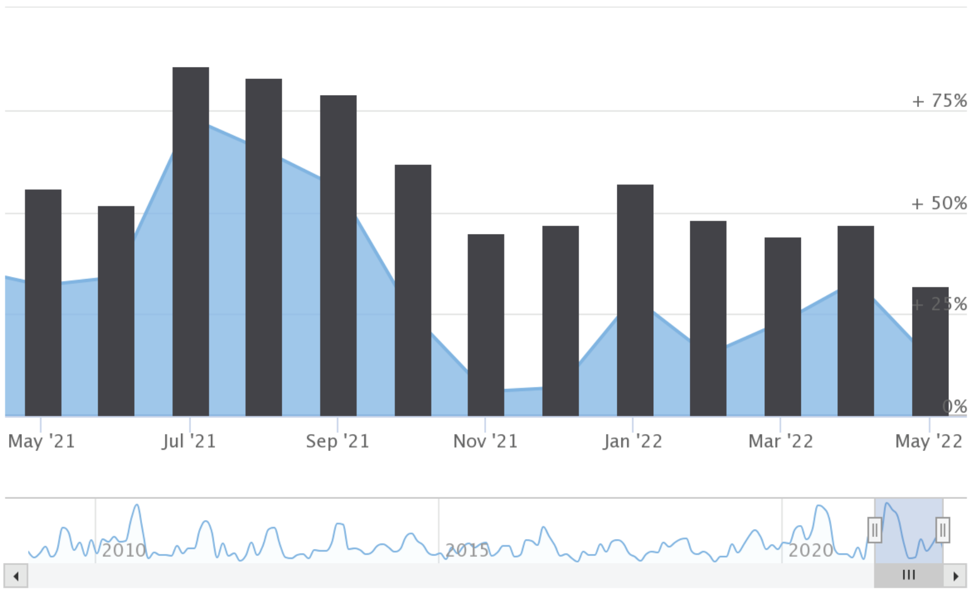


Figure 83: Average rainfall amount and rainy days
[“Addis Ababa Climate Weather Averages,” n.d.]

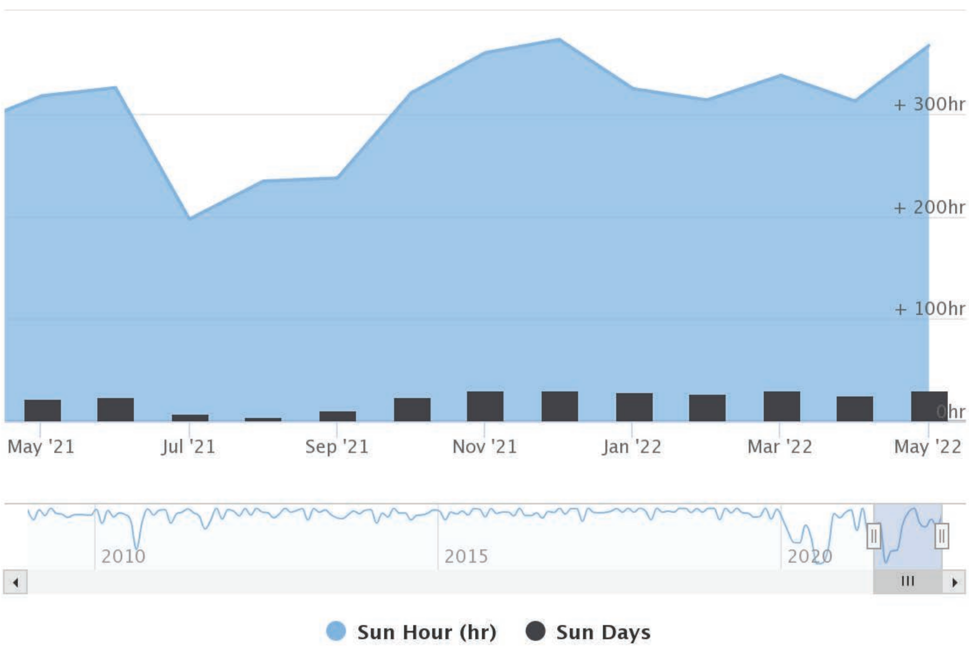


Figure 83: Average rainfall amount and rainy days [“Addis Ababa Climate Weather Averages,” n.d.]

We have a mean value of 6:40 hours of sunshine each day, with an average of 2439 hours of sunlight per year. We can get the most important facts and trends about sunshine and daylight hours for the full year from the above chart.

Then if we see the wind trend charts:

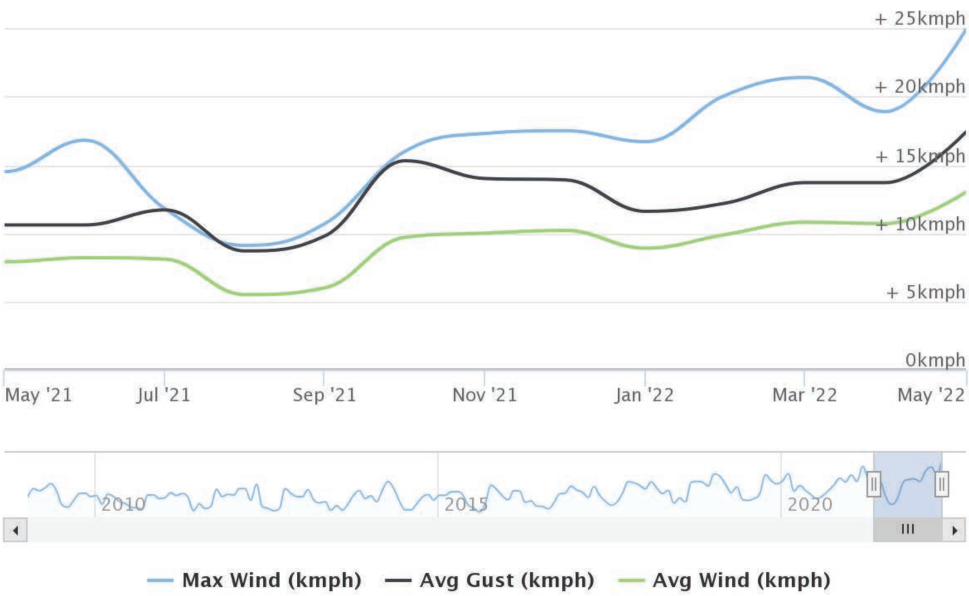


Figure 83: Average rainfall amount and rainy days [“Addis Ababa Climate Weather Averages,” n.d.]

There are notable fluctuations in average wind speed from May 2021 to May 2022. keeping the wind speed in the range of a light breeze to a moderate breeze (2 and 3 on the Beaufort scale), but if we see in May 2022 the wind category falls in 4 on the Beaufort scale.

Force (Beaufort scale)	Equivalent speed			Description	Specifications for use at sea
	mph	knots	km/h		
0	0–1	0–1	0–1	Calm	–
1	1–3	1–3	1–5	Light air	Ripples with the appearance of scales are formed, but without foam crests.
2	4–7	4–6	6–11	Light breeze	Small wavelets, still short, but more pronounced. Crests have a glassy appearance.
3	8–12	7–10	12–19	Gentle breeze	Large wavelets. Crests begin to break. Foam of glassy appearance. Perhaps scattered.
4	13–18	11–16	20–28	Moderate breeze	Small waves, becoming larger; fairly frequent white horses.
5	19–24	17–21	29–38	Fresh breeze	Moderate waves, taking a more pronounced, longer form; many white horses are formed. Chance of some spray.
6	25–31	22–27	39–49	Strong breeze	Large waves begin to form; the white foam crests are more extensive everywhere. Probably some spray.
7	32–38	28–33	50–61	Near gale	Sea heaps up and white foam from breaking waves begins to be blown in streaks along the direction of the wind.
8	39–46	34–40	62–74	Gale	Moderately high waves of greater length; edges of crests begin to break into spindrift. The foam is blown in well-marked streaks.
9	47–54	41–47	75–88	Severe gale	High waves. Dense streaks of foam along the direction of the wind. Crests of waves begin to topple, tumble and roll over.
10	55–63	48–55	89–102	Storm	Very high waves with long overhanging crests. The resulting foam, in great patches, is blown in dense white streaks along the direction of the wind. The whole surface of the sea takes on a white appearance. The "tumbling" of the sea becomes more immense and shock-like. Visibility affected.
11	64–72	56–63	103–117	Violent storm	Exceptionally high waves (small and medium-size ships might be, for a time, lost to view behind the waves). The surface is covered with long white patches of foam lying along the direction of the wind. Everywhere, the edges of the wave crests are being blown into froth. Visibility affected.
12	73–83	64–71	118–133	Hurricane	The air is filled with foam and spray. Sea completely white with driving spray; visibility very seriously affected.

Figure 87: The Beaufort Scale for wind categorization [Cardia and Lovatelli 2017]

CLIMATE HISTORY

If we see the past statistical data, the variation is climate change is clearly visible. From our research it is likely to presume that this change in climate can be because of two possible aspects:

- Global climate change that is clearly affecting the weather of whole world.
- Massive urbanization: that in urban centers specially is affecting the environment to the maximum.

As countries like Addis Ababa, they are more likely to depend on climate conditions because they survive on their agriculture which is directly linked with sunny days and rainfall. So, such drastic changes in temperature and the rainfall can cause damage to the production as well as can have a huge impact on consumers.

The trend can be seen in wind as we discussed in previous climate introduction the wind speed falls in 4th category of Beaufort scale in this current year however it was in 2nd and 3rd scale in past years.

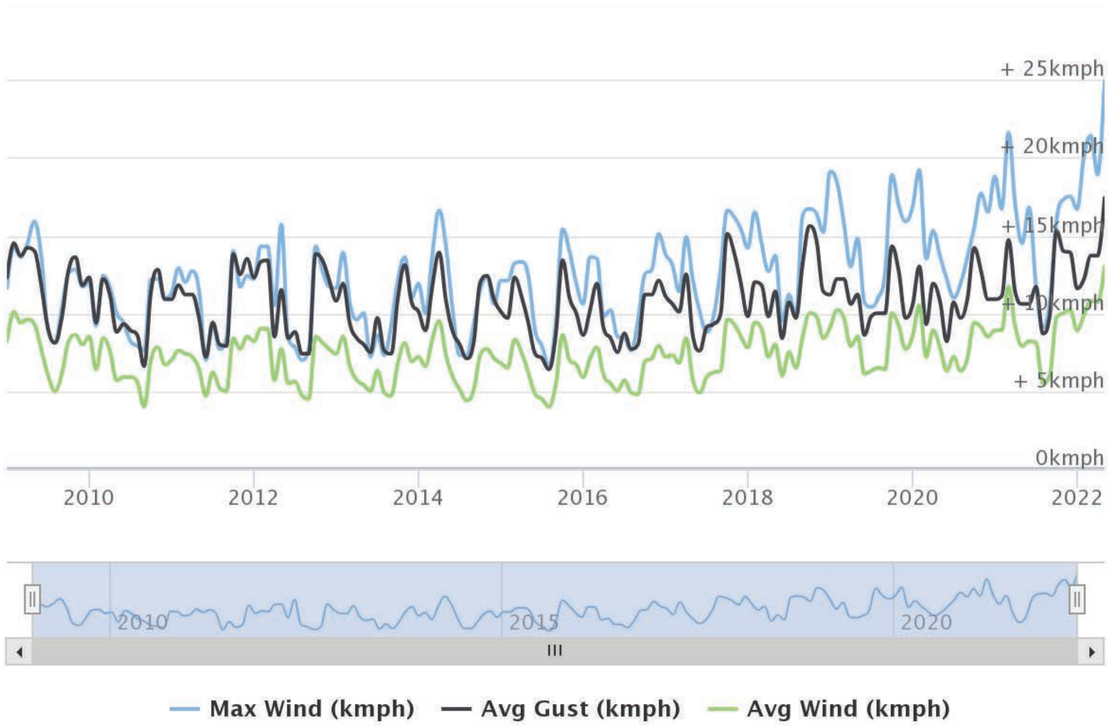


Figure 88: Average and max wind speed and gust from 2010 to 2022 [“Addis Ababa Climate Weather Averages,” n.d.]

The same trend is followed in average temperature. In past years the maximum temperature never goes above 25°C but this year it crossed the value of 25°C. the average annual temperature has risen from 1955 and 2015 by 1.65 °C but from 2015 to 2022 we can see another increase in temperature reaching the limit of 28°C approximately.

If we see the minimum temperature trend went from 11°C in April 2009 up to 15°C in April 2019. But now from 2019 to 2022 it has fallen to 14°C.

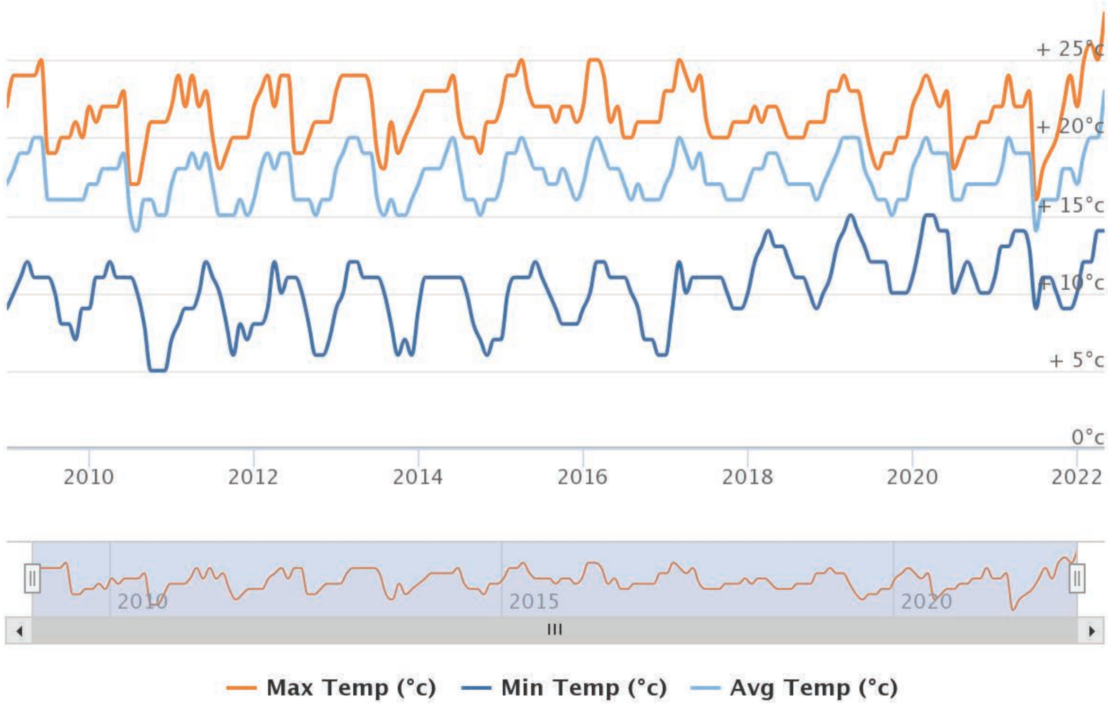


Figure 88: Average and max wind speed and gust from 2010 to 2022 [“Addis Ababa Climate Weather Averages,” n.d.]

NATURAL DISASTERS AND ENVIRONMENTAL ISSUES

From climate history there was a decreasing trend in rainfall till 2015 from 1954.

This decline is mostly due to cyclical patterns of several dry years followed by a few exceptionally wet years. A graph from Addis Ababa's Observatory displaying the rainfall pattern between 1960 and 2010, as well as another graph illustrating the tremendous quantity of rainfall in 2019 in comparison to the general tendency, serve as proof of this occurrence.

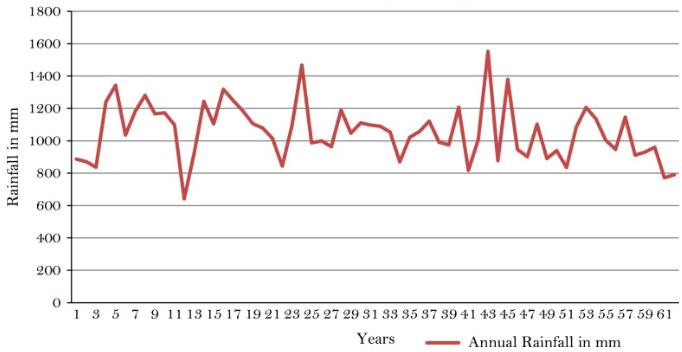


Figure 90: Rainfall trend from 1954 to 2015 [National library of Medicine, n.d.]

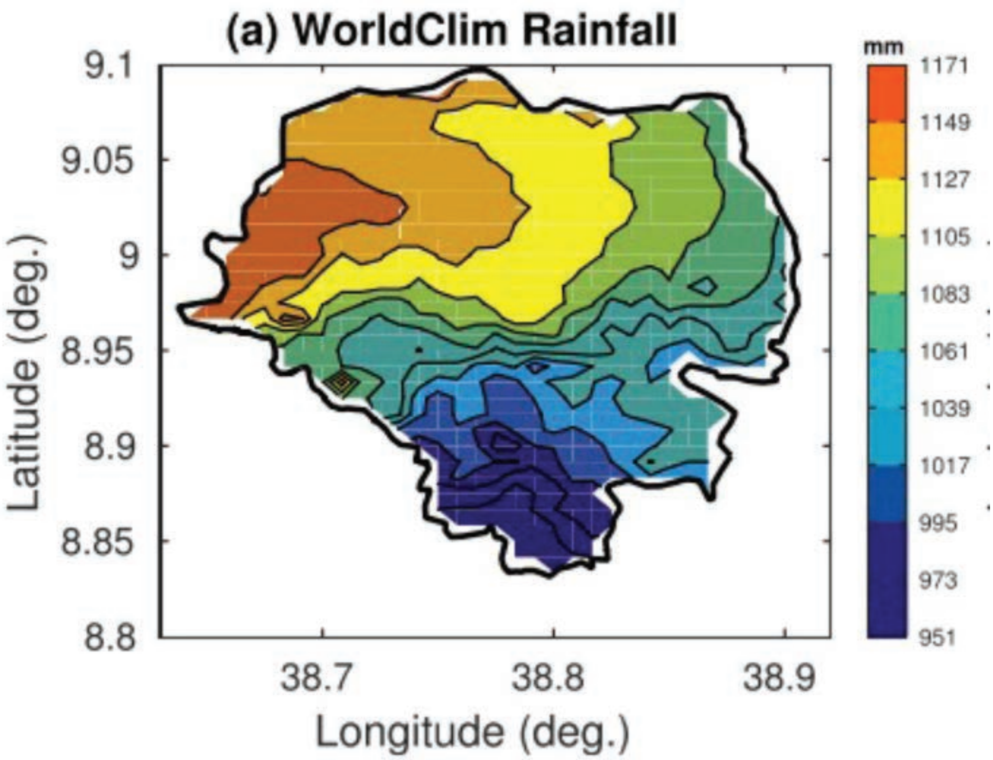


Figure 91: Addis Ababa mean annual rainfall from 1950 to 2000 [Arsiso, Mengistu Tsidu, and Stoffberg 2018b]

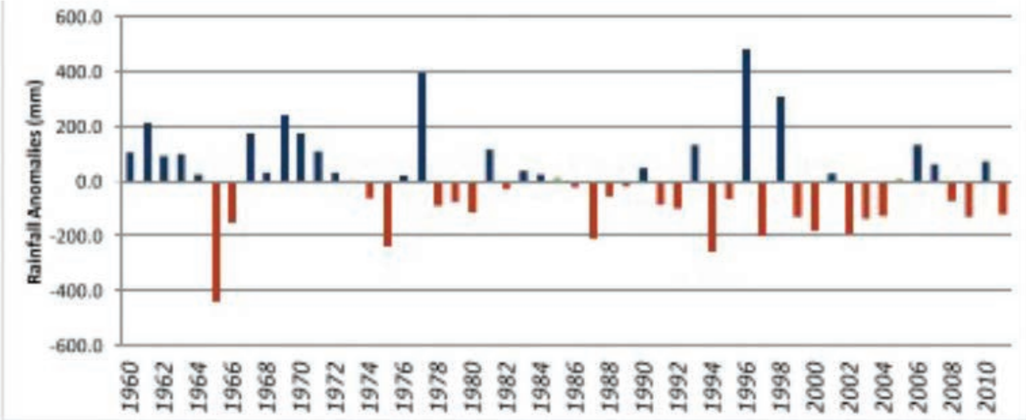


Figure 92: Addis Ababa Observatory Annual Rainfall from1960 to 2010 - Arsiso, Mengistu Tsidu, & Stoffberg, 2018
(Arsiso, Mengistu Tsidu, and Stoffberg 2018b)

This graph shows a comparison of extreme ranges of statistical data of both dry and wet years from 1960 to 2010.

If we see the annual trend of rainfall, there is a clear change from 2010 till 2022. But there is a drastic rise of rainfall in 2017 and the trend goes on till 2022.

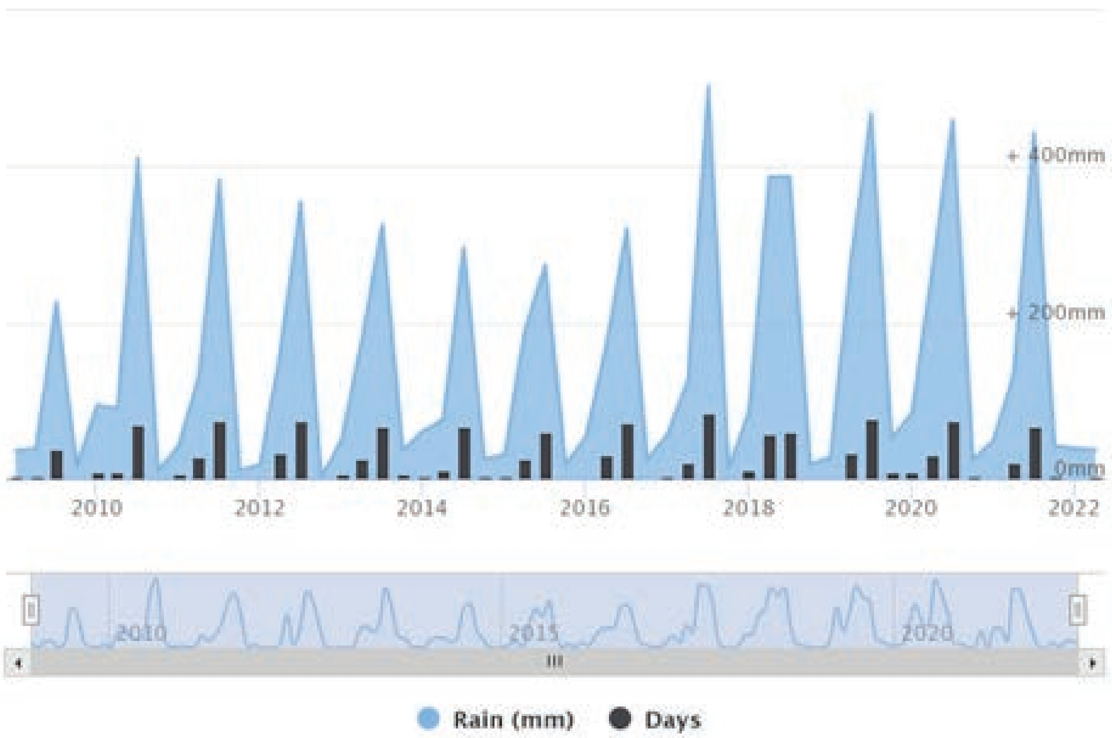


Figure 93: Average rainfall amount and rainy days from 2010 till 2022
["Addis Ababa Climate Weather Averages," n.d.]

From all this we mapped the flooding pattern from 1983 till 2019.

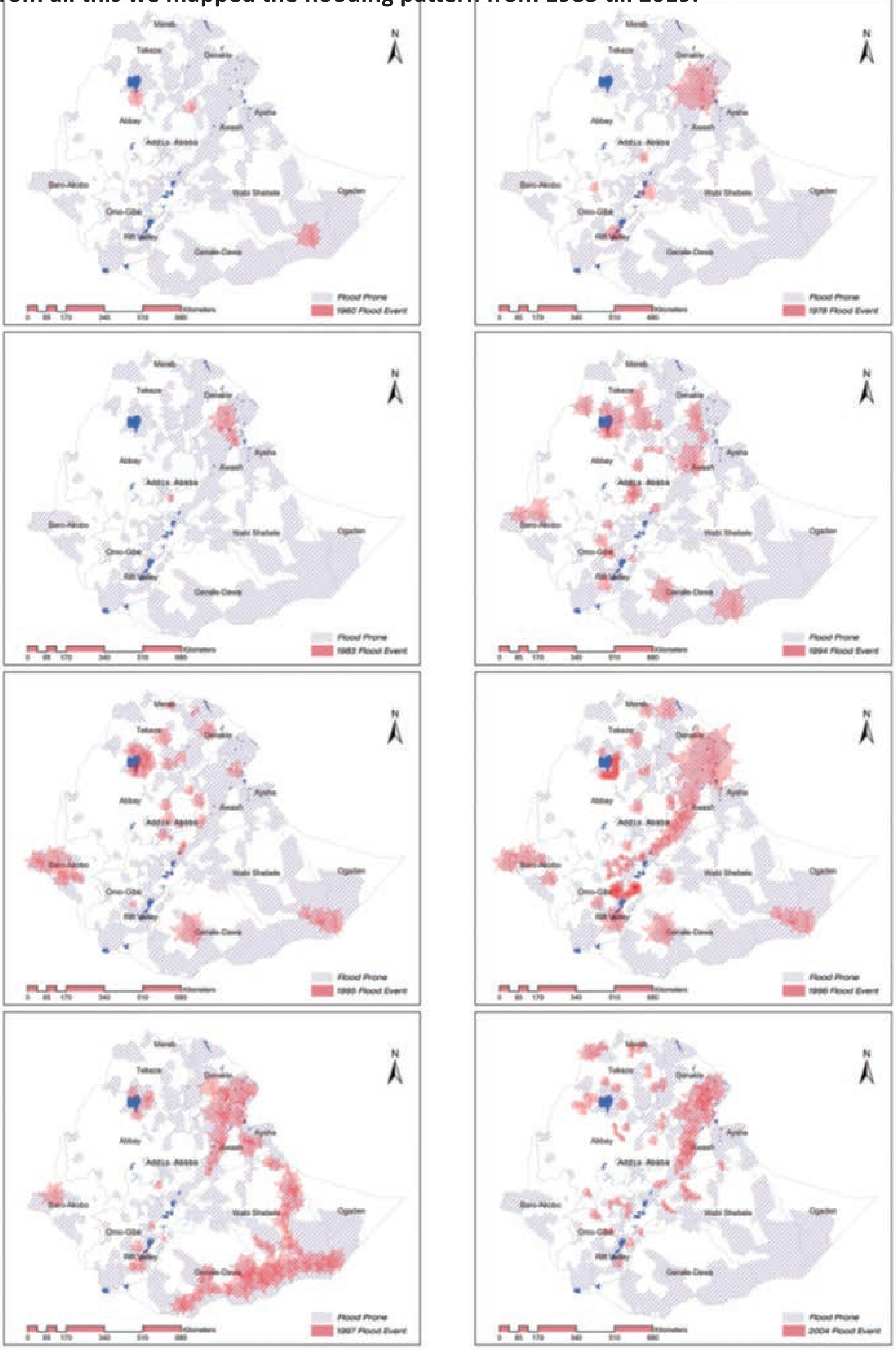


Figure 94a: Addis Ababa flooding maps in different years
[Mamo, Berhanu, and Melesse 2019]

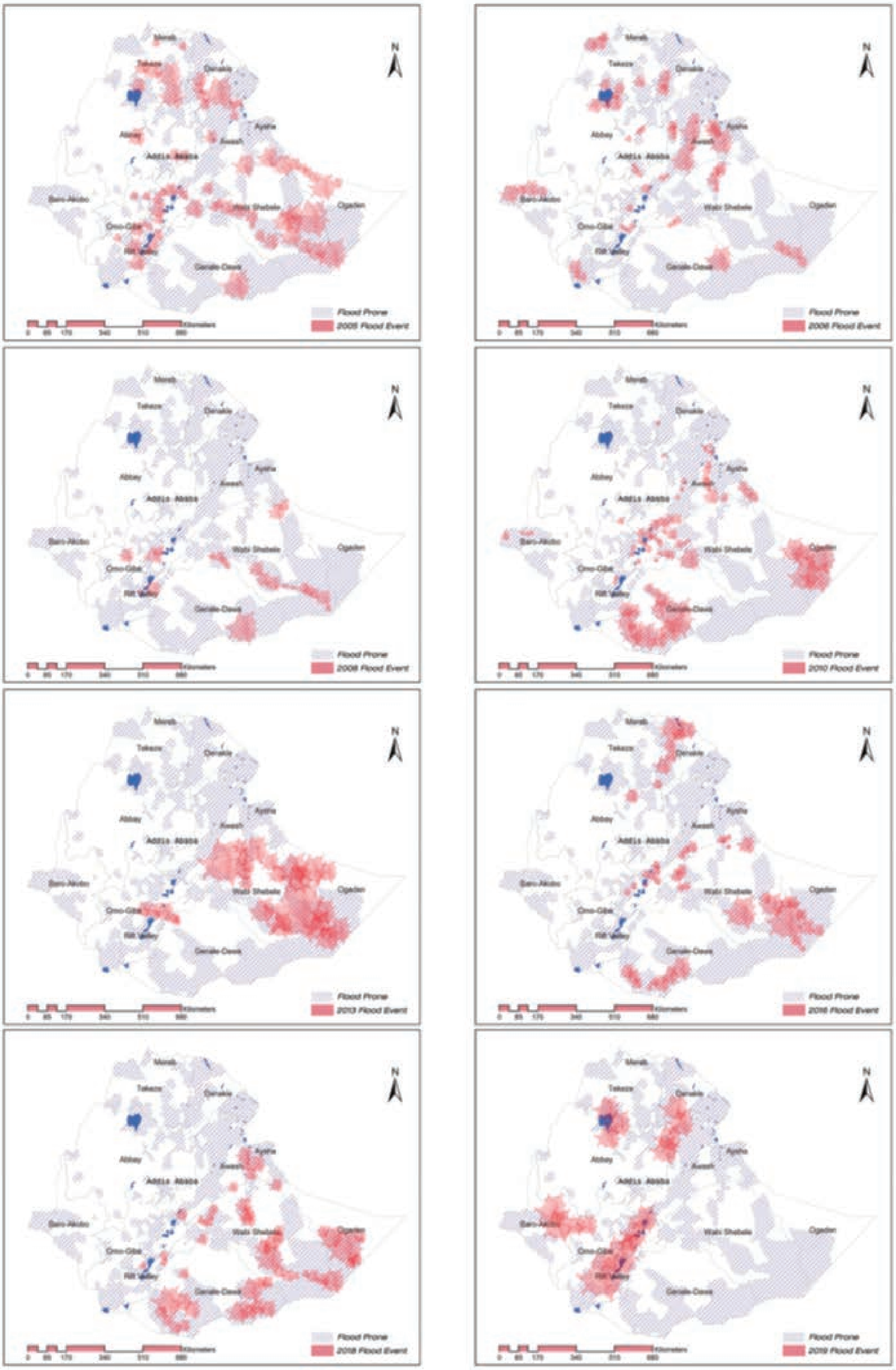


Figure 94b: Addis Ababa flooding maps in different years [Mamo, Berhanu, and Melesse 2019]

Addis Ababa has been increasingly flooded since 1988. The city's rapid economic expansion is, of course, greatly increasing the urbanization rate; also, a rise in summer season precipitation is projected, perhaps resulting in flooding.

Due to severe climatic occurrences and upper catchment activity, Addis Ababa is prone to riverine and flash floods. An inadequate drainage system, fast house growth near riverbanks, and the use of improper construction materials all contribute to the susceptibility to floods.

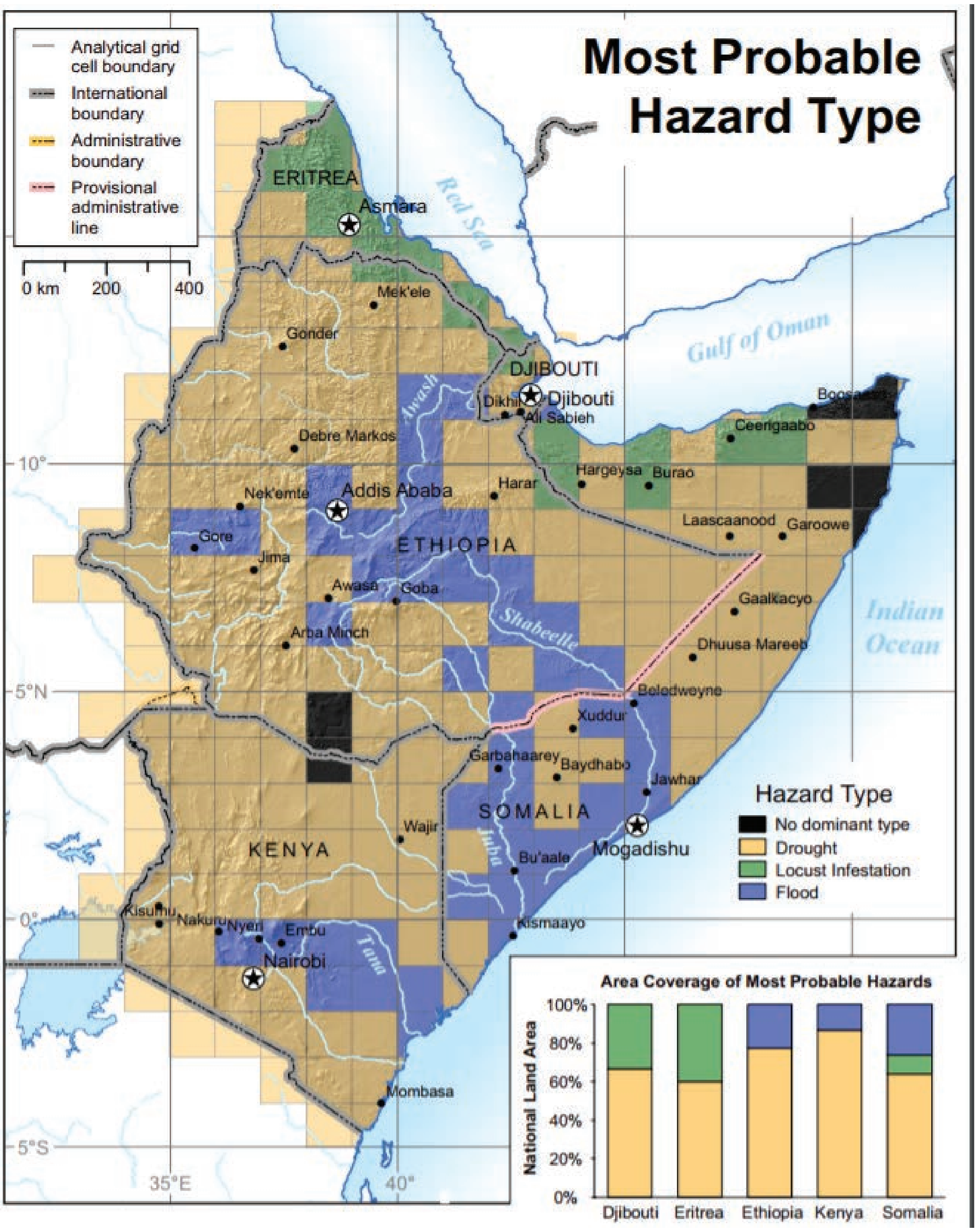


Figure 95: Hazards affecting Addis Ababa
["A Climate Trend Analysis of Addis Ababa (Ethiopia's Sprawling Capital)," n.d.]

Above map shows that Ethiopia is facing a huge problem of droughts and then flooding issue in some areas including Addis Ababa.

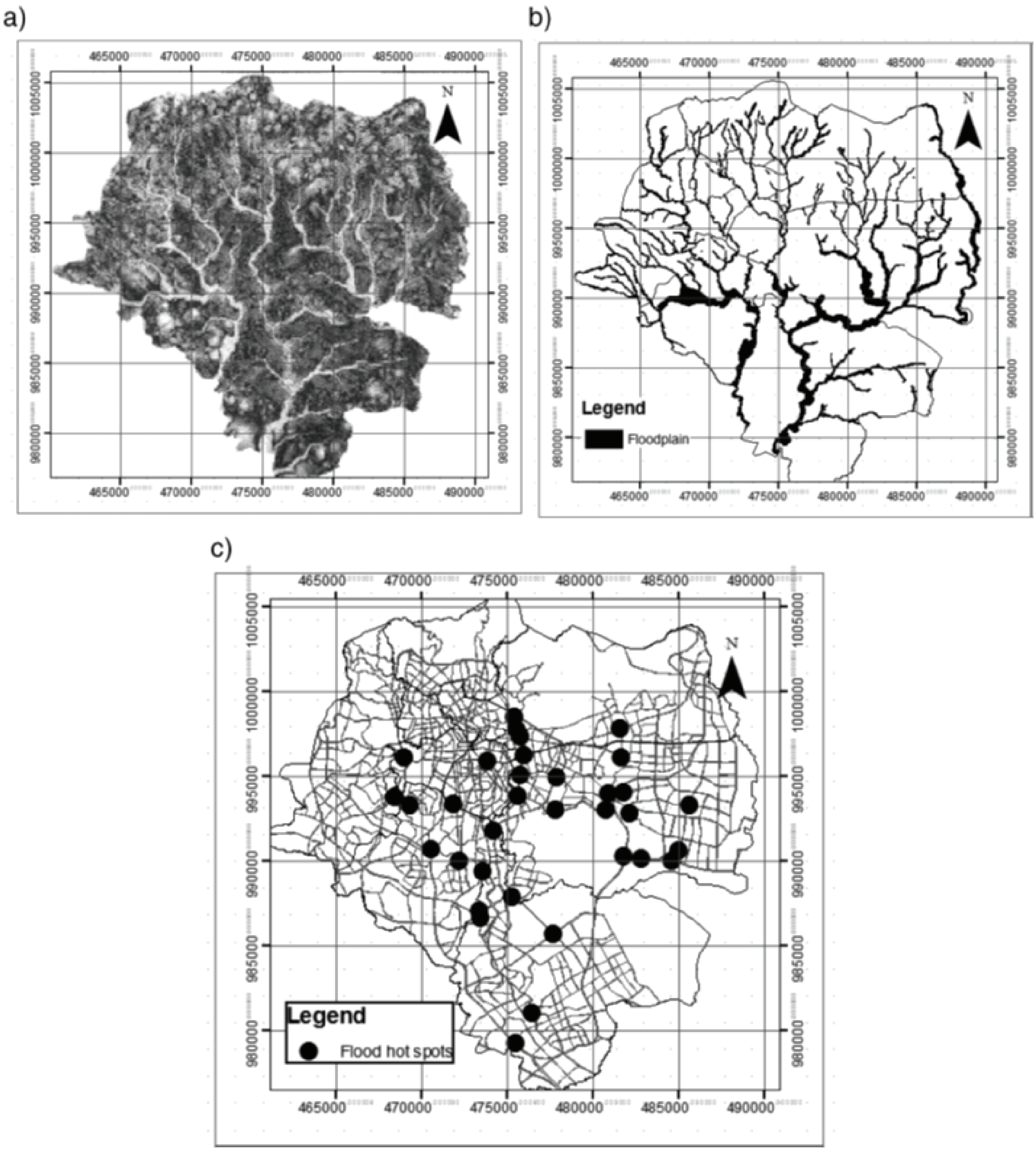


Figure 96: Areas of Addis Ababa at flood risk
Figure 24- a - Areas of fluvial flood risk based on wetness index
Figure 24- b - Delineation based on aerial photographs and field mapping
Figure 24- c - Hot spots of street flooding areas as a result of improper drainage network design
[Mamo, Berhanu, and Melesse 2019]

There are three main rivers that crosses the city that are the main risks of flooding. In the above image the hotspots are marked that shows the points of street flooding due to poor drainage system.

