



Ethiopian Institute of Architecture, Building Construction and
City Development (EIABC)

Department of Urban and Regional Planning

**Strategies for Managing and Mitigating Flood Challenges
towards Sustainable Urban Planning: Case of Addis Ababa,
Ethiopia**
By
Betelhem Shimelis

MAY 1, 2024
ADDIS ABABA UNIVERSITY
Addis Ababa, Ethiopia



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Advisor

Aramde Fetene (PHD)

AN M.Sc. THESIS SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES OF
ADDISABABA UNIVERSITY IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR DEGREE OF MASTER OF SCIENCE IN URBAN PLANNING.

MAY 1, 2024

ADDIS ABABA UNIVERSITY
Addis Ababa, Ethiopia

Declaration

I, Bethlehem Shimelis, do hereby declare to Addis Ababa University School of Graduate Studies that this thesis is a product of my original research work, and it has not been submitted to any other university for any academic degree. Materials and information other than my own are dually acknowledged.

Name: Betelhem Shimelis

Signature:

Date of Submission:

Supervisor's approval

This is to certify that the above declaration made by the candidate is correct to the best of my knowledge as an advisor.

Approved by: _____

Thesis Advisor Signature

Date

Managing Urban Flooding, Their Execution and Difficulties Addis Ababa City

Approved by:

_____	_____	_____
Thesis Supervisor	Signature	Date
_____	_____	_____
Internal Examiner	Signature	Date
_____	_____	_____
External Examiner	Signature	Date
Tilahun Derib (PhD)	_____	
Chairperson, Department of URP	Signature	Date

Abbreviations and Acronyms

AACDRMC:	Addis Ababa City Disaster Risk Management Commission
AAEPA:	The Addis Ababa Environmental Protection Authority
AACRA:	Addis Ababa City Roads Authority
AAWSA:	Addis Ababa Water and Sewerage Authority
ACM :	Adaptive co-management
DPSIR:	Driver-Pressure-State-Impact
DRM:	Disaster Risk Management
FGD:	Focus group discussion
FEMA:	Federal Emergency Management Agency
GDP:	Gross domestic product
IWRM:	Integrated Water Resources Management
KII:	Key informant interview
MLIT:	Ministry of Land, Infrastructure, Transport, and Tourism
MoDMR:	Ministry of Disaster Management and Relief
NFIP:	National Flood Insurance Program
NbS:	Nature-based Solutions
UN:	United Nation

Acknowledgements

First, I would like to thank God, for letting me through all the difficulties. I have experienced your guidance day by day. You are the one who let me finish my degree. I will keep on trusting you for my future.

I would like to acknowledge and give my warmest thanks to my supervisor Dr. Aramde Fetene who made this work possible. His guidance and advice carried me through all the stages of writing my project.

Finally, I would also like to give special thanks to my family as a whole for their continuous support and understanding when undertaking my research and writing my project. Your prayer for me was what sustained me this far.

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Abstract

Urban flooding poses significant challenges to cities worldwide, and Addis Ababa, the capital city of Ethiopia, is no exception. As urbanization accelerates and climate change impacts become more pronounced, understanding and effectively managing flood risk in Addis Ababa are imperative for ensuring the city's resilience and sustainable development. This study aims to develop a comprehensive framework for urban flood risk management in Addis Ababa, integrating urban planning, environmental sustainability, and disaster risk reduction strategies.

Primary data collection involved key informant interviews (KII), focus group discussions, and field observations, supplemented by secondary data obtained from online sources and relevant organizations. The collected data were analyzed using both qualitative and quantitative methods. Qualitative data from KII and focus group discussions were thematically analyzed to identify key factors influencing flood risk and the effectiveness of existing institutional frameworks and policies. Additionally, quantitative data were presented and interpreted using tables, graphs, and charts to visualize trends and patterns in flood vulnerability, institutional strengths and weaknesses, and policy effectiveness.

Findings reveal that Addis Ababa's institutional frameworks for flood mitigation and disaster risk reduction are governed by entities such as the Addis Ababa City Disaster Risk Management Commission (AACDRMC), the City Master Plan, the Environmental Protection Authority (AAEPA), the City Roads Authority (AACRA), and the Water and Sewerage Authority (AAWSA). Existing policies encompass flood risk management, urban development, building codes, environmental protection, disaster preparedness, and land use regulations.

Advantages of Addis Ababa's current institutional structures and policies include collaboration and coordination, a robust regulatory framework, environmental protection measures, and capacity building. However, weaknesses persist, including inadequate infrastructure, limited public engagement and awareness, inconsistent enforcement of regulations, and insufficient financial resources.

Based on these findings, key recommendations include the implementation of integrated flood planning and infrastructure, the development of climate-resilient infrastructure, community engagement and awareness initiatives, and strengthened regulatory enforcement mechanisms.

Key words: Urban flooding, Environmental sustainability, Public engagement, Resilience

Chapter One

1 INTRODUCTION

1.1 Background of the study

Flooding stands as one of the most prevalent and dangerous natural disasters worldwide. Between 1994 and 2013, nearly 2.5 billion individuals experienced its devastating impact, accounting for a substantial 43% of all recorded natural disasters in the Glob. Unprecedented years like 1998 and 2010 saw flood-related losses surpassing \$40 billion. In this regard, with the ominous backdrop of climate change, rapid urbanization, and burgeoning global population, the influence of coastal, fluvial, and pluvial flooding is poised to intensify significantly in the coming decades. In light of these challenges, effective flood risk management emerges as an imperative necessity. Notably, natural approaches to flood risk reduction are increasingly gaining traction (Van Wesenbeeck, 2017).

Among these global concerns, this study focuses on a specific locality of Addis Ababa, which is a sprawling metropolis nestled within the Entoto, Furi, Yerer and Wechecha mountain ranges.

The primary sources of flooding in Addis Ababa are river inundation and stormwater runoff from steep slopes. Data from the Ministry of Labour and Social Affairs paints a stark picture, highlighting numerous flooding incidents over the years. In 2005, seven major incidents affected 362 households and 1302 family members. Recent data underscores the urgency of addressing flooding in Addis Ababa. According to the latest reports from the Addis Ababa City Administration (AACDRMC, 2023), flooding incidents have been on the rise in recent years, with significant impacts on residents and infrastructure. For example, in 2023, there were 20 major flooding incidents reported, affecting over 2,000 households and causing extensive damage to roads and buildings. Similarly, in 2022, flooding affected 1,800 households, leading to widespread displacement and economic losses (AACDRMC, 2022). These incidents highlight the pressing need for effective flood risk management strategies in the city.

Subsequently, in 2008 nine flood incidents, impacting 131 households and 352 family members, while in 2009 about 317 households and 647 family members were affected across six incidents. By 2010, reports indicated that 147 individuals were affected, with 39 residential houses sustaining damage. The proliferation of informal housing and agricultural activities, particularly in high-slope regions like the Jemo mountain series, Repi hills, and the Akaki Riverbanks, have exacerbated the

city's flood vulnerability (Workalemahu, 2015). The same source revealed that at the municipal level, multiple sectors bear responsibilities related to water management, yet there exists a glaring lack of coordination in storm water management efforts.

In this study, we focus on Addis Ababa, a sprawling metropolis nestled within the Entoto, Furi, Yerer, and Wechecha mountain ranges. The city grapples with recurring flood hazards, primarily driven by torrential seasonal rains that engorge its waterways, leading to destruction along their banks and substantial property losses.

The city administration has initiated a comprehensive analysis of flood-prone areas, resulting in ongoing flood protection efforts. However, while these efforts have seen progress, challenges remain in addressing the increasing frequency and intensity of flooding events.

This multifaceted strategy encompasses various measures, including the construction of retaining walls, dikes, and river course enhancements, alongside the creation of weirs and rain runoff retention ponds. Additionally, non-structural initiatives like reforestation, zoning revisions near water bodies, and robust early warning systems are integral components of this preparedness plan. While the introduction mentions the lack of coordination in storm water management, it is crucial to examine the roles and responsibilities of key stakeholders involved in flood management in Addis Ababa. These stakeholders may include government agencies, local authorities, community organizations, and NGOs. Understanding their roles and interactions is essential for identifying coordination issues and improving flood management efforts in the city.

Therefore, this research aims to comprehensively investigate the causes of urban flooding, the effectiveness of existing institutional frameworks and flood protection measures, opportunities for improved flood management, challenges confronting these efforts, and the alignment of city planning with Addis Ababa's master plan in the context of natural hazard mitigation.

1.2 Problem statement

Natural disasters have historically posed substantial threats to global human populations. Among these, floods are the most prevalent and widespread, occurring in practically every region of the world due to their frequency and nature (Selamawit, December 2018).

In the context of Addis Ababa, the city is susceptible to multiple natural hazards, including flooding and landslides as highlighted in its structural plan. Floods frequently affect areas adjacent to rivers like Kechene, Kurtume, Banteyeketu, and Kebena, particularly during rainy seasons. The

risk of landslides is notably high in steep and geologically weak terrains, such as Yeka, Gullele, Nefasilk-Lafto, and Kolfe-Keranio sub-cities.

In recent years, there have been several instances of loss of property and life due to flooding in Addis Ababa. For example, in 2018, heavy rainfall caused a devastating flood in the Kolfe Keranio sub-city, resulting in the destruction of homes and infrastructure. The floodwaters swept away houses, leaving many families homeless and leading to tragic loss of life.

Additionally, in 2020, flooding in the Akaky Kaliti sub-city of Addis Ababa resulted in the displacement of residents and damage to property.

In another instance in 2017, heavy rainfall in Addis Ababa led to severe flooding in the Nifas Silk-Lafto sub-city, causing widespread damage to homes and infrastructure. The floodwaters inundated residential areas, displacing many families and resulting in the loss of property.

Furthermore, in 2019, flooding in the Bole sub-city of Addis Ababa resulted in the destruction of houses and public infrastructure. The rapid onset of the floods caught many residents off guard, leading to tragic loss of life and significant damage to property in the area.

Several neighbourhoods of the city were inundated after heavy rain on 17 August 2021. Roads were submerged, cars stranded and buildings damaged.

Addis Ababa faces significant vulnerabilities to natural disasters, particularly urban flooding and landslides. The city's susceptibility to these hazards is exacerbated by factors such as inadequate infrastructure, rapid urbanization, and geographical features. Historical incidents of flooding, including those in Kolfe Keranio, Akaky Kaliti, Nifas Silk-Lafto, and Bole sub-cities, underscore the urgent need for effective flood mitigation and disaster risk reduction measures.

Moreover, recent flooding events in August 2021 have further highlighted the ongoing challenges faced by the city, with neighborhoods inundated, infrastructure damaged, and lives disrupted. Addressing these issues requires a comprehensive understanding of the causes and drivers of urban flooding, an assessment of existing institutional frameworks and policies, an evaluation of past mitigation measures, and the development of integrated strategies for enhancing flood resilience and urban sustainability.

This research, aim to delve into the root causes of urban flooding in Addis Ababa, analyze the effectiveness of current policies and measures, and propose actionable strategies for reducing flood risk and building resilience. By addressing these pressing challenges, we can contribute to the development of a safer, more resilient city for its residents and future generations.

1.3 Objective of the study

The general objective of this study is to develop a holistic framework for urban flood risk management in Addis Ababa that integrates urban planning, environmental sustainability, and disaster risk reduction to enhance the city's resilience to flooding. The specific objectives are:

- to assess the main causes of flooding in Addis Ababa
- to analyze the existing institutional frameworks and policies governing flood mitigation and disaster risk reduction in Addis Ababa, identifying strengths, weaknesses, and areas for improvement.
- to evaluate the effectiveness of current flood prevention and mitigation measures
- to propose integrated strategies for flood risk reduction and urban resilience enhancement in Addis Ababa.

1.4 Research question

- What are the primary drivers and factors contributing to urban flooding in Addis Ababa?
- How effective are the existing institutional frameworks and policies governing flood mitigation and disaster risk reduction in Addis Ababa, and what are the key strengths, weaknesses, and areas for improvement within these frameworks?
- What is the performance assessment of current flood prevention and mitigation measures in Addis Ababa?
- How can integrated strategies be developed to address flood risk reduction and urban resilience enhancement in Addis Ababa?

1.5 Scope and limitation of the study

The study is only concerned with the issue of flooding in Addis Abeba City and its causes and effects. However, because the term "causes and consequences of flooding" is so broad, it can be challenging to discuss all the topics and concepts that fall under it. In order to assess the opportunities and challenges of preventing flooding, as well as the organizational structure for flood mitigation, this study focused on assessing the main causes of flooding. In fact, gathering the necessary primary data has proven to be very challenging for the researcher. Challenges

included the refusal of the interviews with the chosen sample. To retain the paper's quality at its highest level, the researcher overcame the difficulties in some way. .

1.6 Significance of the study

The significance of this study lies in its potential to address the recurring issue of flooding in Addis Ababa and mitigate its adverse socioeconomic impacts. By pinpointing and comprehending the underlying causes and effects of flooding, the research aims to provide valuable insights for reducing and preventing future incidents.

The findings of this study will offer essential knowledge to a wide range of stakeholders, including local communities, governmental agencies, and non-governmental organizations. By understanding the dynamics of flooding in Addis Ababa, these stakeholders can develop informed strategies and interventions to enhance flood resilience and mitigate risks effectively.

Moreover, the study holds particular relevance for urban authorities in Addis Ababa, given the city's rapid growth and increasing vulnerability to natural hazards. The research findings will equip these authorities with the necessary information and knowledge to manage flood risks and ensure sustainable urban development.

Beyond Addis Ababa, the study's insights and recommendations can benefit other cities in Ethiopia facing similar challenges. By sharing best practices and lessons learned, this research contributes to broader efforts to enhance disaster resilience and urban planning across the country.

Finally, this study fulfills a requirement for the award of an M.Sc. degree in urban planning. By conducting rigorous research and producing valuable insights, the study contributes to the academic advancement and professional development of the researcher, while also offering practical benefits to the community at large.

1.7 Organization of the document

There are five chapters in this thesis. The backdrop of the study, the explanation of the problem, the aims and research questions, the relevance of the study, the scope and limitation of the investigation, and definitions of key terms are all included in Chapter One's general introduction to the thesis. The second chapter reviews relevant material and discusses several ideas that are pertinent to the topic. The third chapter, which addresses methodological concerns, includes discussions of the basic descriptions of the research field, the data sources and acquisition strategies, and the methodology for data analysis. The discussion and analysis of the study's processed primary and secondary data are also covered in the fourth chapter. The fifth chapter, which is the last, is devoted to conclusion and recommendation.

Chapter Two

2 LITERATURE REVIEW

2.1 The concept of flood

An extreme occurrence brought on by a natural phenomenon that seriously jeopardizes human life and means of subsistence is called a natural disaster. Natural processes in the atmosphere, hydrosphere, biosphere, or geosphere cause these occurrences (Glade, 2017).

