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## Abstract

Climate change can be caused either by nature or by man-made. Worldwide studies show that human activity is the main cause of greenhouse gas emission. Whichever the cause could be, climate change is a key threat of human life, particularly in the developing countries, the risk of human life is high. In this regard, Ethiopia is one of the developing countries and therefore the suffering it receives from climate change is becoming very serious.

The study aims at identifying the threat and impact of climate change and any related issues that hinder the people from maintaining their habits with particular focus of climate change in Addis Ababa, the capital city of Ethiopia.

Flooding and landslides attributed 40% of loss of green spaces in Addis Ababa and 90% of industries discharge their waste directly into nearby rivers. The average age of vehicles on the city's roads is found to be 17years. Among the vehicles in the city, 50% generate nearly 90% of hydrocarbon and carbon monoxide emissions.

Finally, possible solutions that could mitigate the climate change in Addis Ababa were recommended.

## ACRONYMS

African Union	AU's
Automated Meteorological Data Acquisition System	AMeDAS
Carbon Dioxide	CO <sub>2</sub>
Cardiovascular Diseases	CVDs
Climate Change	CC
Climate Resilient Green Economy	CRGE
Dega, Amharic Alphabet:	ደጋ
Greenhouse Gases	GHGs
Gross Domestic Product	GDP
Growth and Transformation Plan II	GTP II
Intergovernmental Panel on Climate Change	IPCC
Landscape Design	LD
Methane	CH <sub>4</sub>
Nitrous oxide	N <sub>2</sub> O
Horn of Africa	HOA
Qola zones, Amharic Alphabet:	ቆላ ዞኖች
United Nations Economic Commission for Africa	UNECA
Urban Development Planning	UDP
Woina Dega Zones, Amharic Alphabet:	የወይና ደጋ ዞኖች
World Health Organization	WHO

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# Chapter One

## 1. Introduction

### 1.1. Background

Greenhouse gases (GHGs) emissions are increasing in the atmosphere leading the world to weather events. All nations do agree on one thing, human activities like the burning of fossil fuels, deforestation, and agriculture give more GHGs to the atmosphere. Greenhouse gases are not one single gas, for example, carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), and nitrous oxide (N<sub>2</sub>O) are one of the more relevant greenhouse gases that caused climate change (Zegeye, 2018). At the beginning of the industrial period, greenhouse gas emissions in the atmosphere rapidly grow. Climate change is a consequence of greenhouse gases emission (Ledley, 1999).