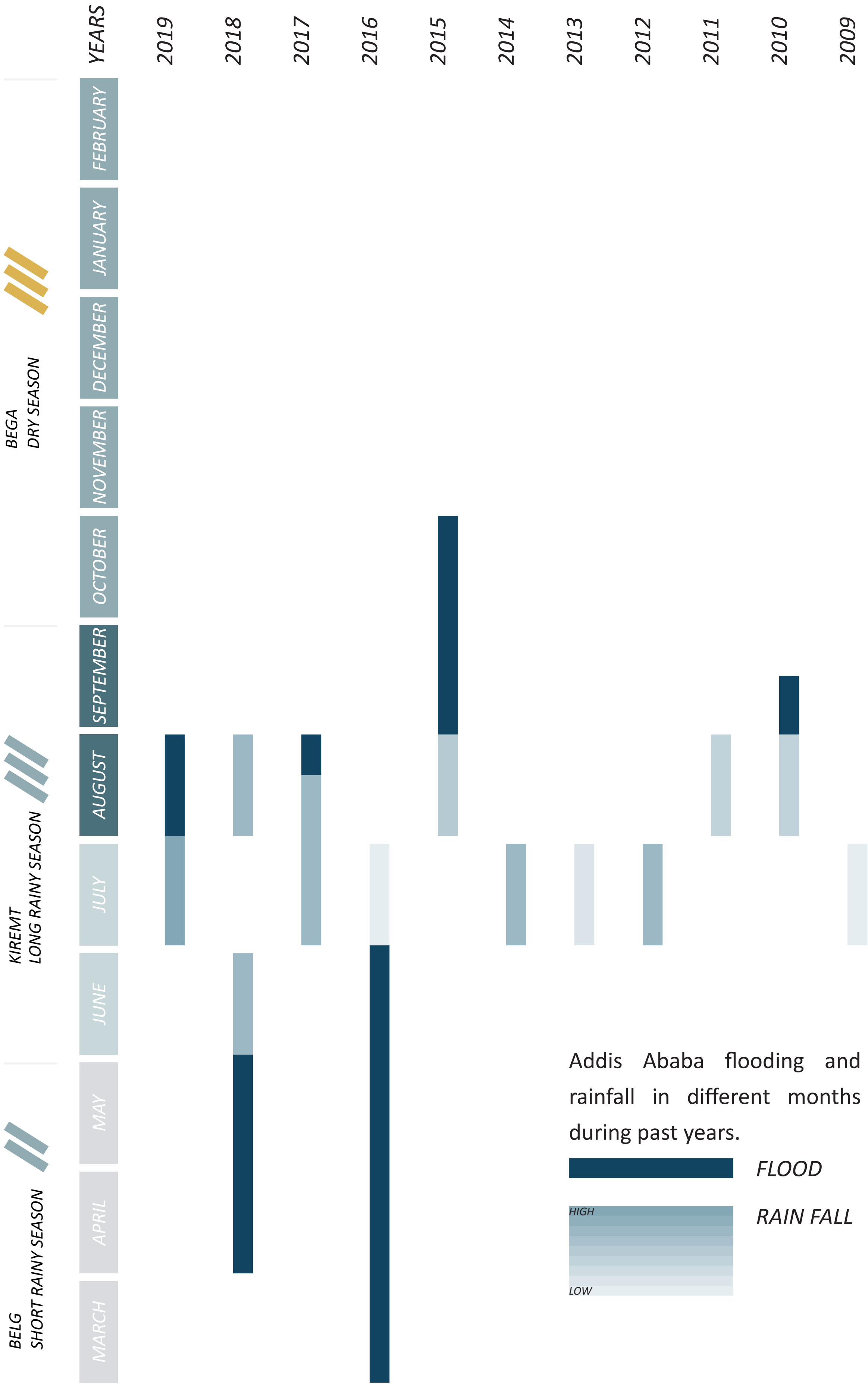


Figure 97: Seasons division in Addis Ababa [By Author]

Variable rainfall, low rainfall, and drought are all current conditions in Addis Ababa and the outlying neighborhoods, and they are anticipated to recur with CC. The city's most serious and inherent danger from the drought is a lack of water supplies, which is deemed a major risk that requires urgent and continuous management.

The current exceptional dry conditions in Addis Ababa are expected to remain, with longer periods between rains. Droughts would have an impact on the city's water supply, water-dependent enterprises, Addis Ababa's green areas, biodiversity, and water courses if they were to occur frequently and for an extended period.

Figure 98: Urban flooding due to drainage collapse in Addis Ababa [“Urban Flooding Due to Drainage Collapse in Addis Ababa,” n.d.]

Flooding in Addis Ababa is caused by more than just rain. There are several issues that contribute to flooding in this city; both the natural environment and human activities have a significant impact on this phenomenon.

DEFORESTATION IN ADDIS ABABA

Urban forests are not getting the attention they need, according to a 2013 Addis Ababa report on Planning for the Conservation and Sustainable Use of Urban Forestry. They have not been executed throughout the years, resulting in a major deterioration of the city's urban forest due to a high rate of deforestation. This is mostly due to rapid population increase mixed with increasing urbanization, as well as the resulting criminal exploitation.

In 2013, less than 5000 hectares of forest were covered, with increasingly low species diversity due to decades of monoculture plantation expansion practices.

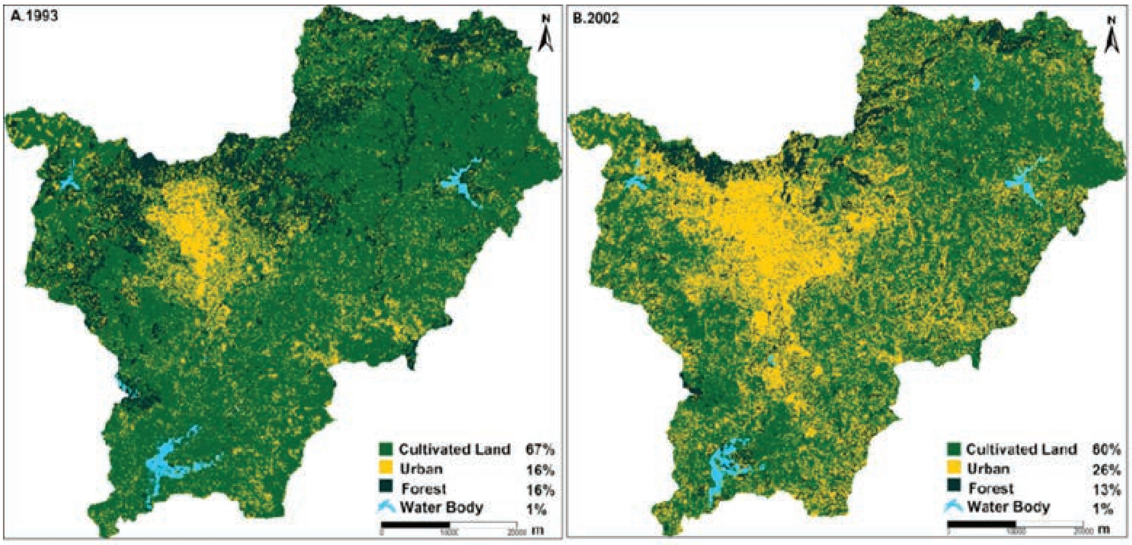


Figure 99: Land use map
[Birhanu et al. 2016b]

Addis Ababa was originally known as Forest City, but unregulated growth and commercial development, and including urban sprawl, have had disastrous consequences for natural areas, as well as the advancement of the urban heat island in many districts.

SUMMARY

Since 1988 Addis Ababa is increasingly affected by flooding. The rapid economic growth of the city increases the urbanization rate significantly, furthermore, an increase in summer season precipitation is expected with a possible risk of flooding.

Flood-related catastrophes in Africa have been on the rise over the past 50 years, with floods accounting for about half of all disasters in Sub-Saharan Africa since 1981. Addis Ababa (the capital of Ethiopia and Africa) is home to one-fourth of the country's urban population and accounts for around half of the country's GDP growth.

Low-income groups are pushed to dwell in flood-prone regions as a result of fast urbanization and population growth, and the city's inadequate drainage systems exacerbate the danger of floods. Even from typical storms, the decrease of green structures and rise in impervious area in urban areas creates more surface runoff, and the situation will worsen when impoverished people reside in flood-prone locations such as riverine and low-lying floodplains.

3- ENVIRONMENTAL IMPLICATIONS

ENVIRONMENT | INTRODUCTION AND OVERVIEW

Ethiopia has a high-level policy to pursue agriculture-based industrialization in order to attain middle-income status by 2025 while avoiding net carbon emissions increases. Environmental difficulties are a crucial factor for the effective fulfillment of this high-level goal, as the economy is now strongly reliant on agricultural and forest resources, and the country has a history of extensive, severe environmental deterioration. Erosion and land degradation, deforestation and forest degradation, water shortages, biodiversity loss, and other sorts of pollution are the key environmental challenges impacting Ethiopia, aside from climate change. While environmental concerns are frequently regarded individually, they are in fact intricately intertwined, and studies are increasingly attempting to analyze them simultaneously, despite the fact that this is a difficult task for researchers.

Environmental deterioration is pervasive and severe in Ethiopia, according to a review of the scholarly literature. Agriculture and deforestation, in particular, have had devastating consequences, particularly on soils, increasing the susceptibility of many individuals to basic supplies like food and water insecurity. This research focuses on these challenges, their connections to the Ethiopian economy, and their consequences for economic progress.

Figure 100: Ethiopian Highlands
[Exploring Africa, n.d.]

FORESTRY

According to certain historical reconstructions, Ethiopia's forest cover has decreased from roughly 40% to around 3% during the previous century. Ethiopia's deforestation rate is around average when comparison to those other East African countries. East Africa, on the other hand, has the continent's second greatest rate of deforestation. Over the previous 100 years, deforestation and land erosion in Addis Ababa have approached catastrophic levels in Ethiopia.(Deribew and Dalacho 2019)

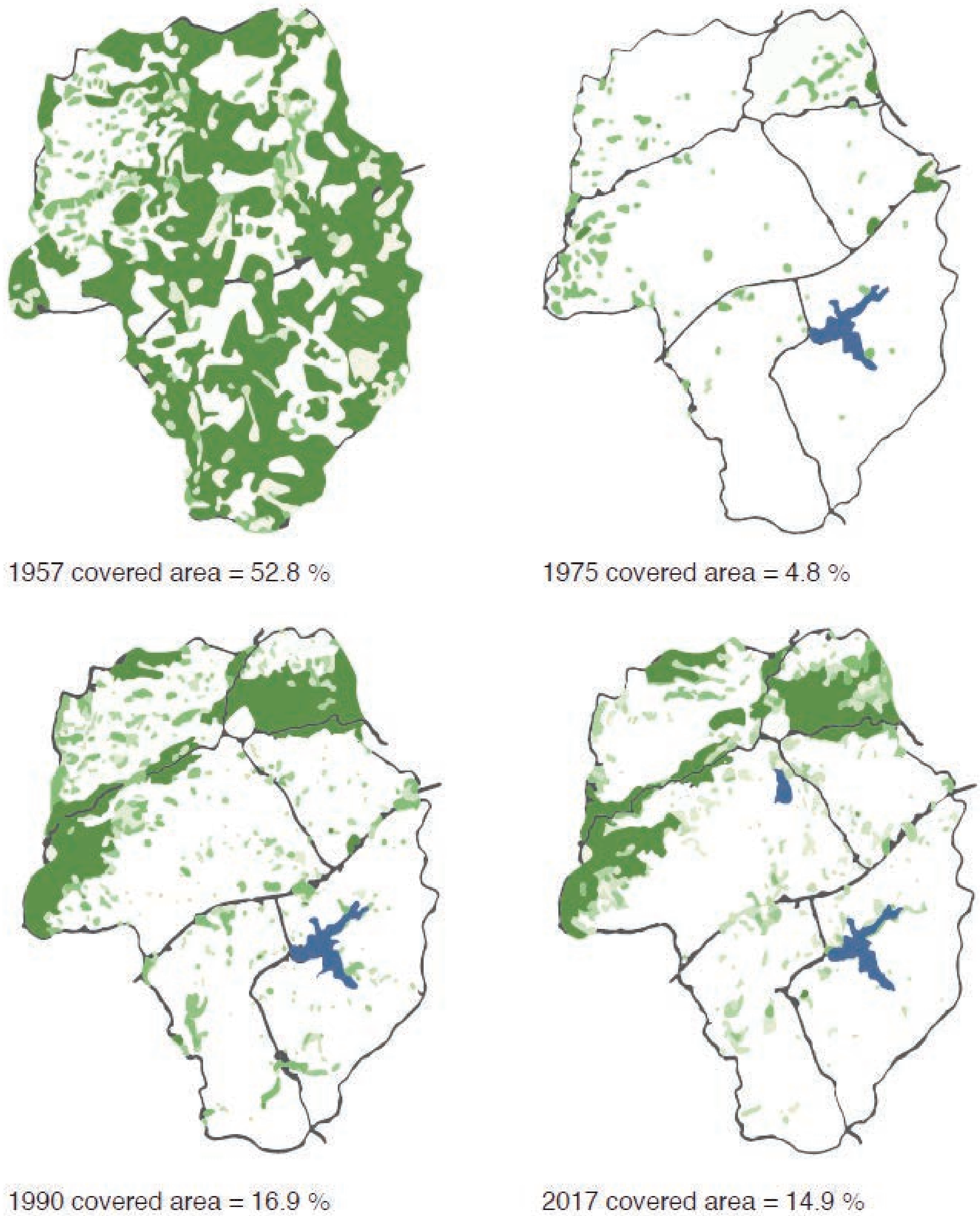


Figure 101: Forest cover of Addis Ababa of last 60 years (Deribew and Dalacho 2019)

DEFORESTATION AND FOREST DEGRADATION ISSUES

The reasons for the deforestations are as follow:

1- Urbanization

The population of Addis Ababa is fast expanding at a rate of 3.8 percent per year, and indigenous residents have been unable to adapt their livelihood methods to meet consumer demands for food, firewood, and other natural assets.(Deribew and Dalacho 2019)

2- Less awareness and lower rate of education

Deforestation in their region has been exacerbated by a lack of awareness campaigns, as well as a lack of laws to safeguard the trees. The lower the degree of education, the lower the rate of deforestation.

3- Bushfires

Before to the bushfires of 2000, the most recent big outbreak occurred in 1984, when 308,200 hectares of woodland were burned. After nearly three months of large-scale wildfires that destroyed over 300,000 hectares of natural forests, Ethiopia has failed to adequately safeguard its remaining forest resources.

4- Use of wood for construction, charcoal, and farming purposes

In Ethiopia, charcoal is a key source of energy for cooking, heating, and lighting. Many individuals rely on the earnings from the sale of charcoal for their livelihood. Rural farmers sell fuelwood and trees for building use as a source of revenue during dry seasons, which has largely contributed to the degradation of woodland and shrubland.(Alem et al. 2010)

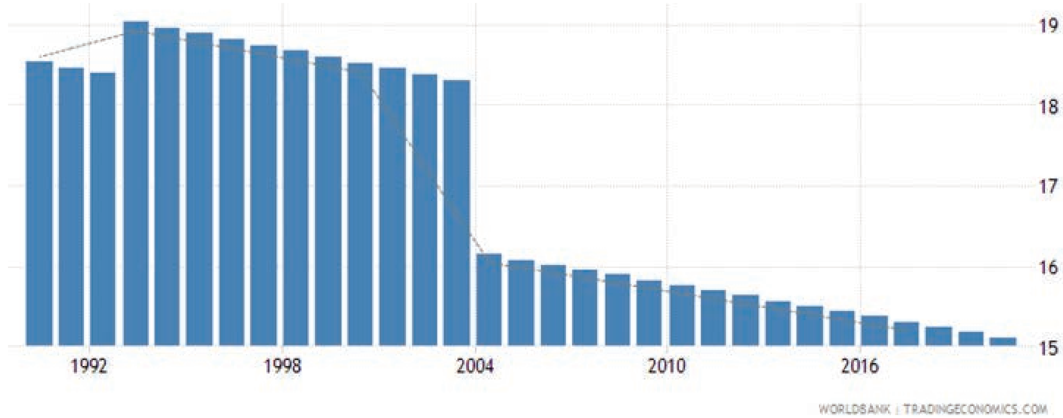


Figure 102: Ethiopia forest area (% of land area) [World Bank | Trading Economics, n.d.]

RESTORATION OF FORESTS

To counter this issue huge efforts by organizations to save the resources.

1- Since 2000, many reforestation programs been installed by governmental organizations and different NGO's. In 2007 more than 700 million trees were planted.

"There is plan to restore forest on 15 mln hectares and increase coverage by 7 mln hectares by 2030, says Government."(Abebech Tamene, n.d.)

Every year, the nation transplants more than 3-4 billion tree saplings. Environmental improvements have already begun to help the town, with results such as more spring water, an increased water table, and reduced soil erosion and floods.

Figure 103: Planting for World Environment Day 2012 (Open Learn Create, n.d.)

2- Spreading awareness of how to use less space and increase productivity using agricultural technology.

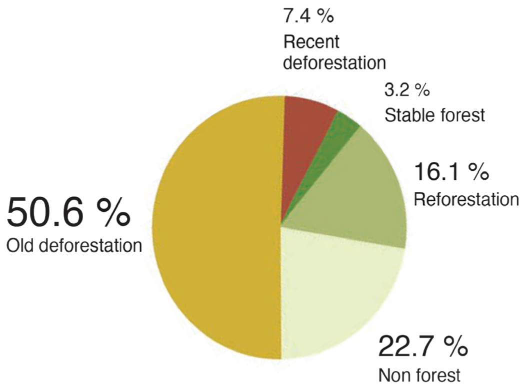
3- The woodlands around Addis Ababa, Ethiopia's capital, are patrolled each day. People are ruining the woodlands *for fuel and building despite the protection.*

4- Many women and girls currently spend their days gathering firewood, bark, branches, and dried leaves from eucalyptus trees and logs from nearby forests. They march up to 16 (Eucalyptus globulus) on their backs, bringing it to market to sell as fuelwood (firewood, charcoal, and kindling) to city people. The average daily wage is between $1 and $3.

Figure 104: Amone Ayesa collects wood in the Entoto forest outside of Addis Ababa, Ethiopia (MONGABAY, n.d.)

5- Growing eucalyptus as it grows faster than other native species of plants in Ethiopia just to meet the need for fuel wood.(Alem et al. 2010) However, the trees' need for water has had a negative influence on the ground.(MONGABAY, n.d.)

Figure 105: Eucalyptus trees in Addis Ababa, Ethiopia (MONGABAY, n.d.)



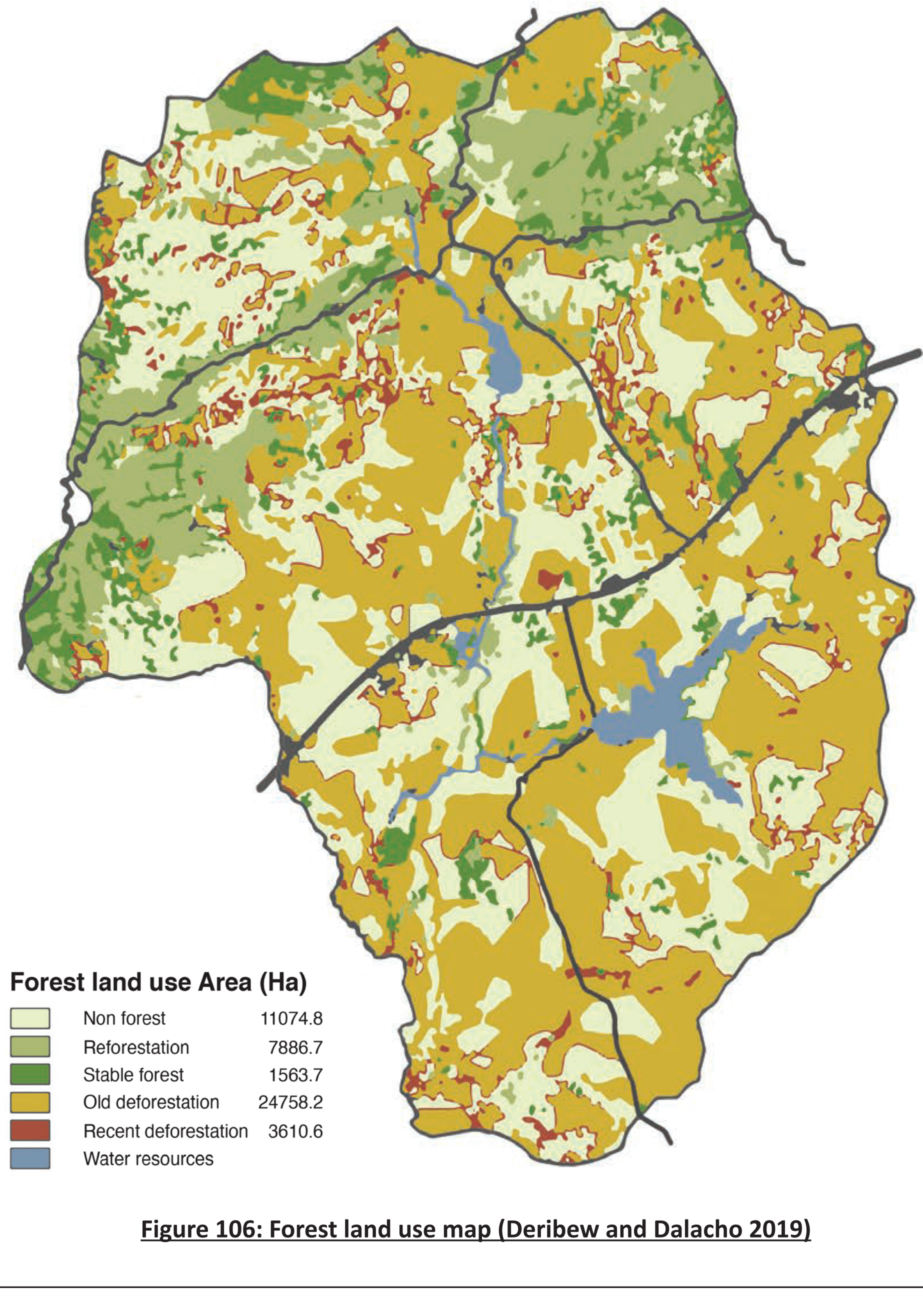


Figure 106: Forest land use map (Deribew and Dalacho 2019)

SOIL AND LAND

Soil erosion happens naturally in the landscape as a result of water and wind erosion, but human actions exacerbate it by many orders of magnitude over background rates.

Changes in land use, particularly the loss of forest and riparian vegetation. This topsoil flow has downstream consequences, resulting in siltation of waterways and

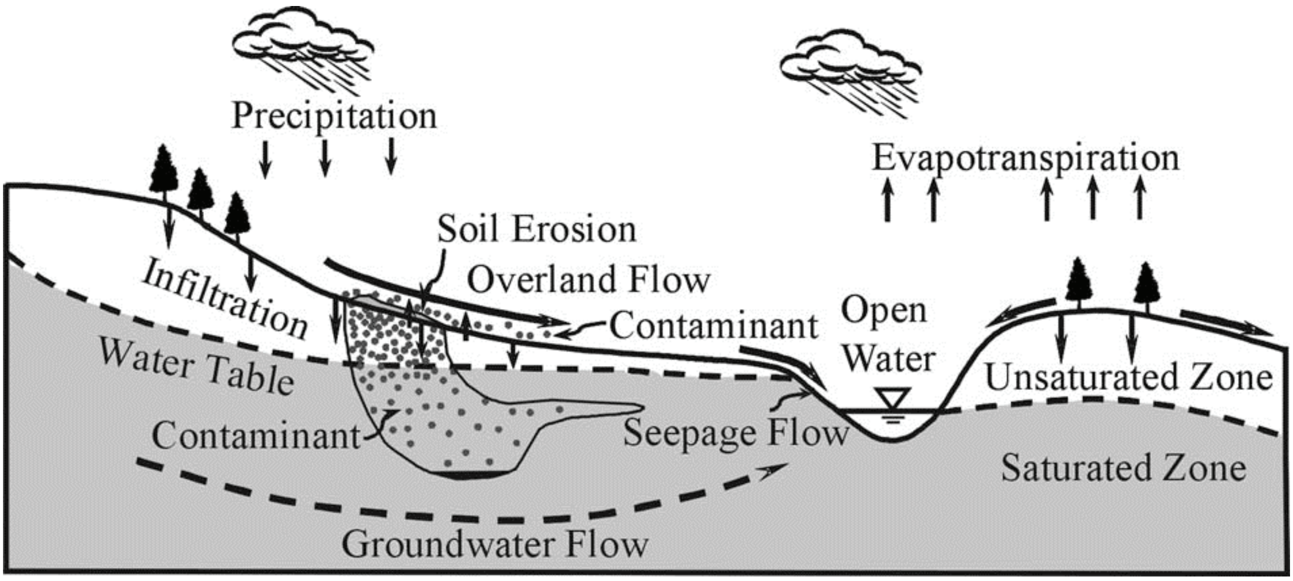


Figure 107: Sketch of flow, soil erosion, and contaminant transport in a watershed (He et al. 2007)

biological changes in waterways and wetland habitats. Soil erosion is enhanced when intensive agricultural methods are used on cleared land with insufficient soil protection measures.

The ecosystem provides water, biodiversity, economy, and social services ("LAND DEGRADATION IN ETHIOPIA: ITS EXTENT AND IMPACT L. Berry Commissioned by Global Mechanism with Support from the World Bank," n.d.). In both poor and high-income countries, land degradation occurs in practically all terrestrial ecosystems and agro-ecologies.

Figure 108: Soil erosion, Ethiopia [MONGABAY, n.d.]

Sub-Saharan Africa has seen the world's most severe land degradation, accounting for 22% of the worldwide price of soil erosion (Bossio et al. 2004).

Land resources in Ethiopia, like those in other SSA countries, are rapidly deteriorating due to proximate drivers such as habitat destruction, soil erosion, farmland expansion, and overgrazing, as well as underlying drivers such as a weak regulatory context and organizations, demographic growth, ambiguous land user rights, low local community empowerment, and poverty in general.("Principles, Practices and Developmental Processes Integrated Soil Fertility Management in Africa: Principles, Practices and Developmental Process" 2009)

Land degradation is especially severe in Ethiopia's north and north-western regions, where steep hillsides have been cultivated for generations and are vulnerable to significant soil erosion.

Figure 109: Farmer Makaba Wasu sowing tef, the local grain crop, has already lost part of his one-hectare field to river erosion ("Soil Erosion Ethiopia," n.d.)

Land degradation has several major environmental consequences, including fast loss of habitat and biodiversity, changes in water flows, and sedimentation of reservoirs and coastal zones. Land degradation in Ethiopia has resulted in a loss of chemical, physical, and biological properties of soil, which has a direct impact on the types of plants grown in the area, reduced availability of potable water, reduced volumes of surface water, aquifer depletion due to lack of recharge, and biodiversity loss.

Figure 109: Farmer Makaba Wasu sowing tef, the local grain crop, has already lost part of his one-hectare field to river erosion ("Soil Erosion Ethiopia," n.d.)

For land degradation different solutions can be opt:[Gashaw, Bantider, and Silassie 2014]

1- Adding nutrients to rebuild the topsoil for vegetation

2- Buffering soil acidity

3- Covering riverbanks with green lands to protect soil erosion

Figure 111: River erosion at due to deforestation upstream is destroying agricultural land in Ethiopia ("Soil Erosion Ethiopia," n.d.)

SUMMARY

All these adds to flooding events. Due to deforestation and land erosion the flood events cannot be slow down. The land erosion changes the course of water that is dangerous as it effects neighborhood population. But this can be saved by more forestation and treatment of soil erosion.

4- URBAN DEVELOPMENT

URBAN DEVELOPMENT OF ADDIS ABABA

Ethiopia is the only African country that has never been colonized by a foreign power. Throughout the years, political regimes altered not just the country's economic and social institutions, but also the urban development of Addis Ababa, leaving traces of the country's transitions observable to this day. As a result, six major transition timeframes may be identified:

1. Early diplomacy (1887-1936)
2. The Italian occupation (1936-1941)
3. The Imperial regime (1941-1874)
4. The dergue era (1974-1991)
5. The post-dergue era (1991-1999
6. Urbanization till present (2000- now)

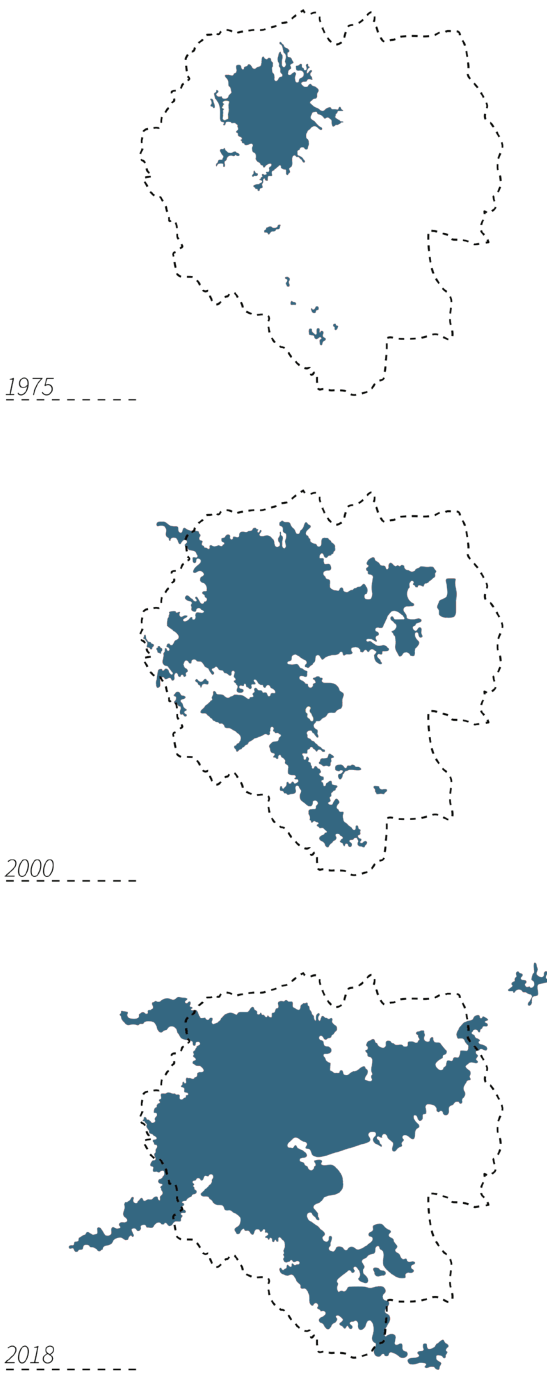


Figure 112: Urbanization in last 50 years in Addis Ababa [By Author]

Figure 113: Current condition of Addis Ababa [From Google Earth pro]

Figure 114: Urbanization Addis Ababa 1936 (Subačiūtė, de Graaf, and Zhou 1962)

Many masterplans for a new Addis Ababa have been offered throughout the years, all with the goal of changing the city. However, none of them were fully completed because to the lack of consistency in governing parties and often a lack of funding, leaving Addis Ababa underdeveloped for many years.

Addis Ababa today is a metropolis formed by the complexities of its historical past.

The city of Addis Ababa had no fundamental infrastructure when it was founded. The only roads built were those linking the several sefers to the city's center area and Gebbi. Addis Ababa's development and population expansion are mutually beneficial. The famine of 1889-892, as

(Image taken from research done by TU DELFT UNIVERSITY)

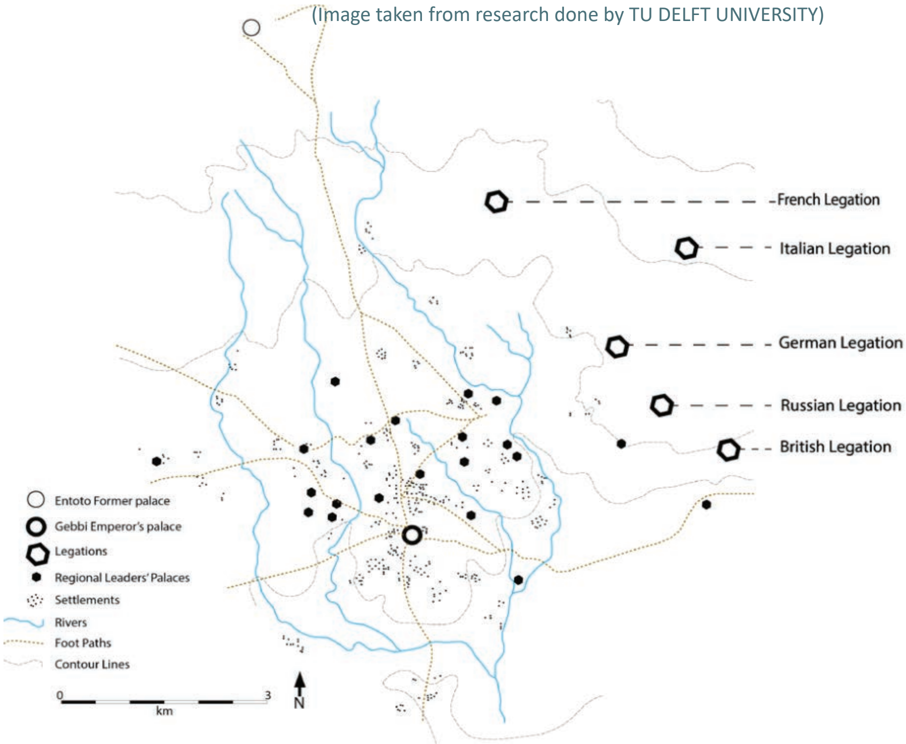


Figure 115: Addis Ababa 1890's with assumed location of the early diplomatic institutions (Subačiūtė, de Graaf, and Zhou 1962)

well as the Battle of Adwa, resulted in a significant population inflow. ("10.2307_j.Ctt24hjxj," n.d.)

During the Italian rule, Addis Ababa mostly expanded towards the south and east. Due to its frigid temperature and steep topography, which the Italians thought may be the ideal

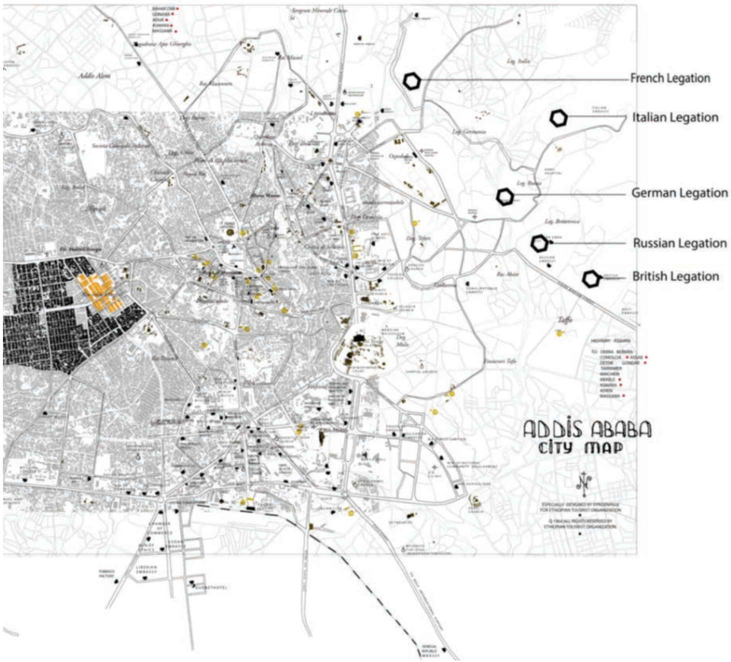


Figure 116: Map of Addis Ababa in 1964 (Subačiūtė, de Graaf, and Zhou 1962)

(Image taken from research done by TU DELFT UNIVERSITY)

setting for Ethiopian patriot bands, the northern half of the city was excluded from the master planning (Mahiteme 2007). Second, the Italians sought to link the city to the train station that was located in the south (“10.2307_41967609,” n.d.). The Lideta airport’s construction in the southeast of the city highlighted this area’s urbanization.