When a flood's waters directly result from precipitation, atmospheric processes can be directly linked to the occurrence. That is, rainfall amounts occur that are significantly higher than what is typical for the afflicted area. Land that is often dry can only be impacted when those rainfalls are over average, which results in a flood. Thus, it is impossible to define the minimum amount of rainfall required to cause a flood. A precipitation event that results in flooding in one place could be quite normal for another place. In general, as a region's yearly average rainfall rises, so does the threshold for flood-producing rainfalls (Doswell, 2003).

In Sub-Saharan Africa, flooding is currently one of the biggest risks to cities. Urbanization is encouraged by the high demand for housing brought about by the high rate of natural increase in population and the migration toward cities. Many buildings are erected in flood-prone areas with inadequate or no design, frequently lacking proper infrastructure, particularly drainage systems. Due to this, they are quite vulnerable (Ramaramanana, 2021).

(Sinafikish, 2013) defined flooding as, flood is used in a broader sense to cover several river activities that causes damage that is inundation of floodplains and adjacent terraces, bank cutting, river channel shifting, and debris torrents during normally high discharge.

Floods are among disasters that cause widespread destruction to human lives, properties and the environment every year and occur at different places with varied scales across the globe. Flood disasters are caused by natural phenomena, but their occurrences and impacts have been intensified through human actions and inactions (Glago, 2021).

Flash floods- Flash floods are defined as floods that occur during or shortly after the precipitation that causes the rise of water. As a result, flash floods happen in tiny catchments where the drainage basin's response time is short. The likelihood of a flash flood is influenced by a variety of hydrological elements, including topography gradients, soil types, vegetation cover, human settlement, previous rainfall, and more. Even a relatively modest quantity of rainfall can cause flash flooding in areas with steep, rocky terrain or in densely populated areas. These hydrological

variables control how the catchment reacts to a precipitation event. A flash flood, then, is unmistakably the outcome of the combination of both hydrological and climatic conditions (Doswell, 2003).

Flash floods occur when there are rapid, intense downpours. A flash flood occurs when there is more rain than the earth or sewage system can hold. The excess water runs downhill. Although it can occur anywhere in the nation, low-lying areas with inadequate drainage are more likely to experience flash floods. These floods can occur kilometres distant from the location of a storm and can build in a matter of minutes (Korte, 2023).

There are instances where flash floods develop despite the absence of ideal thunderstorm conditions and substantial rainfall. Orographic precipitation is what happens when moist air is pushed higher over mountains by the wind flow. Heavy rainfall can occur when very wet air is forced upward. The rocky, steep topography also encourages quick runoff of the precipitation (Doswell, 2003).

The effects of flash floods on the economy, society, and environment are comparable to those of other types of "river floods." The main distinction is that the effects of flash floods are typically localized and happen quickly, often without much warning. However, because of their fast onset, flash floods can have catastrophic impacts and, depending on development and land use in the impacted basins, result in a significant loss of life (Petersen, 2001).

Several debris dam failure incidents could occur during a flash flood. While not all flash floods include a "wall of water," they are all, by definition, characterized by swiftly rising floodwaters. Flash flooding is more frequent in cities than in the rural areas surrounding a city because urbanized areas encourage runoff of rainfall rather than allowing the majority of the rain to be absorbed into the ground. A metropolis needs far less precipitation than a rural location of equivalent size to have a flash flood (Doswell, 2003).

River floods- The complicated phenomenon of river flooding can be impacted by shifts in the physical, terrestrial, climatic, and socioeconomic systems. Even though human encroachment into danger areas and an increase in the potential for damage in floodplains may be the primary reasons in many river basins, the observed changes are likely to be related to the climate (Kundzewicz, 2008). Unlike flash floods, river floods generally take days or even months to occur. This is due to the fact that they typically come from numerous separate rainfall episodes dispersed over many days and occur in enormous basins involving 'main stem' rivers like the Missouri or the Nile. In

actuality, multiple flash flood events may take place during a river flood event. Again, hydrological reasons frequently contribute to river floods, but they do not affect river floods as much as flash floods do. While isolated thunderstorm systems might result in flash floods, a stationary synoptic-scale weather pattern is more often the cause of river floods. Many times over a period of days or even months, localized significant rainfall storms occur, each adding their rainwater falls on the tributaries, which subsequently empty into a river's main stem. In reaction to all of the input rainfall, the river steadily rises. Concurrent snow melt and other factors other from rainfall can enhance the likelihood of a river flooding in a given situation (Doswell, 2003).

Coastal Floods

Tsunamis, storms, or extremely high tides could cause flooding in coastal areas. Additionally, long-term events like subsidence and sea level rise may contribute to the ocean's slow invasion. The most common causes of this type of flooding are storm surges and strong winds that coincide with high tides. Due to low air pressure, sea levels have risen, which is what caused the surge. In particular arrangements, such as large estuaries or enclosed marine areas, a combination of shall owing the seabed and delaying return flow amplifies the piling from water (Gumi, 2020).

Snowmelt floods

The spring thaw generates melt water flow in highland and high-latitude regions where significant snow accumulation occurs over the winter. Rapid temperature increases may speed up melting, which could result in floods that can reach lower reaches of river systems. If the thaw occurs during a period of intense rainfall, the severity of melt water floods will increase, and if the subsoil is still frozen, it could become even worse. Major snowfields in headwaters are a seasonal occurrence that might cause beneficial flooding in downstream places, but serious effects can happen on smaller scales, especially in areas prone to swings between cold and warmer rainy winter weather (Gumi, 2020).

Floods Arising from Non-precipitation Events- In addition to causing floods directly, there are numerous more ways that precipitation, even after it has fallen, can do so. There is a chance that dams that have been built to contain flowing water will collapse (Doswell, 2003).

Flood canal so arise through the melting of snow-fall. When the winter's snowpack is particularly thick, a sudden shift to mild conditions in the spring can cause exceptionally quick melting and runoff of the snowmelt. During eruptions, snow and ice deposits on volcanic summits may melt quickly. The subsequent flow, which frequently contains volcanic ash and is transformed into a

viscous sludge, roars down the mountainside and is known as alahar . Ice dams can form on rivers during the winter and late spring when ice can accumulate on them in frigid climes. As a result of the ice dams, the land upstream of them occasionally floods. Once the ice dam has broken up, a flash flood wave may surge downstream from the ice dam's location (Doswell, 2003).

Along the edges of the world's seas and even with big freshwater lakes, additional flood situations may arise. Large waves that break on the shallow water near the shore can flood the shorelines during tsunamis, which are often brought on by underground earthquakes and landslides. All types of storms, including tropical cyclones, have the potential to cause storm surges that flood shorelines when the storms are close to the land. Seiches, which are surges of water (often oscillatory) within confined bodies of water, can cause flooding on the borders of large lakes. Seiches can be brought on by atmospheric causes or earthquakes (Doswell, 2003).

Storm Floods-Due to strong onshore gusts, low air pressure, and occasionally high tides, storm surges flood coastal boundaries. Drag is caused by friction between the water and the moving air. Water can build up to depths of over 7 meters, depending on the distance over which this process (fetch) takes place and the wind speed. Storm surges are frequently brought on by hurricanes (tropical cyclones) and intense low-pressure systems. The storm surge brought on by the tropical cyclone accounts for nine out of ten fatalities (Gupta, 2022).

Dam and Levee Failures- In formerly flood-prone areas, dams and levees can open up development opportunities. However, as more development occurs in these same areas, the number of people whose livelihoods depend on the safe operation of dam and levee infrastructure increases. When dams and levees fail to provide the intended functions, such as flood protection, water supply, and hydropower, that is when they fail, according to engineering terminology. Failure thus refers to any flooding brought on by an uncontrolled or managed water flow that endangers people's lives, property, or way of life. Overtopping, breaching, structural collapse, leakage, damage to or failure of hydraulic control systems (e.g., gates and valves), disoperation, and operational decisions that purposely keep water levels high (in which case floods may result from controlled flow) are some of the modes of failure that cause flooding (Council, 2012).

Effects of Human Activities on Flooding

Moving into flood-prone areas entails hazards to life and property, but also frequently requires clearing the land of its original flora and changing the ground cover's features. Because plant and soil work together to store rainwater, when that vegetation is destroyed, rainfall runoff may

significantly rise. In locations where the land and its native flora have been destroyed (for either construction or cultivation), heavy rainfall is more likely to drain and pour into streams and rivers, increasing the risk of flash floods and river floods (Doswell, 2003).

Building and road construction both contribute to increased runoff and a rise in the likelihood of localized urban flooding. Regardless of previous rainfall, such construction significantly raises the portion of rainfall that runs off. In the headwater areas of streams and rivers, human-caused fires can also result in increases in the runoff potential, albeit only temporarily. It is clear that human activities are raising the likelihood of floods all over the planet (Doswell, 2003).

2.2 Causes and impacts of flooding

The most frequent disaster-causing danger, floods have caused widespread illness and mortality worldwide. The location and terrain of the area, as well as the built environment's features and human demography, all have a direct bearing on how floods affect human communities. (Weiwei Du, 2012).

The effects of a specific flood on one's health depend on the circumstances. Floods can cause hypothermia, injury, drowning, and animal attacks, among other urgent health effects. There are health hazards linked to patient evacuations, medical professional losses, and the destruction of medical infrastructure, which includes necessary medications and supplies. In the medium run, secondary effects of flooding include communicable infections, malnutrition, poisoning, infected wounds, injury sequelae, and poor mental health. Chronic illness, disability, poor mental health, and diseases associated with poverty, such as malnourishment, are possible long-term effects. (Weiwei Du, 2012).

Floods affect societies in many different ways that are not limited by time or place. While some of these effects are well-studied and readily apparent, others are more subtle, and less is understood about their intricate mechanisms and long-term consequences. The most obvious and immediate effect of floods is the physical harm that results from flooding coming into touch with property, cultural material, or people, which can inflict injuries or even result in fatalities. For a single event, as the floods in the Danube and Elbe watershed in Central Europe in 2002 and 2013, direct flood damage can reach billions of US dollars. The losses that happen outside of the flood event in location and time, like losses from business disruption, have more indirect economic ramifications. For example, the 2011 flood in Thailand caused a shortage of auto parts, which led to the closure of auto factories both inside and outside the flood zone (Philip Bubeck, 2017).

Transport networks facilitate the flow of people and goods, which supports economic activity. Transportation infrastructure may sustain direct or indirect damage during extreme weather events, endangering public safety and leading to serious disruptions with repercussions for the economy and society. Flooding is the main weather-related disruption to the transportation sector, particularly when it occurs as a result of heavy precipitation (Maria Pregolato, 2017)

Floods occur when soil and vegetation are unable to absorb rainwater. Additionally, floods can result from a river overflowing its banks and overflowing onto the floodplain. (Glago, 2020) Urbanization has also become a significant contributor to flooding in cities, making it more probable for a river to flood if its drainage basin is located in a city. In some metropolitan areas, poor drainage is a key contributor to floods, whereas in others, improper drainage system management is to blame. Flooding incidents have been linked closely to unplanned urban living in several emerging nations (Glago, 2020).

For instance, on June 3, 2015, Ghana saw possibly the worst flood in its history in Accra, the nation's capital, leaving 159 people dead and several others homeless. Flooding has emerged as Ghana's most significant disaster in recent years, especially in its metropolitan centers, where poor management of these places has made the country vulnerable to certain disasters (Glago, 2020).

Dehradun serves as an example of how places with inadequate housing stock and higher physical and social vulnerability are most negatively impacted. In fact, improper storm water drainage is a primary cause of flooding. Nevertheless, it is important to mention narrow streets and effective maintenance of any little infrastructure that is present. In the instance of Dehradun, it is evident that the low-lying districts are most vulnerable to the wrath of urban flooding, especially when these residents are unable to take pre-mitigation measures for their homes. In this scenario, the greatest amount of damage is likewise caused by encroachment in the seasonal rivers (Neha Bansal, 2015).

Multiple causes or conditions can result in excessive water flow in water bodies, but the main reason for flooding in Ethiopia's Rivers Basin is seasonal severe rainfall. In the Awash basin, Ethiopia, the issue of river flooding brought on by excessive rainfall for a brief period of time and the ensuing high river flow may be of major concern. The Awash River's floodplain extends to specific locations that are not typically covered in water during the main season (June, July, August, and September). Typically, the awash basin's low-lying, flat topographic features are where the river or flash flooding occurs. Extreme rainfall in the awash basin highlands leads to

floods downstream and ruins villages on the river's edge in all sections. The main cause of floods in Ethiopia is protracted, heavy rain, which causes rivers to overflow and flood lowland plains near the river banks (Gumi, 2020).

The most important factor in causing a flood is rain, but there are numerous additional ones as well. When it rains, a catchment's characteristics, especially its size, shape, and land usage, determine how much rainwater will end up in the waterways. Most rainfall enters waterways as flow because some of it is "captured" by soil and vegetation. The amount of water in a waterway depends on the size and shape of the river, the vegetation in and around the river, and consequently, the existence of constructions in and next to the canal (Gumi, 2020).

Disasterous floods have plagued Dire Dawa, Ethiopia's second-largest city, throughout its history. Unprecedented floods on August 6, 2006, had a disastrous effect on Dire Dawa's infrastructure, property, and human lives. In 2006, floods in Dire Dawa had such a devastating socioeconomic impact that it resulted in 244 missing persons, 256 deaths, and about 9956 displaced people. The business centers were also seriously damaged by the flood in 2006; the estimated total loss of properties for 123 licensed traders and 882 small-scale traders was 17146493 ET. Birr. Because of the cost of repair and restoration, the storm also had a significant effect on the city administration's financial base. While capital spending remained unchanged or even declined, the city's ongoing expenses for restoration and reconstruction rose by 43%. The total estimated damage caused by the flood to the city's agriculture, trade, and infrastructure sectors, both directly and indirectly, is approximately 97,368,634.36 ET birr (Alemu, 2014).

Urban flooding is an increasing cause of serious economic loss, social unrest, and housing inequity in a large portion of the United States. In older parts of communities, aging and frequently undersized infrastructure, an inability to maintain existing drainage systems, an increase in intense rainfall events, and disorganized watershed management are all factors that contribute to these increases in urban flooding (Marryland University, 2018).

If action is not taken to lessen their effects, the number of severe rainstorm events caused by extreme rainfall is increasing and will continue to worsen urban flooding. "Heavy downpours are increasing nationally, especially over the last three to five decades," the 2017 National Climate Assessment stated, "and increases in the frequency and intensity of extreme precipitation events are projected for all U.S. regions." (Marryland University, 2018).

Similar issues with urban flooding are being faced by communities around the country. However, because these communities have particular hydrological, physical, and social characteristics, it is important to develop solutions locally. Although the severity of urban flooding concerns warrants government oversight and assistance when necessary, primary responsibility must lie at the local level (Marryland University, 2018).

The most important factor in causing a flood is rain, but there are numerous additional ones as well. When it rains, a catchment's characteristics, especially its size, shape, and land usage, determine how much rainwater will end up in the waterways. Since soil and vegetation 'catch' some rainfall, the remaining amount enters streams as flow (Marryland University, 2018).