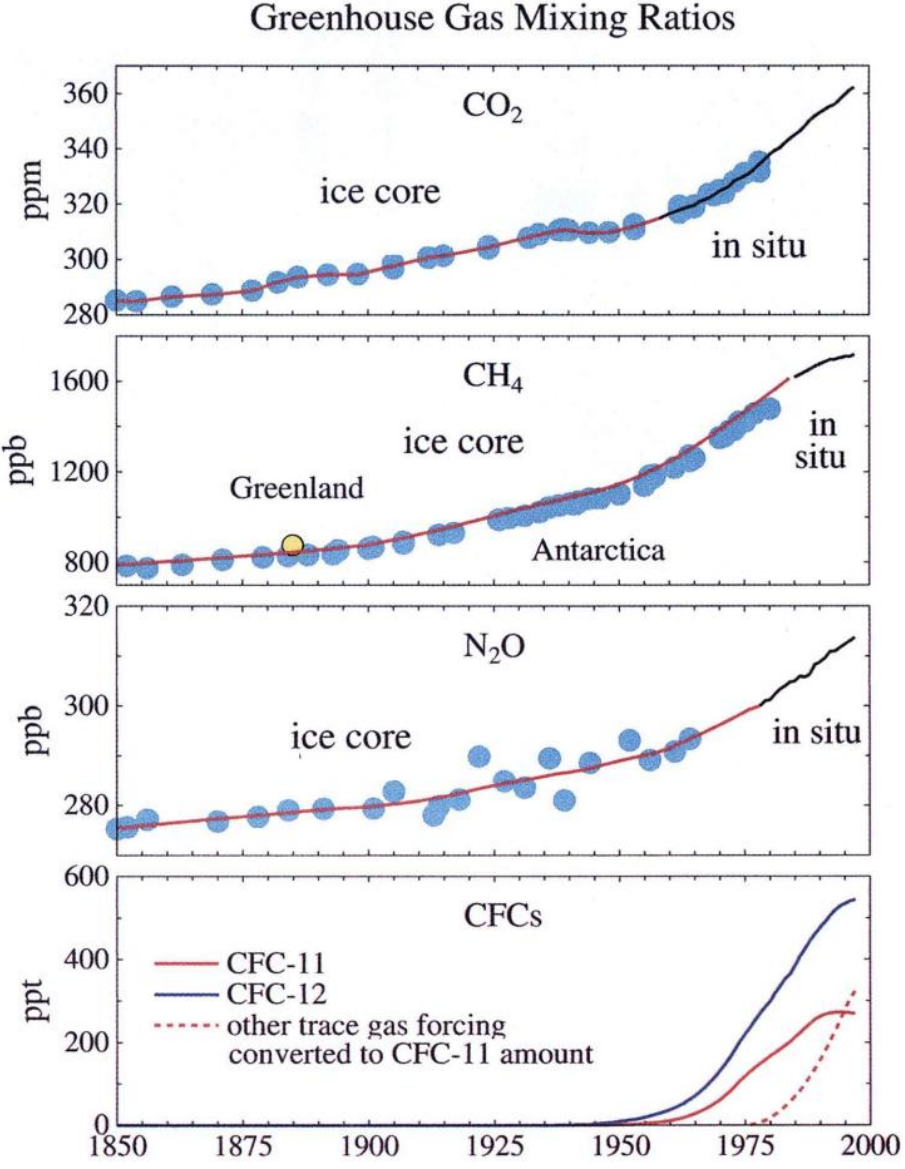


Figure 1 Concentrations of principal anthropogenic greenhouse gases in the industrial era (Ledley, 1999)

According to scientists' belief, the world's temperature has increased by 0.76°C since 1900. The world's rainfall varies, some countries had experienced heavy rain and other country get very little rain per year (Zegeye, 2018). Both high temperature and rainfall variation affect agriculture, especially if they cultivate their fields seasonally like Ethiopia (NATIONAL METEOROLOGICAL AGENCY Addis Ababa, 2007).

The system of nature and humans are affected by climate change. Climate change, a global challenge, is not a myth but a reality, and it is new. Therefore, this global challenge must be addressed internationally by international cooperation (Zegeye, 2018).

Pertinent to this fact, Africa is the most vulnerable nation to climate change. This major challenge led the nation to suffer from exile, war, drought, and similar abuses. African people, politician, and even if the African Union (AU's) concern is to achieve the challenge, the capacity of adaptation recently and future hamper their efforts (Nkomo, 2006) (Tadesse, 2010).

Ethiopia is one of the climate changes affected countries in Africa. Its people are suffering much more than other nations in weather changes. It is because of the country's topography, land use habit, and lack of economy. A mountainous country, Ethiopia covers 1.2 million square kilometers, and it is also the second-most populous country in Africa (NATIONAL METEOROLOGICAL AGENCY Addis Ababa, 2007). According to the World Bank, 78.3 Percent of the population settled in the rural area (The World Bank, 2018).

Ethiopia has got different landscapes and receives a different amount of rainfall. In the southern part, there is high rainfall, Northern part seems dry area with minimum rainfall to mention. In general, the country has huge different rainfall. There are also altitude and temperature differences between the regions in the country (The World Bank Group, 2021). The country is divided into three climate zones:

- A) Alpine vegetation cool zones (Dega (ደጋ)), it is over 2 600 meters above sea level with temperature 0-16 °c.
- B) Temperate Woina Dega Zones (የወይና ደጋ ዞኖች). It is between 1500 and 2500 meters above sea level with temperature between 16 °c and 30 °c.
- C) Hot Qola zones (ቆላ ዞኖች). It is both tropical and arid regions with temperature 27 °c up to 50 °c (The World Bank Group, 2021).

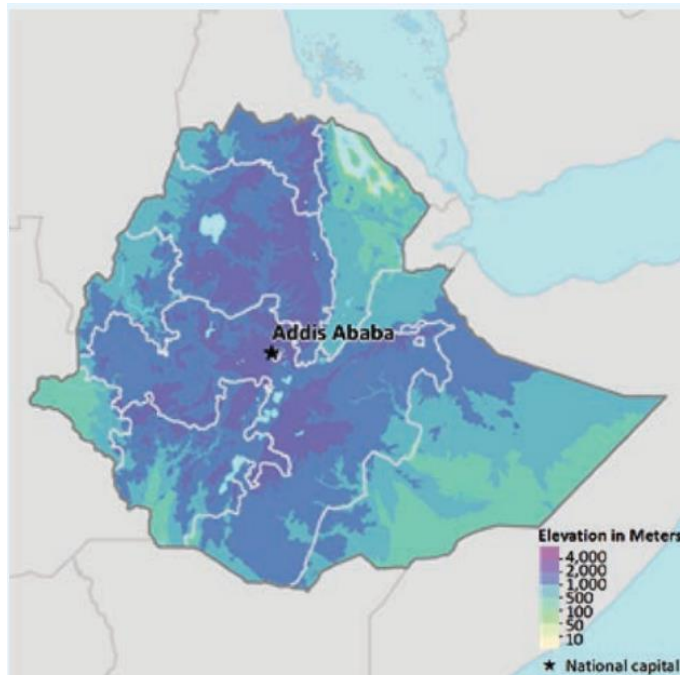


Figure 2 Elevation of Ethiopia (*The World Bank Group, 2021*)