Figure 117: Urbanization Addis Ababa 1941 (Sou et al., n.d.)

(Image taken from research done by TU DELFT UNIVERSITY)

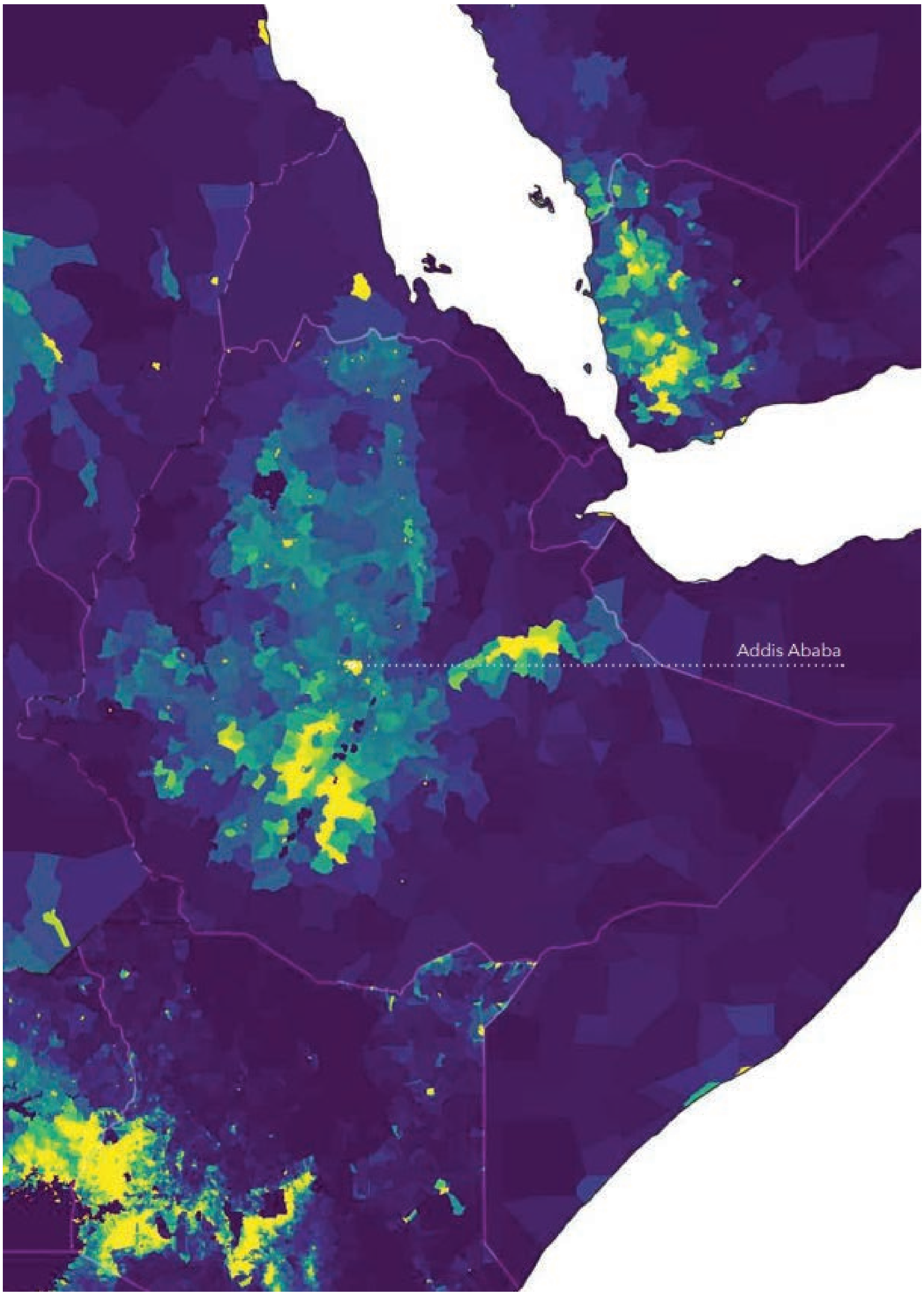


Figure 118: Population density map Addis Ababa (Sou et al., n.d.)

(Image taken from research done by TU DELFT UNIVERSITY)

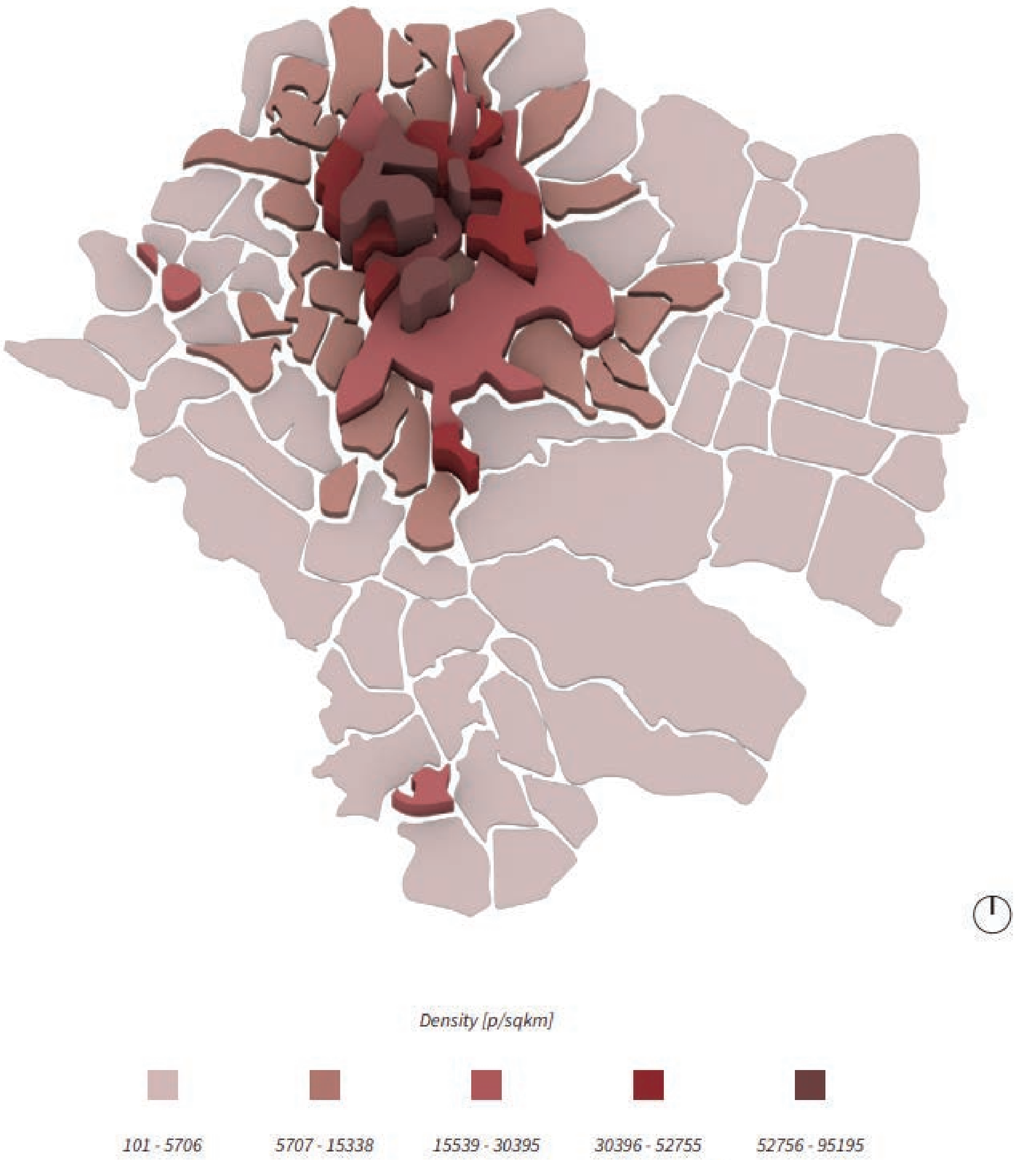


Figure 119: Population density map Addis Ababa (Sou et al., n.d.)

(Image taken from research done by TU DELFT UNIVERSITY)

REASONS OF URBANIZATION| MIGRATION

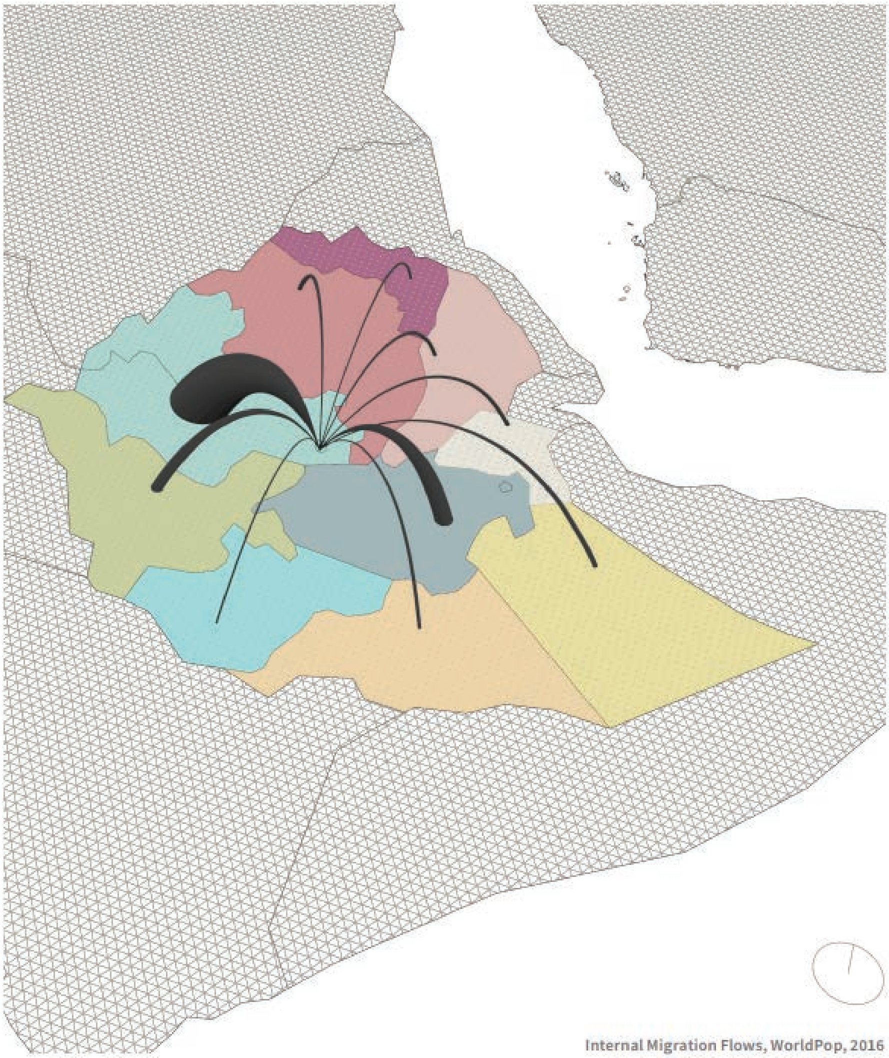
The main reason of urbanization in any city is always due to attraction of opportunities. Human beings strive for better living and for that they work hard and move towards better opportunities.

In 2008, migrants made about 37% of Addis Ababa's population. Most people traveled alone or with one other relative, and relatively few people brought along children. Nearly 90% of them said they had no plans to ever leave Addis Ababa again, and half of them were from other Ethiopian towns.

Contrary to popular belief, the city's educational prospects are the main draw for migrants, particularly female migrants, to go to Addis Ababa. (2010) Moller, p. 6. Nearly 90% of the migrants, who are mostly from rural regions, said they did not want to migrate in the upcoming three years.

The most densely populated district in the entire capital city is the center area (the historic section of Addis Ababa). The southern half of the city, where these regions are primarily agricultural areas, likewise has a lower population density. The two sub-cities of Bole (east) and Nefas Silk Lafto (south-west) both feature thriving neighborhoods and significant new real estate development.

National migration patterns in the direction of Addis Ababa are shown in the diagram below. World population information was used to build this map. Their research focuses on measuring subnational trends of human movement. In short, call data records from mobile phones were used to track population movements (CDRs). The World population organization disseminates statistics gathered for several low- and middle-income nations. The tracking of individual SIM cards through nearby phone towers allows for the estimation of population movements, displacements, and commuting patterns. Based on the tracking techniques, these figures represent an estimation.



29928	West Oromaria
8751	East Oromaria
5790	SNNP
2482	Northeast Somali
2366	Amhara
2175	North Somali
2078	Afar
1702	South Somali
1345	Tigray
964	South Omaria

Figure 120: Migration inside Addis Ababa (Subačiūtė, de Graaf, and Zhou 1962)
(Image taken from research done by TU DELFT UNIVERSITY)

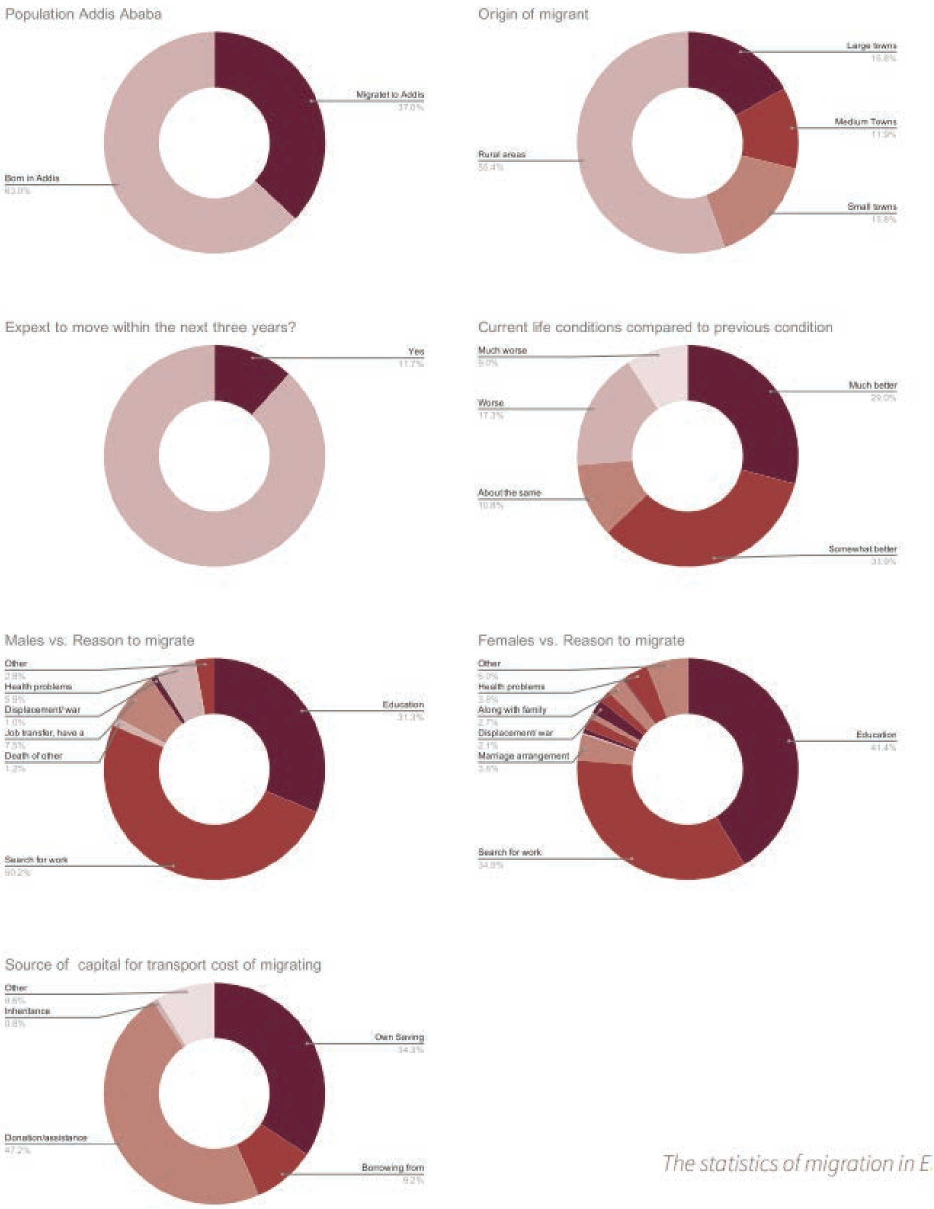


Figure 121: Migration statistics in Ethiopia (Subačiūtė, de Graaf, and Zhou 1962)

(Image taken from research done by TU DELFT UNIVERSITY)

SUMMARY

Although the city's susceptibility, flooded regions, and flood risk aren't assessed for each sub-city, there has been a noticeable rise in urban flooding over the past 20 years as a result of rapid urbanization and climate change effects. The model's output also indicated that losses from green constructions and climate change will result in an increase in peak flow. Additionally, the majority of Addis Ababa's population is compelled to reside in flood-prone and hazardous places including riverine, low-lying floodplains, and unstable slopes owing to economic problems.(Birhanu et al. 2016b)

Figure 120: Migration inside Addis Ababa (Subačiūtė, de Graaf, and Zhou 1962)

5- INFRASTRUCTURAL IMPLICATIONS

MOBILITY

Overview

Addis Ababa, Ethiopia's capital, was founded in 1886 and is located at a height of around 2500 meters above sea level. The city has gone through a variety of political regimes, with the present federal democracy in place since 1991.The city is split into ten sub cities and ninety-nine kebeles on an administrative level.

The city has gone through various planning revisions that have had an impact on its physical and social development. As a result of this expansion, there is an estimated 46 percent of land that is unoccupied or underused.

Simultaneously, the city center has a very high population density (up to 30,000 people per kilometer), putting about 30% of the inhabitants on 8% of the land, with typically terrible living conditions (Official and Only 2018).

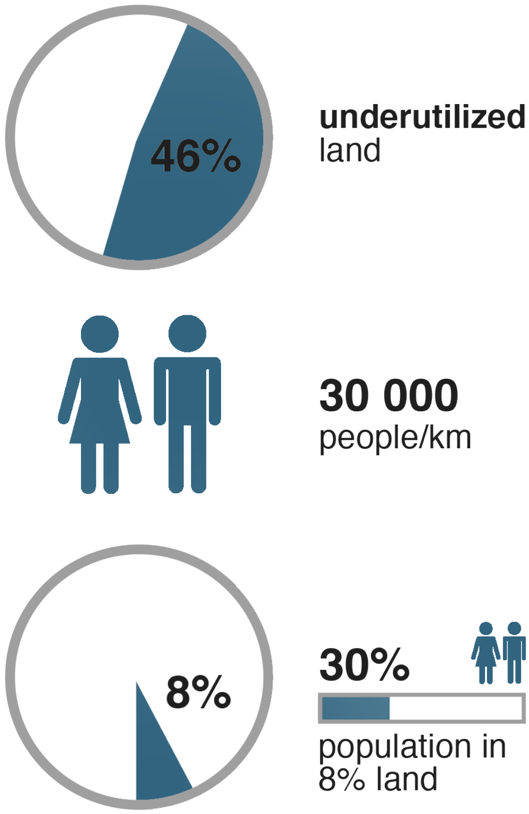


Figure 122: An Intersection in Addis Ababa (https://addisfortune.com/addis-to-build-40-intersections/)

Expansion of the city

From 1937 until 1975, the city's expansion was defined by a compact form of built-up area development. Between 1976 and 1985, the city's entire built-up area increased to 10,838 hectares. The city was expanded to the outside, displacing the rural farming communities. The majority of the rural areas were merged into the municipal border without any restrictions or proper planning.

Political and economic developments in the nation since 1974 were one of the elements that aided growth. The modern metropolis has gone through several stages of development. The city had no intentional urban design and instead followed the structure of a regular military camp.

"Between 1996 and 2000, the physical built-up area of Addis Ababa increased by 909.4 hectares, reaching a cumulative total of 14,672.7 hectares. The emergence of scattered and fragmented communities at the city's periphery, with both legal inhabitants and squatters, defined the city's expansion. Squatter colonies accounted for an estimated 60,000 dwelling units in the city in 2000 (Tabor 2019)."

The city is rapidly expanding, but it is also confronted with new urban difficulties relating to the population's social and economic expectations. It is critical to identify local identity and address the difficulties that the city is facing. "With an estimated present population of almost 4 million, Addis Ababa is straining itself to a new degree of complexity (Tesfaye and Version 2017)."

According to the World Bank's Ethiopian Urban Migration Study 2008, 37 percent of Addis Ababa's citizens were born outside the city and relocated to the city seeking work opportunities over time. "Though it can be said that it is a city that grew out of the needs of its inhabitants, one can still see urban and architectural influences that resulted from trade, infrastructure development, and cultural exchange with countries like France, India, Greece, and Armenia through these different historic contexts. (Tesfaye and Version 2017)"

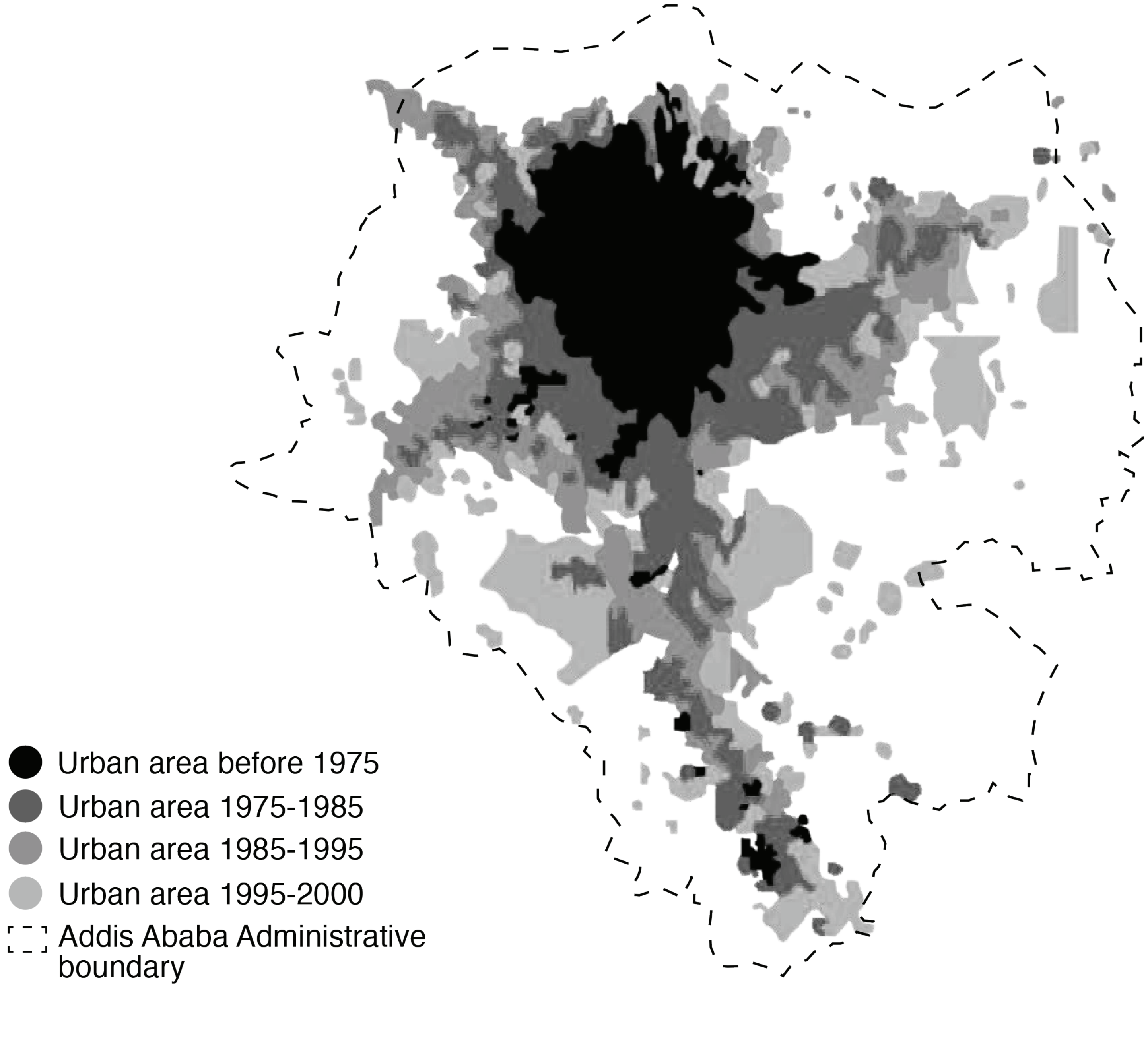


Figure 123: Urban Expansion of Addis Ababa through years [By Author]

Master Plan

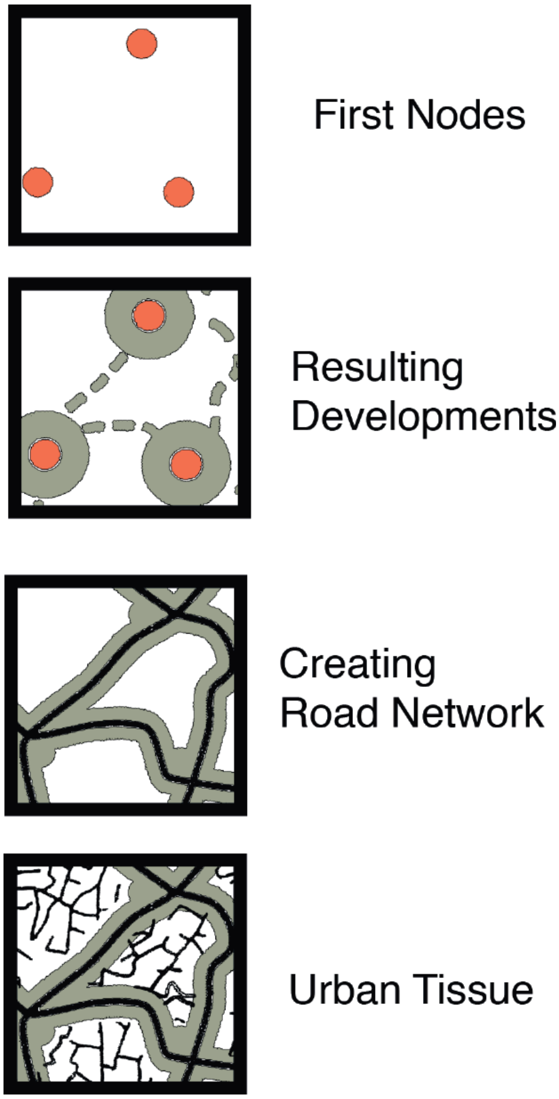


Figure 124: Depiction of the Urban tissue following the master plan (Agonafir, Alemu, and Askabe 2012)

“Modern municipal services were established between 1935 and 1941 (under the Italian occupation).” The Italian master plan mostly resulted in racially segregated towns such as Addis Ketema. Many of the roads and arching bridges built at the period, as well as arcade stores in Merkato and brick and wood residential buildings, particularly near Casainchis, are still visible today. (Office 2017)”

The first official master plan was prepared in 1986, and Addis Ababa had been revising it every year since then.

The government looked into the major problems with the current road system. It focused on the ring road in particular and offered a road network Conceptual Framework. The findings were included in the City Development Plan.

The Addis Ababa City Development Plan (2002-2012), which replaces the 1986 Master Plan, includes a legislative structural plan, an action-oriented strategic development framework, and management reform.

Six important urban challenges were highlighted for implementation in the plans:

1. *Housing*
2. *Urban road networks*
3. *Industries*
4. *Atmosphere*
5. *Renewal of the inner city*
6. *Upgrading*

Addis Ababa Neighbourhoods and their mobility analysis

Physically, Addis Ababa's rural regions are continually expanding. As a result of this expansion, different sorts of neighborhoods emerge within the same area. The slum regions are becoming more accessible, safer, and connected to the rest of the city as a result of this growth. Nonetheless, the government continues to face challenges in repairing and maintaining the road network.

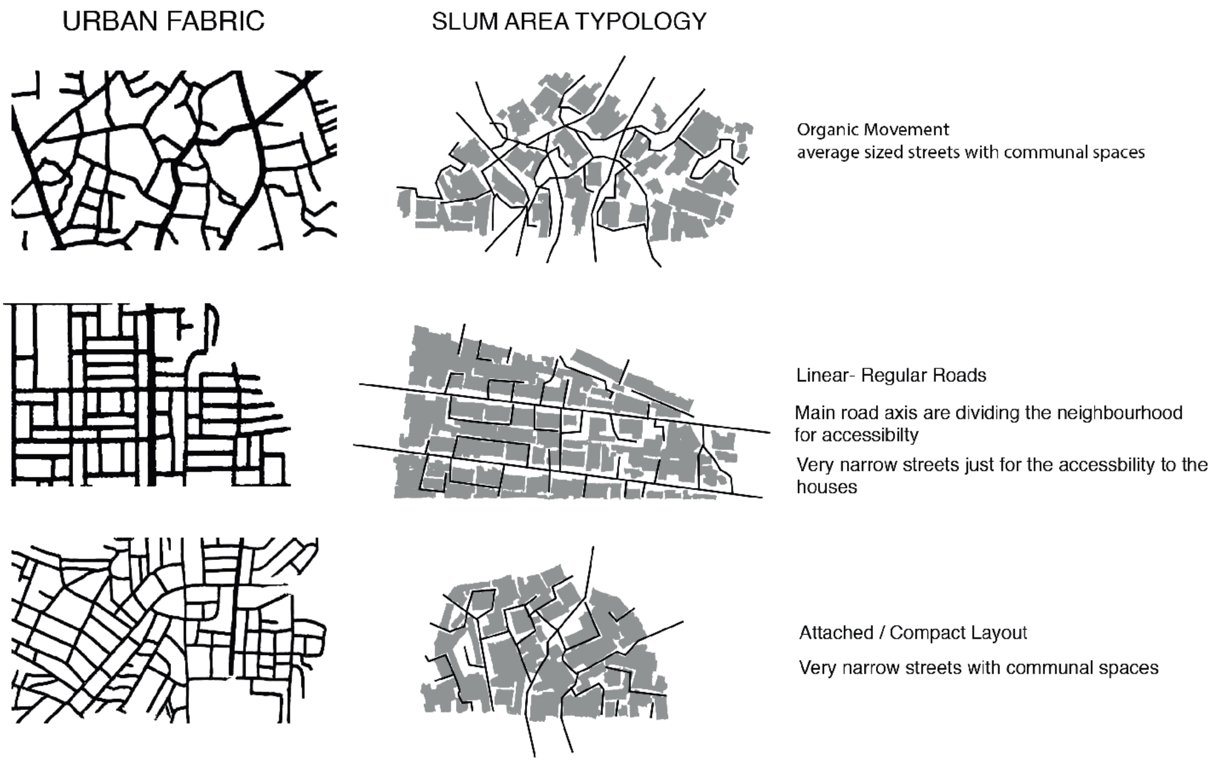


Figure 125: Urban fabric of roads (Agonafir, Alemu, and Askabe 2012)

Road Networks

The existing road network is part of the City Development Plan and follows the master road network's guidelines. Because road transportation infrastructure is supported from the city's own budget, resources for road maintenance are not included. The monies come from the national government, whose budget for Addis Ababa is typically insufficient to cover all of the city's needs.

The extent and quality of the road network are both restricted. Its capacity is limited, on-street parking is common, and the pavement is in poor shape. Despite the fact that the majority of the population walks, there are no sidewalks along a considerable portion of the roadway network (63 percent), which leads to traffic accidents, the majority of which involve pedestrians (Gebeyehu and Takano, n.d.). Traffic congestion is a problem for the system, especially during peak hours. The amount of time spent driving each day has grown, and many delays are caused by traffic congestion, breakdowns, and accidents. Currently, no risk analysis or environmental contamination are included in transportation rules (Division, n.d.).

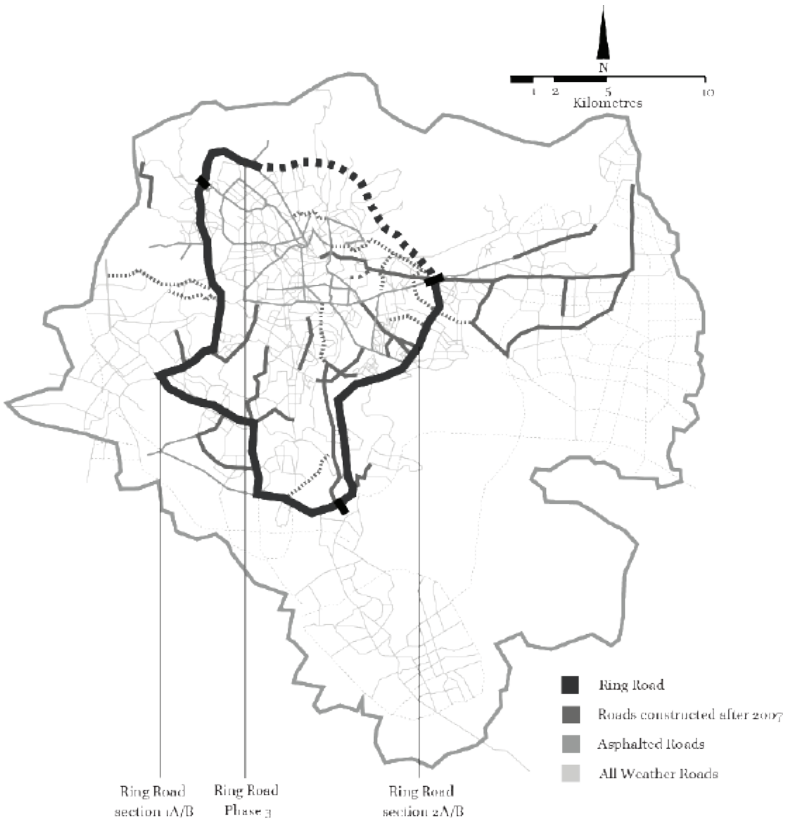


Figure 126: Road networks presentation in Addis Ababa (Nations and Council 2002)

MOPHOLOLGY

TYPES OF RESIDENCES

Kebele Houses (Small Houses and Sheds)

Kebele' dwellings often cannot open windows to bring light into the structures since the window would open onto the neighbor's house on at least three faces. In tiny residences, the only source of light is a single, continually burning light bulb in the centre of the room. Only 7% of tiny dwellings and outbuildings have their own toilet and running water.

The others either share a toilet within a compound or use the district's shared toilet and kitchen.

The most distinguishing aspect of tiny houses and sheds is the social network of its residents, which is difficult to depict within a typology. The close proximity of these single dwelling units forms a large social community "building" in which none of the units can live without the others.

Figure 127: Keble Housing typology(Heisel 2012)

Kebele' dwellings often cannot open windows to bring light into the structures since the window would open onto the neighbor's house on at least three faces. In tiny residences, the only source of light is a single, continually burning light bulb in the centre of the room. Only 7% of tiny dwellings and outbuildings have their own toilet and running water.

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Vertical extension of Kebele

Digging down and building a second storey within the house is one option. As a result, floor heights are normally limited to 1.60m or less.

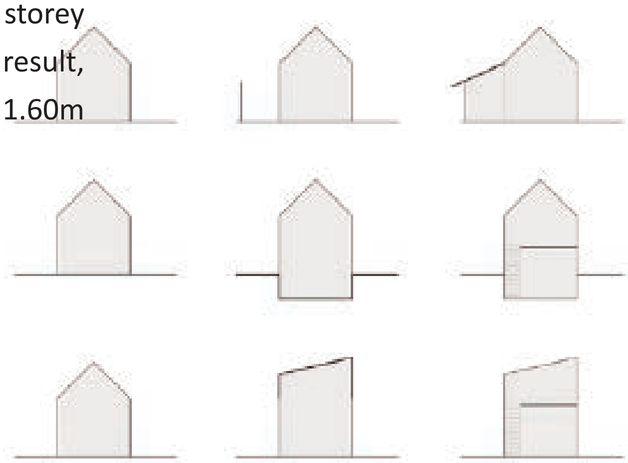


Figure 128: Vertical extension of Kebele [By Author]

The dwelling transforms into the public domain of the streets over the period of a few years. To begin, a modest barrier is erected to keep the house owner safe from the crowds while cooking. The majority of the time, this area is used as a display area to promote things as a source of revenue. The fence gets strengthened into a wall after a given period of time, when no one doubts the fact that this place was formerly a part of the public roadway. The new

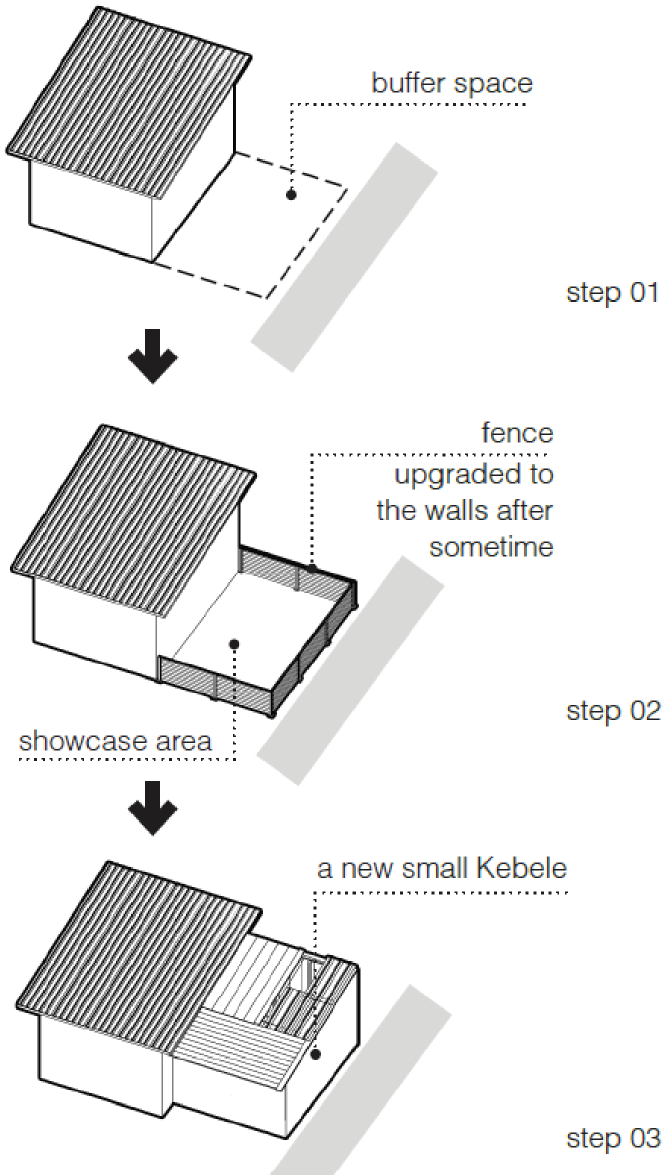


Figure 130: Horizontal extension of Kebele (Sou et al., n.d.)