One type of natural calamity is a flood. However, human actions frequently alter the behaviour of floods. Activities within the catchment, such as removing land for farming, may increase the intensity of a flood, increasing the damage to properties and human lives. Large-scale floods that result from an act and are made worse by it are frequently included in a particular category. The main factors behind the rapid increase in river flow that produces floods are urbanization, draining of wetlands, and deforestation of forests. In addition to altering river flow patterns, reservoir construction can have a number of other detrimental effects that encourage flood (Gumi, 2020).

Urban locations with impermeable surfaces make flooding a bigger issue. High levels of urbanization in river flood plains and other areas of its watershed may also alter how frequently flooding occurs in a certain location. Once the affected urban area was reached, the predictability of flood flows was substantially lower because of the problems associated to impermeable surfaces, drainage systems, solid waste, debris, moveable assets, and therefore the locations of structure (Gumi, 2020).

Increases in rainfall and water levels cause issues when they overcome natural buffer zones and the typical carrying capacity of rivers. By making the system less adaptable to soaking up extra water, changes in how land is used might raise the risk of flooding. Any change in land use within a catchment has the potential to enhance urban flooding downstream (Gumi, 2020).

Inadequate solid waste management systems cause waste to block drainage channels, which increases flood risk. Climate change effects, such as sea level rise and an increase in extreme weather events. Hardening of catchment. Poverty, because poorer people are more exposed to flood risk and are more severely impacted when floods do occur. Poorly managed urbanization, especially the expansion of settlements into coastal and river floodplains (Lucas, 2020).

What flood catastrophes have in common is their capacity to produce significant economic loss, property damage, deaths, injuries, and great emotional suffering for entire communities. Flood catastrophes may also have an impact on infrastructure and property, agricultural endeavours, as well as historical and cultural monuments (Glago, 2020).

2.3 International trends in urban flood management

Engineered solutions, like drainage systems, dykes, and other flood defences, ecosystem-based strategies, like planting mangroves, flood proofing, and elevating buildings, as well as a variety of policy interventions relating to governance, land use planning and zoning, early warning systems, and solid waste management are all methods of managing flood risks (Lucas, 2020).

The rivers that flow through Ibadan, the capital of Oyo State in Nigeria, regularly overflow their channels into the nearby floodplains, causing catastrophic flooding. The main causes of flood danger in Ibadan are the dumping of solid waste, small bridges and culverts, and the expansion of vegetation along river channels (Lucas, 2020).

Adaptive co-management, or ACM, has come to light as a rather new governance strategy and possible remedy for the issues that are occurring. Adaptive co-management is dependent on certain institutional guidelines meant to improve management's capacity for flexibility by strengthening understanding of and reaction to the intricate details and unexpected aspects of social-ecological systems. According to the ACM literature, institutional structures should be polycentric, feature open and participatory governance, be in line with the scale of ecosystems (the bioregional approach), and involve a lot of experimentation in order to promote adaptation. The implementation of the four ACM prescriptions validated their efficacy as instruments to facilitate discursive transformation and present auspicious prospects for enhanced adaptive flood risk management. In a case study of the German Rhine, new policies that have strengthened the resilience of the basin have been enacted, creative concepts and guiding principles have been developed, and innovative flood risk reduction methods have been put into practice (Aerts, 2015). Floodwaters have damaged vital infrastructure, had an effect on the local populace, and interfered with Lagos's business operations. The state government and other stakeholders haven't done much to address the issue of flooding in the Lagos region, nevertheless, based on "current practice" in flood management and flood risk reduction in the context of "living with floods." Regretfully, pertinent information about flood occurrences is not easily accessible, and strategies for making a community resistant to flood risks have remained elusive. Current attempts to identify

vulnerability and simulate floods are essential prerequisites for more successful outcomes in tackling the concerns of flooding in the Lagos region and throughout Nigeria. In order to solve this issue, it is imperative that high-quality data sets—such as surface modeling and comprehensive demographic data—be made more widely available (Baily, 2016).

Nacala, Mozambique, is a heavily populated city with a deep-water harbor and a bustling port that is situated on a coastal inlet. Erosion and soil degradation provide a greater social, economic, and environmental risk. Erosion and soil degradation are now more of a menace to society, the economy, and the environment. The construction of shanties in high-risk areas without adequate drainage, the removal of trees and other natural vegetation cover, industrial development across drainage lines, urban development hardening the catchments, and steeply sloping terrain that accelerates surface runoff and increases the likelihood of erosion are all factors that increase the risk of flooding (Lucas, 2020).

The main priorities for Nacala were determined through a participatory risk assessment process to be reshaping and stabilizing drainage channels, constructing service roads next to drainage channels, lowering erosion risks, and lining drainage channels with drought-resistant plants like vetiver grass or elephant grass. In the less densely populated areas of the city's northern and eastern regions, interventions included re-vegetation, soil bunds, lining erosion gullies with rock bags, and creating recreational areas that could function as retention basins; in the denser inner city, interventions included rehabilitation of natural drains and streams, re-vegetation of embankments with native plant species to prevent gullies from erosion, construction of storm water detention ponds, and re-habiting of vacant (Lucas, 2020).

2.4 Policies, strategies and principles for urban flood management

Urban flood control strategies and plans all have one thing in common: they only concentrate on the hydraulic and engineering components of managing floods. This disregards the important biological, political, social, and environmental dimensions of flood control. Floods cannot really be prevented or controlled; thus, planners and practitioners should focus on increasing the population's resistance to flood threats (Tucci, 2007).

Urban flood control as an adaptable strategy involves a wide range of concerns and activities that are typically not taken into account in flood management, going much beyond the conventional, structural techniques. The hazard-based approach focuses on the capabilities and physical properties of technical, structural flood controls. According to this strategy, adaptation to climate

change entails matching design attributes and capabilities to anticipated precipitation and water levels. If physical modifications are not feasible or cost-effective, non-structural adaptive features may be investigated as a means of lowering residual risk. Structures may be fortified or improved to satisfy these new standards (Tucci, 2007).

The vulnerability-based approach, which aims to lessen the vulnerabilities of the affected population, takes into account the community's resource needs, economic activity in the area, level of development, frequency, and intensity of flooding, as well as the use of land and the land itself. Policies for economic development and community improvement, which are typically outside the purview of flood control policies and plans, might enhance circumstances of vulnerability (Tucci, 2007).

The policy-based approach focuses on creating long-term national or regional action plans (addressing planning and finance, education, health, agriculture, food security, environment, and emergency response), which serve as the foundation for action at the local (urban) level through participation of community groups, civil society organizations, and the private sector (Tucci, 2007).

Three phases comprise a framework for developing strategies to deal with urban flooding: a process to identify potential flood mitigation measures, accounting for regional limitations and environmental factors; an analysis of adaptive and optimal strategies integrating hydrodynamic models and multi-objective optimization; the definition of long-term adaptation pathways; and a method for choosing amongst adaptive strategies and measures by assessing and integrating multiple benefits and multi-functional landscape development (taking into account location, implementation times, and design of selected measures in the urban space) (Alida Alvesa & Vojinovic, 2016).

A comprehensive flood control system that boosts urban resilience to adapt to shifting risks. A vibrant civil society is necessary, but so is efficient urban water governance. Understanding that cities are urban socio-ecological systems is vital in order to collaboratively develop multifunctional solutions for the intricate problem of flood protection in highly populated metropolitan regions (Sørensen, et al., 2016).

The impact of climate change on precipitation patterns may increase the susceptibility of urban infrastructure to flooding. Strategies for mitigating flooding must be created so that people, activities, or other infrastructure are not jeopardized in the event of an infrastructure breakdown.

An emerging paradigm known as "safe-to-fail" broadly characterizes adaptive scenarios in which infrastructure failure is permitted but the effects of the failure are controlled or minimized. Infrastructure is typically created to be "fail-safe" when they offer strong defence when the hazards are precisely estimated and fall within a planned safety factor. However, the "fail-safe" paradigm needs to be questioned because the risks and uncertainties facing urban infrastructure are growing significantly as a result of climate change. A multi-criteria decision analysis analytic hierarchy process algorithm is used in this framework to evaluate possible flooding solutions based on various infrastructure resilience features, prioritizing "safe-to-fail" and "fail-safe" options based on stakeholder preferences (Yeowon Kim, 2017).

The storm water system can now handle local runoff levels as a result of this improvement. The performance of the combined sewer system has improved as a result of the installation of this system, as has local storm water management. Nearly all of the storm water that used to drain into the combined system is now insignificant, and it now drains nearly exclusively wastewater. This kind of integrated planning considers not only the results of reducing flood risk but also their economic and environmental effects (Tucci, 2007).

2.5 Analytical Framework of the Study

The DPSIR framework appears to be the best suitable analytical framework for this study. The various interactions between the causes and effects of flooding are important to demonstrate for the purposes of flood study.

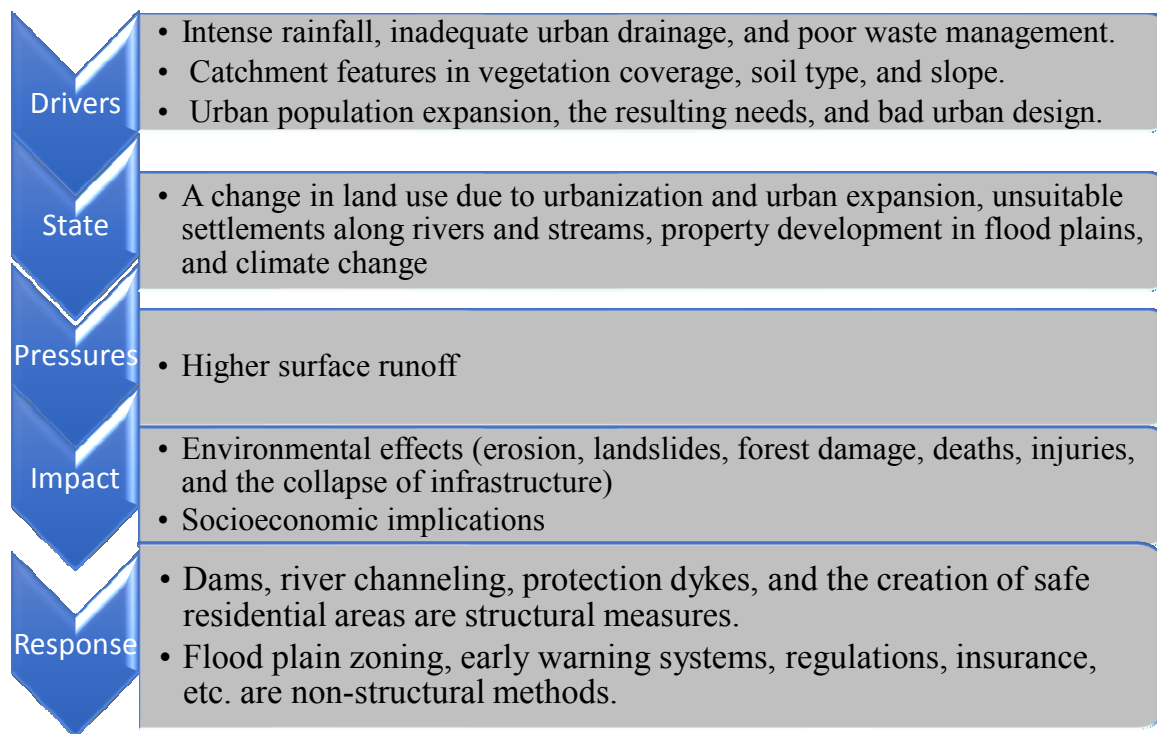


Figure 1. DPSIR framework for Flood assessment

Chapter Three

3 MATERIALS AND METHODS

3.1 Description of the Study Area

The focal point of this research encompasses Addis Ababa, the capital city of Ethiopia. Established in 1886, it stands as one of Africa's most ancient and sprawling metropolises, boasting a population that has burgeoned to approximately four million residents. At an elevation averaging 2,400 meters above sea level, it also holds the distinction of being one of the world's highest cities (Un-Habitat, 2008).

According to the 2007 census conducted by the Central Statistical Agency (CSA, 2007), Addis Ababa's population at the time was recorded at 3,384,569. Considering the city's remarkable population growth trajectory, extrapolations for the year 2019 estimate a staggering 7.8236 million inhabitants, yielding a population density of approximately 5,165 individuals per square kilometer.

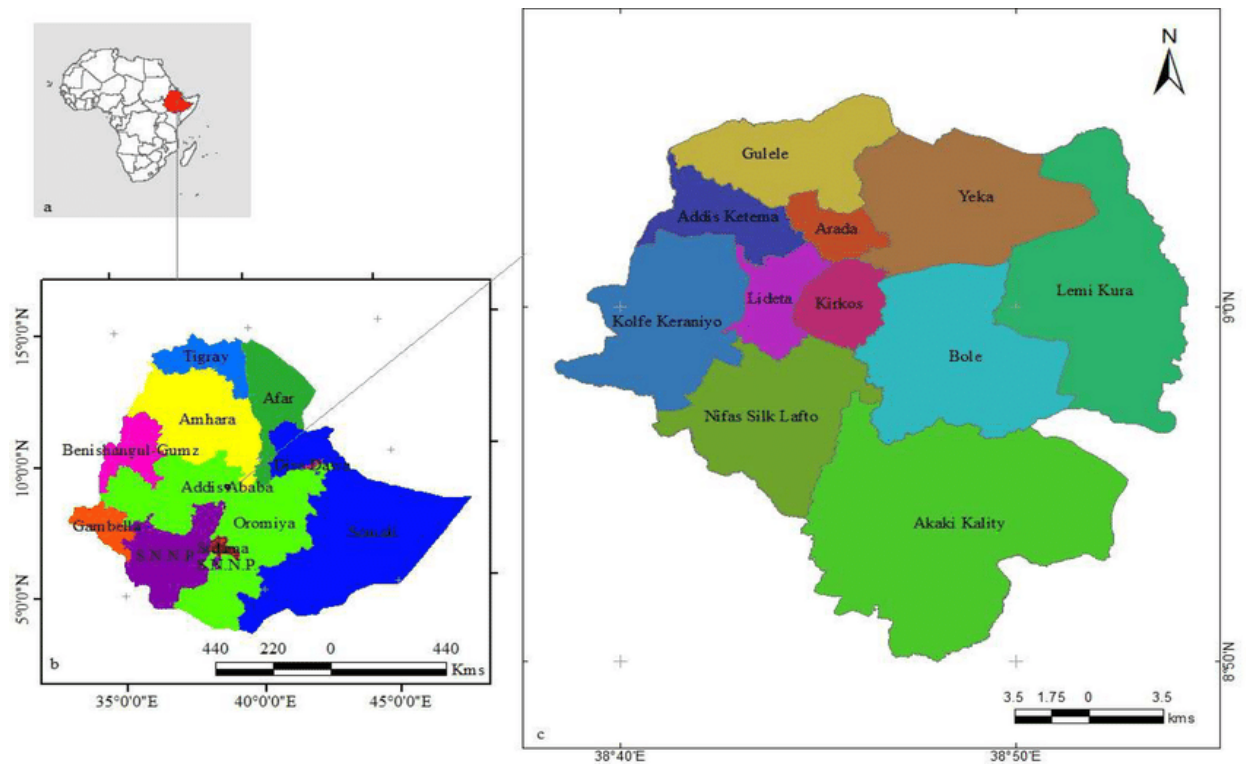


Figure 2. Location map of Addis Ababa city

3.1.1 Topography

The name 'Addis Ababa' originates from the Amharic language, signifying "new flower." This sprawling urban landscape spans a total surface area of 54,000 hectares and is geographically

positioned at 9° 2' N, 38° 42' E. Addis Ababa resides within a unique highland climate zone characterized by its lofty altitude, which exerts a tempering influence on temperatures throughout the year. Its proximity to the equator further ensures minimal temperature variations from month to month (Dubbale, 2010).