Water resource is one of the most affected sectors by climate change. Fluctuations in water resource can be the main problem in Sub-Saharan African countries for the future. Water availability is the major key for a country's economic development. The speed of the hydrological cycle might be increased because of high temperature, variable rainfall worldwide due to climate change. The stream flow and water resources volumes will be affected by the rainfall repetition and change. As a results, exposed the area for severe flooding or serious droughts that can affect the extent of water scarcity (Bisrat Kifle Arsisoa, 2017).

In the countries of Sub-Saharan increasing the rate of urbanization. Ethiopian political and administration city, Addis Ababa, is one of urbanization rate growth cities in Sub-Saharan. Like the capital of other countries, the number of people migrating from the countryside to this city is high. See table 1 below shows the rate of population growth in Addis Ababa. Water is one of the basic necessities of life for human beings; Addis Ababa city's water supply must be commensurate with economic activity and population. A city's water consumption increases as the population growth of, and the economy grows. Although construction, manufacture and trained activities are alarmingly increasing in Addis Ababa to bring it to the level of other major cities, considerations have not been made in supplying the water supply accordingly. It is exposing the city to water shortages. To see how the climate change affect the local water supply, it is possible to mention the variation of water level in the reservoir. During the rainy season, enough water enters the reservoir or if there is heavy rain, the city is in danger of

flooding. This can only be implemented if the city planning and the administrative structure have been thoroughly studied (Bisrat Kifle Arsisoa, 2017).

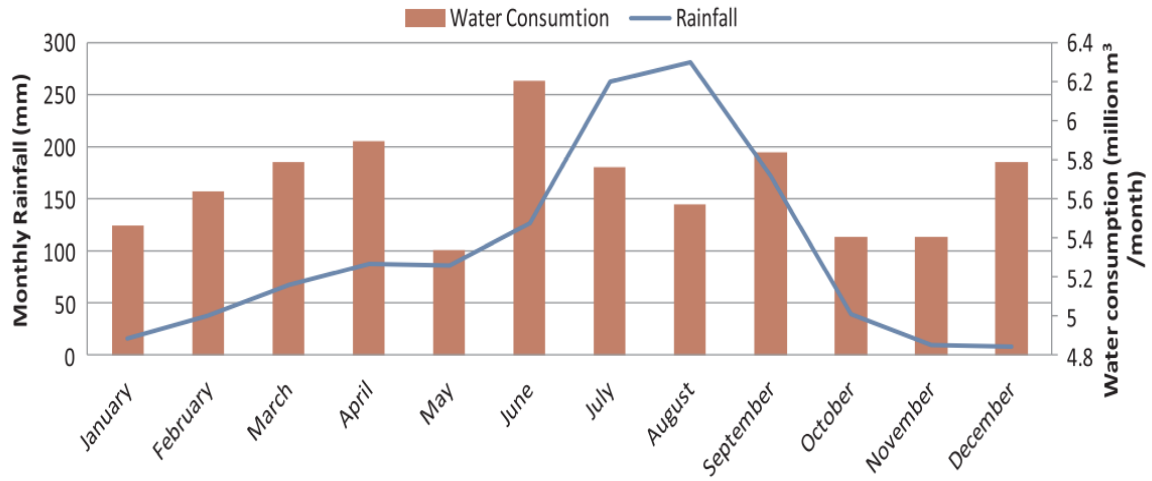


Figure 3 Monthly observed water consumption versus mean monthly rainfall (2012) (Bisrat Kifle Arsisoa, 2017)

Year	Population	GrowthRate	Growth
2022	5227794	4,44 %	222270
2021	5005524	4,42 %	211825
2020	4793699	4,39 %	201716
2019	4591983	4,37 %	192309
2018	4399674	4,36 %	183709
2017	4215965	4,36 %	176038
2016	4039927	4,37 %	169142
2015	3870785	4,36 %	161843
2014	3708942	4,36 %	155076
2013	3553866	4,36 %	148391
2012	3405475	4,37 %	142580
2011	3262895	4,36 %	136426
2010	3126469	4,36 %	130722
2009	2995747	4,36 %	125087
2008	2870660	4,37 %	120188
2007	2750472	2,29 %	61563
2006	2688909	2,08 %	54759
2005	2634150	2,08 %	53571
2004	2580579	2,08 %	52625
2003	2527954	2,08 %	51481
2002	2476473	2,08 %	50433
2001	2426040	2,08 %	49339
2000	2376701	2,08 %	48467
1999	2328234	2,08 %	47414