Condominiums

In just five years, the 'Condominium Housing Project' sought to construct 170,000 homes in Addis Ababa. Construction has been or is presently taking place on 103 construction sites across the city, 51 of which are in the heart of the city. Condominiums are essentially the same as apartments, however there are some significant changes because to the different occupant structure. The 'Condominium Housing Project' is a city-improvement initiative.

Fortunately, the city has recognized the problem and is revamping the system to keep neighborhoods together. However, when it comes to the interaction between units and the public sphere, condos and apartments face the same issues. Unfortunately, this poses a far greater difficulty for condominiums. Unlike a family who chooses to live in an apartment, many residents in condominium blocks have been displaced or relocated from their previous existence of relying on microenterprises.

The woman of a model family in Addis Ababa's informal sector bakes and sells "injera"8 every day as the family's sole source of income. She can barely support her family after spending the previous years building a network of clients in her area.

The scenario depicted does not reflect a solitary incidence, but rather the great majority of Addis Ababa households.
The physical characteristics of their dwelling are undoubtedly enhanced by uprooting families like these from their normal social networks. On the other

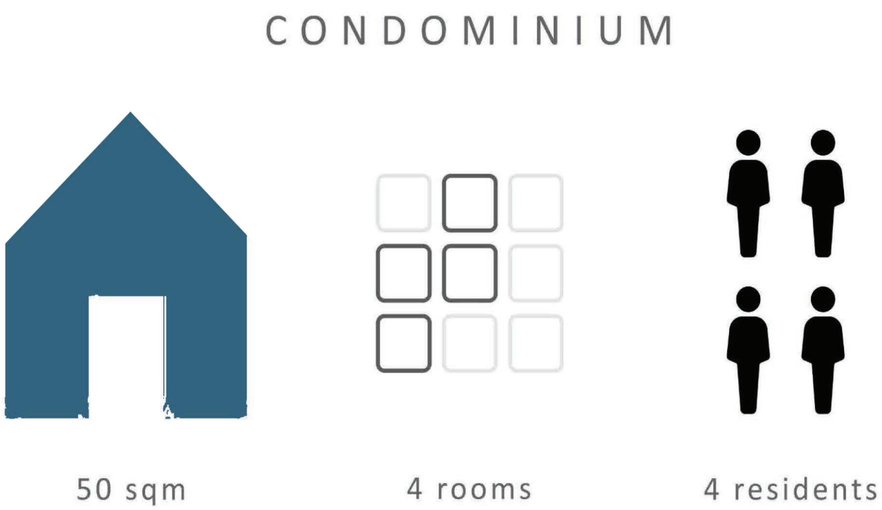


Figure 131: Condominium typology(Heisel 2012)

hand, they may lose their source of income as a result of this procedure, making life in the enhanced conditions impossible.

Some condominiums include an open kitchen that is also used as a living and dining space.

In many situations, the new owner moves the kitchen into a bedroom to provide a contained cooking environment due to the nature of Ethiopian traditional meals.

The 10/90, 20/80, and 40/60 schemes are three alternative funding techniques offered to low-income users. The various projects cater to people of various economic levels and range in terms of flat size, quality, and building expenses.

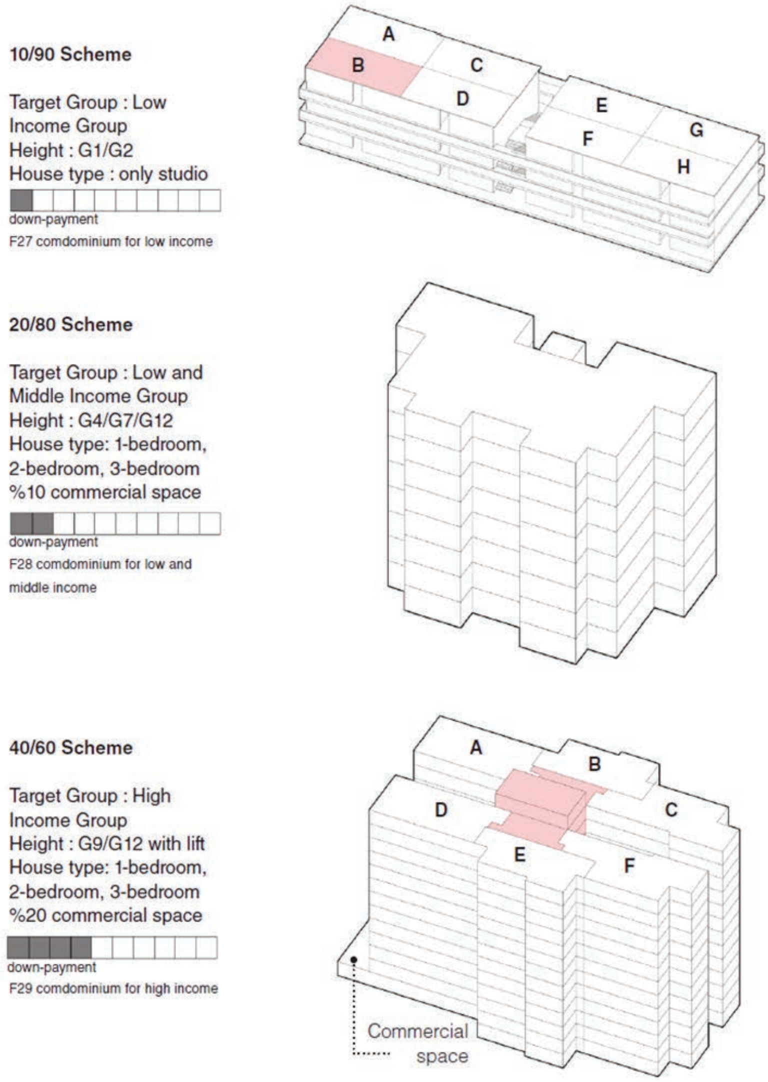


Figure 132: Condominium layouts (Heisel 2012)

Unit Typlogies in each condominium blok

Unit Type	Floor Area	Percentage in each blok
Studio	<20	20
1-Bed	20-30	40
2-Bed	30-45	20
3-Bed	>45	20

Figure 133: Condominium block space and typology (Heisel 2012)

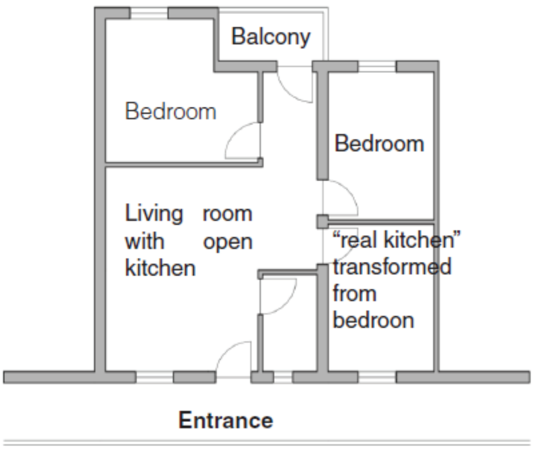


Figure 134: Typical Condominium layout (Heisel 2012)

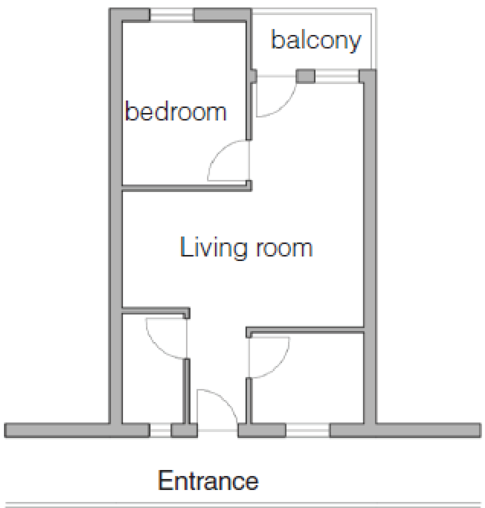


Figure 135: One bedroom Condominium Layout (Heisel 2012)

Villas

Households that stand alone are typical of the high-income class who reside in low-density areas.

Plots are frequently enclosed, and owners have security guards or dogs.
People who live in villas can generally afford a servant (86 percent), which is why service quarters are frequently located behind the home.

Figure 136: Villa's typology(Heisel 2012)

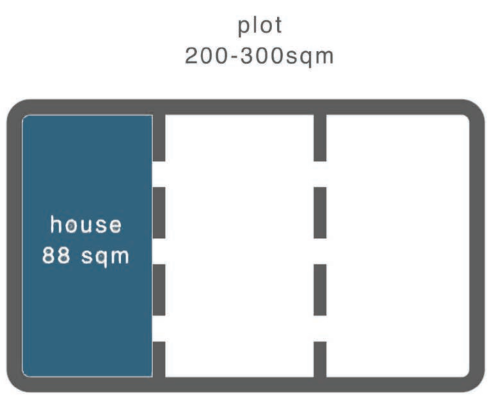


Figure 137: Size of a villa (Heisel 2012)

Villas were described as "luxurious villas nestled in safe neighbourhoods, high rises affording all of the trappings of a "Western" lifestyle, all contributing to the construction of a new, contemporary metropolis."

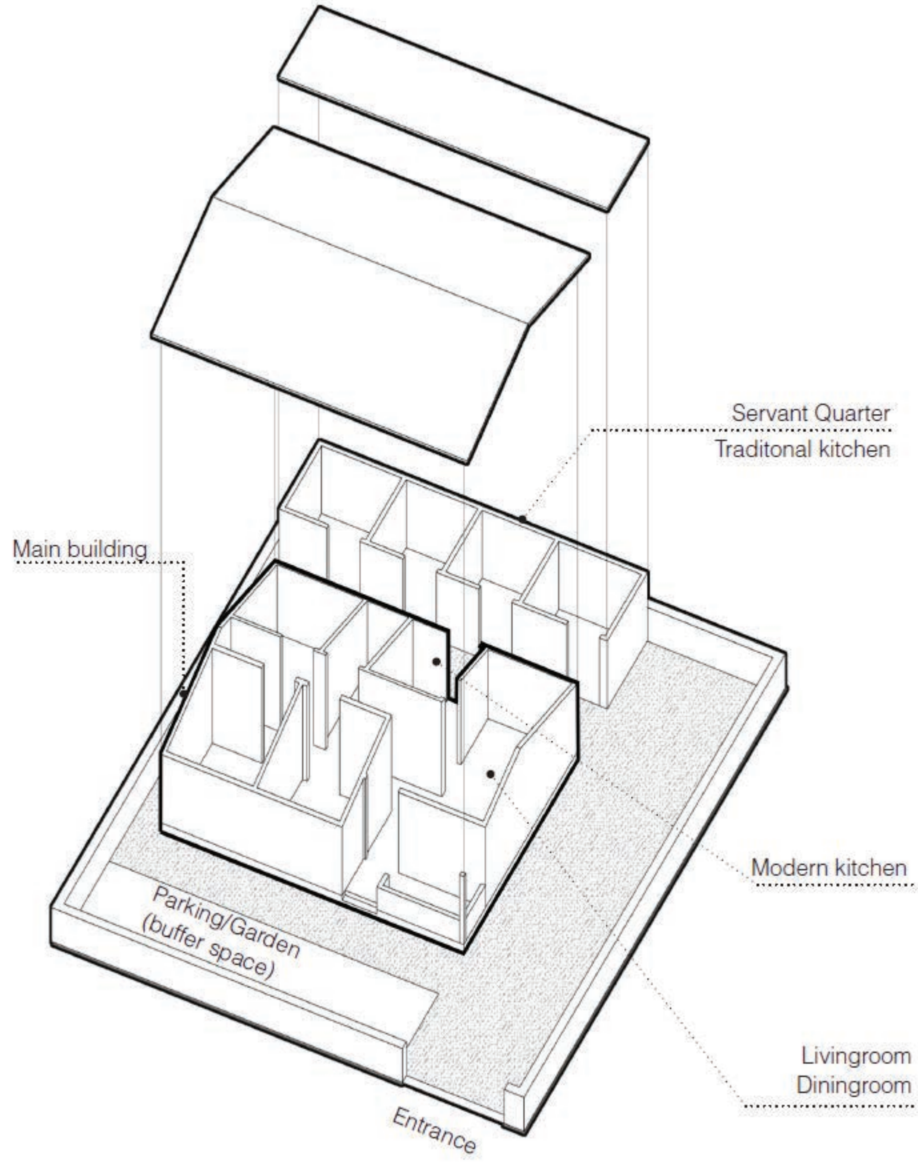


Figure 138: Exploded View of a villa (Heisel 2012)

Apartments

The size of an average apartment is the following:
Average unit area 53.2m^2, 4.77 person per one unit. Every year, the city loses 30% of its drinkable water owing to leaks in the municipal water system. Aside from this alarming fact, the low water pressure caused by these defects in the system causes everyday water difficulties in buildings with more than four floors.

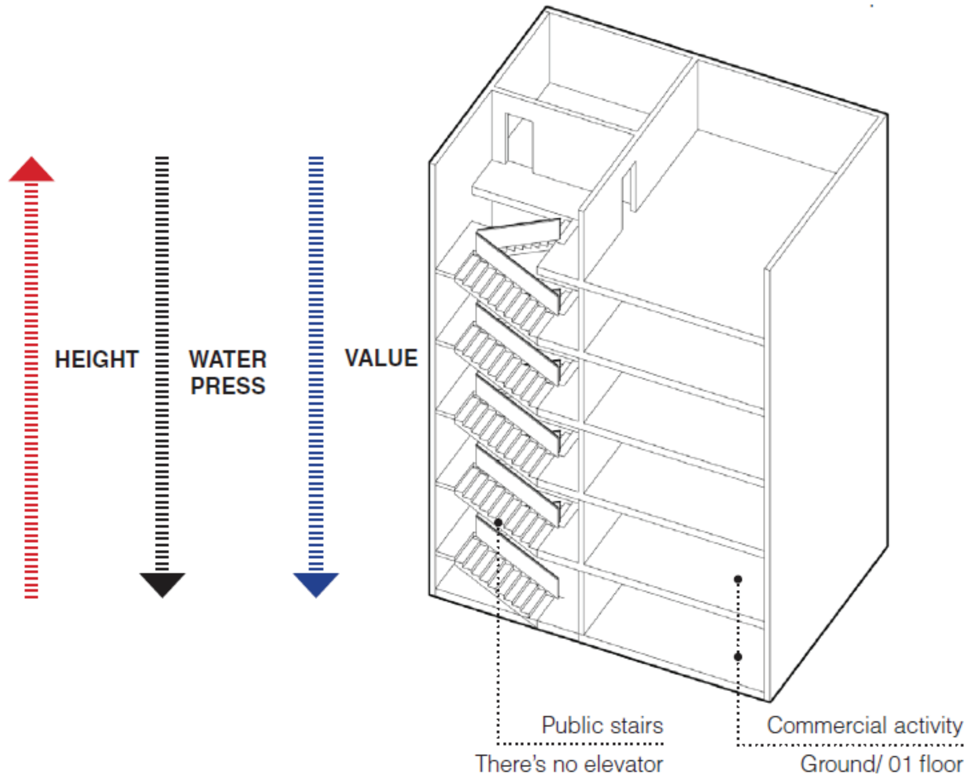


Figure 139: Section view of apartments in Addis Ababa (Heisel 2012)

Finally, the majority of Addis Ababa's residents (Heisel 2012)."
"These buildings normally contain a large choice of stores, restaurants, and other amenities on the ground and first levels because of the height of the apartment."

SUMMARY

Highways and urban drainage are inextricably linked; existing and new roads disrupt natural drainage patterns, and this reliance has grown over time. Flooding disrupts the road network, which leads to increased congestion and delays during the wet season.

For housing techniques and the way society works its visible that they don't use any technique for flood resiliency. And during floods they endure a lot of damage specially in kebele housing.

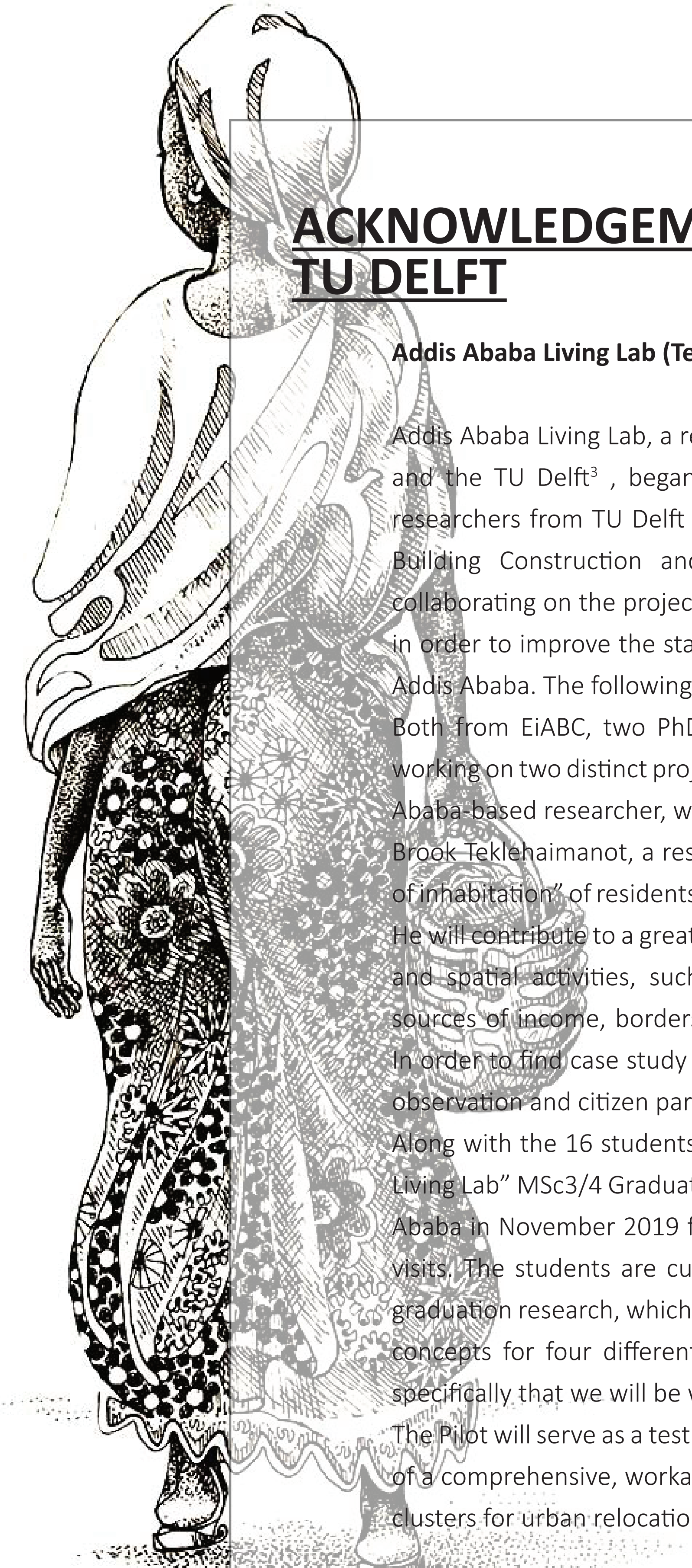
4.5 - PATTERNS OF LIVING

We found some real time pictures in Addis Ababa to understand the way they live there. Through the pictures we can understand the quality of living and their domestic culture, what they do in daily life for their work and regular resting and interacting activities. How the five elements of urban design work there.
How their **pathways** are, every house has its own **identity** because of material and colors, but if we go for new construction style of apartments, it is losing its character.
Each **node** has its own significant element because there are some coffee shops at the nodes making it busier and creating a sense of security.
We are attaching below the pictures of different areas to define different elements of **districts.**
The **edges** are mostly made of corrugated metals for boundaries.

PATTERNS OF LIVING

- COMMUNITY SPACES
- HOUSEHOLD PRACTICE
- INCOME PRODUCTION
- CONSTRUCTION TECHNIQUES
- FRINGES

THE LIMITATION OF THIS SECTION IS THAT WE COULD NOT VISIT SITE OURSELVES, SO WE FOUND THESE IMAGES FROM ***A RESEARCH OF A STUDENT OF TU DELFT*** *AND THANKS TO THEM WE ARE USING THEIR IMAGES. OTHERWISE UNDERSTANDING SITE CHARACTER WOULD HAVE BEEN DIFFICULT.*



ACKNOWLEDGEMENT TU DELFT

Addis Ababa Living Lab (Technische Universiteit Delft, n.d.)

Addis Ababa Living Lab, a research initiative financed by NWO-WOTRO[2] and the TU Delft[3] , began two years ago, in May 2019. A group of researchers from TU Delft and the Ethiopian Institute for Architecture Building Construction and City Development (EiABC)[4] have been collaborating on the project's initial research outputs for the past years in order to improve the standard of living for resettlement residents in Addis Ababa. The following few years will be devoted to this task.
Both from EiABC, two PhD candidates joined the project and began working on two distinct project components. Yonas Alemayehu, an Addis Ababa-based researcher, will examine historical and present urban.
Brook Teklehaimanot, a researcher at TU Delft, examines the "patterns of inhabitation" of residents in the various urban settings of Addis Ababa. He will contribute to a greater understanding of urban community social and spatial activities, such as habitation patterns, social structures, sources of income, borders, and construction methods and materials. In order to find case study locations and test ethnographic methods of observation and citizen participation, he did fieldwork in Addis Ababa.
Along with the 16 students from the associated TU Delft "Addis Ababa Living Lab" MSc3/4 Graduation Studio, the entire team traveled to Addis Ababa in November 2019 for intensive meetings, a workshop, and site visits. The students are currently working on the final stages of their graduation research, which will provide 16 different architectural design concepts for four different Addis Ababa locations. In which one site specifically that we will be working on is facing flood issues.
The Pilot will serve as a test case and feedback loop for the development of a comprehensive, workable framework for building resilient dwelling clusters for urban relocation in Addis Ababa.

Figure 2: Women in Addis Ababa 2 (Eduardo Di Muro, n.d.)

[2] WOTRO Science for Global Development, a cross-domain effort of NWO, plans, funds, and supports research for inclusive global development. The goal of the WOTRO research programs is to provide information and abilities that support long-term fixes for

Project partners

TU Delft, Faculty of Architecture and the Built Environment (TUD-BK, Prof.dr.ir. Marja Elsinga, PI), Ethiopian Institute for Architecture, Building Construction and City Development (EiABC, Dr. Elias Yitbarek), Federal Housing Corporation, Addis Ababa (Zekarias Sebsbie, Mahlet Yared), Mecanoo architecten, Delft (Prof.ir. Dick van Gameren), RAAS Architects, Addis Ababa (Rahel Shawl)

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Daily supervisor: Dr. Maartje van Eerd (EUR-IHS)

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User-committee

Senait Damtew, Timnit Eshetu (Addis Ababa City Government), Tsegaye Moshe (Ministry of Urban Development and Housing)

Project managers

Ir. Frederique van Andel (TUD-BK), Dr. Elias Yitbarek (EiABC)

social and ecological issues in low- and middle-income nations (LMICs).

[3] The oldest and largest public technical university in the Netherlands is Delft University of Technology (TU Delft), which is situated in Delft, the Netherlands.

[4] In Addis Abeba, Ethiopia, there is an institute for architecture and civil construction called the Ethiopian Institute of Architecture, Building Construction, and City Development (EiABC).

[5] This image was published on Middle East Monitor, creating new perspective| page after an event of flash flood in Addis Ababa. Around 217 localities were at high risk due to this flooding in the Addis Ababa, according to concerned institution.

3.9.1 - COMMUNITY SPACES

(Images taken from research done by TU DELFT UNIVERSITY)

Social hubs in Addis Ababa vary by neighborhood, although they virtually usually occupy major or subsidiary streets, informal marketplaces, green spaces, and compound interior courtyards. Social spaces are crucial among low-income communities because they offer communal places for encounters, where women prepare food, wash dishes, and/or look after children together. The streets serve as social gathering places.

Figure 140: internal courtyard of compund- Household activities and children playing [Subačiūtė, n.d.) (Subačiūtė, de Graaf, and Zhou 1962]

Figure 141: Coffee sellers in Informal settlements in Tallian [Subačiūtė, n.d.) (Subačiūtė, de Graaf, and Zhou 1962]

Figure 142: Open green spaces activities - men resting, Addis Ababa [Subačiūtė, n.d.) (Subačiūtė, de Graaf, and Zhou 1962]

Figure 143: Informal markets on Kolfe
[Subačiūtė, n.d.) (Subačiūtė, de Graaf, and Zhou 1962]

Figure 144: Playing activities in streets in Tallian
[Subačiūtė, n.d.) (Subačiūtė, de Graaf, and Zhou 1962]

Figure 145: People having lunch in Kechene
[Subačiūtė, n.d.) (Subačiūtė, de Graaf, and Zhou 1962]

Figure 146: Outdoor sports activity - Football field in Kolfe
[Subačiūtė, n.d.) (Subačiūtė, de Graaf, and Zhou 1962]

3.9.2 - Household Practice

(Images taken from research done by TU DELFT UNIVERSITY)

The intimate relationship between the indoor home and the compound's outdoor courtyard areas represents domestic spaces. Many activities, such as laundry, drying clothing, drying grains, and children playing, take place outside due to the limited size of the dwellings.

Figure 147: Compound activities - drying grain and vegetables [Subačiūtė, n.d.) (Subačiūtė, de Graaf, and Zhou 1962]

Figure 148: Children playing in backyards in Gerji
[Subačiūtė, n.d.) (Subačiūtė, de Graaf, and Zhou 1962]

Figure 149: Compound activities – drying clothes
[Subačiūtė, n.d.) (Subačiūtė, de Graaf, and Zhou 1962]

Figure 150: Cooking areas in Gerji
[Subačiūtė, n.d.) (Subačiūtė, de Graaf, and Zhou 1962]

Figure 151: Injera preparation room in Gejri
[Subačiūtė, n.d.) (Subačiūtė, de Graaf, and Zhou 1962]

Figure 152: Compund activities - Drying clothes and spices in Kechene [Subačiūtė, n.d.) (Subačiūtė, de Graaf, and Zhou 1962]

Figure 153: Pile of tires that helps in washing clothes in Gejri [Subačiūtė, n.d.) (Subačiūtė, de Graaf, and Zhou 1962]

3.9.3 - INCOME PRODUCTION

(Images taken from research done by TU DELFT UNIVERSITY)

In low-income social groupings, tasks are divided between men and women. Men go to work and return home after work, while women look after the children and the home. As a result, women generate additional revenue within the dwelling units or in the courtyard, while males generate income outdoors.

Figure 154: Income generation source - women making mats and selling in merkato in Kolfe [Subačiūtė, n.d.) (Subačiūtė, de Graaf, and Zhou 1962]

Figure 155: Low-income group women source by washing clothes for middle income group in Kolfe [Subačiūtė, n.d.) (Subačiūtė, de Graaf, and Zhou 1962]

Figure 156: Street shop of tailor in Kolfe [Subačiūtė, n.d.) (Subačiūtė, de Graaf, and Zhou 1962]

3.9.4 - CONSTRUCTION TECHNIQUES

(Images taken from research done by TU DELFT UNIVERSITY)

The scale of the projects being created in Addis Ababa varies greatly. As a result, the materials used differ. Concrete is commonly utilized in freshly constructed buildings, although indigenous, low-cost materials are extensively employed in informal settlements.

Figure 157: Use of concrete in new building complexes, Addis Ababa [Subačiūtė, n.d.) (Subačiūtė, de Graaf, and Zhou 1962]

Figure 158: Walls of informal settlement made of Chika and stones in Tallian [Subačiūtė, n.d.) (Subačiūtė, de Graaf, and Zhou 1962]

Figure 159: Use of broken tiles and concrete for pavements in Kechene [Subačiūtė, n.d.) (Subačiūtė, de Graaf, and Zhou 1962]

Figure 160: Stone pavements and corrugated metal fence in Tallian [Subačiūtė, n.d.) (Subačiūtė, de Graaf, and Zhou 1962]

Figure 161: Governmental houses made of concrete blocks in Kolfe [Subačiūtė, n.d.) (Subačiūtė, de Graaf, and Zhou 1962]

Figure 162: Informal houses walls made of Chika and stones and wooden frames in Kechene [Subačiūtė, n.d.) (Subačiūtė, de Graaf, and Zhou 1962]

3.9.5 – Fringes

(Images taken from research done by TU DELFT UNIVERSITY)

Many boundaries may be observed in Addis Ababa, including those that demarcate streets, compounds, and houses.

Figure 163: Facade materials in Gerji
[Subačiūtė, n.d.) (Subačiūtė, de Graaf, and Zhou 1962]

Figure 164; Informal shops operated from courtyard of the house in Gejri
[Subačiūtė, n.d.) (Subačiūtė, de Graaf, and Zhou 1962]

Figure 165: Corregated metal fences in different colors to identify the individuality in Kolfe [Subačiūtė, n.d.) (Subačiūtė, de Graaf, and Zhou 1962]

Figure 166: House exterior in Gejri [Subačiūtė, n.d.) (Subačiūtė, de Graaf, and Zhou 1962]

4.6 - SUMMARY

Ethiopia's capital and largest city is Addis Ababa. It also acts as Oromia's regional capital. The city's population was expected to be 2,739,551 people in the 2007 census. Addis Ababa is Ethiopia's most developed and significant cultural, artistic, economical, and administrative centre.

Addis Ababa is a grassland biome at an elevation of 2,355 meters (7,726 feet) and is located at 9°1′48′′N 38°44′24′′E. The city is located at the foot of Mount Entoto and is part of the Awash River's watershed. Addis Ababa climbs from its lowest point in the southern fringe, at Bole International Airport, at 2,326 meters (7,631 feet) above sea level, to almost 3,000 meters (9,800 feet) in the Entoto Mountains to the north ("Country Files (GNS)," n.d.).

Ethiopia as a country is prone to flooding. Flood-related catastrophes in Africa have been on the rise over the past 50 year, with floods accounting for about half of all disasters in Sub-Saharan Africa since 1981. Addis Ababa (the capital of Ethiopia and Africa) is home to one-quarter of the country's urban population and accounts for around half of the country's GDP growth. Despite the city's tremendous economic expansion and urbanization, flooding remains the city's biggest development concern. In addition to severe rainfall and catastrophic climatic events, substantial changes in the impervious area exacerbate urban floods (Birhanu et al. 2016c).

Due to extreme climatic events and upper catchment activity, Addis Ababa is prone to riverine and flash floods, and this susceptibility is exacerbated by an inadequate drainage system, fast house expansion near river banks, and the use of improper building materials ("Addis Ababa, Ethiopia: Enhancing Urban Resilience," n.d.). From 1951 to 2002, a century of rainfall analysis, focusing on the rainy season (June to September: JJAS), revealed an increasing tendency of rainfall of around 18 mm each decade (Conway, Mould, and Bewket 2004). Eastern Africa's yearly rainfall is anticipated to rise, according to the Intergovernmental Panel on Climate Change (IPCC) study (Eriksen and Rosentrater 2008).

A new research utilizing high-resolution models in the coupled Model Intercomparison Project Phase 5 (CMIP5) under the Representative Concentration Pathway (RCP) 4.5 scenario on Ethiopian summer (Kiremt) season similarly showed an increase in precipitation.

Low-income groups are pushed to dwell in flood-prone regions as a result of fast urbanization and population growth, and the city's inadequate drainage systems exacerbate the danger of floods. Even from typical storms, the decrease of green structures and rise in impervious area in urban areas creates greater surface runoff (Douglas et al. 2008), and the situation will worsen when impoverished people reside in flood-prone locations such as riverine and low-lying floodplains. The following figure shows the topography of the city and how its prone to urban flooding.

Hence there is a need to adapt to modern contemporary systems that provide the city a sense of safety and increase its resilience in terms of urban flooding. In recent studies, it was explored in Addis Ababa that the need to adopt techniques such as LSM (Land-based storm water management systems) that might enhance community livelihoods. Insecure tenure, legislative barriers to rainwater gathering in condos, the loss of green space

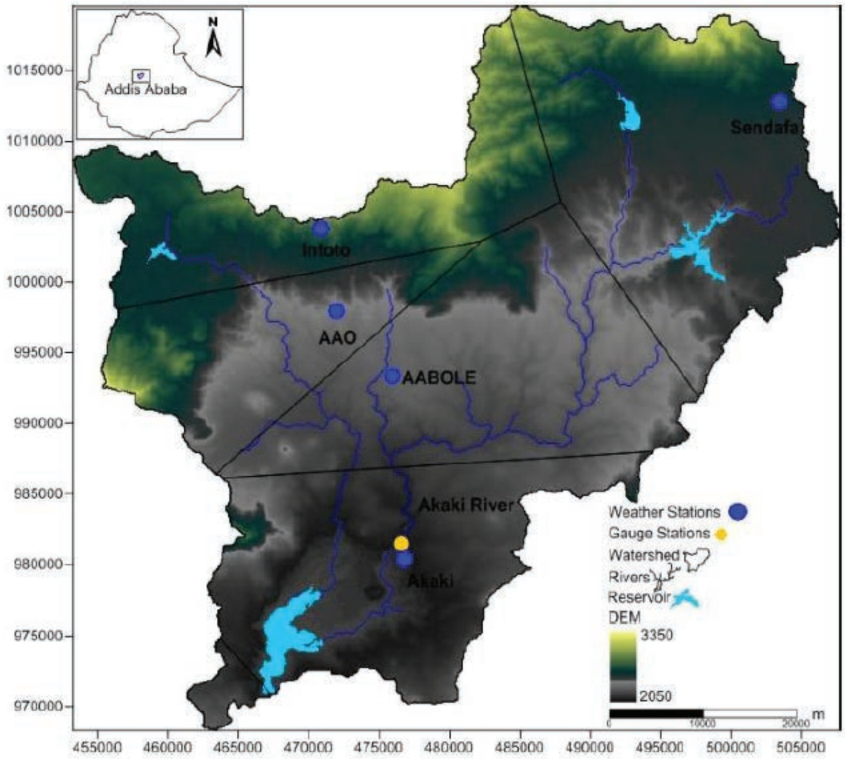


Figure 167: Addis Ababa topography
[Birhanu et al. 2016c]

at the watershed level, inadequate water infrastructure, and contamination of local water resources are all important obstacles to water-resilient livelihoods (Ababa, Herslund, and Mguni 2018). LSM may be used as part of a strategy and point of intervention to scale down federal initiatives like the Urban Food Security Program and the Climate-resilient Green Economy in order to align with local objectives and projects. Continuous professional growth of practitioners, authorities, and user group training are other significant factors in encouraging water-sensitive behavior.

PART 4A| STRATEGIES PROPOSED FOR ADDIS ABABA FOR FLOOD RESILIENCE BY LEARNING FROM RESEARCH

Figure 168: Monument of Karl Marx [28] (Eduardo Di Muro, n.d.)

[28] A book written by Eduardo Di Muro which illustrates the social character of urban capitals of Africa. He tried to explain the scenes of community, markets and streets and drew the culture through his drawings.

|05

THEORETICAL AND THEMATIC FRAMEWORK

Figure 169: Grand Ethiopian Renaissance Dam under construction ("Addis Ababa as a Palimpsest Palimpsest Palimpsest Palimpsest," n.d.)

5.1 - INTRODUCTION

After studying the resilience and its link with Addis Ababa we discussed the city's basic elements that verified the problem statement. This theoretical framework supports the research problem of this project. So, in this we are studying the details of the qualities of resilience city in term of Addis Ababa. Apart from that we will discuss the needs of different groups that will help us in creating a thematic framework, to define strategies for master planning of the site.