3.1.2 Climate

In the Ethiopian context, the city of Addis Ababa experiences a mild and temperate climate, characterized by summers (from June to September) that bring higher rainfall, in contrast to the relatively drier winters (from December to February). This climate classification aligns with an Oceanic Subtropical Highland Climate. The average temperature hovers around 16°C, with mean maximum and minimum temperatures ranging between 22.9°C and 10.2°C respectively. This elevated rainfall is chiefly attributed to intense precipitation during the months of July to September (Addis Ababa resilience project office, 2021).

A historical analysis of rainfall and temperature data spanning the past three decades revealed that Addis Ababa has undergone periods of both aridity and excessive precipitation. Rainfall exhibited a significant upswing between 2005 and 2010, whereas the 1980s recorded levels consistently below the average. The total annual precipitation fluctuated, with a low of 929.4 mm in 1999 to a high of 1567.9 mm in 1993, averaging 1230.3 mm annually during the preceding three decades (Kahsay, 2016).

Climatic data compiled by Ethiopia's National Meteorological Agency covering the period from 1981 to 2010 indicated mean annual temperatures of 23.3°C and 10.7°C for maximum and minimum temperatures, respectively, within Addis Ababa. While temperature and rainfall patterns are subject to variances contingent on elevation and prevailing wind patterns, climate projections anticipate no substantial alterations in rainfall seasonality, save for minor monthly fluctuations. Concurrently, seasonal temperatures are projected to rise by 1.5–2°C (Lindley, 2015).

Considering the projected rise in seasonal temperatures, it becomes imperative to assess the potential implications for future flood risk in Addis Ababa. Higher temperatures may exacerbate precipitation patterns, leading to more intense rainfall events and increased surface runoff, which could in turn elevate the likelihood of flooding.

3.1.3 Vegetation

Historically, Addis Ababa was enveloped in native, indigenous flora, encompassing the Afro-montane forest and woodland ecosystems. Indigenous tree species such as *Juniperus procera*, *Olea europaea* subsp. *cuspidata*, *Podocarpus falcatus*, *Hygnia abyssinica*, and *Erica arborea* once dominated the natural forest landscapes at altitudes surpassing 3,000 meters above sea level (Yeshitela, 2015).

However, the advent of urbanization and a burgeoning population at the turn of the 20th century precipitated a significant decline in woody vegetation. The exploitation of woody vegetation for construction and fuelwood became prevalent among city dwellers and local farmers in the vicinity (Kahsay, 2016).

At present, only a scant few remnants of natural forest persist, with exotic species, particularly *Eucalyptus*, prevailing. Furthermore, aside from peri-urban forests situated on the city's periphery, Addis Ababa is adorned with limited urban parks, riverfront greenery, and street-side tree canopies that collectively form its designated green spaces (Yeshitela, 2015).

3.1.4 Population

Addis Ababa, positioned as one of Africa's fastest-growing urban centers, currently harbors more than 4.7 million residents, with a notable skew towards a higher female population. As Ethiopia's largest city, it maintains a remarkable annual growth rate of 3.8%, earning it a place among the world's swiftest urbanizing locales. Projections indicate that by 2030, the city's populace is poised to surge to over 7.3 million individuals. Notably, the central districts of Addis Ketema, Arada, and Lideta exhibit a particularly dense concentration of inhabitant (Addis Ababa resilience project office, 2021).

Adding to its dynamism, Addis Ababa boasts a substantial youth demographic, partly attributed to robust rural-to-urban migration and internal displacements. Approximately 11% of the city's residents fall below the age of 5, while a striking 58% of the population is under 30. Despite Ethiopia's recognition as one of Sub-Saharan Africa's rapidly expanding economies, its youth contend with multifaceted challenges, including poverty, unemployment, recurrent droughts, political turbulence, ethnic conflicts, food and water scarcity, displacement, and migration, among others (Addis Ababa resilience project office, 2021).

Furthermore, Addis Ababa holds the distinction of housing a quarter of Ethiopia's urban population and stands as a pivotal driver of the nation's aspirations to attain middle-income status, carbon

neutrality, and economic resilience by 2025. The city's economy displays impressive annual growth, boasting a contribution of approximately 50% to the national GDP, underscoring its indispensable role in Ethiopia's overall economic advancement (World Bank, 2015).

3.2 Type and source of data

In this study, a combination of primary and secondary data sources were employed to gather comprehensive information. Primary data was acquired through key informant interviews, focus group discussions, and field observations. To investigate the subject matter, secondary data was also utilized, obtained through an extensive review of existing literature, as well as an analysis of relevant policies and the master plan of Addis Ababa.

To address the research inquiries pertaining to the institutional and governance framework responsible for urban flood management within the city, a set of structured and semi-structured questionnaires were meticulously developed. These questionnaires served as valuable tools in eliciting the required information.

For the key informant interviews, representatives from various government organizations were carefully chosen. Their involvement was pivotal in ensuring a well-rounded perspective. Moreover, these representatives actively participated in the focus group discussions, aiming to shed light on any concerns or queries raised by members of the local communities.

Throughout these discussions, a semi-structured question catalogue was presented to guide the conversation. Subsequently, the findings from these interactions were qualitatively summarized, allowing for a comprehensive analysis of the data collected.

3.3 Data collection techniques

In this research, a combination of data collection techniques were employed to ensure a comprehensive understanding of the topic. The primary method utilized was key informant interviews conducted with institutions involved in urban flood management at the city level, specifically within the jurisdiction of Addis Ababa.

The selection of these institutions was carried out through purposive sampling, a non-probability sampling technique. This approach allows the researcher to use their judgment to select samples who possess knowledge about the subject under investigation. To ensure the selection of appropriate participants, the researcher conducted a thorough evaluation of the candidates, taking into account their positions and expertise. This step was crucial in guaranteeing that the chosen informants could provide valuable insights into the study's purpose.

To conduct these interviews, regulatory bodies and implementers responsible for urban flood management plans in the city were identified. Each selected institution designated an expert as a key informant, representing their organization. Two key informants, one who work on administration and other is expert from each institution were appointed for the interviews, encompassing both administrative and expert perspectives. The interviews were structured around semi-structured questions, providing a framework for the conversation. However, the discussions also remained open to address any pertinent issues raised by the respondents. The list of organizations approached for key informant interviews includes:

- Addis Ababa Water and Sewerage Authority (AAWSA): An integral municipal organization dedicated to the sustainable provision of potable water to Addis Ababa's urban population. Additionally, AAWSA is responsible for the collection and treatment of liquid waste.
- Addis Ababa Road Authority: A city-level institution tasked with safeguarding roads and drainage systems against flood-related challenges.
- Addis Ababa Rivers and Riversides Development and Climate Change Adaptation Project Office: An office dedicated to projects related to the development of rivers and riversides, with a specific focus on climate change adaptation.
- Fire and Disaster Risk Management Commission under the Addis Ababa city administration: An organization responsible for managing fire and disaster risks within the city.

Following the key informant interviews, focus group discussions were conducted. These discussions were organized in small groups, consisting of six individuals from each representative institution. Additionally, site observations were carried out in flood-prone areas to further complement the data collection process.

In addition to primary data, secondary data was also reviewed to provide a comprehensive context for the research. The documents scrutinized as secondary data sources include:

- Urban Planning Proclamation no 547/2008
- Structural Plan of Addis Ababa (2017 – 2027)
- National Policy and Strategy on Disaster Risk Management (2007)

These secondary data sources offered valuable insights and background information essential for the research's analytical framework.

3.4 Data analysis

In the process of data analysis,

Thematic analysis was conducted to identify and explore key themes related to flood risk factors in Addis Ababa. Data sources included qualitative data from literature review, interviews, and field observations. Relevant text segments were extracted and coded based on recurring concepts and ideas related to flood risk factors. Themes were identified through inductive reasoning, grouping similar codes into overarching themes such as Land Use Change, Poor Drainage System, Climate Change, and Interconnections. Sub-themes were developed under each major theme to capture specific aspects contributing to flood risk, supported by examples extracted from the data. Quantitative data on vulnerable areas categorized by region were collected from field surveys, satellite imagery, and government reports.

Quantitative vulnerability assessment results were triangulated with qualitative insights on flood risk factors and mitigation efforts to provide a comprehensive understanding. Findings from both approaches were synthesized to identify commonalities, discrepancies, and interrelationships between spatial patterns of vulnerability and underlying causes of flooding. By integrating quantitative and qualitative data, a holistic view of flood risk management efforts in Addis Ababa emerged, emphasizing the need for targeted interventions and collaborative approaches.

Findings from thematic analysis, spatial vulnerability analysis, and integration of methods were synthesized to discuss the implications of flood vulnerability, underlying causes, and mitigation strategies. Identified themes, spatial patterns, and interconnections were discussed in relation to the broader context of flood risk management in Addis Ababa, emphasizing the importance of proactive measures and collaborative efforts.

The data analysis culminated in summarizing the key findings related to flood vulnerability, causes, mitigation strategies, strengths, weaknesses, and recommendations for action.

The implications of the findings on policy development, urban planning, community engagement, and infrastructure improvement were discussed to inform evidence-based decision-making and promote sustainable flood risk management practices in Addis Ababa.

Chapter Four

4. RESULT AND DISCUSSION

Addis Ababa, the vibrant capital city of Ethiopia, faces increasing challenges related to flood vulnerability due to various environmental, urban development, and climatic factors. Understanding the multifaceted nature of flood risk is crucial for effective mitigation and adaptation strategies. In this section, I present the results of a thematic analysis that explores the interconnected factors contributing to flood vulnerability in Addis Ababa. Through the lens of land use change, poor drainage systems, and the impacts of climate change, this analysis sheds light on the complex dynamics shaping flood risk within the city. By examining the interactions between these factors, I aim to provide insights that can inform evidence-based policies and interventions to enhance flood resilience and mitigate the impacts of flooding in Addis Ababa.

4.1. Thematic Analysis of Flood Risk Factors

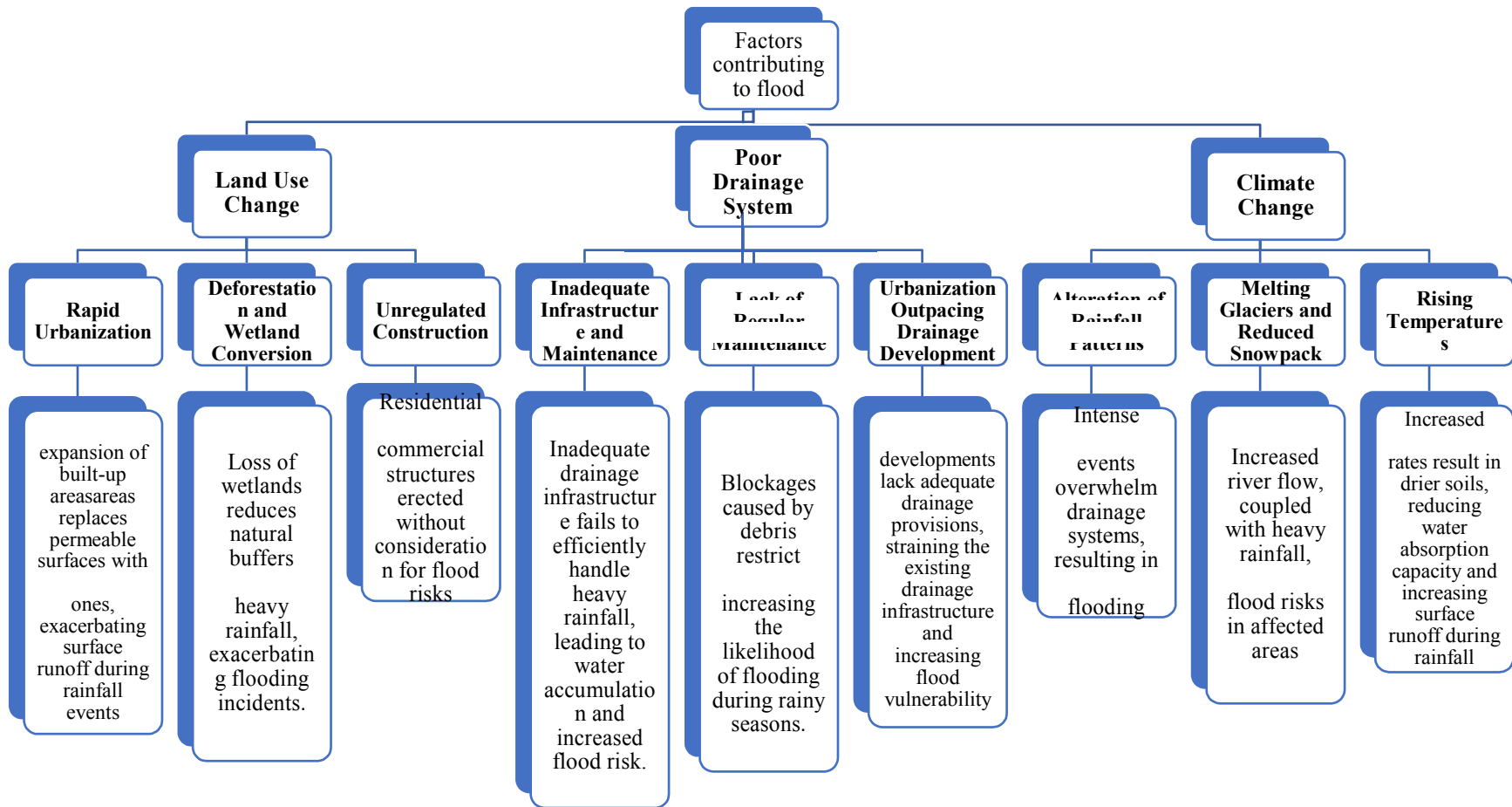


Figure 3. Factors Contributing to flood Vulnerability in Addis Ababa

Cross-cutting Theme: Interconnections: The interconnections between land use change, poor drainage systems, and climate change exacerbate flood risks.