Theoretical framework deals with the qualities of resilient city that helps with defining the core elements, necessary for master planning. Considering different income groups is one of the mandatory topics. As to create a stable society we need to integrate the community rather than creating a gated society, this way they can stabilize their own community by participating in deriving solutions for natural hazards with the help of authorities

THEORETICAL FRAMEWORK

- Question under consideration for Resilient Addis Ababa

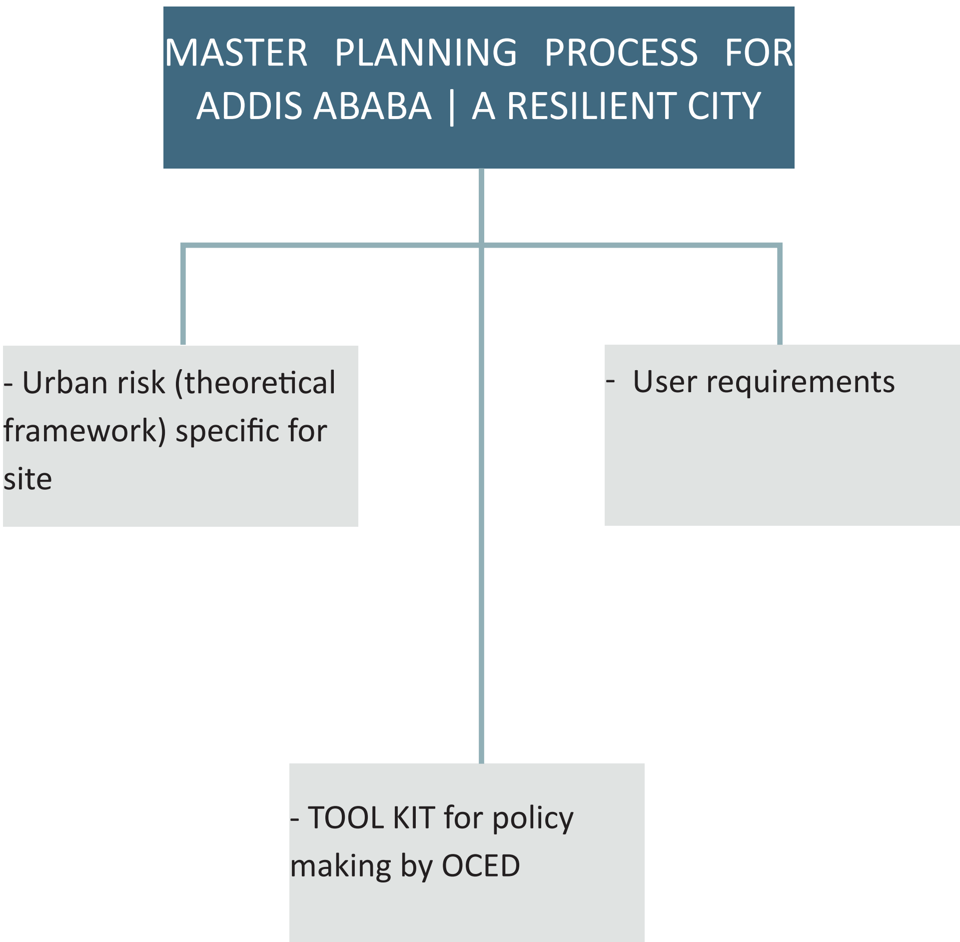
MASTER PLANNING

- TOOL KIT for policy making by OCED
- User requirements
- Planning guidelines and policies by user need
- Urban risk (theoretical framework) specific for site

5.2 - QUESTIONS CONSIDERED FOR BUILDING URBAN RESILIENCE MASTER PLAN

WHO?	Stakeholders	Includes: city, the residents (people living there under threat), government and organiza-tions.
WHAT?	Type of Engagement	The engagements required in existing urban fabric. Participation of organizations and residents, the funding mechanism and available re-sources.
WHEN?	Phase Planning Phase implementation	Rapid change in urban infrastructure and changes in resilience in current environment and the future. Identification of potential areas that are under threat in present and prospec-tive areas that have probability of being prone to disasters and the urban fabric for imple-mentation of resilient solutions.
WHERE?	Scale and level of involve-ment	Identification of level of damage that can happen at certain area and spatial boundaries under threat to define the level of engagement required and involvement of concerned parties.
WHY?	Purpose Data collection etc	Defining the motive or problem to propose solutions and restoration for a resilient city.

Table 3: Questions considered for urban resilience
[Meerow, Newell, and Stults 2016b]


MASTER PLANNING PROCESS FOR ADDIS ABABA | A RESILIENT CITY
- Urban risk (theoretical framework) specific for site
- User requirements
- TOOL KIT for policy making by OCED

5.3 - TOOL KIT FOR POLICY MAKING BY OCED

After the start of 2000s, many governmental sectors worked on policy making for the resilient infrastructure to protect it and implement it. It includes first defining the critical infrastructure sector, national schemes or incentives that reinforce the resiliency of these elements. However, the time is changing and every new second there is a new challenge ahead of us, so, the critical infrastructure resiliency policies are not always adequately effective to deal with 21st century risk landscape.

Among the difficulties that critical infrastructure resilience policies must overcome are the variety and complexity of shock events, the heightened interdependences and interconnectedness, climate change, the growing affluence of digitalization that principally transforms critical infrastructure sectors, as well as aging infrastructure. Numerous researchers have concluded that by incorporating ideas like adaptability, flexibility, and robustness into the design of critical infrastructure and their regulatory frameworks, a shift in emphasis from protection to resilience would help policymakers better account for uncertainty.

Following the proposal of OECD[29] (The Organization for Economic Cooperation and Development) for critical risk resiliency, several fora gave it importance. In G7 Ise-Shima summit the basic principles for the promotion of quality infrastructure investments and emphasis on resilience against natural hazards, terrorism, and cyber-attack risk (G7, 2016)(Meerow, Newell, and Stults 2016b)

In UN sendai framework for Disaster risk reduction was to significantly lessen the damage done by disasters to infrastructures and basic services (United Nations Office for Disaster Risk Reduction, 2015(Nations Office for Disaster Risk Reduction, n.d.))

In the OECD (The Organization for Economic Cooperation and Development) framework infrastructure resilience is one of its 10 key challenges (OECD, 2017) (Getting Infrastructure Right 2017).

Following all the OECD (The Organization for Economic Cooperation and Development) worked on preparing a toolkit that will guide in making policies for resilient infrastructure.

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[29] An intergovernmental organization with 38 member nations, the Organization for Economic Co-operation and Development (OECD; Organization de cooperation et de development economies, OCDE) was established in 1961 to promote economic growth and international trade. It is a group made up of nations that identify as being committed to democracy and the market economy. The forum offers a forum for members to discuss policy experiences, look for solutions to common issues, identify best practices, and coordinate their national and international policies.

TOOL-KIT FOR POLICY MAKING BY OCED | TO INTEGRATE RESILEINCE IN PLANNING AND DESIGN

ALL-HAZARDS AND THREATS	Single-hazard policies are not sufficient to build infrastructure resilience. An all-hazards and threats forward-looking approach to critical infrastructure resilience and security enable policy makers and operators to better prepare for the unexpected.
SYSTEM-LEVEL	Infrastructure assets are usually only the components of a wider complex system, which should be considered in its entirety in a comprehensive resilience strategy. A system approach allows for prioritising the most critical components, and addresses weak points that create critical vulnerabilities for the entire system.
MULTI-SECTORAL COORDINATION	Addressing interdependencies in policies requires policy makers and operators to go beyond a silo-based approach and to target the critical infrastructure sectors together. While operators tend to be well aware of their own dependencies upon critical sectors, they may not be as conscious of the dependencies others have upon their own services.
PUBLIC-PRIVATE COOPERATION	Although governments continue to own, invest in, and operate critical infrastructure in some sectors, a large share of critical in-frastructure is either privately owned or operated. The resilience of these systems depends upon governments partnering with infrastructure operators from the public and private sectors in resilience efforts through the establishment of relevant governance arrangements.
LIFE-CYCLE APPROACH	Different resilience measures may apply at different phases of the infrastructure life cycle: robustness and redundancies require invest-ments in the design phase, while business continuity planning and maintenance pertains to the operations, and adaptability can be based on infrastructure retrofitting. Thus, it is im-portant to set-up a comprehensive policy that enables resilience throughout infrastructure life cycle.
ENTIRE RISK MANAGEMENT CYCLE	A comprehensive resilience policy should incorporate measures throughout the entire risk management cycle, from risk as-sessment to risk prevention, emergency preparedness, response, recovery, and reconstruction.
RISK-BASED AND LAYERED APPROACH	Given the considerable degree of uncertainty about future risks, the manifold dimensions of infrastructure systems vulnerability, and all the interrelationships between these systems, the prioritisation of resilience measures is essential. A risk-based and layered approach helps account for complex interdependencies, for all-hazards and across the infrastructure life cycle.
TRANSBOUNDARY DIMENSION	Risks arising from interdependencies and interconnectedness cannot be fully mitigated without incorporating their international dimension. Fostering international cooperation is key to infrastructure resilience.

Table 4: Policy Toolkit on Governance of Critical Infrastructure Resilience
("5. POLICY TOOLKIT ON GOVERNANCE OF CRITICAL INFRASTRUCTURE RESILIENCE | 101 5. Policy Toolkit on Governance of Critical Infrastructure Resilience" 2019)

SOURCE: POLICY TOOLKIT ON GOVERNANCE OF CRITICAL INFRASTRUCTURE RESILIENCE | 101 5.

OBJECTIVES OF TOOL KIT

1. Choose the important assets, systems, and services where efforts in resiliency and security are most needed, map out (inter-) dependencies, and identify vital infrastructure.

2. Create strong relationships with operators of critical infrastructure in order to foster mutual trust, exchange knowledge about risks and vulnerabilities, and come to an understanding on a shared mission and policy goals.

3. Assume joint responsibility for safeguarding vital infrastructure components and ensuring prompt service restoration.

CRITICAL INFRASTRUCTURE | DEFINATION: Critical infrastructure are systems, assets, facilities, and networks that provide essential services for the functioning of the economy and the safety and well-being of the population. While definitions of critical infrastructure differ across countries, this definition is not prescriptive and aims to encompass the largest set of definitions identified in the OECD Survey on Critical Infrastructure Resilience.

POLICY TOOLKIT ON GOVERNANCE OF CRITICAL INFRASTRUCTURE RESILIENCE | 101 5. Policy Toolkit on Governance of Critical Infrastructure Resilience
[“5. POLICY TOOLKIT ON GOVERNANCE OF CRITICAL INFRASTRUCTURE RESILIENCE | 101 5. Policy Toolkit on Governance of Critical Infrastructure Resilience” 2019]

"Resilience | DEFINATION: the capacity of systems to absorb a disturbance, recover from disruptions and adapt to changing conditions while retaining essentially the same function as prior to the disruptive shock (adapted from OECD, 2014[Boosting Resilience through Innovative Risk Governance 2014]). This definition includes the ability to withstand shocks with as little loss of functionality as possible under the specific circumstances, limiting the duration of potential service interruption by minimizing the recovery time, as well as adapting to new conditions and improving systems' functionality."

POLICY TOOLKIT ON GOVERNANCE OF CRITICAL INFRASTRUCTURE RESILIENCE | 101 5.
Policy Toolkit on Governance of Critical Infrastructure Resilience [("5. POLICY TOOLKIT ON GOVERNANCE OF CRITICAL INFRASTRUCTURE RESILIENCE | 101 5. Policy Toolkit on Governance of Critical Infrastructure Resilience" 2019]
Boosting Resilience through Innovative Risk Governance [Boosting Resilience through Innovative Risk Governance 2014]

5.4 - USER REQUIREMENT

Access to public health

Improve safety and security

Resilient infrastructure

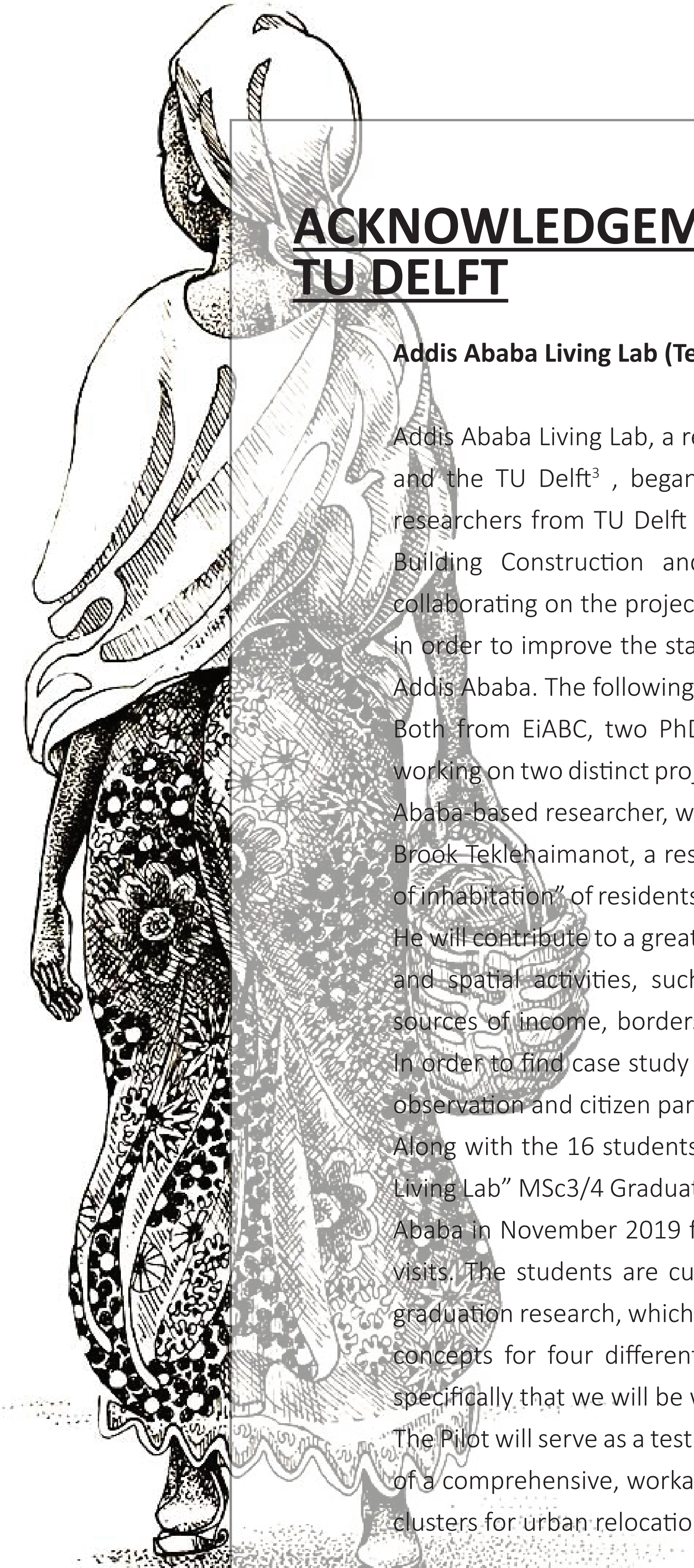
Increases participation in the fabric of the city

Creating a community by building clusters of houses is giving home to people. The idea of home is living in secure place that you own. Resilient housing provides you safety from natural hazards. Creating densities of housing that is inclusive of every income group allows you a thorough approach which reduces poverty and includes sense of community and understanding. Where people work together for their issues.

The idea of housing clusters is not just eating sleeping and a place to live but an idea of providing sustainable community that can survive every category of stresses and shocks.

So, this sustainable and inclusive society provide access to basic needs including public health and social security. It also boosts urban prosperity and give rise to economic development. These factors are good indicators of resilient city as we discussed earlier. All these factors actually, promotes bottom-up approach because this way neighborhood works for themselves through proper networking and with the help of authorities.

Furthermore, a new system has been devised to better estimate user expectations by assessing the present socio-economic categories in the neighborhood: [OCHA Services, n.d.]



ACKNOWLEDGEMENT TU DELFT

Addis Ababa Living Lab (Technische Universiteit Delft, n.d.)

Addis Ababa Living Lab, a research initiative financed by NWO-WOTRO[2] and the TU Delft[3] , began two years ago, in May 2019. A group of researchers from TU Delft and the Ethiopian Institute for Architecture Building Construction and City Development (EiABC)[4] have been collaborating on the project's initial research outputs for the past years in order to improve the standard of living for resettlement residents in Addis Ababa. The following few years will be devoted to this task.
Both from EiABC, two PhD candidates joined the project and began working on two distinct project components. Yonas Alemayehu, an Addis Ababa-based researcher, will examine historical and present urban.
Brook Teklehaimanot, a researcher at TU Delft, examines the "patterns of inhabitation" of residents in the various urban settings of Addis Ababa. He will contribute to a greater understanding of urban community social and spatial activities, such as habitation patterns, social structures, sources of income, borders, and construction methods and materials. In order to find case study locations and test ethnographic methods of observation and citizen participation, he did fieldwork in Addis Ababa.
Along with the 16 students from the associated TU Delft "Addis Ababa Living Lab" MSc3/4 Graduation Studio, the entire team traveled to Addis Ababa in November 2019 for intensive meetings, a workshop, and site visits. The students are currently working on the final stages of their graduation research, which will provide 16 different architectural design concepts for four different Addis Ababa locations. In which one site specifically that we will be working on is facing flood issues.
The Pilot will serve as a test case and feedback loop for the development of a comprehensive, workable framework for building resilient dwelling clusters for urban relocation in Addis Ababa.

Figure 2: Women in Addis Ababa 2 (Eduardo Di Muro, n.d.)

[2] WOTRO Science for Global Development, a cross-domain effort of NWO, plans, funds, and supports research for inclusive global development. The goal of the WOTRO research programs is to provide information and abilities that support long-term fixes for

Project partners

TU Delft, Faculty of Architecture and the Built Environment (TUD-BK, Prof.dr.ir. Marja Elsinga, PI), Ethiopian Institute for Architecture, Building Construction and City Development (EiABC, Dr. Elias Yitbarek), Federal Housing Corporation, Addis Ababa (Zekarias Sebsbie, Mahlet Yared), Mecanoo architecten, Delft (Prof.ir. Dick van Gameren), RAAS Architects, Addis Ababa (Rahel Shawl)

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Daily supervisor: Dr. Nelson Mota (TUD-BK)

Yonas Alemayehu Soressa (EiABC)

Promotors: Prof.dr.ir. Marja Elsinga (TUD-BK), Dr. Elias Yitbarek (EiABC)

Daily supervisor: Dr. Maartje van Eerd (EUR-IHS)

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User-committee

Senait Damtew, Timnit Eshetu (Addis Ababa City Government), Tsegaye Moshe (Ministry of Urban Development and Housing)

Project managers

Ir. Frederique van Andel (TUD-BK), Dr. Elias Yitbarek (EiABC)

social and ecological issues in low- and middle-income nations (LMICs).

[3] The oldest and largest public technical university in the Netherlands is Delft University of Technology (TU Delft), which is situated in Delft, the Netherlands.

[4] In Addis Abeba, Ethiopia, there is an institute for architecture and civil construction called the Ethiopian Institute of Architecture, Building Construction, and City Development (EiABC).

[5] This image was published on Middle East Monitor, creating new perspective| page after an event of flash flood in Addis Ababa. Around 217 localities were at high risk due to this flooding in the Addis Ababa, according to concerned institution.

INTERVIEWS

The results are taken from a project done TU DELFT university. Survey and the interviews from the people living there by the TU DELFT was really helpful in this research program. Because of limitatiions of not being able to visit there, so i read the interviews and the results are taken from those interviews.

TESFAYE BEYENE

Tesfaye Beyene lived in the area for 38 years, after relocation from the Sunshine construction site, near Stefano's Church. Tesfaye Beyene lives with 3 sons and other 6 renters, in the 8x10m plot. He enjoys the neighborhood, it is a "good, relaxing area", that cherish community-based living.
However, Tesfaye Beyene thinks youth-elderly community center is missing in the area, where all the residents could meet up. The amenities as shopping center or proper playground for children are missing as well.

Tesfaye goes to Kidus Paulos Church near-by, built by Haile Selassie, every day. His wife prepares injera every day because better food recourses are limited. The area has a quite good water and sanitation system; however, many houses are overcrowded.

Tesfaye Beyene feels like a voice of the community, their leader, therefore he has defined the biggest problem in the area: informal settlements near the river. It is not only illegal, but also bring a huge danger for the people living there.

Because of the rainy season, the river is expanding, flooding the neighborhood and the informal settlements. It weakens the slope and creates danger of slope sliding any time, destroying the houses. Informal settlements block the river and people throw their trash, sewage and used water away straight to the stream, polluting the area. Informality brings illegal actions and therefore sangers the neighborhood.

[Subačiūtė, n.d.) (Subačiūtė, de Graaf, and Zhou 1962]

INTERVIEWS

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MULUGETA

Mulugeta is 79 years old man, who has 6 children. The oldest child goes to the university and is married. In an extended one-bedroom house, Mulugeta lives with his wife and youngest child. In the backyard of his house, he built 5 rooms for renting, where 3 renters and 2 other kids with their families live. He extended the house from one bedroom to two-bed room house with bigger living room.

The kitchen and bathroom are shared with other 10 inhabitants of the compound.

The rent of the household is 380birr, which was increased because Mulugeta extended his house illegally. 36 years ago, when he was relocated from Sheraton site, the price of the household was 30birr. Mulugeta is a gardener. He believes in the greenery as a tool to help the Kolfe site to become more permanent and increase the quality of living conditions. Mulugeta started planting trees under the conditions of the previous government, that wished to avoid de forestation.

Later, he received a scholarship due to it. At the beginning, community was against it, but time passed by, and they started respecting his initiative. Nowadays, he wishes for his own bigger inner garden.

Community celebrates important holidays together, invites each other for coffee, lunch, or dinner. They gather money for weddings, funerals, and other big occasions. The uncertainty about the future bothers Mulugeta: he receives only 1000birr pension and has little savings, as well as proper living conditions. He would love to live closer to road, to be able to open his own shop.

[Subačiūtė, n.d.) (Subačiūtė, de Graaf, and Zhou 1962]

INTERVIEWS

The results are taken from a project done TU DELFT university. Survey and the interviews from the people living there by the TU DELFT was really helpful in this research program. Because of limitatiions of not being able to visit there, so i read the interviews and the results are taken from those interviews.

SABA AND KIDAN

In a small one-bedroom house provided by the government, costing 330 birr per month for its rent, Saba lives with her mother Kidan and two sons. It is a two-room house with an extension. Bedroom is shared between Saba and her mother, whilst extension by her two sons.

The important utilities of the house are located outside: small, shared kitchen and bathroom. The house is obviously too small for 4 people, but the extensions cost money which this family cannot spare. Saba is the only working inhabitant. She earns 500birr a month by washing clothes for middle-income group families.

Saba wishes to make an extension for her living room, however materials cost restricts her: 1 eucalyptus pole costs 80birr, while 1 corrugated metal sheet for roofing - 250birr - it is too expensive. Saba believes moving to an apartment in condominium block would be to everyone's benefit: it would be sanitary and clean, moreover, she would OWN the place, whilst she would not need to pay rent for the government. Her oldest son fell down the wall, injured his head and due to high medical costs, were left untreated. He is now mentally ill and incapable of normal living; his learning capabilities became limited.

However, because Saba and Kidan lived in the neighborhood for 35 years already, Saba feels safe letting her oldest son to wander in the neighborhood: she feels that neighbors live community life and take care of each other. Within the community, they gather money for weddings, funerals and other big occasions. Saba and Kidan lives in the Kolfe area for 35 years already. They lived near Fuluha hot springs.

[Subačiūtė, n.d.) (Subačiūtė, de Graaf, and Zhou 1962]

5.4 - USER REQUIREMENTS

URBAN DEWELLERS		RURAL MIGRANT
HOME FOR GROWING FAMILY		TRAINING & EDUCATION
EDUCATION	OPEN SPACES	SOCIAL NETWORKING
PRIVACY	RESILIENT HOUSE	JOB OPPORTUNITIES
SECURITY FROM NATURAL HAZARDS	TRAINING & EDUCATION	SECURITY FROM NATURAL HAZARDS
BASIC AMENITIES	SECURE INCOME	FLEXIBILITY IN DWELLINGS
CHILDCARE		BASIC AMENITIES

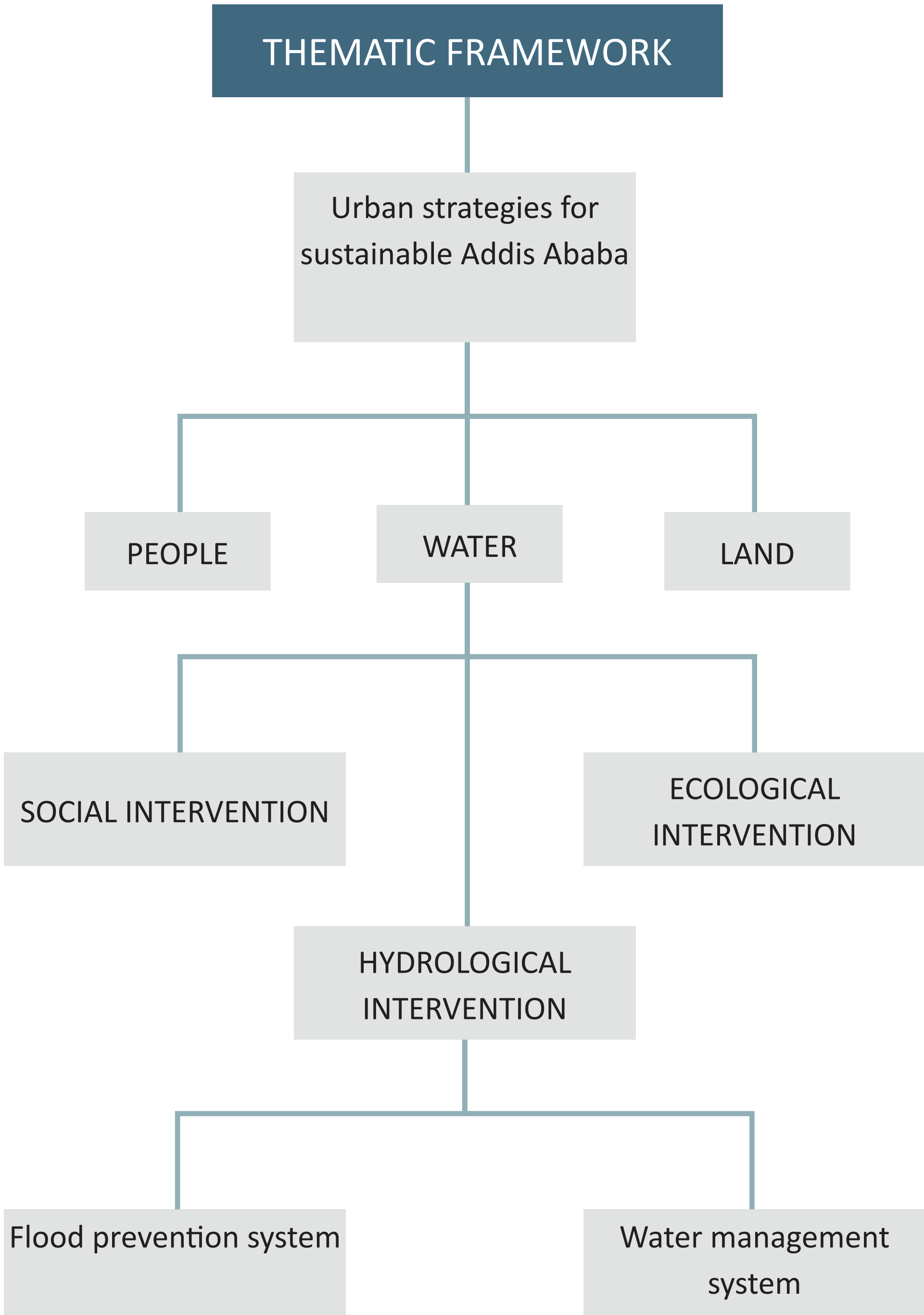
Table 5: User requirements (By Author)
[Subačiūtė, n.d.) (Subačiūtė, de Graaf, and Zhou 1962]

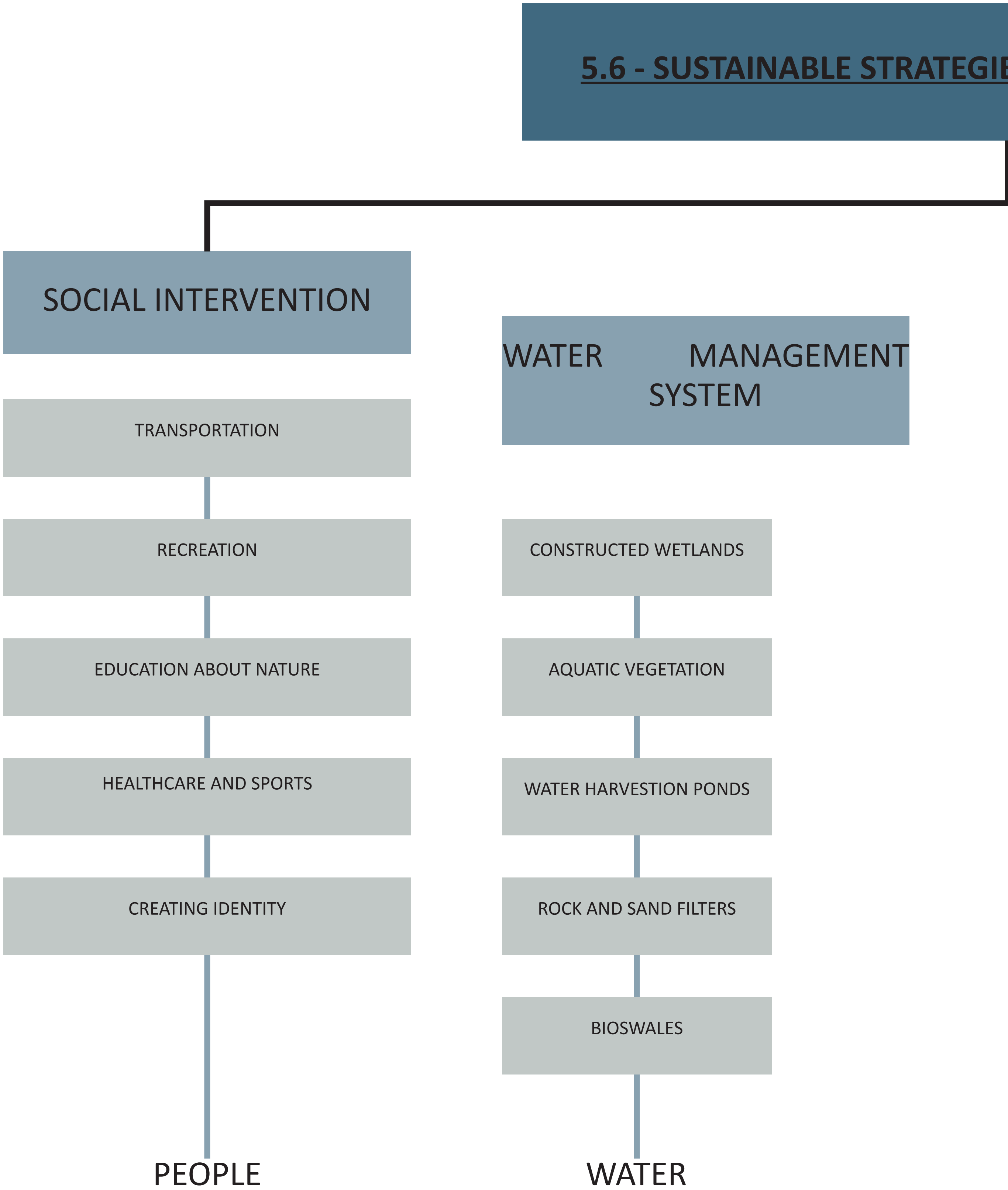
THEMATIC FRAMEWORK FOR ADDIS ABABA

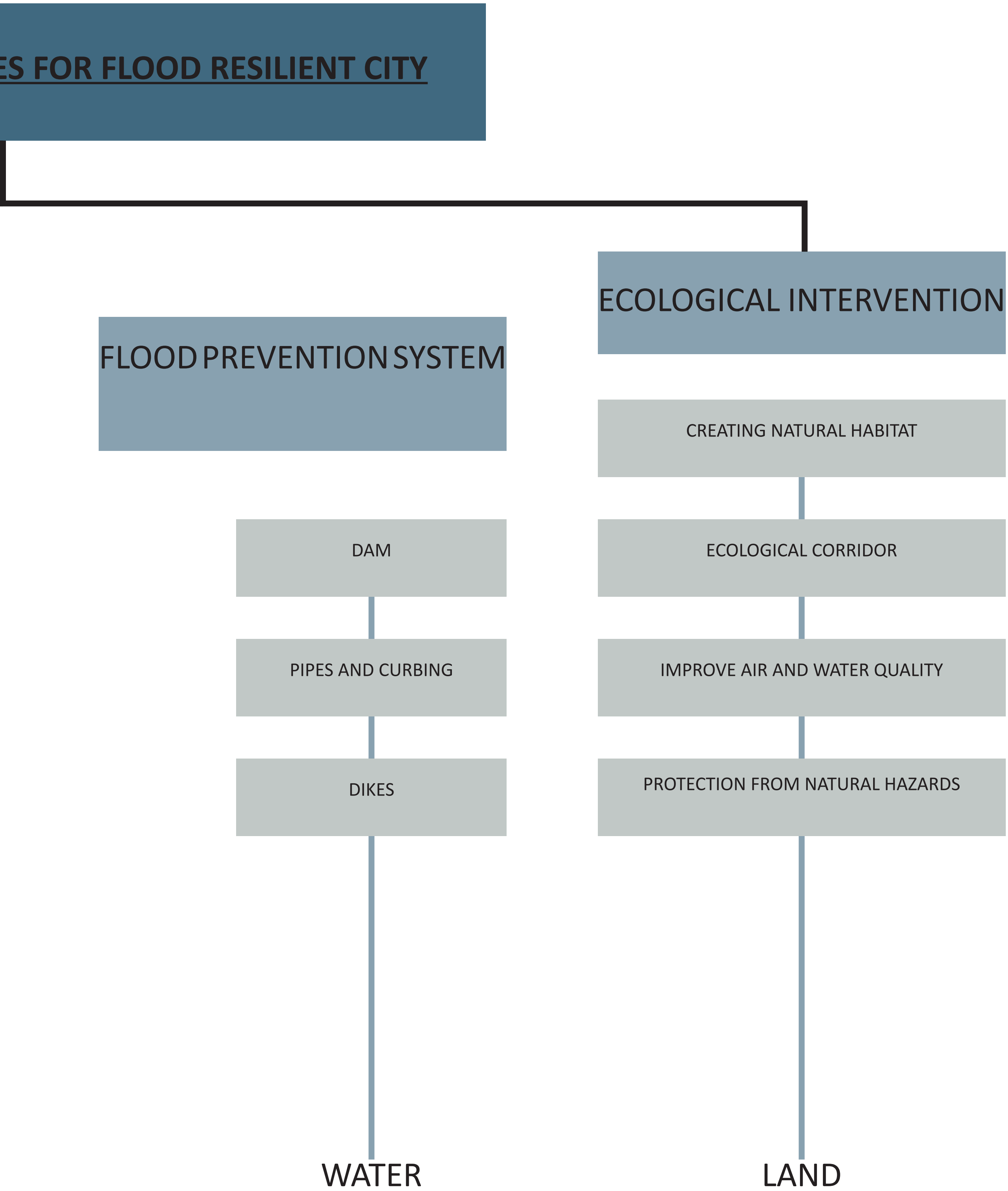
From the theoretical framework summery we have points to consider while deriving main strategies for planning. In this chapter we will define the urban resilience framework for the Addis Ababa, and we will work on the indicators that will make the master planning for a resilient city. But we need to consider the limitations as well. As in term of architecture we can give solutions with design part but for policy making authorities needs to step in for implementation.

5.5 - INTRODUCTION

In this we will propose a framework for the strategies of master planning. First, we will define urban resilience with reference to Addis Ababa then we will define the indicators of resilience and identify the existing indicators and from there we will define what is lacking that will help in proposing strategies.

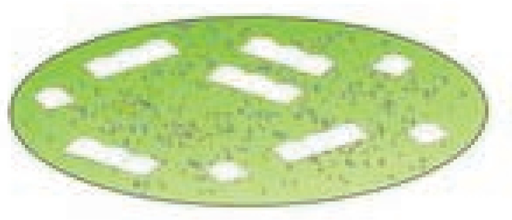

THEMATIC FRAMEWORK
Urban strategies for sustainable Addis Ababa
PEOPLE
WATER
LAND
SOCIAL INTERVENTION
ECOLOGICAL INTERVENTION
HYDROLOGICAL INTERVENTION
Flood prevention system
Water management system


5.6 - SUSTAINABLE STRATEGIE
SOCIAL INTERVENTION
TRANSPORTATION
RECREATION
EDUCATION ABOUT NATURE
HEALTHCARE AND SPORTS
CREATING IDENTITY
PEOPLE
WATER MANAGEMENT SYSTEM
CONSTRUCTED WETLANDS
AQUATIC VEGETATION
WATER HARVESTION PONDS
ROCK AND SAND FILTERS
BIOSWALES
WATER

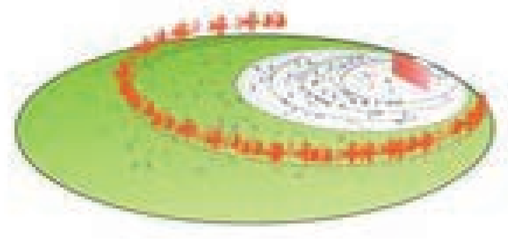

ES FOR FLOOD RESILIENT CITY
FLOOD PREVENTION SYSTEM
DAM
PIPES AND CURBING
DIKES
WATER
ECOLOGICAL INTERVENTION
CREATING NATURAL HABITAT
ECOLOGICAL CORRIDOR
IMPROVE AIR AND WATER QUALITY
PROTECTION FROM NATURAL HAZARDS
LAND

5.7 - SUSTAINABLE PLACEMAKING STRATEGIES

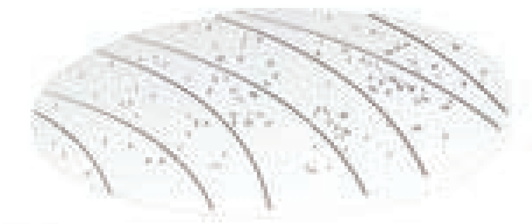
Strategies devised by Stoss company for sustainable placemaking while reviving the Thames river front.



Market fair

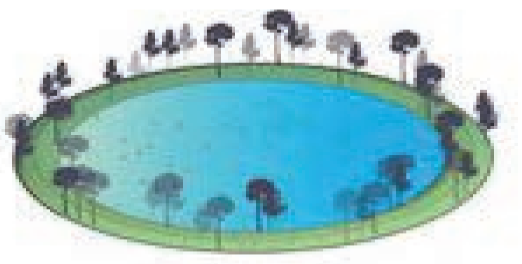


Palms in the park



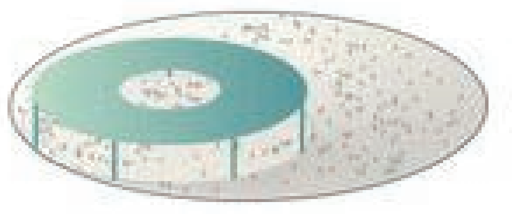
Plaza

Forest Habitat

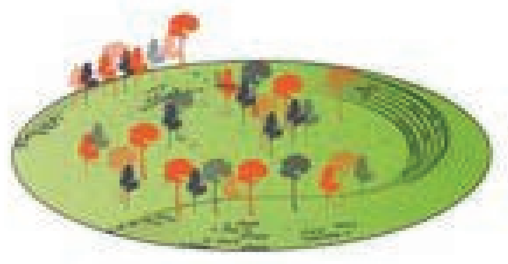


Community pool

Ice Skating (for places having such winters)



Event pavilion



Public Amphitheater

Figure 170: Sustainable placemaking strategies
[STOSS, n.d.]

Strategies devised by Stoss company for sustainable placemaking while reviving the Thames river front.

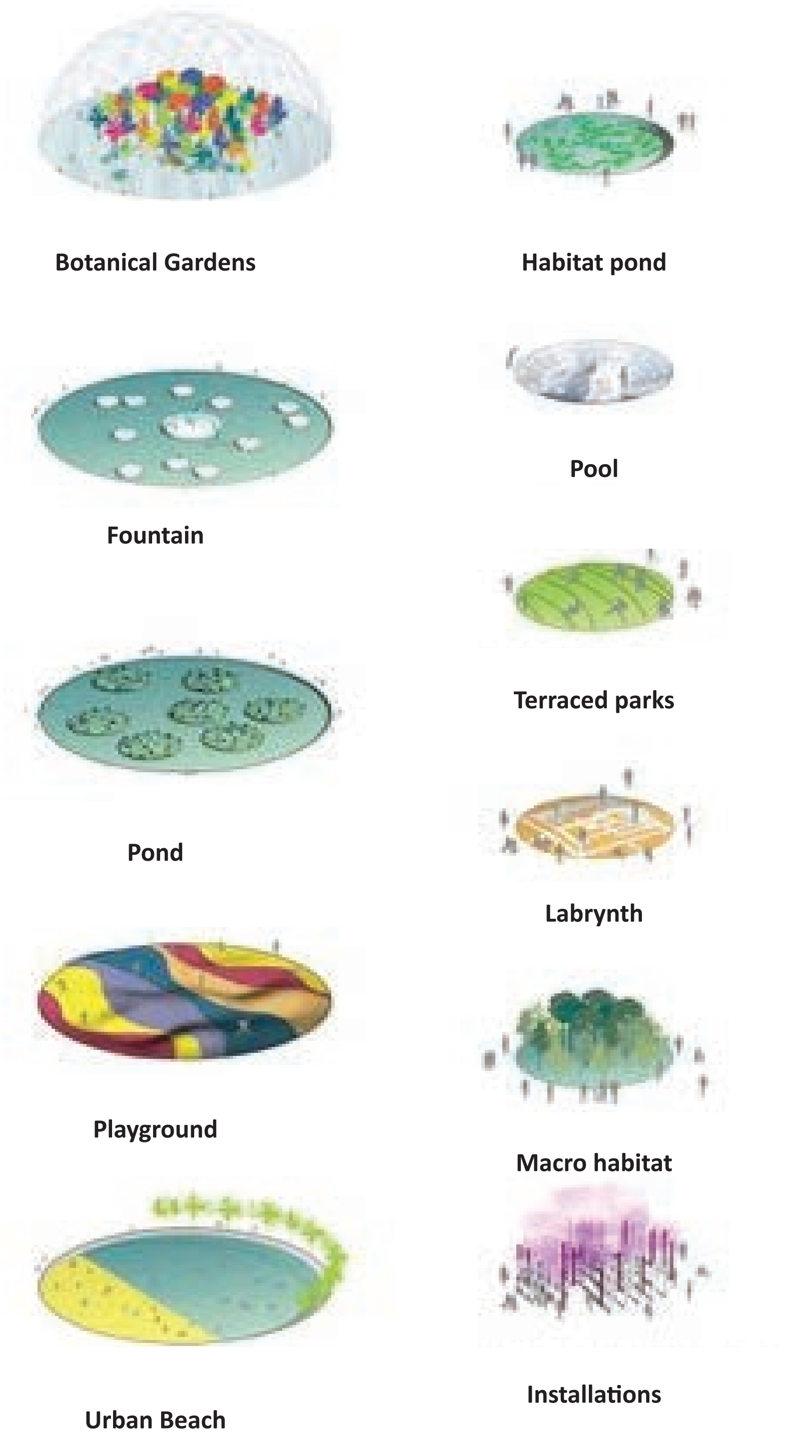
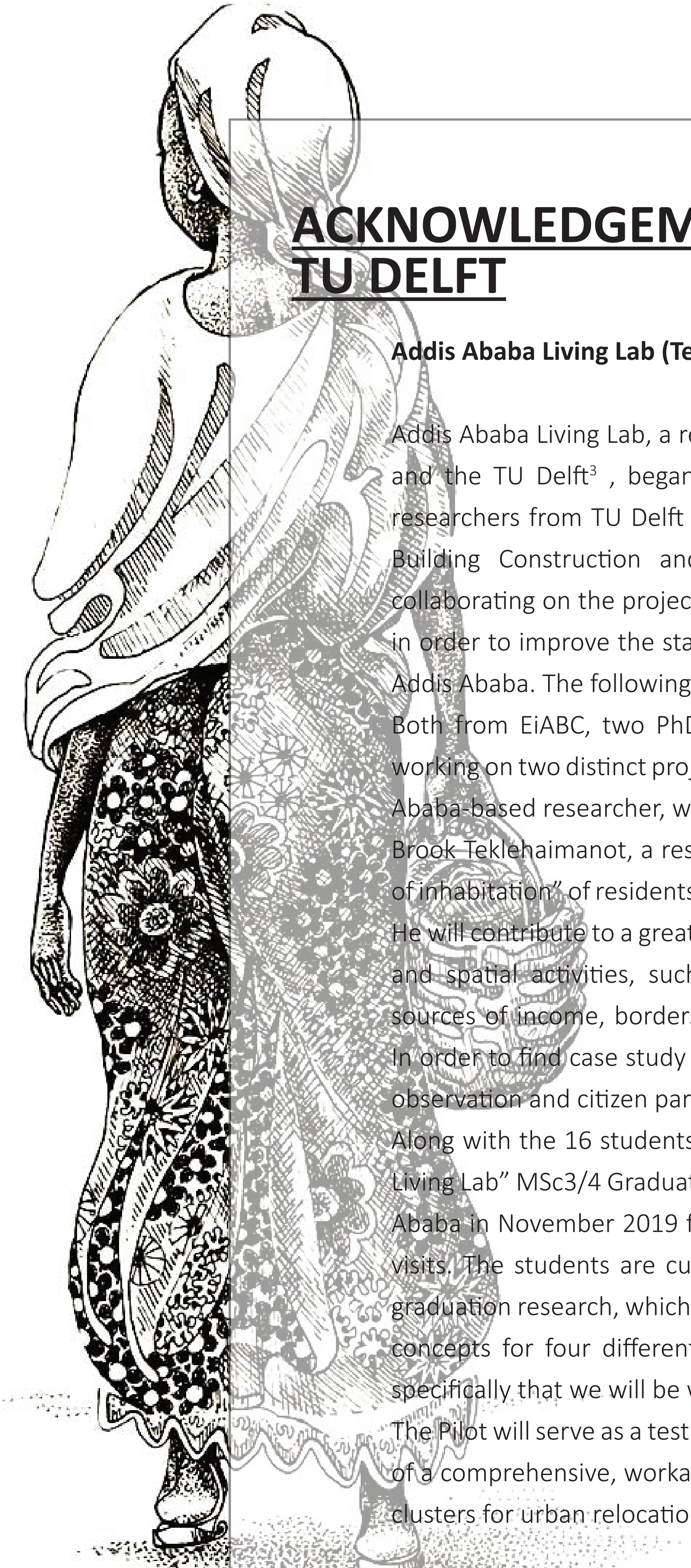


Figure 170: Sustainable placemaking strategies
[STOSS, n.d.]



ACKNOWLEDGEMENT TU DELFT

Addis Ababa Living Lab (Technische Universiteit Delft, n.d.)

Addis Ababa Living Lab, a research initiative financed by NWO-WOTRO[2] and the TU Delft[3] , began two years ago, in May 2019. A group of researchers from TU Delft and the Ethiopian Institute for Architecture Building Construction and City Development (EiABC)[4] have been collaborating on the project's initial research outputs for the past years in order to improve the standard of living for resettlement residents in Addis Ababa. The following few years will be devoted to this task.

Both from EiABC, two PhD candidates joined the project and began working on two distinct project components. Yonas Alemayehu, an Addis Ababa-based researcher, will examine historical and present urban.

Brook Teklehaimanot, a researcher at TU Delft, examines the "patterns of inhabitation" of residents in the various urban settings of Addis Ababa. He will contribute to a greater understanding of urban community social and spatial activities, such as habitation patterns, social structures, sources of income, borders, and construction methods and materials. In order to find case study locations and test ethnographic methods of observation and citizen participation, he did fieldwork in Addis Ababa.

Along with the 16 students from the associated TU Delft "Addis Ababa Living Lab" MSc3/4 Graduation Studio, the entire team traveled to Addis Ababa in November 2019 for intensive meetings, a workshop, and site visits. The students are currently working on the final stages of their graduation research, which will provide 16 different architectural design concepts for four different Addis Ababa locations. In which one site specifically that we will be working on is facing flood issues.

The Pilot will serve as a test case and feedback loop for the development of a comprehensive, workable framework for building resilient dwelling clusters for urban relocation in Addis Ababa.

Figure 2: Women in Addis Ababa 2 (Eduardo Di Muro, n.d.)

[2] *WOTRO Science for Global Development, a cross-domain effort of NWO, plans, funds, and supports research for inclusive global development. The goal of the WOTRO research programs is to provide information and abilities that support long-term fixes for*

Project partners

TU Delft, Faculty of Architecture and the Built Environment (TUD-BK, Prof.dr.ir. Marja Elsinga, PI), Ethiopian Institute for Architecture, Building Construction and City Development (EiABC, Dr. Elias Yitbarek), Federal Housing Corporation, Addis Ababa (Zekarias Sebsbie, Mahlet Yared), Mecanoo architecten, Delft (Prof.ir. Dick van Gameren), RAAS Architects, Addis Ababa (Rahel Shawl)

Research Team

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Promotors: Prof.ir. Dick van Gameren (TUD-BK), Dr. Henk Jonkers (TUD-CiTG)

Daily supervisor: Dr. Nelson Mota (TUD-BK)

Yonas Alemayehu Soressa (EiABC)

Promotors: Prof.dr.ir. Marja Elsinga (TUD-BK), Dr. Elias Yitbarek (EiABC)

Daily supervisor: Dr. Maartje van Eerd (EUR-IHS)

Educational Team:

Dr. Nelson Mota (coordinator), ir. Harald Mooij, Prof. ir. Dick van Gameren, ir. Frederique van Andel

Project Advisors

Mulu Haile (Mission for Community Development Program, Addis Ababa), Thomaz Ramalho Machado Teixeira (UN Habitat), Dr Edo Abraham (TUD-CiTG)

User-committee

Senait Damtew, Timnit Eshetu (Addis Ababa City Government), Tsegaye Moshe (Ministry of Urban Development and Housing)

Project managers

Ir. Frederique van Andel (TUD-BK), Dr. Elias Yitbarek (EiABC)

social and ecological issues in low- and middle-income nations (LMICs).

[3] The oldest and largest public technical university in the Netherlands is Delft University of Technology (TU Delft), which is situated in Delft, the Netherlands.

[4] In Addis Abeba, Ethiopia, there is an institute for architecture and civil construction called the Ethiopian Institute of Architecture, Building Construction, and City Development (EiABC).

[5] This image was published on Middle East Monitor, creating new perspective| page after an event of flash flood in Addis Ababa. Around 217 localities were at high risk due to this flooding in the Addis Ababa, according to concerned institution.

5.8 - PLANNING GUIDELINES AND POLICIES BY USER NEED

MIGRANT

LOW-INCOME GROUP

Domestic servant for high-income groups

renting out

stable income

generate more additional income

work/live units

supporting traditional dwelling patterns

household activities done together

Facade materials individuality depending on dwellers

good quality green space secured

Flexible housing arra

decreased downpayment f

shared facilities

good quality living conditions

open courtyards for social interaction

Resilient space in affordable budget

Flexible open space

Integration of informal markets

Community living

Income generation options at home for women

5.8 - PLANNING GUIDELINES AND POLICIES BY USER NEED

MIDDLE-INCOME GROUP

HIGH-INCOME GROUP

Own property

extra space

Office jobs

Maintain own property

Daycare center for children

Panoramic view

Big appartment

More privacy

Easy access to basic public facilities

from flooding with sponge gardens

ngements

large balcony

or appartments

Private open space

Well defined amenities and accessibility to them

hire local economically weaker social groups for jobs (ex. maid)

Results are taken fron TU DELFT Survey.

5.9 - WATER MANAGEMENT STRATEGIES

There are two phases of resilient architectural solution.

1- urban scal intervention

2- unit level intervention

INTERVENTIONS

URBAN SCALE

1- SPONGE ARCHITECTURE

4 Strategies for spong architecture

1- Protect

2- Delay

3- Store

4- Release

UNIT SCALE

1-Elevating structures

2- Water harvesting

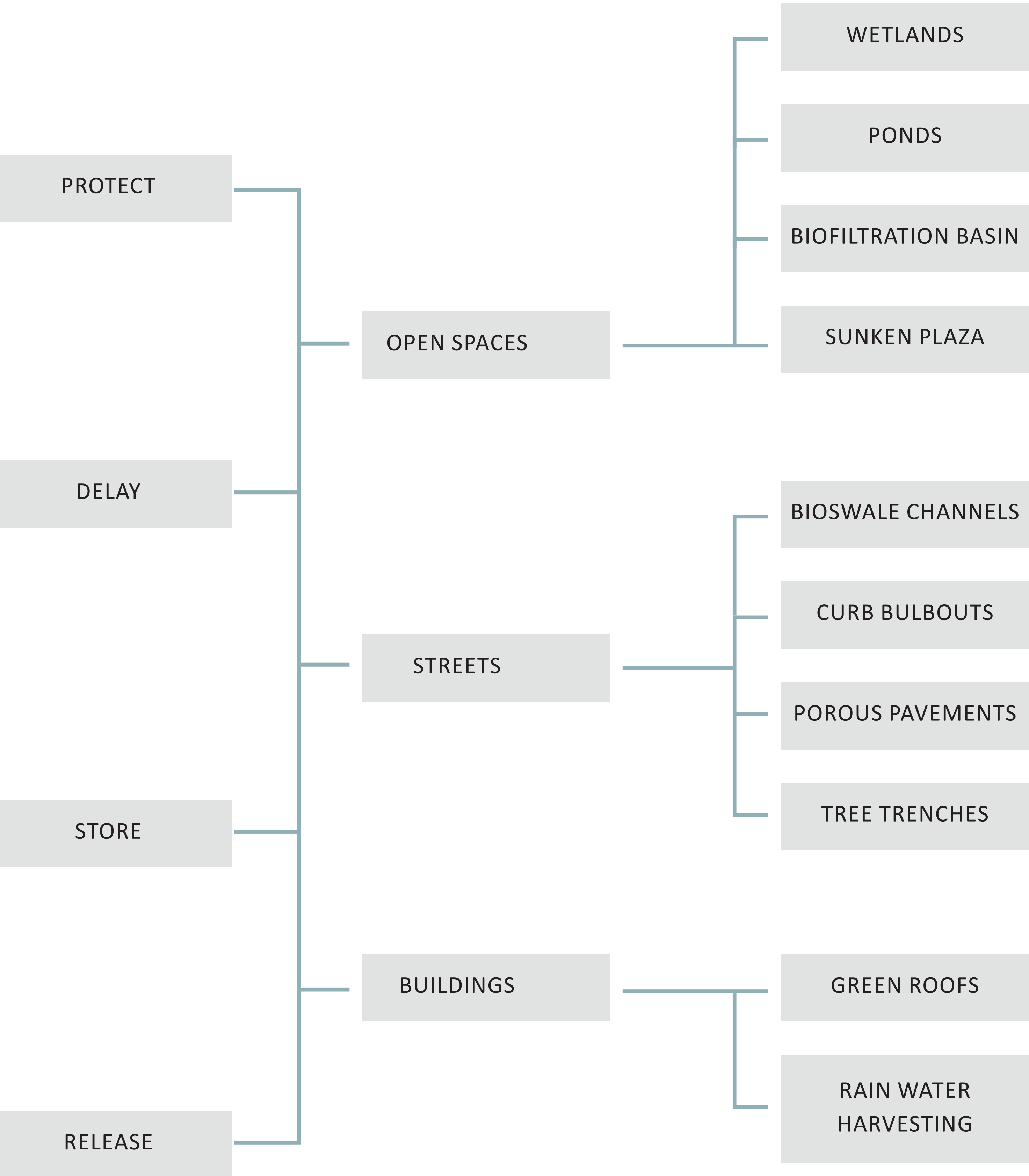
3- Proposing sponge gardens

4- Water reserviours for storing

5- Introducing small water chanels along the pedestrian pathway

Interconnected strategies

SPONGE ARCHITECTURE



SCHEME OF WATER MANAGEMENT IN SPONGE ARCHITECTURE

STRATEGY - PROTECT

THE CITY'S BLUE-GREEN GRID FROM ENCROACHMENT AND POLLUTION

PROTECT is the most important of the four strategies of Sponge Architecture. "Protect" requires the protetion of the city's blue-green infrastructure from encroachment, infrastructure developers, and pollution. This measure also attempts to identify the functioning natural systems, and restore the polluted and degraded water systems. Regulations and Policy measures to tackle encroachment and pollution are also one of the ways to help in the protection of natural systems.

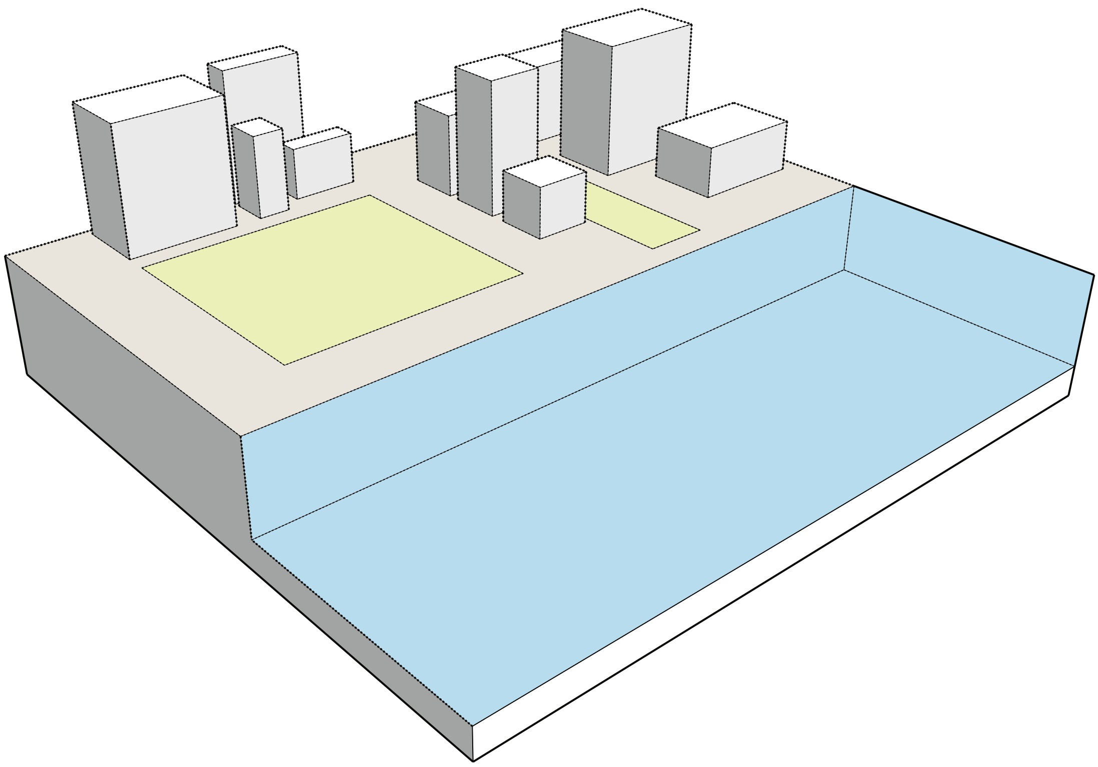


Figure 171: Protect (By Author)

STRATEGY - DELAY

STORMWATER SURFACE RUN-OFF INTO THE RIVERS AND SEA

DELAY is a vital principle to mitigate the risk of flooding after a flooding or hazardous event. This measure requires landscape infrastructure to slow down rainwater runoff . Natural ground cover, tees, and topographic variations along with landscape infrastructure can delay this run-off from overloading stormwater drain inlets, canals, rivers, and other water bodies.

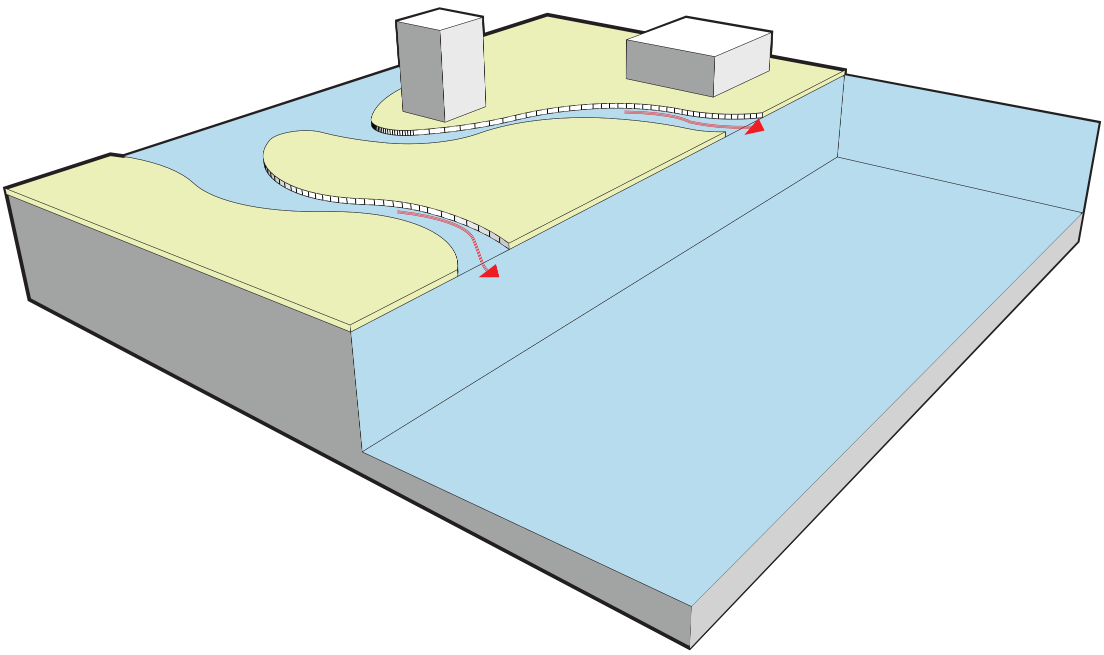


Figure 172: Delay (By Author)

STRATEGY - STORE

RAINWATER IN BASINS, RESERVOIRS, TANKS ETC.

STORE is the principle to remove the risk of water scarcity by storing all the excess water from flooding or storms or cyclones. Chennai's water supply is through a network of reservoirs. The creation of a sponge landscape infrastructure like green roofs, rainwater harvesting systems, detention tanks, ponds, etc. can ensure water availability instead of scarcity.

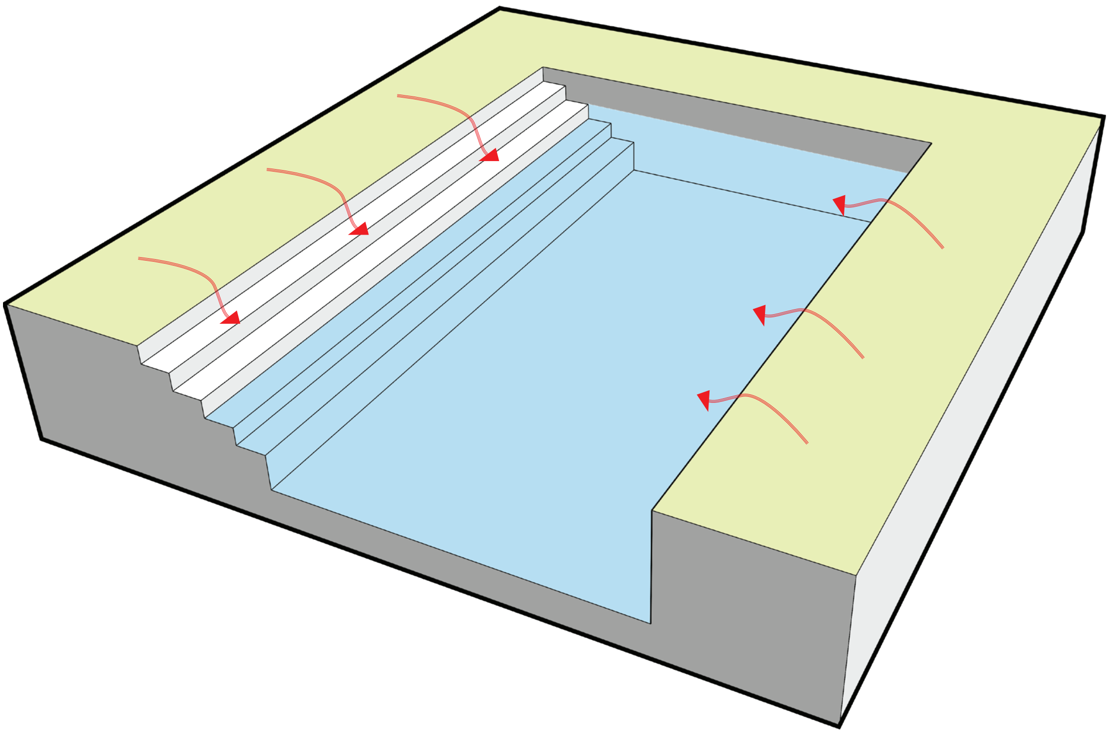


Figure 173: Store (By Author)

STRATEGY - RELEASE

RAINWATER INTO THE UNDERGROUND AQUIFIERS
TO RECHARGE THE WATER TABLE

RELEASE is the principle that refers to water management of the stormwater runoff which is directed to the aquifer without polluting it. Chennai's households run on aquifi ers for drinking water. This system, along with diverting runoff into the aquifer, the protection of natural aquifer- zones, ensuring groundwater is pollution-free, also includes avoiding the overexploitation of groundwater.

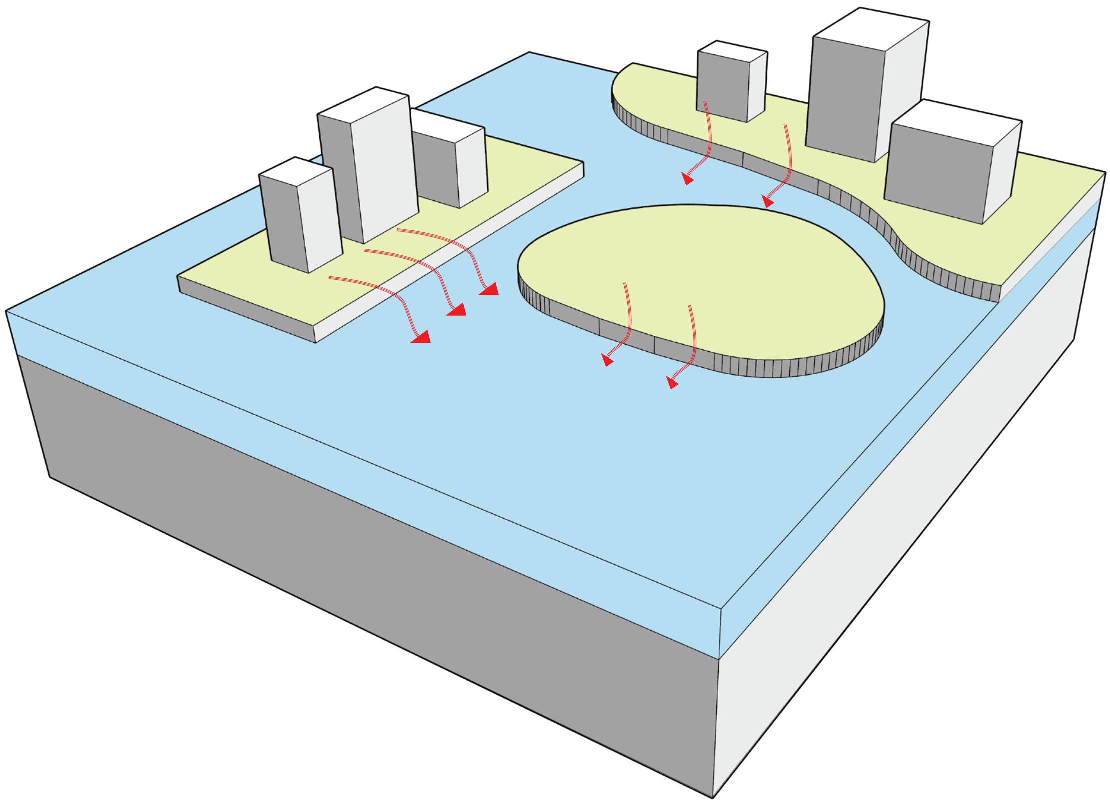


Figure 174: Release (By Author)

5.10 - FLOOD RISK MANAGEMENT STRATEGY

WHEN TO IMPLEMENT STRATEGY	STRATEGY	MOTIVE OF THE STRATEGY	HOW TO IMPLEMENT
Strategies before the flood hits	Risk prevention	To avoid loss To control the loss	Resilient infrastruc-ture and water storage reservoirs Zoning of areas and proper planning
	Défense assess		
	Risk lessening		
During disaster	Prepare before the flood approach	Foods happen we can't stop the flood, but we can control the affect of disaster with proper planning and policies	Alarming the residents and be aware of weather forecast
Post disaster	Recovery from disaster	Learn from loss	Regeneration and insurance

Figure 175: Flood Risk Management Strategies

(BASED ON RAADGEVER ET AL., 2018; MATCZAK ET AL., 2015) [MEEROW, NEWELL, AND STULTS 2016B]

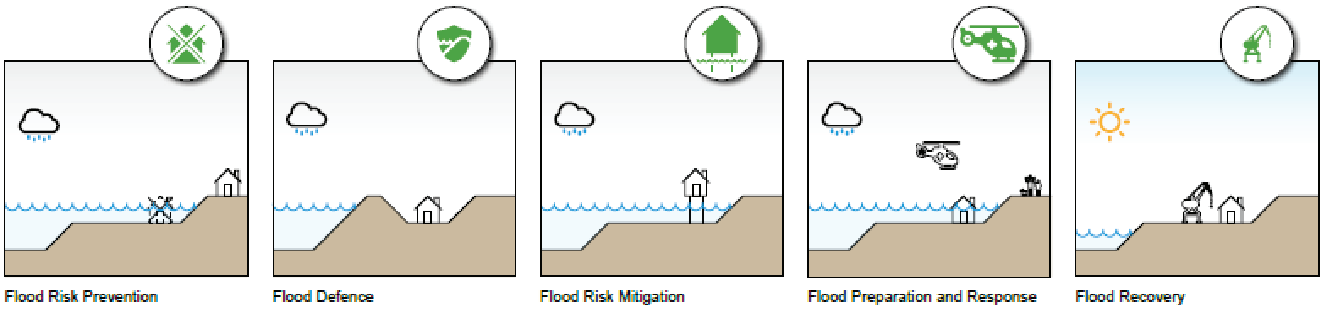


Figure 176: Flood resilient housing strategy ["DisasterResilientHouses," n.d.]

Streets as social public space for connection of community

Mixing different income groups for opportunities

Possiblities for icome generation

Blue and green infrastructure for creating buffer zones

Resilient city

Shared open spaces for buffer zones during floods

5.11 - DESIGN GOAL

The site of Arada is flood prone site and the river Bantyket is crossing from this area which is dividing the neighborhoods. Our design can serve as a prototype in this area and improve the living style of the residents who are living in flood prone zone. Our main idea is to extend the existing project of the Addis Ababa which beautifying sheger project.

We examined the habitation patterns of people of Addis Ababa, and we also discussed the city at Macro scale. So now we need provide a design that can fit in flood prone areas in Addis Ababa. Using public spaces as buffer zones.

PART 4B|
STRATEGIES
CONCLUSION ON SELECTED SITE OF OUR CASESTUDY

Figure 170: Mursi (Sou et al., n.d.)

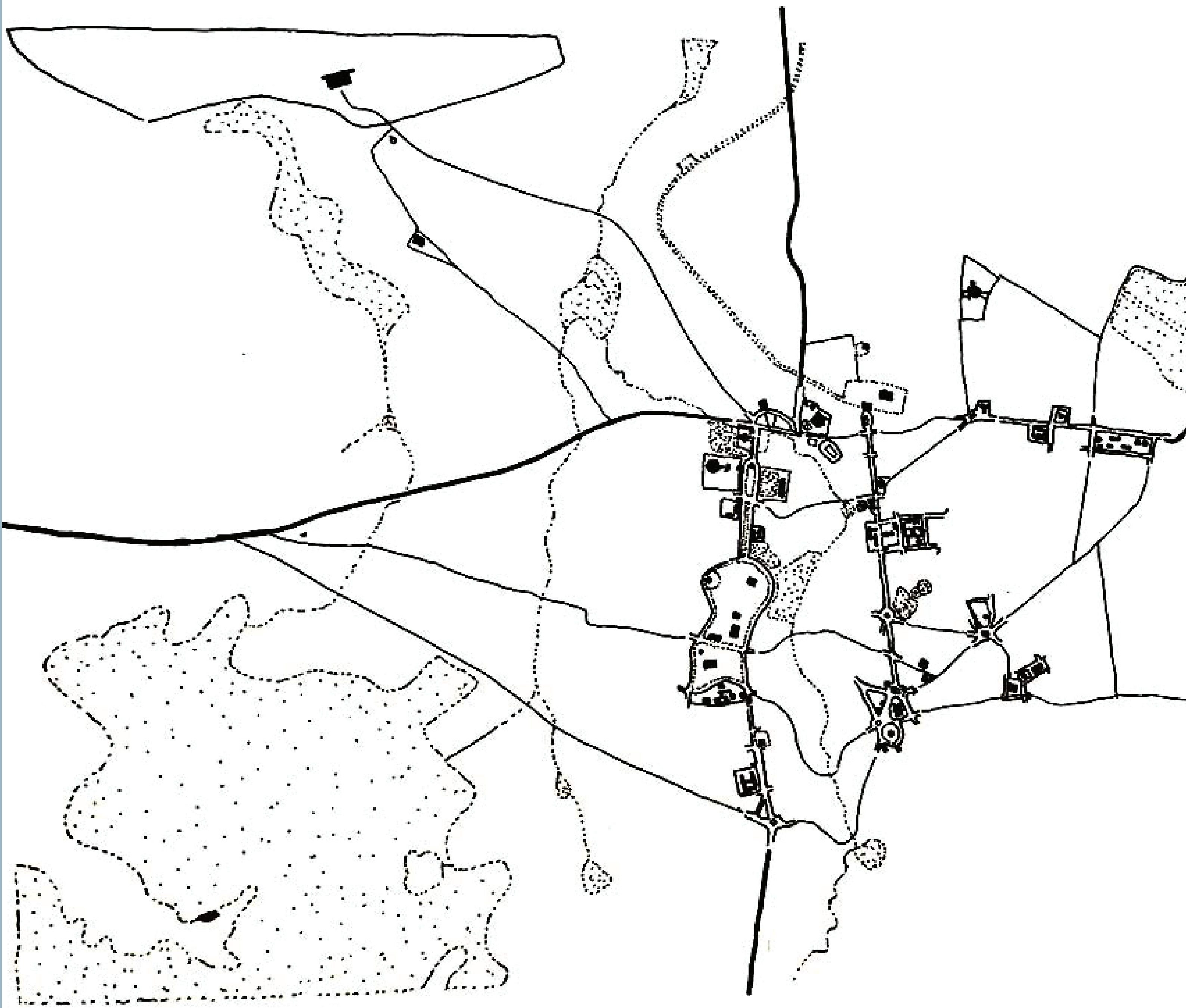


Figure 177: Sketch of Addis Ababa [30] (Gary White 2015)

|06

SELECTED SITE STUDY AND STRATEGY IMPLEMENTATION

[30] Book by Bouwer Serfontein, Gary White, and Marguerite Pienaar | Africa is unquestionably more than just a continent with isolated villages in the savannah and bush. African cities and metropolitan areas are among the fastest developing in the world, and the continent is rapidly becoming more urbanized. One hundred of the most connected and significant cities on the continent are shown in Africa Drawn. The goal of this book is to map the urban shape and structure of African cities, as well as to explain and provide examples of how these various locations were created.