- **Description:** The interplay between rapid urbanization, inadequate drainage infrastructure, and climate change amplifies flood vulnerabilities in Addis Ababa.
 - *Example:* Rapid urbanization exacerbates poor drainage and loss of natural water absorption areas, intensifying flood risks amid changing climatic conditions.

This thematic analysis underscores the multifaceted nature of flood risk factors in Addis Ababa, highlighting the need for integrated and adaptive flood management strategies to mitigate the growing threat of flooding in the city.

4.2. Existing institutional frameworks and policies

This integrated result study presents a comprehensive analysis of flood mitigation and disaster risk reduction efforts in Addis Ababa, integrating qualitative insights with quantitative data. The analysis aims to provide a holistic understanding of institutional frameworks, existing policies, strengths, weaknesses, and policy effectiveness in addressing flood risks and enhancing resilience in the city.

4.2.1 Institutional frameworks

Roles and Responsibilities: The data highlights several key institutional frameworks responsible for flood prevention and disaster risk reduction in Addis Ababa. These include the Addis Ababa City Disaster Risk Management Commission (AACDRMC), City Master Plan, Environmental Protection Authority (AAEPA), Roads Authority (AACRA), Water and Sewerage Authority (AAWSA), and City Planning and Development Management Bureau. Each institution has distinct roles and responsibilities, such as policy development, infrastructure planning, environmental protection, and community engagement.

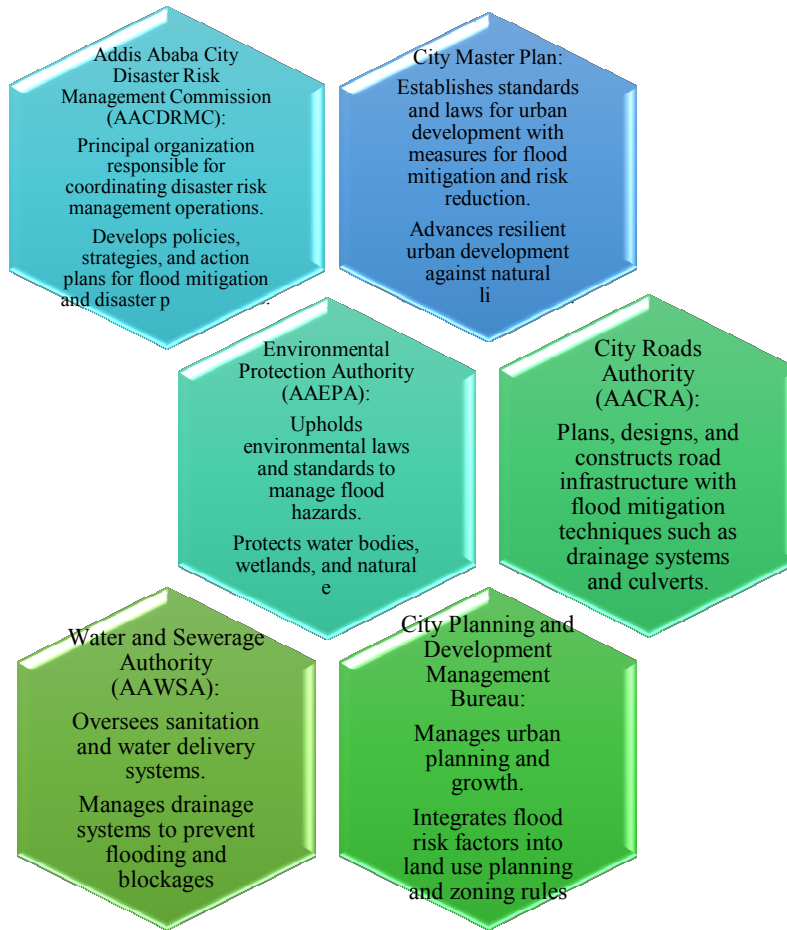


Figure 4. Institutional Frame Work

Coordination and Collaboration: The data emphasizes the importance of coordination among these institutions to effectively manage flood risks. The AACDRMC serves as the coordinating body, facilitating collaboration between government agencies, stakeholders, and communities involved in disaster risk management operations.

4.2.2 Existing policies

Policy Landscape: Addis Ababa has established various policies and regulations aimed at reducing flood risks and enhancing disaster resilience. These policies cover a wide range of areas, including flood risk management, urban development, building codes, environmental protection, disaster preparedness, land use planning, and early warning systems.

Policy Objectives: The policies aim to promote sustainable development, community participation, infrastructure resilience, and environmental preservation. They emphasize the

importance of incorporating disaster risk reduction into urban planning, infrastructure development, and community engagement processes.

Quantification of Policy Types: This table quantifies the frequency of different policy types related to flood mitigation and disaster risk reduction in Addis Ababa. It provides an overview of the diversity and distribution of policies addressing various aspects of flood risk management and resilience-building in the city.

Table 1. Quantification of Policy Types

Policy Type	Frequency
Flood Risk Management Policy	1
Urban Development Policy	1
Building codes and standards	1
Environmental Protection Policy	2
Disaster Preparedness and Response Policy	1
Regulations for Land Use and Zoning	1
Disaster Risk Management Policy for Addis Ababa	1
Floodplain Management Policy	1
Policy governing flood early warning system	1
Policy addressing climate change adaptation	1

The quantification of policy types reveals the presence of diverse policies aimed at managing flood risk and enhancing disaster resilience in Addis Ababa. While the frequency of policies varies across different areas of focus, their collective presence underscores the city's commitment to addressing the multifaceted challenges posed by floods and disasters. Moving forward, continued efforts to implement, monitor, and adapt these policies will be essential for promoting sustainable development and safeguarding the well-being of the city's residents.

Policy Effectiveness Ratings:

This table presents the effectiveness ratings assigned to each policy based on criteria such as clarity of objectives, implementation success, community impact, and adaptation to changing conditions.

It offers insight into the perceived effectiveness of individual policies in achieving their intended objectives and contributing to overall flood mitigation and disaster risk reduction efforts.

Table 2. Policy Effectiveness Ratings

Policy	Effectiveness Rating
Flood Risk Management Policy	4
Urban Development Policy	3
Building codes and standards	4
Environmental Protection Policy	3
Disaster Preparedness and Response Policy	4
Regulations for Land Use and Zoning	3
Disaster Risk Management Policy for Addis Ababa	4
Floodplain Management Policy	3
Policy governing flood early warning system	5
Policy addressing climate change adaptation	3

The effectiveness ratings provided in the table are typically assigned by experts or stakeholders involved in flood mitigation and disaster risk reduction efforts in Addis Ababa. These ratings determined through expert opinions based on their knowledge and experience in the field. It's important to ensure that the individuals assigning the ratings have relevant expertise and knowledge of the policies and their implementation context in order to provide accurate assessments of effectiveness.

The effectiveness ratings are assigned based on the perceived impact and success of each policy in achieving its intended objectives. The ratings are interpreted as follows:

- **Rating 5:** Highly Effective - The policy demonstrates exceptional clarity of objectives, successful implementation, significant positive impact on the community, and high adaptability to changing conditions.
- **Rating 4:** Effective - The policy is well-defined with clear objectives, has achieved successful implementation with positive community impact, and demonstrates good adaptability to changing conditions.

- **Rating 3:** Moderately Effective - The policy has clear objectives and has been moderately successful in implementation, with some positive impact on the community and moderate adaptability to changing conditions.
- **Rating 2:** Ineffective - The policy lacks clarity of objectives and has been minimally successful in implementation, resulting in limited impact on the community and poor adaptability to changing conditions.
- **Rating 1:** Highly Ineffective - The policy lacks clear objectives, has been largely unsuccessful in implementation, and has had negligible impact on the community with poor adaptability to changing conditions.

The effectiveness ratings provide valuable insights into the performance of policies related to flood mitigation and disaster risk reduction in Addis Ababa. By understanding the strengths and weaknesses of each policy, stakeholders can identify areas for improvement and refine strategies to enhance overall effectiveness in addressing flood risks and building resilience in the city. Ongoing evaluation and adaptation of policies will be crucial for ensuring continued progress towards sustainable flood management and disaster risk reduction in Addis Ababa.

4.2.3 Strengths and weakness



Figure 5. Strengths and weakness

4.3 Current flood prevention and mitigation measures

4.3.1 Flood vulnerable areas, cause of vulnerability and measurement taken

The analysis of flood vulnerability in Addis Ababa, incorporating both quantitative and qualitative approaches, revealed multifaceted insights into the distribution of flood risk, underlying causes, and mitigation efforts across the city

Quantitative Analysis: A quantitative assessment revealed a total of 67 areas identified as vulnerable to flooding within Addis Ababa. These areas were categorized by region, with the highest concentration of vulnerable areas observed in the West region (37 areas), followed by South (11 areas), North (10 areas), Central (7 areas), and East (2 areas). This distribution provides valuable information regarding the geographic spread of flood risk within the city.

Table 3. Identified flood vulnerable areas

Number	Region (Parts of the City)	Number of Flood risk Areas
1	Western Addis Ababa	37
2	Southern Addis Ababa	11
3	Northern Addis Ababa	10
4	Central part of Addis Ababa	7
5	Eastern Addis Ababa	2
	Total	67

The following table shows the locations of the vulnerable areas in the districts where they are located. The table is based on the old zoning of the city.

Table 4. Division of flood vulnerable area by Sub-city

Number	Region	Sub-city	Flood risk
1	Central	Arada	7
2	North	Yeka	4
		Gulele	6
3	East	Bole and lemikura	2
4	West	Addis ketema	17
		Kolfekeranio	20
5	South	Akkaikality	10
		Nifasselklafto	1
		Total	67

Qualitative Content Analysis: Qualitative content analysis elucidated several key themes related to the causes of flooding and the corresponding solutions being implemented. Common causes identified included land splits along rivers, inadequate drainage infrastructure, construction on slopes, proximity of houses to rivers, and blockages in pipes and roads. To address these issues, solutions such as building support walls, constructing adequate drainage canals, making houses flood-resistant, and ensuring the maintenance of drains were proposed. Additionally, challenges in flood risk management were identified, including accessibility issues, laborious tasks for individuals, and unresolved issues requiring further attention. **Integration of Methods:** The integration of quantitative and qualitative analyses provided a comprehensive understanding of flood risk in Addis Ababa. The quantitative assessment identified the extent of vulnerability across different regions, while the qualitative analysis shed light on the underlying causes, mitigation efforts, and challenges faced. By triangulating findings from both approaches, a holistic view of flood risk management efforts emerged, highlighting the need for targeted interventions and collaborative approaches to mitigate flood risk effectively.

Discussion of Findings: The findings underscore the importance of proactive measures to address flood vulnerability in Addis Ababa, particularly in light of increasing urbanization and climate change impacts. Collaborative efforts involving government agencies, stakeholders, and communities are essential for implementing effective flood risk management strategies. Furthermore, the identification of vulnerable areas and the underlying causes of flooding provide valuable insights for prioritizing interventions and allocating resources efficiently.

4.4 Proposed integrated strategies

This research aimed to analyse strategies for flood risk reduction and urban resilience enhancement in Addis Ababa, with a focus on sustainable urban planning, community participation, and environmental conservation. Through content analysis of relevant data, key themes, strengths, weaknesses, and recommendations for action were identified to inform evidence-based decision-making and policy development.

Table 5. Proposed Integrated Strategies

Key Themes	Quantification	Relationships between Themes	Strengths	Weaknesses	Recommendations for Action
1. Sustainable Urban Planning	Frequently mentioned	Intersects with Environmental Conservation through incorporation of green infrastructure	Emphasis on sustainable urban planning and community participation	Challenges in infrastructure maintenance and limited financial resources	Strengthen coordination between government agencies and local communities; Allocate sufficient resources for infrastructure improvement
2. Community Participation	Frequently mentioned	Essential for successful implementation of sustainable urban planning initiatives	Emphasis on sustainable urban planning and community participation	Challenges in infrastructure maintenance and limited financial resources	Enhance public awareness and education programs to promote community participation
3. Environmental Conservation	Highlighted multiple times	Intersects with Sustainable Urban Planning through green infrastructure	Emphasis on sustainable urban planning and community participation	Challenges in infrastructure maintenance and limited financial resources	Strengthen coordination between government agencies and local communities; Allocate sufficient resources for infrastructure improvement
4. Infrastructure Improvement	Mentioned less frequently	Critical for managing excess water during heavy rainfall	Emphasis on sustainable urban planning and community participation	Challenges in infrastructure maintenance and limited financial resources	Allocate sufficient resources for infrastructure improvement; Enhance public awareness and education programs to promote community participation
5. Institutional Capacity Building	Mentioned less frequently	Critical for coordinating and implementing community-led initiatives and effective response	Emphasis on sustainable urban planning and community participation	Challenges in infrastructure maintenance and limited financial resources	Strengthen coordination between government agencies and local communities; Allocate sufficient resources for infrastructure improvement

Chapter Five

5 CONCLUSION AND RECOMMENDATION

5.1 Conclusion

After conducting a comprehensive analysis of flood risk factors, institutional frameworks, policies, existing flood prevention measures, and proposed strategies for flood risk reduction and urban resilience enhancement in Addis Ababa, several key conclusions can be drawn.

Comprehensive Understanding of Flood Risk: The integration of quantitative and qualitative analyses provided a nuanced understanding of flood risk in Addis Ababa. The quantitative assessment identified vulnerable areas across different regions, while the qualitative analysis illuminated the underlying causes, mitigation efforts, and challenges faced.

Multifaceted Nature of Flood Risk Factors: Findings from thematic analysis, qualitative content analysis, and institutional frameworks highlight the multifaceted nature of flood risk in Addis Ababa. Factors such as rapid urbanization, inadequate drainage infrastructure, land use change, and climate change impacts contribute to the city's vulnerability to flooding.

Need for Collaborative Approaches: Addressing flood risk in Addis Ababa requires collaborative efforts involving government agencies, stakeholders, and communities. The identification of vulnerable areas, underlying causes, and proposed solutions underscores the importance of integrated and coordinated approaches to flood risk management.

Importance of Proactive Measures: Proactive measures are essential to mitigate flood risk and enhance urban resilience in Addis Ababa. Sustainable urban planning, community participation, environmental conservation, infrastructure improvement, and institutional capacity building emerge as key strategies for flood risk reduction.

Challenges and Opportunities: While challenges such as limited coordination among agencies, inadequate infrastructure, and financial constraints exist, there are opportunities for improvement. Strengthening coordination, allocating resources, enhancing public awareness, integrating sustainable urban planning, and investing in environmental conservation can address these challenges and enhance resilience to floods.

In conclusion, the integrated analysis provides valuable insights into flood risk factors, existing institutional frameworks, policies, and proposed strategies for flood risk reduction and urban resilience enhancement in Addis Ababa. By adopting collaborative approaches, implementing proactive measures, and addressing challenges, the city can effectively mitigate flood risk, protect

its residents and infrastructure, and build a more resilient future amidst increasing urbanization and climate change impacts.