AFRICA IN WORLD MAP

ETHIOPIA IN AFRICA MAP

ADDIS ABABA IN ETHIOPIA MAP

BOLE IN ADDIS ABABA
(SITE IS IN SUB-CITY ARADA)

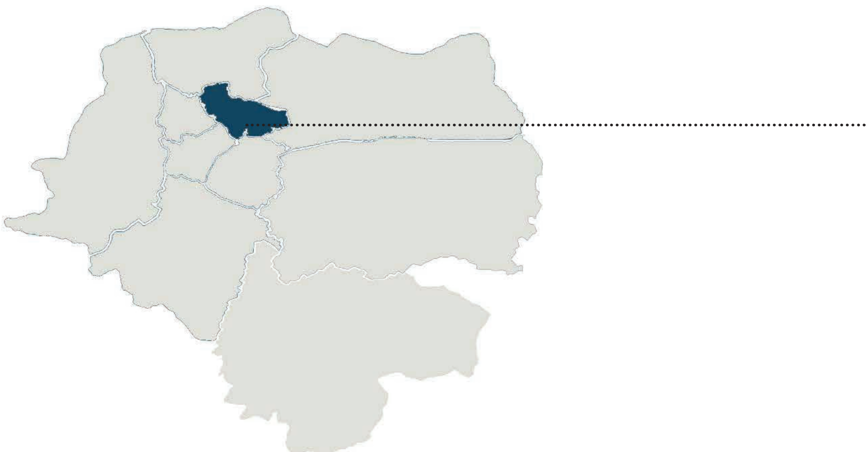
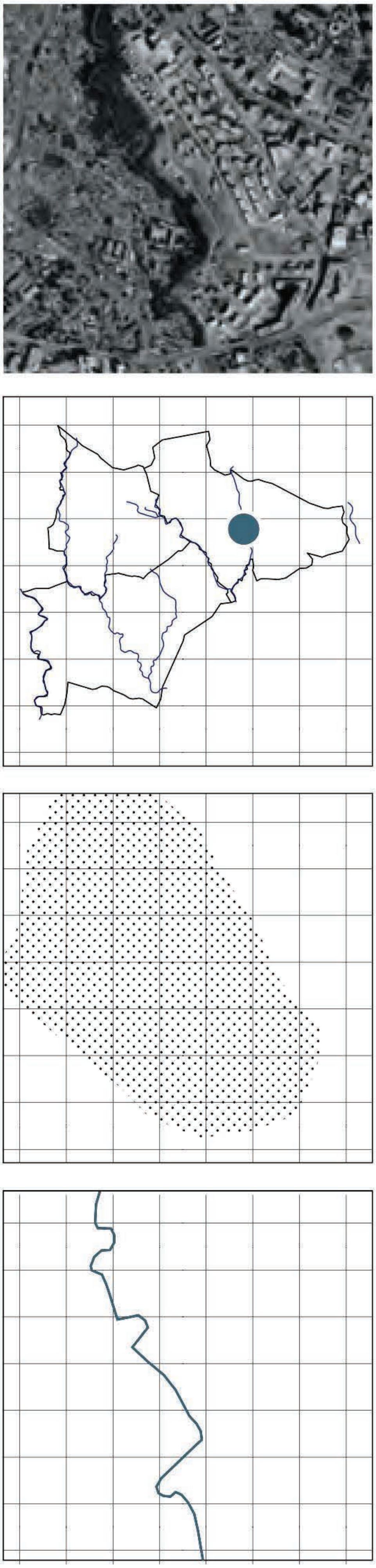


Figure 107: Location of Site in Arada, Addis Ababa

6.1 - SUB CITY AND SITE LOCATION IN ADDIS ABABA



There are no more vacant sites in the center of Addis Ababa. Nowadays, the areas surrounding rivers are used for (re)building dwellings or for the creation of riverbank beautification projects. The existing kebele dwelling is (in part) destroyed and replaced by one-sided structures, either for condominiums or the Beautifying Sheger project. However, it would be wiser to develop these excellent sites in a way that maintains a connection between the housing stock and the river. One particular location was selected because the goal was to create a strategic project that could serve as a system for numerous crucial zones near rivers in Addis Ababa. This site is distinguished by its desirable location, the steep terrain, and the intricate network of built kebele homes and historical structures. This location is distinguished by its great location, steep terrain, intricate network of constructed kebele housing, old structures, freshly constructed condominium ensembles, and a fabric that is prone to flooding (Figure 55: Flood risk map of Addis Ababa).

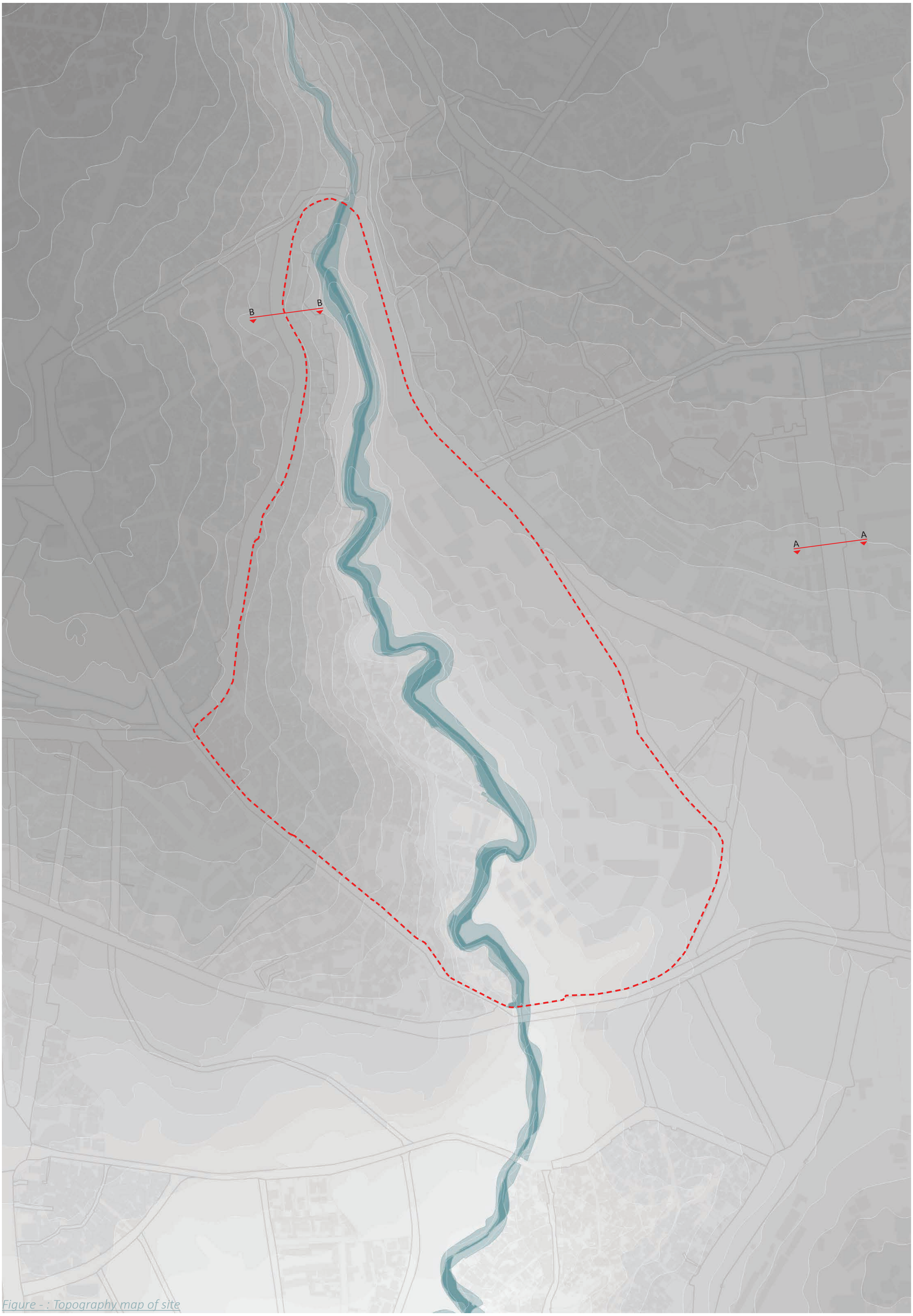


Figure - : Topography map of site

6.2 - SITE INFORMATION

Piassa has been selected as the site. It is situated in the center of the city, in close proximity to significant historical, social, and infrastructure structures and locations.

Periphery: 3648,8 m
Acreage: 620543 m² / 62 ,05 Hectare
River size: 7m - 13m rain period 13 m and more.

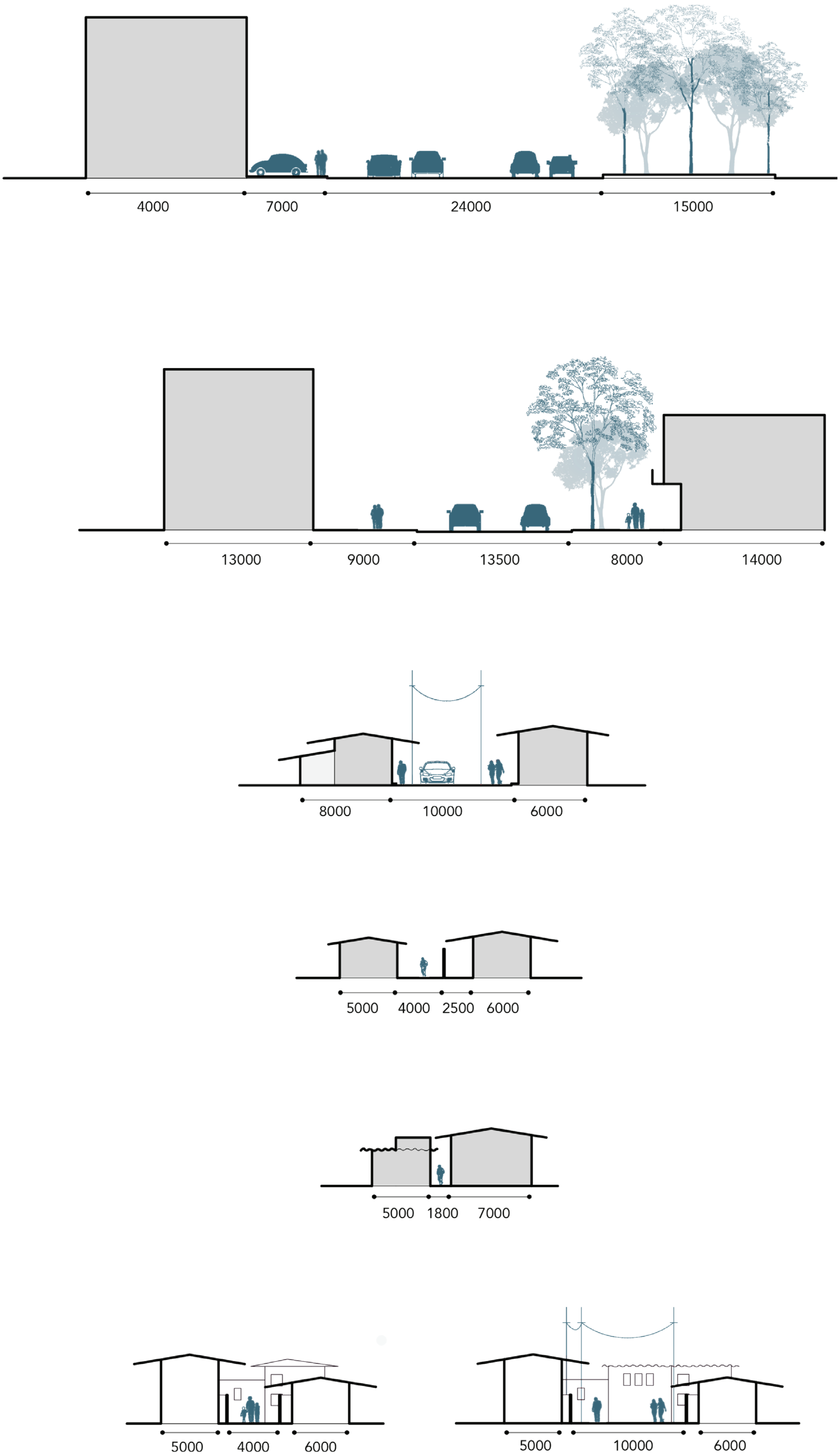


Figure : Sections (Reference taken from TU DELFT)

River Bantyketu

Site

Lowest point

Highest point

Figure - : Evolution of buildings of site ((Reference taken from TU DELFT)

6.3 - EVOLUTION OF SITE

The photographs that follow demonstrate how a typical cluster inside Basha Wolde has changed over time. According to the timeline, the current state of the site changed into a collage of several architectural typologies from earlier eras in just 130 years. It started out as a group of Tukul huts that the Oromo people of western Ethiopia used. The structures were covered in dry grass and banana leaves and constructed of woven bamboo. The Serategna Sefer and Basha Wolde Chilot are situated in the city's center, a significant historical area still surrounded by significant buildings. This indicates that it is a prime location for development. As a result, the government began redeveloping the eastern Sefer in 2011. New business structures dominate the Sefer's southeast. There is currently no informal housing or other structures in the region west of the commercial area. The Serategna Sefer is still largely unaltered, save for a few modestly sized housing buildings built in the 2000s and the 1970s.

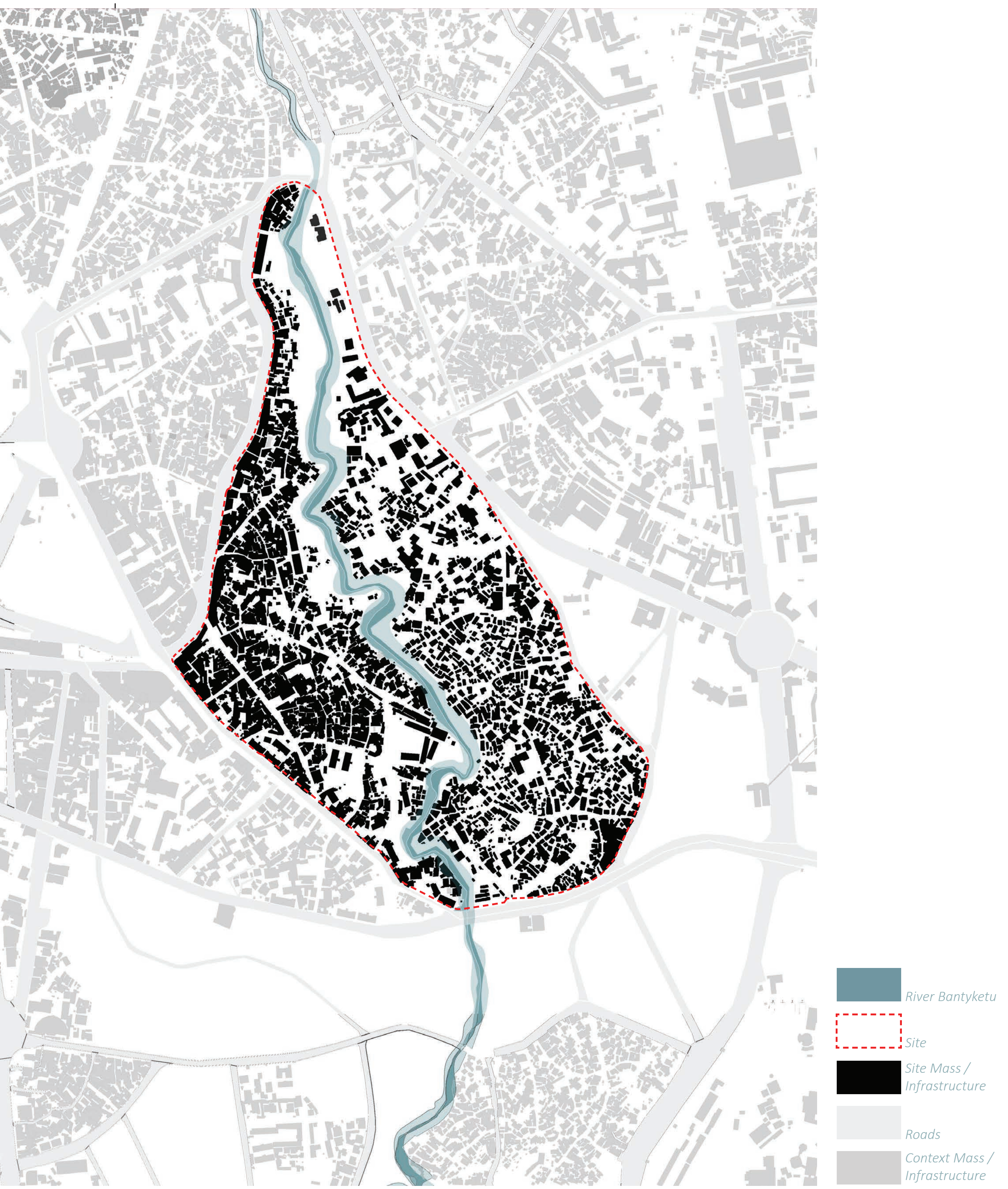


Figure - : Evolution of site | Site in 2000

It is obvious from the development throughout time that the site is at a prime location in the center of the urban metropolis. Urbanization is also evident; in 150 years, the city grew to be eight times larger than it was at the end of the 19th century.

In 2000, the area's kebele housing was finished. At the moment, a sizable portion of the property has been destroyed and replaced with (20/80) condominium housing. Due to its desirable position, the pressure from the real estate market poses a threat to the remaining kebele homes. Additionally, the second stage of the Addis Abeba Riverside Green Development Project's Beautifying Sheger Project, which involves building squares and doing roadside greenery work, has started.

Figure - : Evolution of site | Site in 2021

Kebele housing 2020

1 - Small scale

2 - Threatened by demolition

Condominium 2021

1 - Large scale

2 - Result of previous demolition

Figure - : Site Infrastructure

6.4 - SITE INFRASTRUCTURE

As discussed before, government is replacing old kebele housing with new condominium and the beautifying Sheger project is in progress. So, continuing that we need to understand the infrastructure of the site to observe the pattern of living. That will help us understand their difficulties of flooding and lifestyle.

Water

Old buildings

Old construction area

New condominiums

Rebuilt area / Under development

Education services

Safety services

Formal functions

Informal functions

Business center

River Bantyketu

Site

Context Mass / Infrastructure

Roads

Figure - : Site Blues's and green's

6.5 - GREEN AND BLUE's OF SITE

The river and the vegetation next to it serve as indicators of the condition of the river. The river creates a physical boundary that cannot be crossed. The ground is also significantly steeper here than it is elsewhere on the property.

***Figure - : River image (**(Reference taken from TU DELFT)*

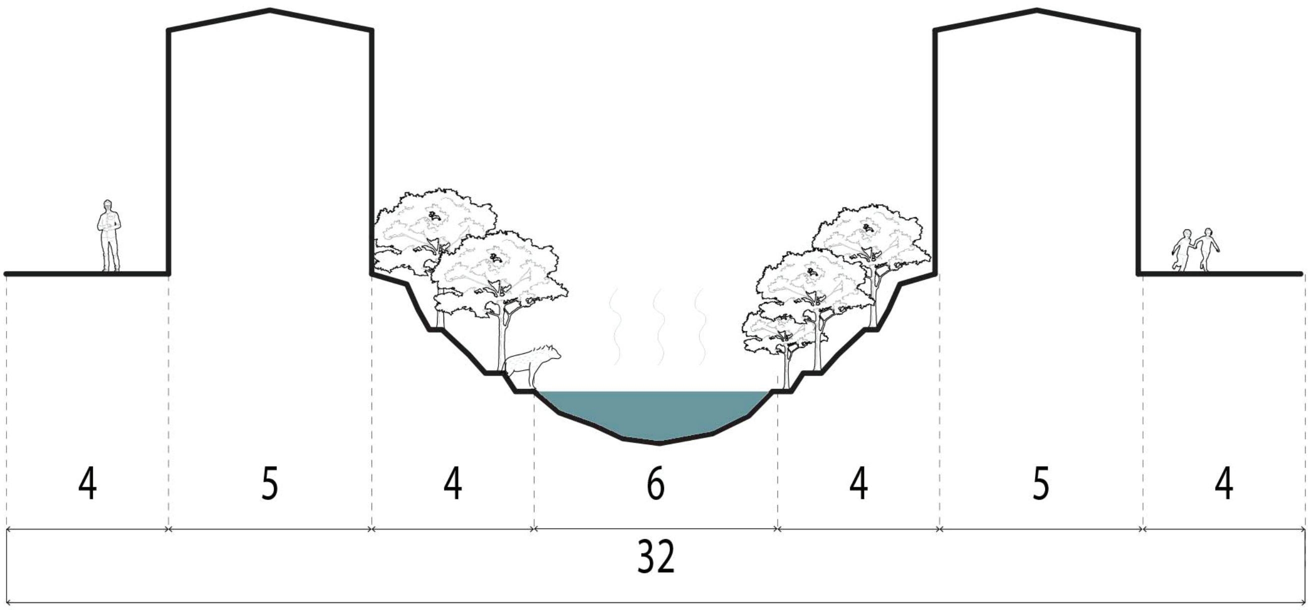


***Figure - : Site section** (Reference taken from TU DELFT)*

6.6 - SITE’s CONSTRUCTION MATERIALS

The construction materials ranges according to the year of construction. The one on the left side are the old construction. Starting from river the materials are corrugated metal and Chika sheets and moving towards road the construction materials are more sustainable and made of brick. However the new construction on the right side is made of concrete blocks.

Figure - : Site’s construction materials

6.7 - SITE's CONDITION

The construction materials ranges according to the year of construction. The one on the left side are the old construction. Starting from river the materials are corrugated metal and Chika sheets and moving towards road the construction materials are more sustainable and made of brick. However the new construction on the right side is made of concrete blocks.

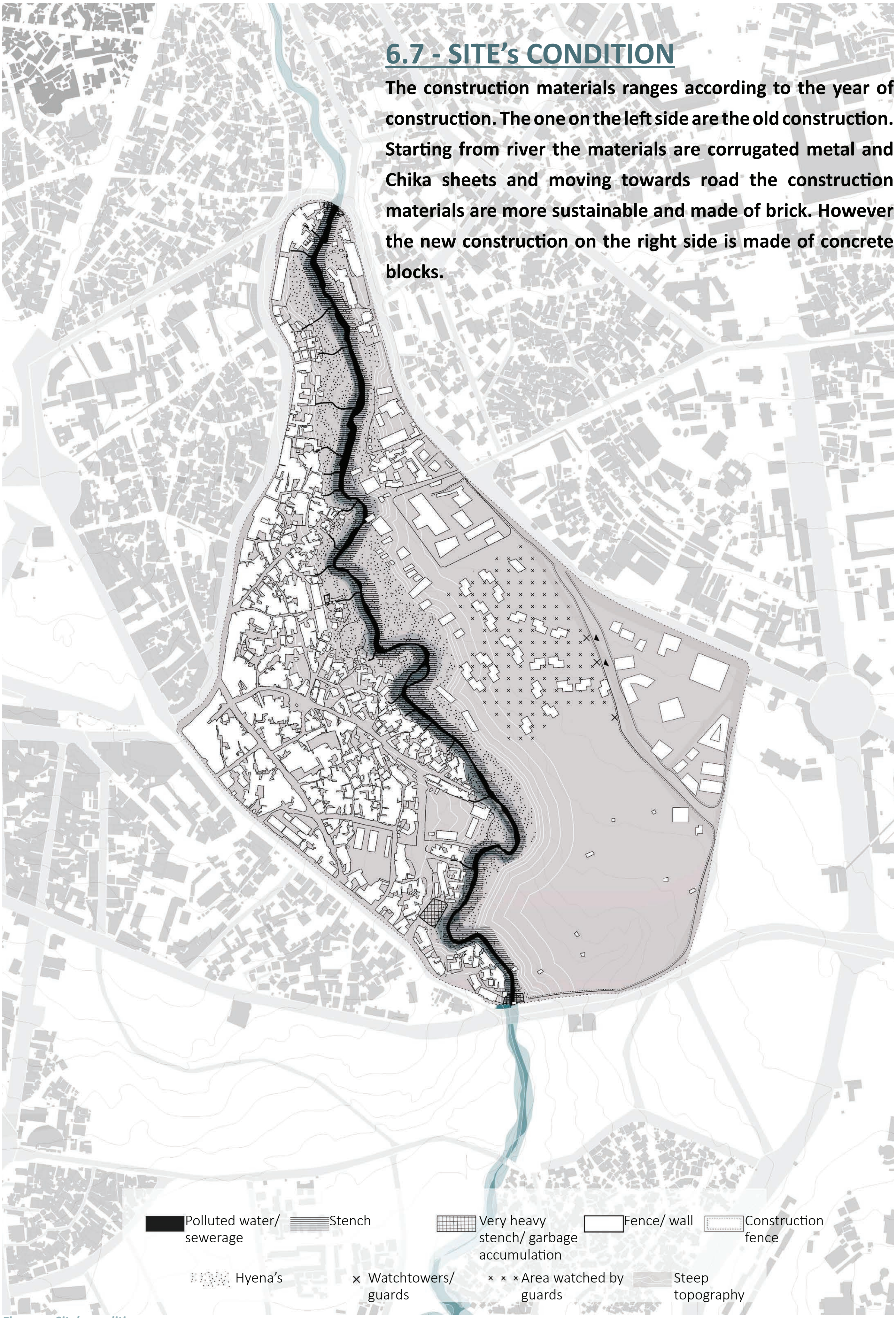


Figure - : Site's condition

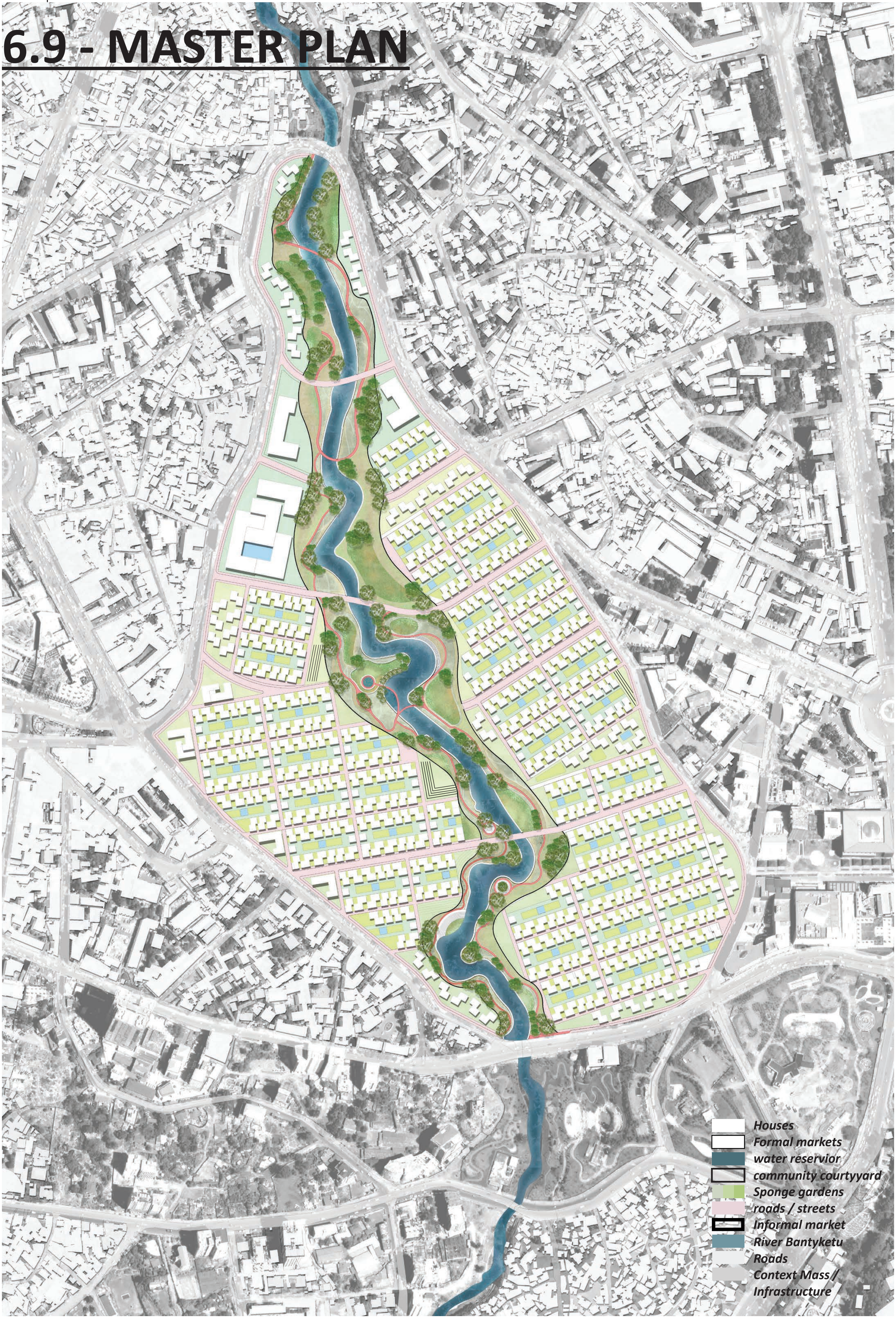
6.8 - DESIGN CONCEPT

THE FLOW OF WATER WITHOUT INTERVENTIONS


THE FLOW OF WATER BY INTRODUCTING
WATER MANAGEMENT SYSTEM

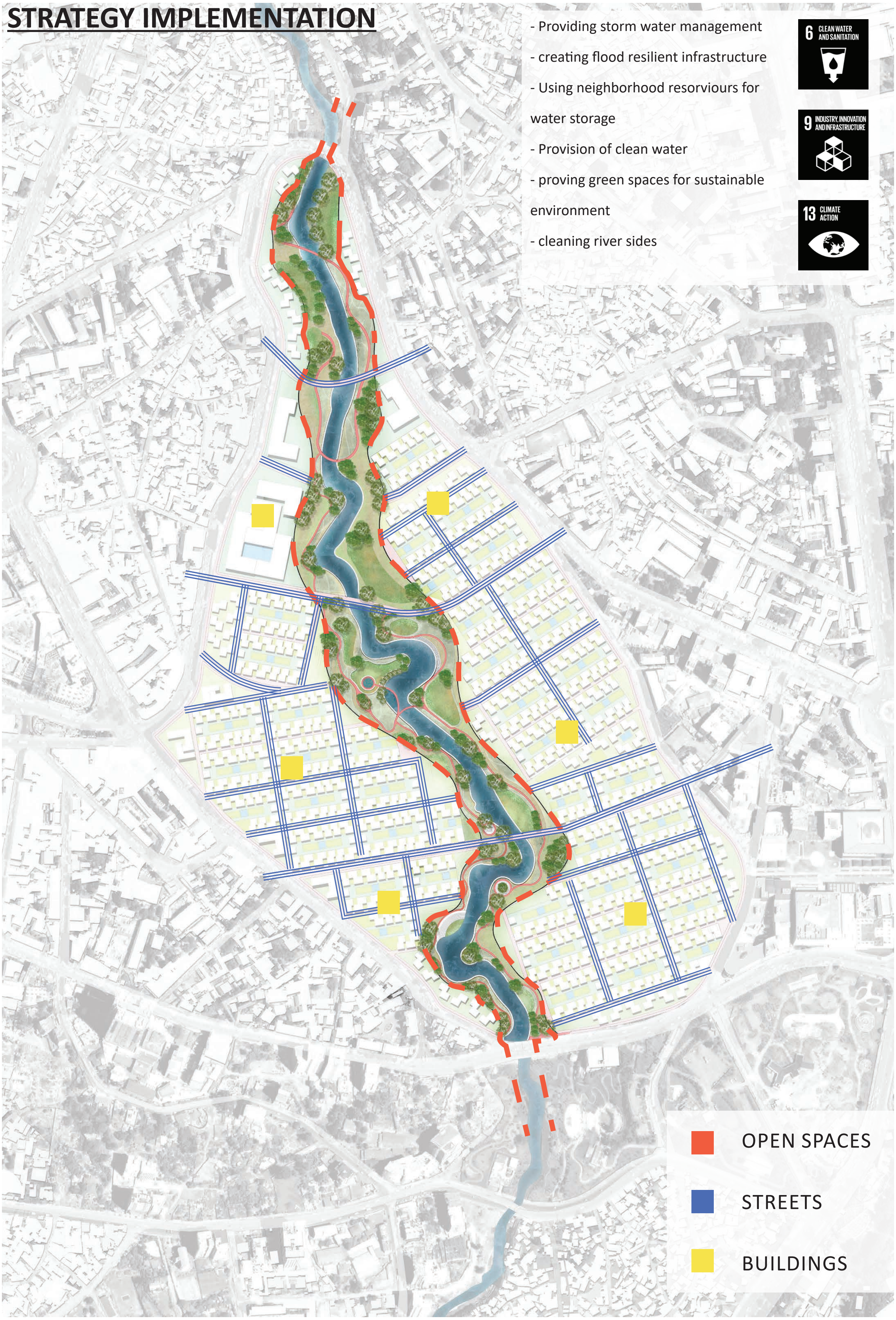
THE FLOW OF WATER BY INTRODUCTING GREEN INFRASTRUCTURE

6.9 - MASTER PLAN

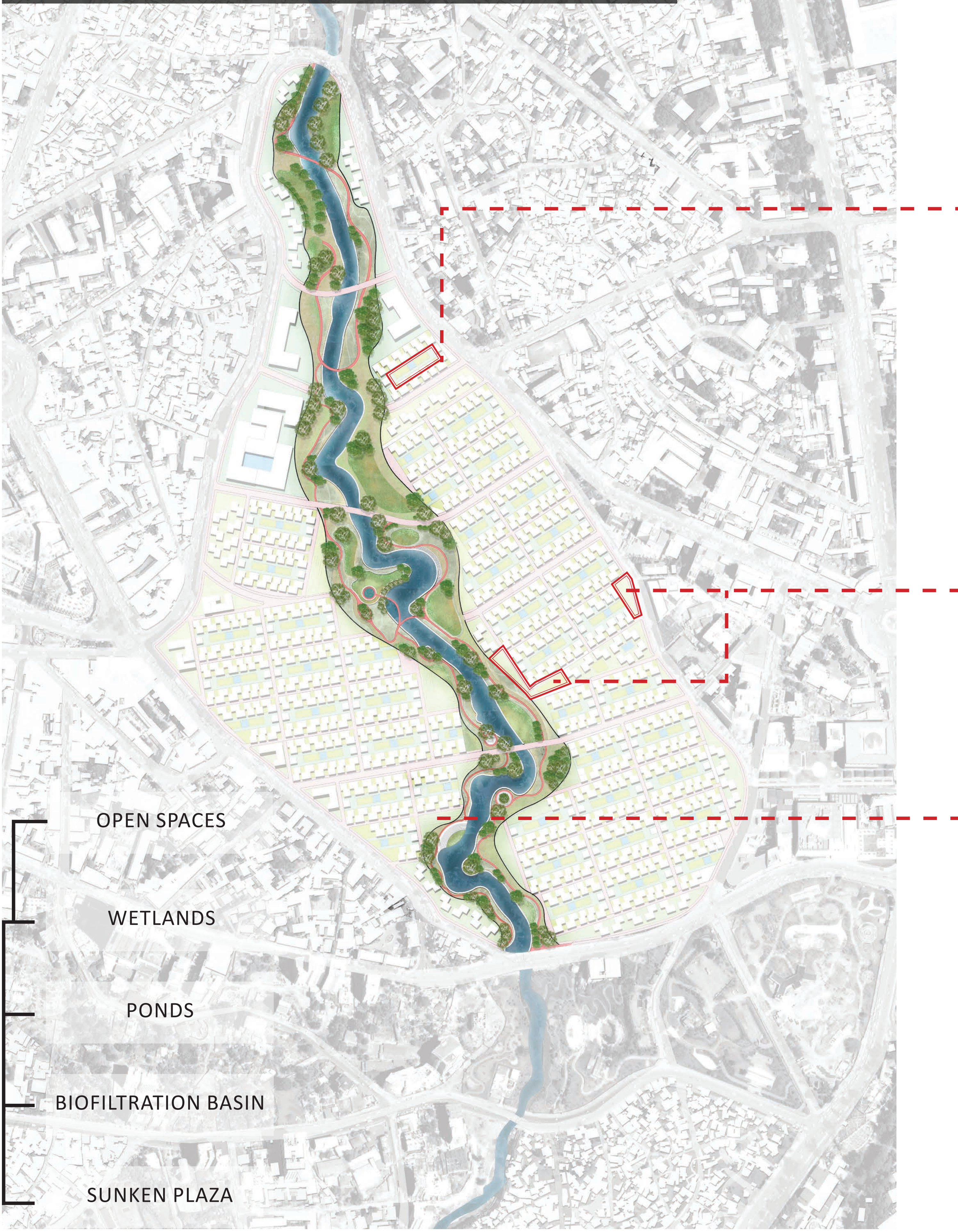


STRATEGY IMPLEMENTATION

- Providing storm water management
- creating flood resilient infrastructure
- Using neighborhood resorviours for water storage
- Provision of clean water
- proving green spaces for sustainable environment
- cleaning river sides