5.2 Recommendation

By implementing the following recommendations and embracing an integrated approach that melds sustainable urban planning, community participation, and environmental preservation, Addis Ababa can decisively diminish flood risks and fortify urban resilience. In so doing, the city will not only hew to its master plan but also adhere to global norms and standards in disaster risk reduction, fashioning a future characterized by sustainability and resilience for both the city and its riversides. Based on the findings the key recommendations include:

Integrated Flood Planning and Infrastructure: Prioritize integrated urban planning that includes flood risk mitigation in land use policies and invest in drainage infrastructure to manage excess water.

Climate-Resilient Infrastructure: Develop climate-resilient infrastructure, including flood-resistant designs and sustainable water management, to adapt to changing precipitation patterns and climate-induced flood risks.

Community Engagement and Awareness: Engage communities in flood risk awareness, early warning systems, and evacuation planning to protect vulnerable populations.

Regulatory Enforcement: Strengthen enforcement of building codes and land use regulations, penalizing violations and preventing construction in flood-prone areas.

International Collaboration and Funding: Collaborate with international organizations to secure financial support and align with global disaster risk reduction standards and practices.

Preservation of Natural Ecosystems: Protect and restore crucial natural ecosystems like wetlands and forests to enhance flood control and maintain sustainable land management practices.

Capacity Building and Training: Enhance the capabilities of regional institutions involved in emergency readiness and response through focused training initiatives and collaboration with stakeholders.

Comprehensive Flood Risk Assessment: Conduct a comprehensive evaluation of flood risk, considering topography, rainfall trends, and drainage systems to prioritize mitigation efforts effectively.

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APPENDIX

Appendix 1: Publishable Article

Managing urban flooding, their execution, and difficulties in Addis Ababa, Ethiopia

Betelhem Shimelis

Addis Ababa University, Ethiopian Institute of Architecture, Building Construction and City development (EIABC), Department of Urban Planning, Addis Ababa, Ethiopia

Email: shimelisbeta45@gmail.com

Abstract

Urban flooding poses significant challenges to cities worldwide, and Addis Ababa, the capital city of Ethiopia, is no exception. As urbanization accelerates and climate change impacts become more pronounced, understanding and effectively managing flood risk in Addis Ababa are imperative for ensuring the city's resilience and sustainable development. This study aims to develop a comprehensive framework for urban flood risk management in Addis Ababa, integrating urban planning, environmental sustainability, and disaster risk reduction strategies.

Primary data collection involved key informant interviews (KII), focus group discussions, and field observations, supplemented by secondary data obtained from online sources and relevant organizations. The collected data were analyzed using both qualitative and quantitative methods. Qualitative data from KII and focus group discussions were thematically analyzed to identify key factors influencing flood risk and the effectiveness of existing institutional frameworks and policies. Additionally, quantitative data were presented and interpreted using tables, graphs, and charts to visualize trends and patterns in flood vulnerability, institutional strengths and weaknesses, and policy effectiveness.

Findings reveal that Addis Ababa's institutional frameworks for flood mitigation and disaster risk reduction are governed by entities such as the Addis Ababa City Disaster Risk Management Commission (AACDRMC), the City Master Plan, the Environmental Protection Authority (AAEPA), the City Roads Authority (AACRA), and the Water and Sewerage Authority (AAWSA). Existing policies encompass flood risk management, urban development, building codes, environmental protection, disaster preparedness, and land use regulations.

Advantages of Addis Ababa's current institutional structures and policies include collaboration and coordination, a robust regulatory framework, environmental protection measures, and capacity building. However, weaknesses persist, including inadequate infrastructure, limited public engagement and awareness, inconsistent enforcement of regulations, and insufficient financial resources.

Based on these findings, key recommendations include the implementation of integrated flood planning and infrastructure, the development of climate-resilient infrastructure, community engagement and awareness initiatives, and strengthened regulatory enforcement mechanisms.

Key words: Urban flooding, Environmental sustainability, Public engagement, Resilience

1 Introduction

Flooding stands as one of the most prevalent and dangerous natural disasters worldwide. Between 1994 and 2013, nearly 2.5 billion individuals experienced its devastating impact, accounting for a substantial 43% of all recorded natural disasters in the Glob. Unprecedented years like 1998 and 2010 saw flood-related losses surpassing \$40 billion. In this regard, with the ominous backdrop of climate change, rapid urbanization, and burgeoning global population, the influence of coastal, fluvial, and pluvial flooding is poised to intensify significantly in the coming decades. In light of these challenges, effective flood risk management emerges as an imperative necessity. Notably, natural approaches to flood risk reduction are increasingly gaining traction (Van Wesenbeeck, 2017).

Among these global concerns, this study focuses on a specific locality of Addis Ababa, which is a sprawling metropolis nestled within the Entoto, Furi, Yerer and Wechecha mountain ranges.

The primary sources of flooding in Addis Ababa are river inundation and stormwater runoff from steep slopes. Data from the Ministry of Labour and Social Affairs paints a stark picture, highlighting numerous flooding incidents over the years. In 2005, seven major incidents affected 362 households and 1302 family members. Recent data underscores the urgency of addressing flooding in Addis Ababa. According to the latest reports from the Addis Ababa City Administration (AACDRMC, 2023), flooding incidents have been on the rise in recent years, with significant impacts on residents and infrastructure. For example, in 2023, there were 20 major flooding incidents reported, affecting over 2,000 households and causing extensive damage to roads and buildings. Similarly, in 2022, flooding affected 1,800 households, leading to widespread displacement and economic losses (AACDRMC, 2022). These incidents highlight the pressing need for effective flood risk management strategies in the city.

Subsequently, in 2008 nine flood incidents, impacting 131 households and 352 family members, while in 2009 about 317 households and 647 family members were affected across six incidents. By 2010, reports indicated that 147 individuals were affected, with 39 residential houses sustaining damage. The proliferation of informal housing and agricultural activities, particularly in high-slope regions like the Jemo mountain series, Repi hills, and the Akaki Riverbanks, have exacerbated the city's flood vulnerability (Workalemahu, 2015). The same source revealed that at the municipal

level, multiple sectors bear responsibilities related to water management, yet there exists a glaring lack of coordination in storm water management efforts.

In this study, we focus on Addis Ababa, a sprawling metropolis nestled within the Entoto, Furi, Yerer, and Wechecha mountain ranges. The city grapples with recurring flood hazards, primarily driven by torrential seasonal rains that engorge its waterways, leading to destruction along their banks and substantial property losses.

The city administration has initiated a comprehensive analysis of flood-prone areas, resulting in ongoing flood protection efforts. However, while these efforts have seen progress, challenges remain in addressing the increasing frequency and intensity of flooding events.

This multifaceted strategy encompasses various measures, including the construction of retaining walls, dikes, and river course enhancements, alongside the creation of weirs and rain runoff retention ponds. Additionally, non-structural initiatives like reforestation, zoning revisions near water bodies, and robust early warning systems are integral components of this preparedness plan. While the introduction mentions the lack of coordination in storm water management, it is crucial to examine the roles and responsibilities of key stakeholders involved in flood management in Addis Ababa. These stakeholders may include government agencies, local authorities, community organizations, and NGOs. Understanding their roles and interactions is essential for identifying coordination issues and improving flood management efforts in the city.

Therefore, this research aims to comprehensively investigate the causes of urban flooding, the effectiveness of existing institutional frameworks and flood protection measures, opportunities for improved flood management, challenges confronting these efforts, and the alignment of city planning with Addis Ababa's master plan in the context of natural hazard mitigation.

The general objective of this study is to develop a holistic framework for urban flood risk management in Addis Ababa that integrates urban planning, environmental sustainability, and disaster risk reduction to enhance the city's resilience to flooding. The specific objectives are:

- to assess the main causes of flooding in Addis Ababa
- to analyze the existing institutional frameworks and policies governing flood mitigation and disaster risk reduction in Addis Ababa, identifying strengths, weaknesses, and areas for improvement.
- to evaluate the effectiveness of current flood prevention and mitigation measures

- to propose integrated strategies for flood risk reduction and urban resilience enhancement in Addis Ababa.

2 Materials and Methods

2.1 Study area

The study area of the research is Addis Ababa city the capital city of Ethiopia .Established in 1886 and with four million population, Addis Ababa is one of the oldest and largest cities in Africa. At an average altitude of 2400 meters, it is also one of the highest. (UN-HABITAT, 2008)

According to the 2007 census, the total population of the city was 3,384,569 (CSA 2007). Looking back to the population increase of the city, the estimated population as per the year 2019 is 7.8236 Million. The population density is estimated to be 5,165 individuals per square kilometer available. Addis Ababa is an Amharic word which means “new flower”. The total surface area of the city is 54,000 hectares. Addis Ababa is located at 9° 2' N, 38° 42' E. The city possesses a mix of highland climate zone. The high elevation moderates temperatures year-round, and the city's position near the equator means that temperatures are very constant from month to month. (Dubbale Daniel A., 2010)

In Addis Ababa, the climate is warm and temperate. Summers are much rainier (June to September) than winters. The city’s location is classified as (Oceanic Subtropical Highland Climate) by Köppen and Geiger. The average temperature is 16oC, and the average maximum and minimum temperatures range between 22.9oC and 10.2oC. The average humidity of the city is 57.67% and the average annual rainfall is 1184mm⁴, almost double than Barcelona (612 mm) and practically the same as the Scottish city of Glasgow (1,124 mm). This relatively high rainfall is due to the intensity of the rains from July to September (Addis Ababa resilience project office, The City water resilience approach, May 19, 2021).

The results of the examination of the rainfall and temperature data for the past 30 years showed that Addis Abeba has experienced both dry and rainy climate conditions. Rainfall increased significantly over average between 2005 and 2010, but in the 1980s it was practically below average. The total annual rainfall varied from 929.4 mm in 1999 to 1567.9 mm in 1993, with 1230.3 mm on average per year during the previous three decades (Kahsay, 2016).

According to climate data from Ethiopia's National Meteorological Agency, Addis Abeba's mean annual, maximum, and minimum temperatures between 1981 and 2010 were 23.3 oC and 10.7 oC, respectively. Although there are variations in temperature and rainfall patterns across Addis Abeba

depending on elevation and prevailing winds, climate change projections indicated no significant changes in the seasonality of rainfall aside from minor changes in monthly rainfall. Seasonal temperatures are projected to increase by 1.5–2°C (Lindley, 2015).

Addis Abeba has historically been covered in native, natural flora that is a part of the Afro-montane forest and woodland. Native tree species include *Juniperus procera*, *Olea europaea* subsp. *Cuspidata*, *Podocarpus falcatus*, *Hygnia abyssinica*, and *Erica arborea* had dominated the natural forest at high altitudes above 3,000 meters above sea level (Yeshitela, 2015).

Due to urbanization and population increase at the turn of the 20th century, woody vegetation was substantially reduced. For construction and the use of fuel wood, city inhabitants and farmers in the area heavily exploited woody vegetation (Kahsay, 2016).

There are currently very few remaining natural forest sections, and exotic in particular *Eucalyptus*. In addition to the peri-urban forest on the outskirts of Addis Abeba, there are a few urban parks, riverfront vegetation, and street trees in the city that are regarded as green spaces (Yeshitela, 2015).

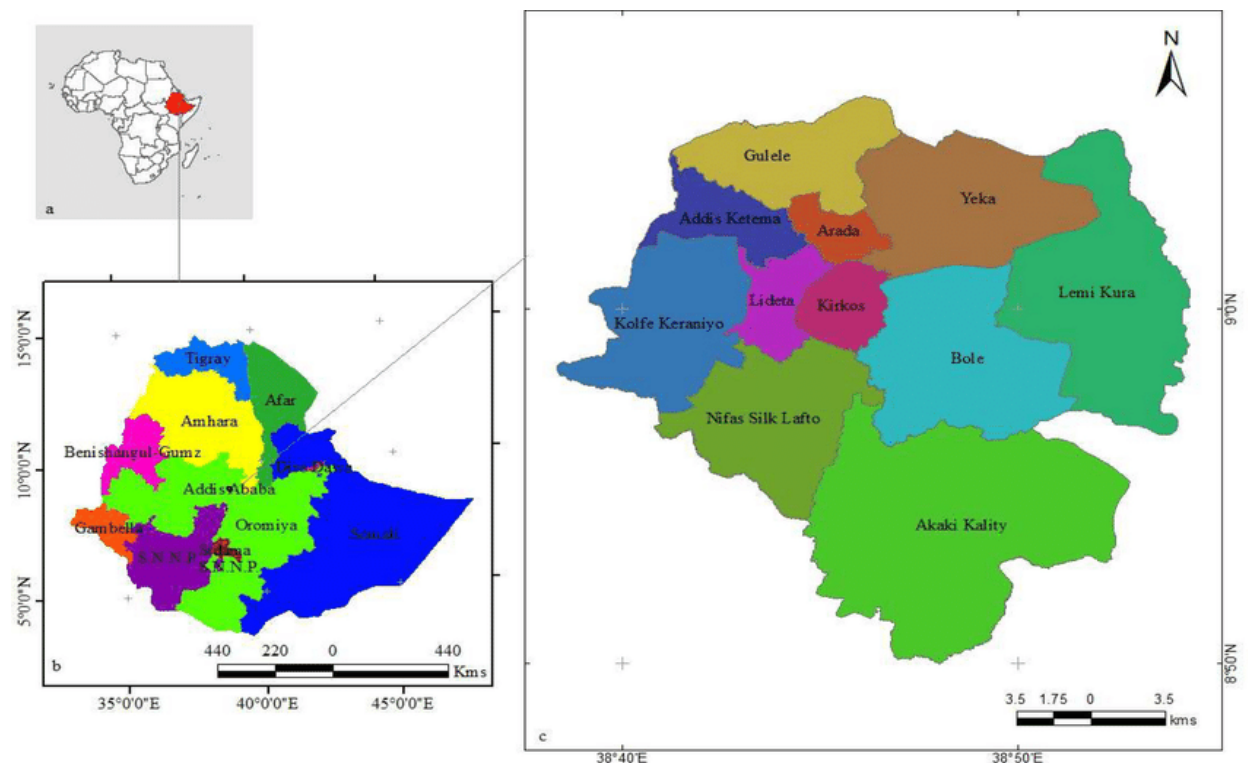


Figure 1. Location map of Addis Ababa city

2.2 Type and source of data

In this study, a combination of primary and secondary data sources were employed to gather comprehensive information. Primary data was acquired through key informant interviews, focus

group discussions, and field observations. To investigate the subject matter, secondary data was also utilized, obtained through an extensive review of existing literature, as well as an analysis of relevant policies and the master plan of Addis Ababa.

To address the research inquiries pertaining to the institutional and governance framework responsible for urban flood management within the city, a set of structured and semi-structured questionnaires were meticulously developed. These questionnaires served as valuable tools in eliciting the required information.

For the key informant interviews, representatives from various government organizations were carefully chosen. Their involvement was pivotal in ensuring a well-rounded perspective. Moreover, these representatives actively participated in the focus group discussions, aiming to shed light on any concerns or queries raised by members of the local communities.