STRATEGY IMPLEMENTATION FOR OPEN SPACES

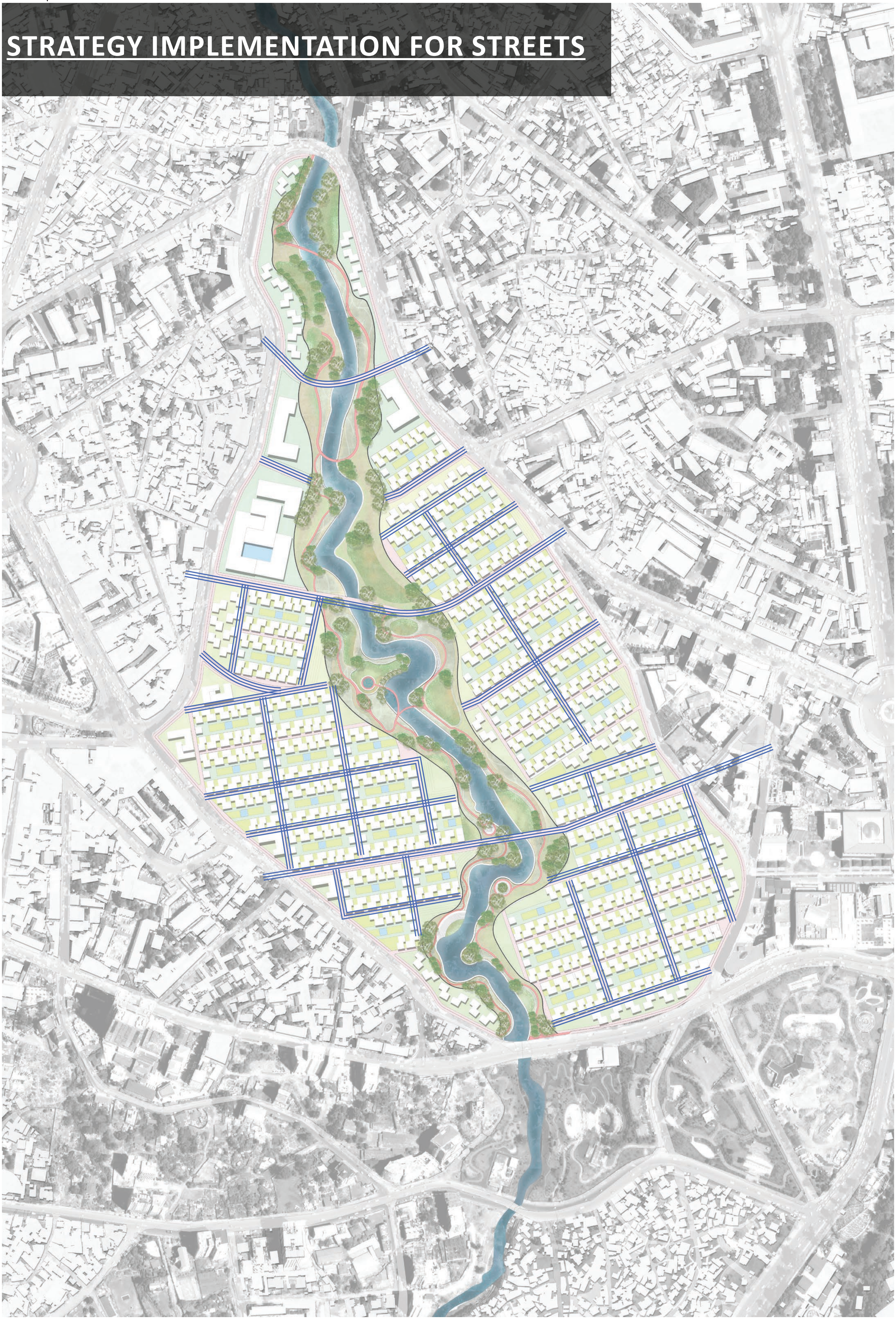


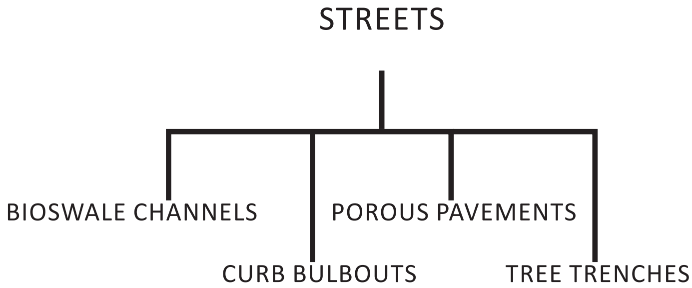
CENTRAL GREEN SPACES FOR FLOODS ACT FOR STORING WATER TO AVOID DAMAGES

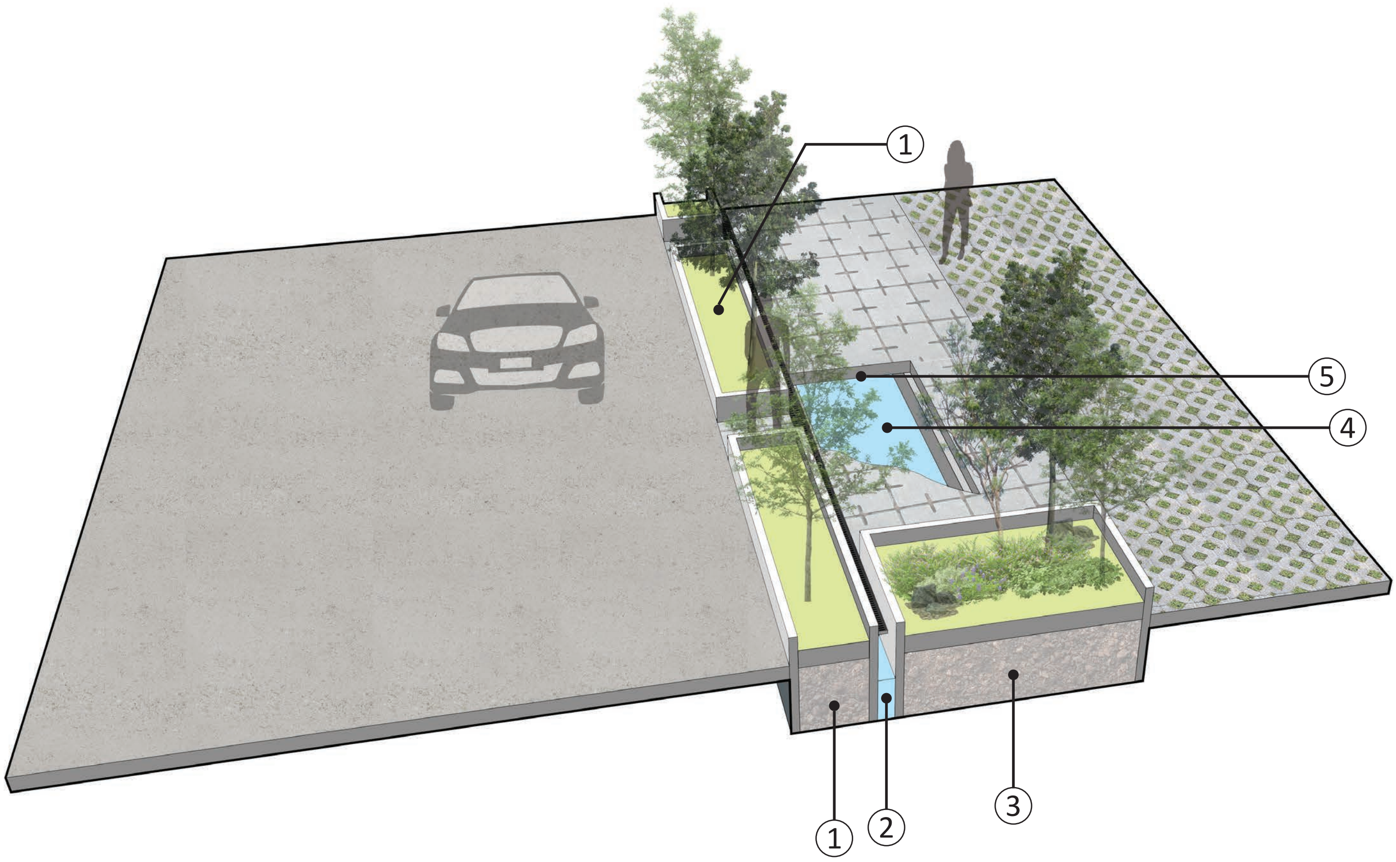
PROVIDING REDUNDANT SPACES

OPEN SPACES THAT ARE FUNCTIONAL IN NORMAL SEASON BUT WILL BE USED FOR STORM WATER MANAGEMENT SYSTEM DURING FLOODING

STRATEGY IMPLEMENTATION FOR STREETS







1- **Pervious planting zone:** absorbs storm water runoff from side roads or side walks

2- **Street channel:** collecting stormwater runoff from catchment areas and directs it towards creek

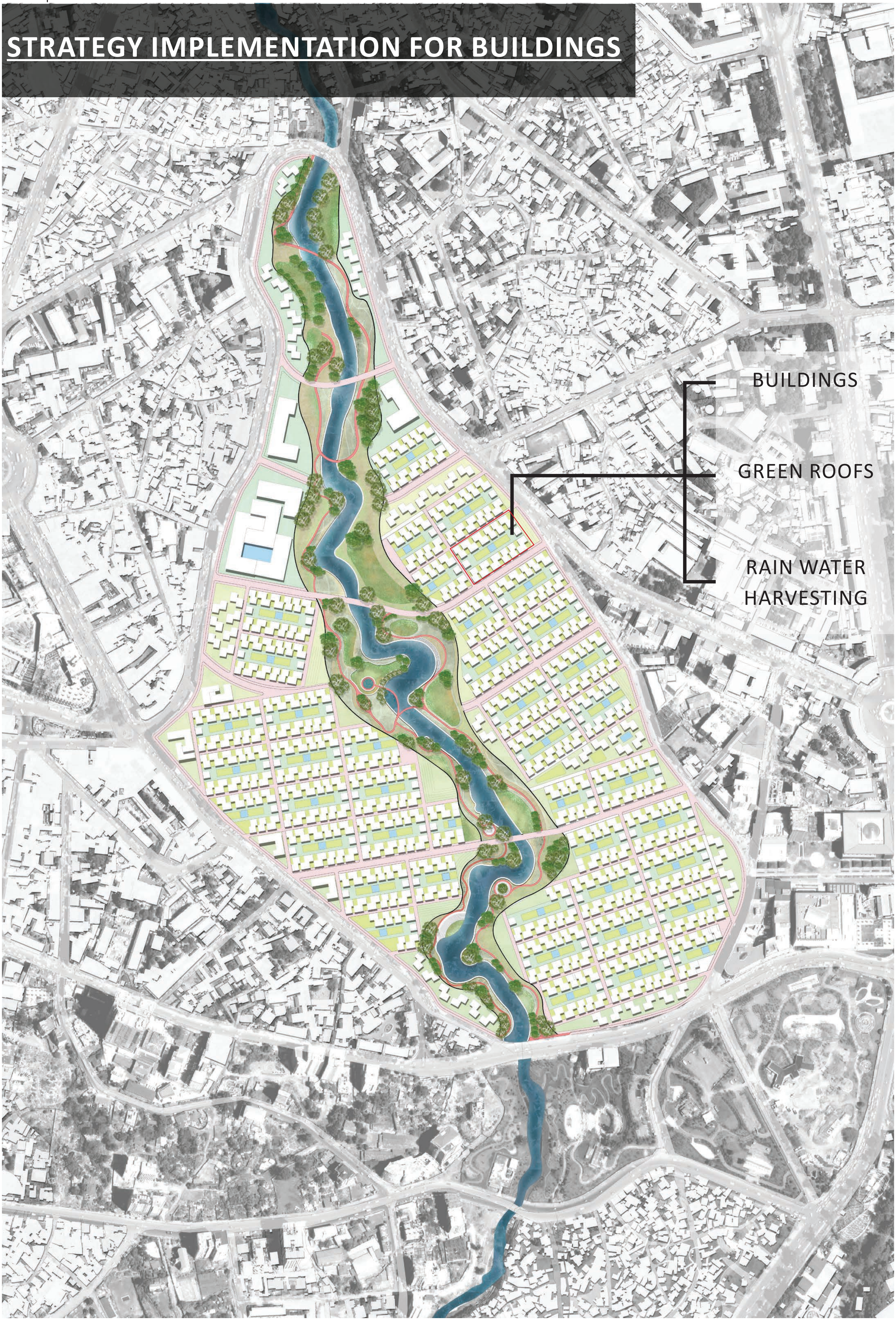
3- **Bioswales:** cleans first flush before releasing it back into channels and towards creek

4- **First flush cistern:** located below street surface, intercepts and captures first flush from each block for release into bioswales

5- **Catch basin:** collects debris and floatable for removal

STORM WATER MANAGEMENT

STRATEGY IMPLEMENTATION FOR BUILDINGS



NEIGHBOURHOOD DETAIL PLANS

GROUND FLOOR

FIRST FLOOR

ENVIRONME

① **Rainwater harvesting** butterfly roofs were designed for capturing rainwater in the central basin of the roof in between the two slopes facing each other. This allowed homeowners to use water for other purposes like flushing toilets, watering plants or even drinking

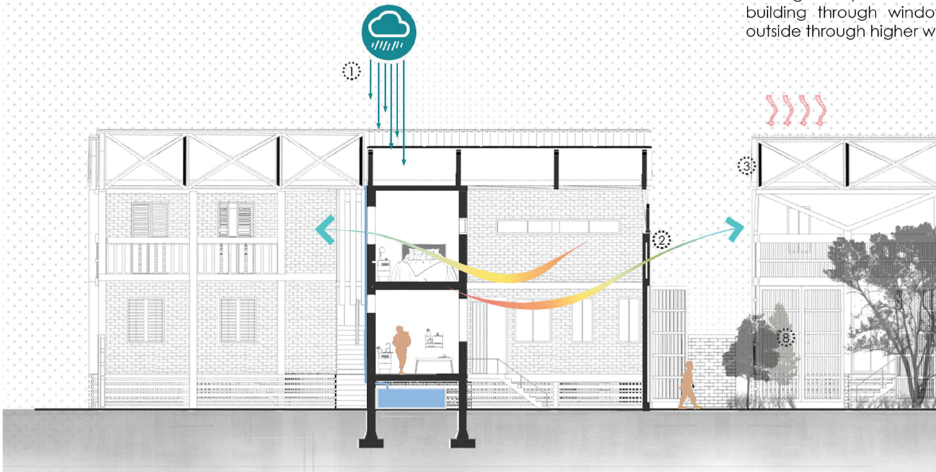
② **Reduce the sun heat** timber sun screen placed to reduce the heat entering the house by windows .

③ **ventilated roof** roofs are raised on trusses and opened to allow air flow . Ventilation benefits a roof when it's hot outside as well .

④ **Flixable parts** operable
inside,but also to Expand
panel are individually
according to the need of

⑤ **renewable energy produ**
facing north to collect m

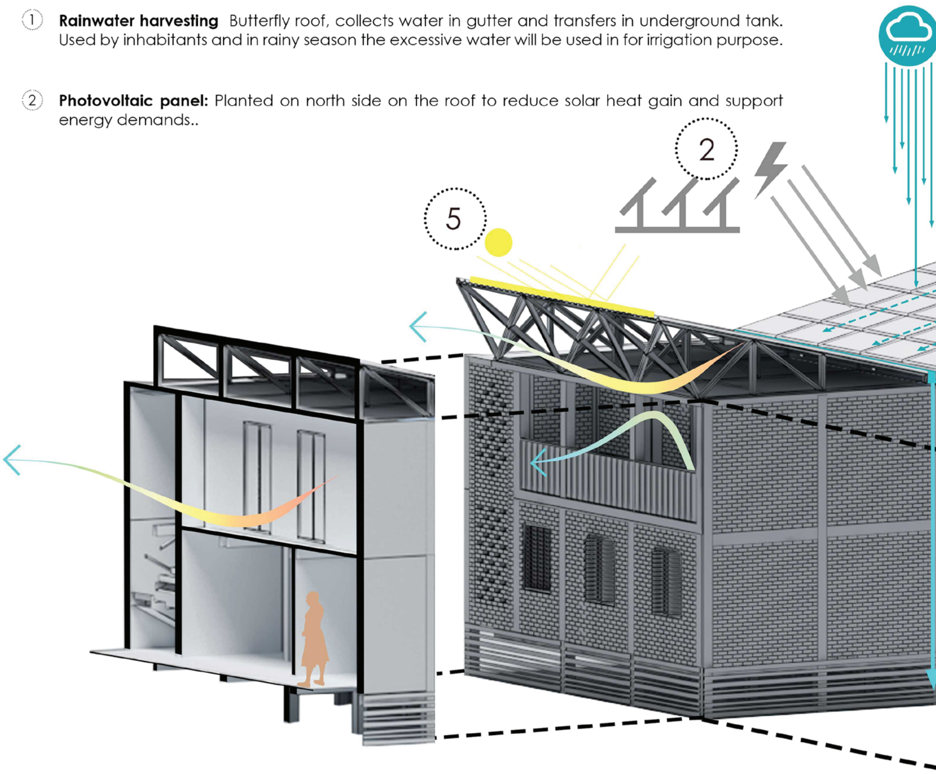
⑥ **Cross ventilation** window
cooling. The system relies
building through windo
outside through higher w



NEIGHBOURH

① **Rainwater harvesting** Butterfly roof, collects water in gutter and transfers in underground tank. Used by inhabitants and in rainy season the excessive water will be used in irrigation purpose.

② **Photovoltaic panel:** Planted on north side on the roof to reduce solar heat gain and support energy demands..



HOUSE IS

NTAL STUDY

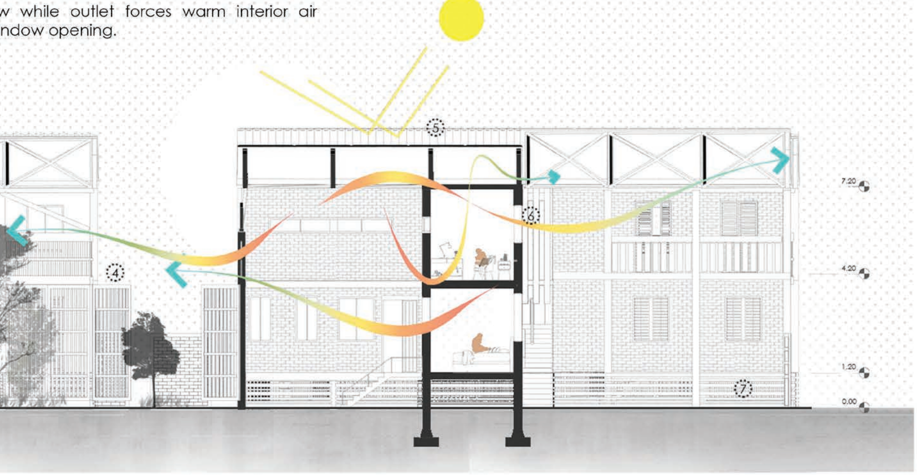
parts not only to provide shades to the the occupational communal space.each operated to allow maximum flexibility the residence.

ction solar panels are placed on the roof aximum amout on sunrays .

s designed to allow is a natural method of on wind to force cool exterior air into the w while outlet forces warm interior air ndow opening.

(7) **Flood resistance** structure is raised by columns to prevent the entry of water into the building.The raised floor may be the most practical and cost-effective way to protect your property and meet building ordinances in flood-prone areas.

(8) **cooling the breeze** locating the an open green space in the middle of the neighberhood helps to cooling the air flow in general and enhance the living qualities in general .

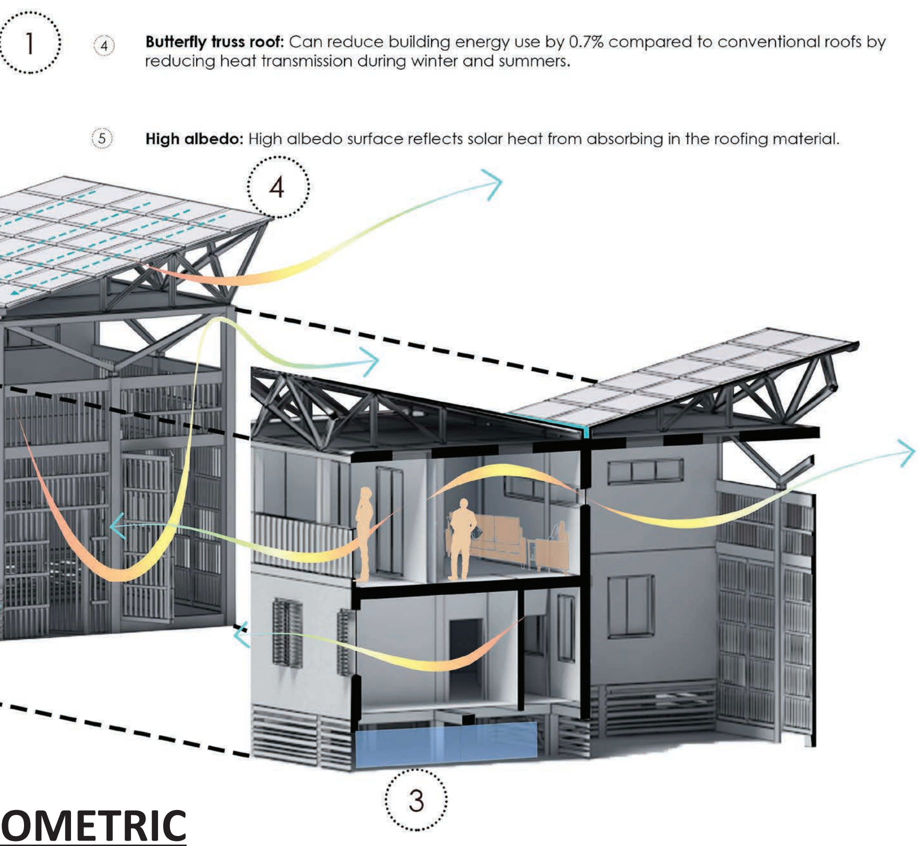


OOD SECTION

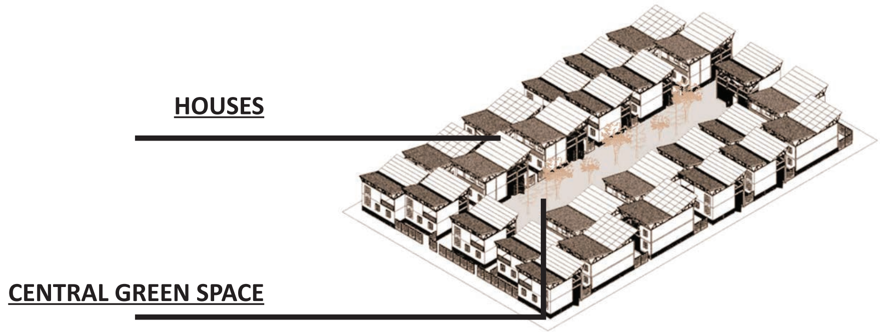
(3) **Reservoir:** tank in the vacant space raised for flooding protection

(4) **Butterfly truss roof:** Can reduce building energy use by 0.7% compared to conventional roofs by reducing heat transmission during winter and summers.

(5) **High albedo:** High albedo surface reflects solar heat from absorbing in the roofing material.



OMETRIC

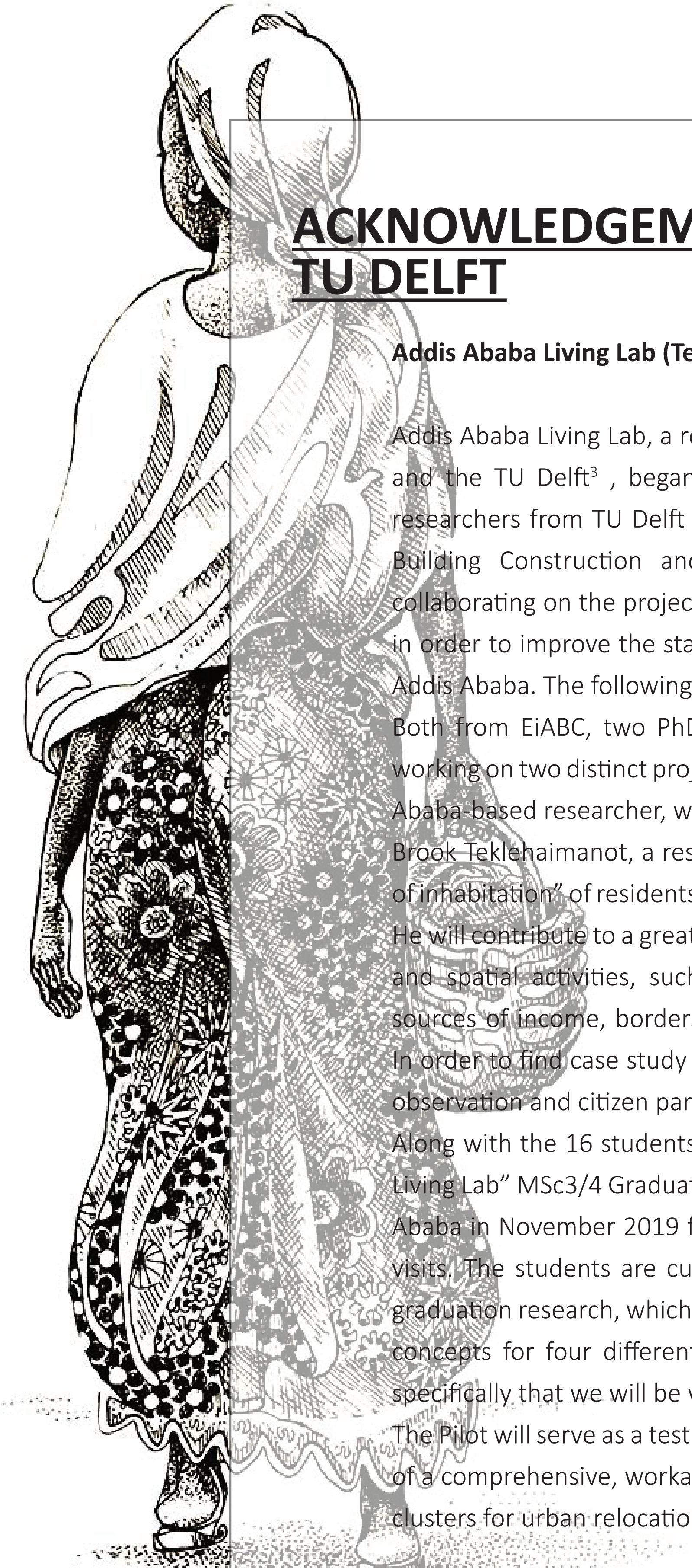



CENTRAL GREEN SPACE IN NEIGHBORHOOD


CENTRAL GREEN SPACE IN NEIGHBORHOOD WITH WATER RESERVIOR

BIRD EYEVIEW SHOWING WATER RESERVIOR

CENTRAL COURTYARD



ACKNOWLEDGEMENT TU DELFT

Addis Ababa Living Lab (Technische Universiteit Delft, n.d.)

Addis Ababa Living Lab, a research initiative financed by NWO-WOTRO[2] and the TU Delft[3] , began two years ago, in May 2019. A group of researchers from TU Delft and the Ethiopian Institute for Architecture Building Construction and City Development (EiABC)[4] have been collaborating on the project's initial research outputs for the past years in order to improve the standard of living for resettlement residents in Addis Ababa. The following few years will be devoted to this task.

Both from EiABC, two PhD candidates joined the project and began working on two distinct project components. Yonas Alemayehu, an Addis Ababa-based researcher, will examine historical and present urban.

Brook Teklehaimanot, a researcher at TU Delft, examines the "patterns of inhabitation" of residents in the various urban settings of Addis Ababa. He will contribute to a greater understanding of urban community social and spatial activities, such as habitation patterns, social structures, sources of income, borders, and construction methods and materials. In order to find case study locations and test ethnographic methods of observation and citizen participation, he did fieldwork in Addis Ababa.

Along with the 16 students from the associated TU Delft "Addis Ababa Living Lab" MSc3/4 Graduation Studio, the entire team traveled to Addis Ababa in November 2019 for intensive meetings, a workshop, and site visits. The students are currently working on the final stages of their graduation research, which will provide 16 different architectural design concepts for four different Addis Ababa locations. In which one site specifically that we will be working on is facing flood issues.

The Pilot will serve as a test case and feedback loop for the development of a comprehensive, workable framework for building resilient dwelling clusters for urban relocation in Addis Ababa.

Figure 2: Women in Addis Ababa [5] (Eduardo Di Muro, n.d.)

[5] This image was published on Middle East Monitor, creating new perspective| page after an event of flash flood in Addis Ababa. Around 217 localities were at high risk due to this flooding in the Addis Ababa, according to concerned institution.

Project partners

TU Delft, Faculty of Architecture and the Built Environment (TUD-BK, Prof.dr.ir. Marja Elsinga, PI), Ethiopian Institute for Architecture, Building Construction and City Development (EiABC, Dr. Elias Yitbarek), Federal Housing Corporation, Addis Ababa (Zekarias Sebsbie, Mahlet Yared), Mecanoo architecten, Delft (Prof.ir. Dick van Gameren), RAAS Architects, Addis Ababa (Rahel Shawl)

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[2] WOTRO Science for Global Development, a cross-domain effort of NWO, plans, funds, and supports research for inclusive global development. The goal of the WOTRO research programs is to provide information and abilities that support long-term fixes for social and ecological issues in low- and middle-income nations (LMICs).

[3] The oldest and largest public technical university in the Netherlands is Delft University of Technology (TU Delft), which is situated in Delft, the Netherlands.

[4] In Addis Abeba, Ethiopia, there is an institute for architecture and civil construction called the Ethiopian Institute of Architecture, Building Construction, and City Development (EiABC).

07

CONCLUSION

Figure 173: Ethiopian man (Kelly Fogel, n.d.)

CONCLUSION

This thesis stems from two specific interests: the study of the phenomenon of resilience applied to urban systems and the interest in how urban planning policies can make urban systems more resilient to a priority issue such as flooding.

The relationship between resilience and flooding is studied in its theoretical scientific assumptions (PART 1) and then applied to the specific case of the city of Addis Ababa (PART 2). This choice - as recalled during the thesis - was attributable to the possibility of having specific data using the system database (USING DATA FROM TU DELFT UNIVERSITY RESEARCH IN COLLABORATION WITH ETHIOPIAN INSTITUTE FOR ARCHITECTURE BUILDING CONSTRUCTION AND CITY DEVELOPMENT (EIABC) AND FINANCED BY NWO-WOTRO).

Given these premises, it is possible to summarize the results and critical issues resulting for this research according to three phases: the first by taking up the research questions, then by examining the results of the Addis Ababa experience and then concluding with references to the empirical concept of urban resilience
Reminding our research question that were considered in the beginning are:

QUESTION 1-What are the possible aspects that make a city more resilient?

QUESTION 2- What are the strategies that can be opted to make a flood resilient city, accommodating climate changes and population density?

QUESTION 3-What kind of interventions can improve the quality of life that can have a dialogue with people and their cultures along with the environmental changes?

QUESTION 4-What kind of Strategical interventions can be introduced to

make a resilient city?

Through this research we found out the answers to these questions which we have concluded below and will link our final remarks with expected outcome that we aimed in the beginning of this project.
So, concluding all the points of research that can answer our research questions are as follow:

QUESTION 1- What are the possible aspects that make a city more resilient?

OUTCOMER CONCERNING RESILIENCE AND URBAN RESILIENCE

As for the first question researchers and scholars (in table 1 of CHAPTER 1 the authors and the main scientific references are indicated) described resilience in different fields according to different aspects and all had one point in common that was the ability of material, society, or a city to be able to absorb shocks and stresses.

To be urban resilient, a city needs to have following balance, because if one element loses its equilibrium the falls to the ground. However, to make it growing despite the fact of disasters it needs to maintain other aspects in equilibrium so collectively the other aspects bring back the equilibrium of disturbed aspect.

So according to the above statements a first conclusion that comes to the research indicators and urban planning policies concerning these balances.

The main indicators can be summarized in the Proportion of basic needs to human population and as an outcome the community integration rather than segregating community and employment.

1. *Providing a safe environment and have effective emergency management*

2. *Have enough financial stability to invest for disasters prevention and in time disasters as a relief*

3. *Have infrastructure that can withstand the stresses*

4. *Being consistent with evolving ecosystem*

5. *Having proper management of network and communication system*

6. *To make it more effective inclusion of expert decision makers and stakeholder's consultation*

7. *Providing basic education against all these factors so bottom-up approach can be opted*

8. *Having continues and ever evolving process of planning*

9. *Priority to health*

10. *Strong social network to work*

as one force in time of need.

These indicators represent the objectives to be pursued for urban planning policies and urban projects (especially infrastructures) aimed at building resilience, but the policies themselves must be such as to keep each of these basic elements intact.
This reasoning is linked to a direct line with the quality of planning policies and infrastructure that – according to the outcomes of PART 1 of this research - should be:

1. reflective means growing with changes

2. robust enough to sustain these shocks

3. supported by redundant spaces which will be buffer zones to accumulates the shocks

4. and having a flexibility of structure matters because if its rigid then it will break down rather than getting mold with the changes

5. It should also be added that just the system, structure and infrastructure won't be sufficient unless the people, stakeholders in it become resourceful to act on their own

6. Finally, the Authorities need to include all the parties to make it inclusive system, aligning the goals of whole community will integrate the system

7. and provide planning tools, infrastructure projects and strategical planning choices that - through sharing with the local community - are effective against problems (resilience), reduce spatial inequalities (i.e., aim to create safety situations in all urban areas) thus creating a solid local community). These topics were detailed in the analysis of the "categories of urban resilience" in the CHAPTER 1.

In the end combing both indicators and qualities to make urban resilient city this can be categorized in four parts:

- ***Health and wellbeing***
- ***Economy and society***
- ***Urban system and services***
- ***Leadership and strategy***

These four priorities are the consequence of the experiences acquired in the international case studies examined and reiterate how the concept of urban resilience must inevitably relate to the multidisciplinary nature of urban policies, from environmental and socio-economic to territorial arguments etc. The broad scientific disciplinary debate summarized here in table 1, which is among the results of the research, falls within this framework So, making a flood resilient city should have all these strong points. But being an architect, we provide strategies based on architecture and planning and play our role by proposing a robust redundant and flexible infrastructure.

QUESTION 2- What are the strategies that can be opted to make a flood resilient city, accommodating climate changes and population density?

RESULTS ACHIEVED FROM URBAN FLOOD RESILIENCE IN FLOOD PRONE COUNTRIES

According to the second main question:

One of the main concerns for making cities resilience is related to climatic changes. The constant changing weather is a result of increasing precipitation in atmosphere and the result is heavy rainfalls during rainy seasons.

Most common issues are water clogging of drainages because they are not well maintained. As well as lack of availability of redundant spaces. Then the network of concrete roads which are not permeable to water. In hilly/sloped areas the terrain channels the water without any guide and water makes its own course. All these issues collectively result in flooding during rains.

The learning from our case studies in management of water and floods at urban scale are:

1- Using polder system to drain water where possible, mostly feasible near seashore areas.

2- Making barriers to protect from water

3- Reorganize sewers system to manage storm water flow using decentralized creative solutions that perfectly syn with local region.

4- Proposing green streets by providing permeable paving or stormwater planters, will act as retention streets as well to save water going to vulnerable areas.

5- Proposing central retention zones, that are multi-functional. During normal days serves the purpose of central parks or community centers but during rainy season it stores the water to avoid flooding.

6- Channel water to direct water to central retention zones. As we can stop the water to an extent but can control its direction of flow.

At unit level bottom-up approach can be opted.

1- The level of the house should be raised to make space for water to *flow under it.*

2- Or the other option can be making floating floors.

The elements mentioned above have also been examined in relation to the Addis Ababa case study from which we can draw an outcome.

The results of our research can be summed up as:

The ***climatic changes*** are affecting the city bad. The percentage of rain is increasing every year and there is no proper intervention to deal with flooding issue.

This is affecting mostly to the people living in urban zones. As there are more opportunities so people tend to move to the urban areas, and it is getting densely populated. The disastrous effects of urban flooding are heavily influenced by the rising urbanization. It makes it more challenging to balance the proportion of services provided to the population rate.

This increased rate results in extra load on surroundings especially sewers as it is related to ***water management system.*** And strictly related to Addis Ababa people move to cities and due to lack of financial situation they are forced to live in flood prone areas. In this situation there are two scenarios:

1. *the scenario in which urban policies and the construction of adequate infrastructures are able to cancel the risks and put these areas in safety*

2. *the scenario in which unfortunately it is not possible to obtain these results. In this second case, the authorities must proceed with different location choices.*

This is a consideration also linked to the concept of urban resilience. In some cases, the city reacts to problems, in other cases it is the construction of targeted infrastructures and urban policies, in others it is not possible and different actions are required.

QUESTION 3-What kind of interventions can improve the quality of life that can have a dialogue with people and their cultures along with the environmental changes?

QUESTION 4-What kind of Strategical interventions can be introduced to make a resilient city?

OUTCOME CONCERNING STRATEGIES PROPOSED ACCORDING TO OUR RESEARCH OF RESILIENCE AND FLOODING IN OUR CASE STUDY ADDIS ABABA

This reasoning relates directly to the last two questions examined.

Both of these issues were addressed directly with the Addis Ababa case study and we can thus summarize the results.

So, from above outcomes we devised strategies based on the main policies defined by the Organization for Economic Co-Cooperation and Development (OCED) for flood resilient management and whose planning guidelines have been studied in CHAPTER 6. It is worth recalling in these conclusions the detailed attention that these guidelines attribute to the role that is covered by the various stakeholders and how this aspect is important for a community integration aimed at favoring the conditions of urban resilience. The results of the study of the strategies envisaged by OCED allow us to learn how to devise strategies as understanding important elements that will have direct effect from these strategies and policies.

Selecting important assets and systems and services where we need resiliency the most, we need to map out our strategies and vital infrastructure.

1. *Creating strong relationships with the experts dealing with infrastructure to create mutual trust and for expert opinion in experienced field.*

2. *For infrastructural management strategies from urban to unit level were devised.*

3. *Taking mutual and equal responsibility for prompt service restorations.*
as well.

From this analysis it was possible to divide the the strategies in three parts:

1. Support for social interventions where the priority is to understand the needs of people and how local communities can collaborate in the selection, design, and maintenance of the infrastructures necessary to improve local urban resilience capacities.

2. Attention to soils and land and ecological aspects. Promote social spaces, community gardens and platforms that unite the community.

3. Last but not least the control of the water with appropriate structures that prevent flooding both in the rainy season and also during the normal season and which - as described in CHAPTER 6 require specific territorial attention from the urban scale to the district and block scale.

All these elements should be considered while planning strategies for flood resilient city. As all arere interlinked, water management has a direct link to people living in specific area and society should also be planned according to culture and its people's need.

FINAL REMARKS:

In the end we can conclude whole research as the climate changing issue cannot by stopped, we need to evolve with it as it's how nature works. But a major failing is the quick urbanization. But also, this one is not easy to be under control. As for better opportunities people migrate to bigger cities and tend to make it more vulnerable to natural disasters. So, cities and nations must therefore develop inclusive and mitigated solutions in order to attain urban flood resilience in light of these main concerns. The need for proper monitoring of climate changes and regular professional checks and maintenance on site should be our priority. Regular maintenance, infrastructural strategies and planning regulations are our way out. Because urban flood risk is not a new concept, but the general public's lack of understanding has made it increasingly well-known recently. Though we can't adopt their exact strategy, we may learn from their techniques and come up with solutions that are tailored to our own culture, requirements, topography, and weather. We must take lessons from developing nations.

The goal of this study on developing nations was to come up with ways to give the locals better chances and a better standard of living.

According to the author, we cannot stop urbanization or climate change, but we can improve the way our policies are carried out. Government and authorities should work on educating people and urban infrastructure but at the same time people need to work on their own as well to play their role in the society resiliency to manage urban flooding and other natural disasters.

So, as we aimed in beginning of research, so we can say that according to this desk job the strategies that have been devised can be useful on site. We need to learn from world and start acting for better environment and it should go both ways by the people and by the higher authorities as well.

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