Throughout these discussions, a semi-structured question catalogue was presented to guide the conversation. Subsequently, the findings from these interactions were qualitatively summarized, allowing for a comprehensive analysis of the data collected.

2.3 Data collection techniques

In this research, a combination of data collection techniques were employed to ensure a comprehensive understanding of the topic. The primary method utilized was key informant interviews conducted with institutions involved in urban flood management at the city level, specifically within the jurisdiction of Addis Ababa.

The selection of these institutions was carried out through purposive sampling, a non-probability sampling technique. This approach allows the researcher to use their judgment to select samples who possess knowledge about the subject under investigation. To ensure the selection of appropriate participants, the researcher conducted a thorough evaluation of the candidates, taking into account their positions and expertise. This step was crucial in guaranteeing that the chosen informants could provide valuable insights into the study's purpose.

To conduct these interviews, regulatory bodies and implementers responsible for urban flood management plans in the city were identified. Each selected institution designated an expert as a key informant, representing their organization. Two key informants, one who work on administration and other is expert from each institution were appointed for the interviews, encompassing both administrative and expert perspectives. The interviews were structured

around semi-structured questions, providing a framework for the conversation. However, the discussions also remained open to address any pertinent issues raised by the respondents.

2.4 Data analysis

In the process of data analysis,

Thematic analysis was conducted to identify and explore key themes related to flood risk factors in Addis Ababa. Data sources included qualitative data from literature review, interviews, and field observations. Relevant text segments were extracted and coded based on recurring concepts and ideas related to flood risk factors. Themes were identified through inductive reasoning, grouping similar codes into overarching themes such as Land Use Change, Poor Drainage System, Climate Change, and Interconnections. Sub-themes were developed under each major theme to capture specific aspects contributing to flood risk, supported by examples extracted from the data. Quantitative data on vulnerable areas categorized by region were collected from field surveys, satellite imagery, and government reports.

Quantitative vulnerability assessment results were triangulated with qualitative insights on flood risk factors and mitigation efforts to provide a comprehensive understanding. Findings from both approaches were synthesized to identify commonalities, discrepancies, and interrelationships between spatial patterns of vulnerability and underlying causes of flooding. By integrating quantitative and qualitative data, a holistic view of flood risk management efforts in Addis Ababa emerged, emphasizing the need for targeted interventions and collaborative approaches.

Findings from thematic analysis, spatial vulnerability analysis, and integration of methods were synthesized to discuss the implications of flood vulnerability, underlying causes, and mitigation strategies. Identified themes, spatial patterns, and interconnections were discussed in relation to the broader context of flood risk management in Addis Ababa, emphasizing the importance of proactive measures and collaborative efforts.

The data analysis culminated in summarizing the key findings related to flood vulnerability, causes, mitigation strategies, strengths, weaknesses, and recommendations for action.

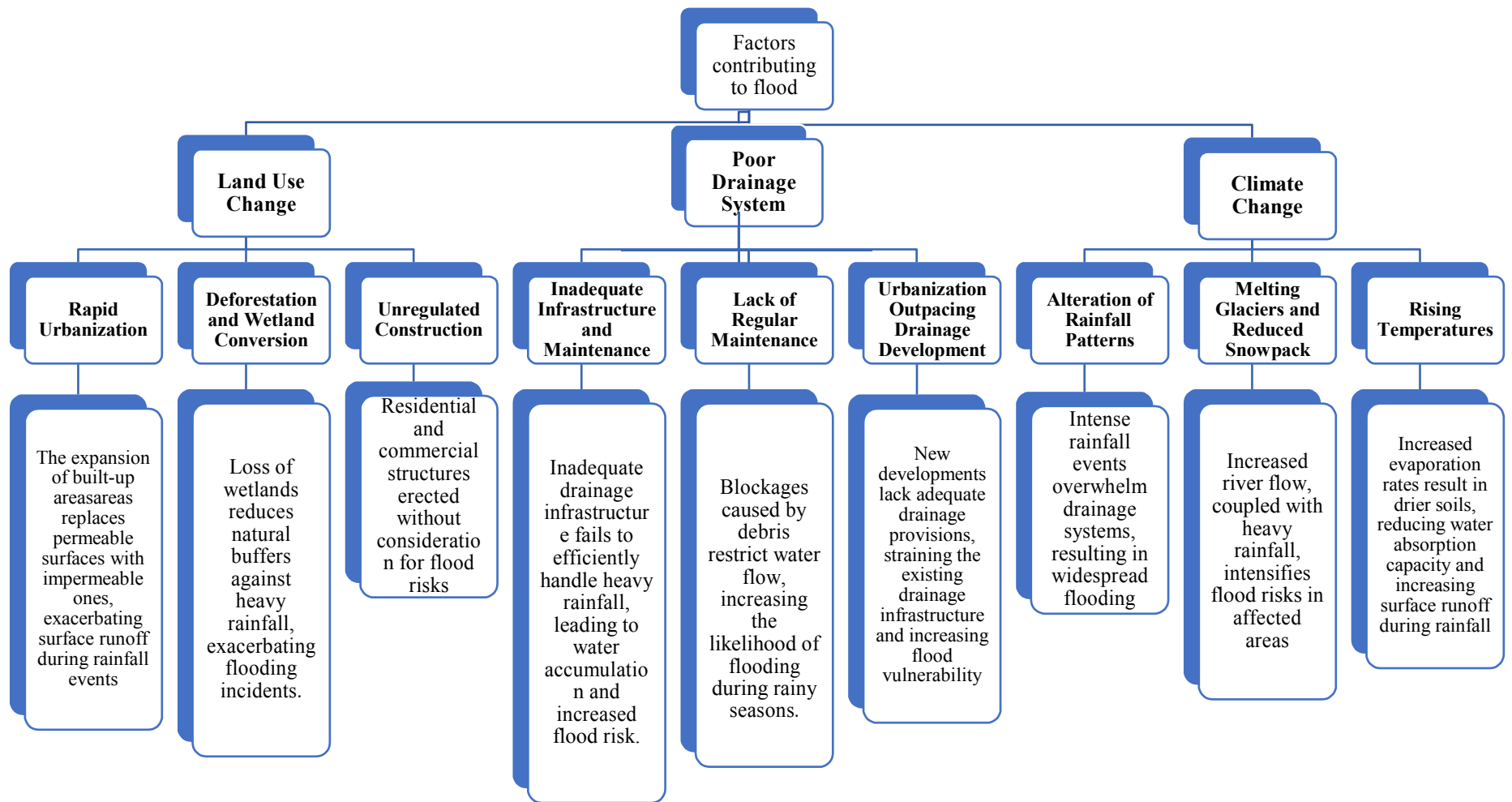
The implications of the findings on policy development, urban planning, community engagement, and infrastructure improvement were discussed to inform evidence-based decision-making and promote sustainable flood risk management practices in Addis Ababa.

3 Result

3.1 The role of land use change for flooding

Addis Ababa, the vibrant capital city of Ethiopia, faces increasing challenges related to flood vulnerability due to various environmental, urban development, and climatic factors. Understanding the multifaceted nature of flood risk is crucial for effective mitigation and adaptation strategies. In this section, I present the results of a thematic analysis that explores the interconnected factors contributing to flood vulnerability in Addis Ababa. Through the lens of land use change, poor drainage systems, and the impacts of climate change, this analysis sheds light on the complex dynamics shaping flood risk within the city. By examining the interactions between these factors, I aim to provide insights that can inform evidence-based policies and interventions to enhance flood resilience and mitigate the impacts of flooding in Addis Ababa.

Results: Thematic Analysis of Flood Risk Factors



Cross-cutting Theme: Interconnections: The interconnections between land use change, poor drainage systems, and climate change exacerbate flood risks.

- **Description:** The interplay between rapid urbanization, inadequate drainage infrastructure, and climate change amplifies flood vulnerabilities in Addis Ababa.
 - *Example:* Rapid urbanization exacerbates poor drainage and loss of natural water absorption areas, intensifying flood risks amid changing climatic conditions.

This thematic analysis underscores the multifaceted nature of flood risk factors in Addis Ababa, highlighting the need for integrated and adaptive flood management strategies to mitigate the growing threat of flooding in the city.

3.2 Existing institutional frameworks and policies

This integrated result study presents a comprehensive analysis of flood mitigation and disaster risk reduction efforts in Addis Ababa, integrating qualitative insights with quantitative data. The analysis aims to provide a holistic understanding of institutional frameworks, existing policies, strengths, weaknesses, and policy effectiveness in addressing flood risks and enhancing resilience in the city.

3.2.1 Institutional frameworks

Roles and Responsibilities: The data highlights several key institutional frameworks responsible for flood prevention and disaster risk reduction in Addis Ababa. These include the Addis Ababa City Disaster Risk Management Commission (AACDRMC), City Master Plan, Environmental Protection Authority (AAEPA), Roads Authority (AACRA), Water and Sewerage Authority (AAWSA), and City Planning and Development Management Bureau. Each institution has distinct roles and responsibilities, such as policy development, infrastructure planning, environmental protection, and community engagement.

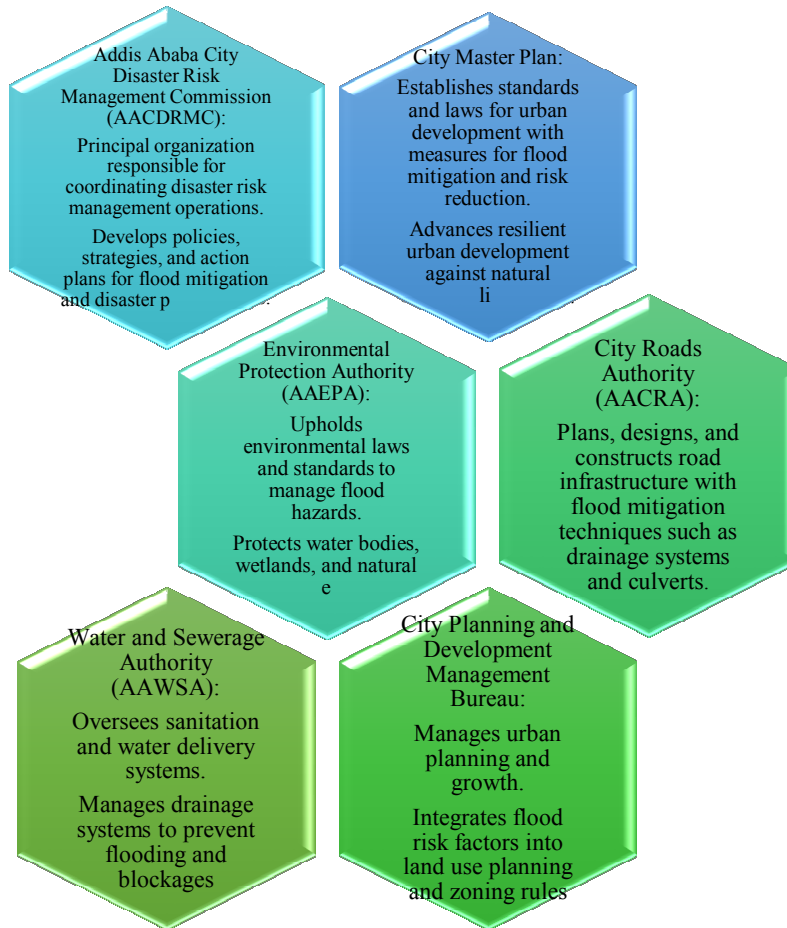


Figure 6. Institutional Frame Work

Coordination and Collaboration: The data emphasizes the importance of coordination among these institutions to effectively manage flood risks. The AACDRMC serves as the coordinating body, facilitating collaboration between government agencies, stakeholders, and communities involved in disaster risk management operations.

3.2.2 Existing policies

Policy Landscape: Addis Ababa has established various policies and regulations aimed at reducing flood risks and enhancing disaster resilience. These policies cover a wide range of areas, including flood risk management, urban development, building codes, environmental protection, disaster preparedness, land use planning, and early warning systems.

Policy Objectives: The policies aim to promote sustainable development, community participation, infrastructure resilience, and environmental preservation. They emphasize the

importance of incorporating disaster risk reduction into urban planning, infrastructure development, and community engagement processes.

Quantification of Policy Types: This table quantifies the frequency of different policy types related to flood mitigation and disaster risk reduction in Addis Ababa. It provides an overview of the diversity and distribution of policies addressing various aspects of flood risk management and resilience-building in the city.

Table 1. Quantification of Policy Types

Policy Type	Frequency
Flood Risk Management Policy	1
Urban Development Policy	1
Building codes and standards	1
Environmental Protection Policy	2
Disaster Preparedness and Response Policy	1
Regulations for Land Use and Zoning	1
Disaster Risk Management Policy for Addis Ababa	1
Floodplain Management Policy	1
Policy governing flood early warning system	1
Policy addressing climate change adaptation	1

The quantification of policy types reveals the presence of diverse policies aimed at managing flood risk and enhancing disaster resilience in Addis Ababa. While the frequency of policies varies across different areas of focus, their collective presence underscores the city's commitment to addressing the multifaceted challenges posed by floods and disasters. Moving forward, continued efforts to implement, monitor, and adapt these policies will be essential for promoting sustainable development and safeguarding the well-being of the city's residents.

Policy Effectiveness Ratings:

This table presents the effectiveness ratings assigned to each policy based on criteria such as clarity of objectives, implementation success, community impact, and adaptation to changing conditions.

It offers insight into the perceived effectiveness of individual policies in achieving their intended objectives and contributing to overall flood mitigation and disaster risk reduction efforts.

Table 2. Policy Effectiveness Ratings

Policy	Effectiveness Rating
Flood Risk Management Policy	4
Urban Development Policy	3
Building codes and standards	4
Environmental Protection Policy	3
Disaster Preparedness and Response Policy	4
Regulations for Land Use and Zoning	3
Disaster Risk Management Policy for Addis Ababa	4
Floodplain Management Policy	3
Policy governing flood early warning system	5
Policy addressing climate change adaptation	3

The effectiveness ratings provided in the table are typically assigned by experts or stakeholders involved in flood mitigation and disaster risk reduction efforts in Addis Ababa. These ratings determined through expert opinions based on their knowledge and experience in the field. It's important to ensure that the individuals assigning the ratings have relevant expertise and knowledge of the policies and their implementation context in order to provide accurate assessments of effectiveness.

The effectiveness ratings are assigned based on the perceived impact and success of each policy in achieving its intended objectives. The ratings are interpreted as follows:

- **Rating 5:** Highly Effective - The policy demonstrates exceptional clarity of objectives, successful implementation, significant positive impact on the community, and high adaptability to changing conditions.
- **Rating 4:** Effective - The policy is well-defined with clear objectives, has achieved successful implementation with positive community impact, and demonstrates good adaptability to changing conditions.

- **Rating 3:** Moderately Effective - The policy has clear objectives and has been moderately successful in implementation, with some positive impact on the community and moderate adaptability to changing conditions.
- **Rating 2:** Ineffective - The policy lacks clarity of objectives and has been minimally successful in implementation, resulting in limited impact on the community and poor adaptability to changing conditions.
- **Rating 1:** Highly Ineffective - The policy lacks clear objectives, has been largely unsuccessful in implementation, and has had negligible impact on the community with poor adaptability to changing conditions.

The effectiveness ratings provide valuable insights into the performance of policies related to flood mitigation and disaster risk reduction in Addis Ababa. By understanding the strengths and weaknesses of each policy, stakeholders can identify areas for improvement and refine strategies to enhance overall effectiveness in addressing flood risks and building resilience in the city. Ongoing evaluation and adaptation of policies will be crucial for ensuring continued progress towards sustainable flood management and disaster risk reduction in Addis Ababa.

3.2.3 Strengths and weakness



Figure 7. Strengths and weakness

3.3 Current flood prevention and mitigation measures

3.3.1 Flood vulnerable areas, cause of vulnerability and measurement taken

The analysis of flood vulnerability in Addis Ababa, incorporating both quantitative and qualitative approaches, revealed multifaceted insights into the distribution of flood risk, underlying causes, and mitigation efforts across the city

Quantitative Analysis: A quantitative assessment revealed a total of 67 areas identified as vulnerable to flooding within Addis Ababa. These areas were categorized by region, with the highest concentration of vulnerable areas observed in the West region (37 areas), followed by South (11 areas), North (10 areas), Central (7 areas), and East (2 areas). This distribution provides valuable information regarding the geographic spread of flood risk within the city.

Table 3. Identified flood vulnerable areas

Number	Region (Parts of the City)	Number of Flood risk Areas
1	Western Addis Ababa	37
2	Southern Addis Ababa	11
3	Northern Addis Ababa	10
4	Central part of Addis Ababa	7
5	Eastern Addis Ababa	2
	Total	67

The following table shows the locations of the vulnerable areas in the districts where they are located. The table is based on the old zoning of the city.

Table 4. Division of flood vulnerable area by Sub-city

Number	Region	Sub-city	Flood risk
1	Central	Arada	7
2	North	Yeka	4
4		Gulele	6
5	East	Bole and lemikura	2
6	West	Addis ketema	17
7		Kolfekeranio	20
8	South	Akkaikality	10
		Nifasselklafto	1
		Total	67

Qualitative Content Analysis: Qualitative content analysis elucidated several key themes related to the causes of flooding and the corresponding solutions being implemented. Common causes identified included land splits along rivers, inadequate drainage infrastructure, construction on

slopes, proximity of houses to rivers, and blockages in pipes and roads. To address these issues, solutions such as building support walls, constructing adequate drainage canals, making houses flood-resistant, and ensuring the maintenance of drains were proposed. Additionally, challenges in flood risk management were identified, including accessibility issues, laborious tasks for individuals, and unresolved issues requiring further attention.

Integration of Methods: The integration of quantitative and qualitative analyses provided a comprehensive understanding of flood risk in Addis Ababa. The quantitative assessment identified the extent of vulnerability across different regions, while the qualitative analysis shed light on the underlying causes, mitigation efforts, and challenges faced. By triangulating findings from both approaches, a holistic view of flood risk management efforts emerged, highlighting the need for targeted interventions and collaborative approaches to mitigate flood risk effectively.

Discussion of Findings: The findings underscore the importance of proactive measures to address flood vulnerability in Addis Ababa, particularly in light of increasing urbanization and climate change impacts. Collaborative efforts involving government agencies, stakeholders, and communities are essential for implementing effective flood risk management strategies. Furthermore, the identification of vulnerable areas and the underlying causes of flooding provide valuable insights for prioritizing interventions and allocating resources efficiently.

3.4 Proposed integrated strategies

This research aimed to analyse strategies for flood risk reduction and urban resilience enhancement in Addis Ababa, with a focus on sustainable urban planning, community participation, and environmental conservation. Through content analysis of relevant data, key themes, strengths, weaknesses, and recommendations for action were identified to inform evidence-based decision-making and policy development.

Table 6. Proposed Integrated Strategies

Key Themes	Quantification	Relationships between Themes	Strengths	Weaknesses	Recommendations for Action
1. Sustainable Urban Planning	Frequently mentioned	Intersects with Environmental Conservation through incorporation of green infrastructure	Emphasis on sustainable urban planning and community participation	Challenges in infrastructure maintenance and limited financial resources	Strengthen coordination between government agencies and local communities; Allocate sufficient resources for infrastructure improvement
2. Community Participation	Frequently mentioned	Essential for successful implementation of sustainable urban planning initiatives	Emphasis on sustainable urban planning and community participation	Challenges in infrastructure maintenance and limited financial resources	Enhance public awareness and education programs to promote community participation
3. Environmental Conservation	Highlighted multiple times	Intersects with Sustainable Urban Planning through green infrastructure	Emphasis on sustainable urban planning and community participation	Challenges in infrastructure maintenance and limited financial resources	Strengthen coordination between government agencies and local communities; Allocate sufficient resources for infrastructure improvement
4. Infrastructure Improvement	Mentioned less frequently	Critical for managing excess water during heavy rainfall	Emphasis on sustainable urban planning and community participation	Challenges in infrastructure maintenance and limited financial resources	Allocate sufficient resources for infrastructure improvement; Enhance public awareness and education programs to promote community participation
5. Institutional Capacity Building	Mentioned less frequently	Critical for coordinating and implementing community-led initiatives and effective response	Emphasis on sustainable urban planning and community participation	Challenges in infrastructure maintenance and limited financial resources	Strengthen coordination between government agencies and local communities; Allocate sufficient resources for infrastructure improvement

4 Conclusion and recommendation

4.1 Conclusion

After conducting a comprehensive analysis of flood risk factors, institutional frameworks, policies, existing flood prevention measures, and proposed strategies for flood risk reduction and urban resilience enhancement in Addis Ababa, several key conclusions can be drawn.

Comprehensive Understanding of Flood Risk: The integration of quantitative and qualitative analyses provided a nuanced understanding of flood risk in Addis Ababa. The quantitative assessment identified vulnerable areas across different regions, while the qualitative analysis illuminated the underlying causes, mitigation efforts, and challenges faced.

Multifaceted Nature of Flood Risk Factors: Findings from thematic analysis, qualitative content analysis, and institutional frameworks highlight the multifaceted nature of flood risk in Addis Ababa. Factors such as rapid urbanization, inadequate drainage infrastructure, land use change, and climate change impacts contribute to the city's vulnerability to flooding.

Need for Collaborative Approaches: Addressing flood risk in Addis Ababa requires collaborative efforts involving government agencies, stakeholders, and communities. The identification of vulnerable areas, underlying causes, and proposed solutions underscores the importance of integrated and coordinated approaches to flood risk management.

Importance of Proactive Measures: Proactive measures are essential to mitigate flood risk and enhance urban resilience in Addis Ababa. Sustainable urban planning, community participation, environmental conservation, infrastructure improvement, and institutional capacity building emerge as key strategies for flood risk reduction.

Challenges and Opportunities: While challenges such as limited coordination among agencies, inadequate infrastructure, and financial constraints exist, there are opportunities for improvement. Strengthening coordination, allocating resources, enhancing public awareness, integrating sustainable urban planning, and investing in environmental conservation can address these challenges and enhance resilience to floods.

In conclusion, the integrated analysis provides valuable insights into flood risk factors, existing institutional frameworks, policies, and proposed strategies for flood risk reduction and urban resilience enhancement in Addis Ababa. By adopting collaborative approaches, implementing proactive measures, and addressing challenges, the city can effectively mitigate flood risk, protect

its residents and infrastructure, and build a more resilient future amidst increasing urbanization and climate change impacts.

4.2 Recommendation

By implementing the following recommendations and embracing an integrated approach that melds sustainable urban planning, community participation, and environmental preservation, Addis Ababa can decisively diminish flood risks and fortify urban resilience. In so doing, the city will not only hew to its master plan but also adhere to global norms and standards in disaster risk reduction, fashioning a future characterized by sustainability and resilience for both the city and its riversides. Based on the findings the key recommendations include:

Integrated Flood Planning and Infrastructure: Prioritize integrated urban planning that includes flood risk mitigation in land use policies and invest in drainage infrastructure to manage excess water.

Climate-Resilient Infrastructure: Develop climate-resilient infrastructure, including flood-resistant designs and sustainable water management, to adapt to changing precipitation patterns and climate-induced flood risks.

Community Engagement and Awareness: Engage communities in flood risk awareness, early warning systems, and evacuation planning to protect vulnerable populations.

Regulatory Enforcement: Strengthen enforcement of building codes and land use regulations, penalizing violations and preventing construction in flood-prone areas.

International Collaboration and Funding: Collaborate with international organizations to secure financial support and align with global disaster risk reduction standards and practices.

Preservation of Natural Ecosystems: Protect and restore crucial natural ecosystems like wetlands and forests to enhance flood control and maintain sustainable land management practices.

Capacity Building and Training: Enhance the capabilities of regional institutions involved in emergency readiness and response through focused training initiatives and collaboration with stakeholders.

Comprehensive Flood Risk Assessment: Conduct a comprehensive evaluation of flood risk, considering topography, rainfall trends, and drainage systems to prioritize mitigation efforts effectively.

Acknowledgements

First, I would like to thank God, for letting me through all the difficulties. I have experienced your guidance day by day. You are the one who let me finish my degree. I will keep on trusting you for my future.

I would like to acknowledge and give my warmest thanks to my supervisor Dr.AramdeFetene who made this work possible. His/her guidance and advice carried me through all the stages of writing my project.

Finally, I would also like to give special thanks to my family as a whole for their continuous support and understanding when undertaking my research and writing my project. Your prayer for me was what sustained me this far.

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Appendix 2

Key Informant Interview Guide to Addis Ababa City Road Authority (AACRA)

Dear respondent,

The main objective of this KII Guide is to compile first-hand data in order to conduct an evaluation on "Managing urban flooding, their execution, and difficulties; in the case of Addis Abeba City." Your responses to the questions are crucial, and we will keep them private and only use them for research analysis. Your name will never be mentioned. You will be consenting to complete this research voluntarily; there will be no monetary reward for your participation. In addition, you have the option to discontinue taking part in the study altogether or to skip any questions you feel uncomfortable answering. Your time commitment for this interview will be one hour.

1. Could you please provide an overview of your role and responsibilities as a stakeholder in managing urban flooding in Addis Ababa City?
2. What are the main challenges you have encountered in executing flood management strategies and initiatives in the city?
3. How would you describe the current state of flood management infrastructure and systems in Addis Ababa City?
4. What are some of the key initiatives or projects that have been implemented to address urban flooding in the city? How successful have they been?
5. In your opinion, what are the primary causes or factors contributing to urban flooding in Addis Ababa City?
6. How effective have the existing early warning systems been in alerting residents and authorities about potential flood events in the city?
7. What are the main obstacles or difficulties you have faced in engaging with local communities and raising awareness about flood risks and preparedness?
8. Are there any specific areas in Addis Ababa City that are particularly prone to flooding? If so, what measures have been taken to mitigate these risks?

9. What are the current strategies in place for urban planning and land use management to minimize the impact of flooding in the city?

10. How do you envision the future of flood management in Addis Ababa City? Are there any long-term plans or strategies being developed to address this issue?

Thank you very much for your time & professional support.

Appendix 3

Key Informant Interview Guide to Addis Ababa Rivers and Riversides Development and Climate Change Adaptation Project Office

Dear respondent,

The main objective of this KII Guide is to compile first-hand data in order to conduct an evaluation on "Managing urban flooding, their execution, and difficulties; in the case of Addis Abeba City." Your responses to the questions are crucial, and we will keep them private and only use them for research analysis. Your name will never be mentioned. You will be consenting to complete this research voluntarily; there will be no monetary reward for your participation. In addition, you have the option to discontinue taking part in the study altogether or to skip any questions you feel uncomfortable answering. This interview will take an hour of your time, including preparation.

1. Could you please provide an overview of the Addis Ababa Rivers and Riversides Development and Climate Change Adaptation Project Office and its role in managing urban flooding in Addis Ababa City?
2. What are the main objectives and goals of the project office regarding urban flooding management in the city?
3. How does the project office collaborate with other stakeholders, such as government agencies, local communities, and non-governmental organizations, to address urban flooding challenges?
4. What are the key strategies and initiatives implemented by the project office to manage urban flooding in Addis Ababa City? How successful have they been?
5. What are the main challenges and difficulties faced by the project office in executing flood management strategies and initiatives in the city?
6. Could you please elaborate on the current state of flood management infrastructure and systems implemented by the project office in Addis Ababa City?
7. How does the project office assess and monitor flood risks in the city? Are there any early warning systems in place?

8. What are the primary causes or factors contributing to urban flooding in Addis Ababa City, according to the project office's assessment?
9. How does the project office engage with local communities to raise awareness about flood risks, preparedness, and the importance of community participation in flood management?
10. Are there any specific areas in Addis Ababa City that are particularly prone to flooding? What measures have been taken by the project office to mitigate these risks?
11. How does the project office integrate climate change adaptation strategies into its flood management plans for Addis Ababa City?
12. Are there any long-term plans or strategies being developed by the project office to enhance flood management in Addis Ababa City?
13. What are the key lessons learned from the project office's experience in managing urban flooding in Addis Ababa City?
14. How do you envision the future of flood management in Addis Ababa City, considering the ongoing efforts by the project office and other stakeholders?
15. Is there any additional information or insights you would like to share regarding the management of urban flooding in Addis Ababa City?

Thank you very much for your time & professional support.

Appendix 4

Dear respondent,

The main objective of this focus group discussion is to compile first-hand data in order to conduct an evaluation on "Managing urban flooding, their execution, and difficulties; in the case of Addis Abeba City." Your responses to the questions are crucial, and we will keep them private and only use them for research analysis. Your name will never be mentioned. You will be consenting to complete this research voluntarily; there will be no monetary reward for your participation. In addition, you have the option to discontinue taking part in the study altogether or to skip any questions you feel uncomfortable answering. This interview will take an hour of your time, including preparation.

1. What are the main causes of urban flooding in Addis Ababa City?
2. How would you describe the impact of urban flooding on the residents and infrastructure of Addis Ababa City?
3. What measures have been taken so far to manage urban flooding in Addis Ababa City? Are they effective?
4. What are the key challenges faced in executing flood management strategies in Addis Ababa City?
5. How aware are the residents of Addis Ababa City about the risks and impacts of urban flooding?
6. What are the potential solutions or strategies that could be implemented to mitigate urban flooding in Addis Ababa City?
7. How can community engagement and participation be improved to enhance flood management efforts in Addis Ababa City?
8. Are there any specific areas in Addis Ababa City that are more prone to urban flooding? If so, what factors contribute to their vulnerability?
9. What role can the government, NGOs, and other stakeholders play in effectively managing urban flooding in Addis Ababa City?

10. How can urban planning and infrastructure development be better designed to prevent or reduce the impact of urban flooding in Addis Ababa City?

Thank you very much for your time & professional support