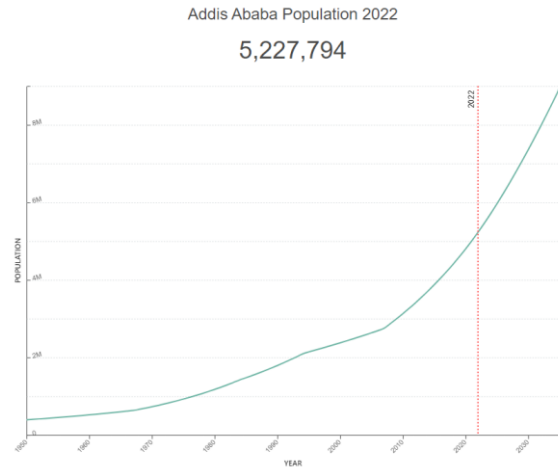


Table 1 Addis Ababa Population Data (Urban Area) (*World Population Review, 2022*)

## 1.2. Organization of the Study

In this scenario the study was proposed to have five major parts. The first part comprises background of the study, statement of the problem, research questions, objectives of the study, significance of the study, scope and limitation of the study, and organization of the paper. The second part incorporates on reviewing of related literature on the issues under study. The third part clarifies on the research methodology adopted. The fourth part presents the major findings of the research, and the last part provides summary, conclusions, and pertinent recommendations. Eventually, it will be closed with references and appendixes.

## 1.3 Statements of the Problems

Climate change is becoming a global challenge. As a result, climate change adaptation and mitigation have become the world’s common language. Climate adaptation and mitigation can be practiced when it comes to changing global or regional climate patterns. The Department of Urban Design and Regional Planning is the main organization for studying the strategies of

climate adaptation and mitigation measures. Urban designers and city planners have worked on nature base tasks mostly. Designing infrastructure such as road design is one of the municipality's main tasks (Pinto, 2014).

Global warming and climate change seem to have the same meaning, but they are different. Global warming is one of the catastrophic consequences of climate change. According to the IPCC press 2021, global warming is getting high fast (IPCC, 2021). The only solution to not be late is to reduce greenhouse gas emission from all nations, developed nations should act now. All nations should create a strong land-use policy, such as where and how to produce building materials with zero emissions and more focus on environmentally friendly human activity. Developing countries such as Ethiopia suffer from food shortages, air-polluted disease, short water sources, etc. Although, Ethiopia is endowed with natural resources, climate change has limited its use of natural resources (NATIONAL METEOROLOGICAL AGENCY Addis Ababa, 2007). The country's natural resources are land-based resources. Due to climate change, there are rainfall variations across the country. As a result, most farmers' land is not in use for two or more seasons (Authority, E. P., & ABABA, A, 1997).

The natural disasters are reported every year. The disasters cause great damages and sometimes loss of human life. For instance, floods and droughts are among many other disasters that destroy residential villages/towns, damage roads, railways, and farm fields (Highland, 2001). Since 1850, twelve warmest years are recorded, eleven of them are between 1995 and 2006 (Bernstein, 2008). According to IPCC 2007 reports, climate change, especially global warming is affecting the world's natural systems.

Global warming is the most dangerous and harmful to sustainable development all over the world. Many developing countries suffer too much, and it can continue if all nations do not work together. All nations must recognize the impact of global warming and must know the reason is mostly man-made (Thomton, 2014). Global warming is becoming the cause of diseases like cardiovascular diseases and malaria. The biggest cause of cardiovascular diseases (CVDs) is air pollution and is one of the leading causes of death in the world (Rajagopalan, 2018). According to the World Health Organization (WHO), 17.9 million deaths were registered in 2019, which is 32 percent of the global number of deaths (World Health Organization, 2021). See central Illustration in figure 4. Malaria epidemic is a seasonal disease in Ethiopia, especially it outbreaks during the farmer's working season that makes the worse. The ecological factor of the transmission of malaria are density of population, humidity, altitude, the change of temperature and deforestation, which are common in Ethiopia (Adugna,

2011; Tulu, 1996). The transmission of malaria is believed to be due to climate change. The spread of the mosquito epidemic is most pronounced during the hot summer months. The reproductive system also depends on the temperature of the environment; when the temperature is 28 C the parasites multiplication in the mosquito (Sporogonic cycles) will be within 9 to 10 days, but if the temperature is above 30 C or below 16 C it takes more days (Alemu, 2011).

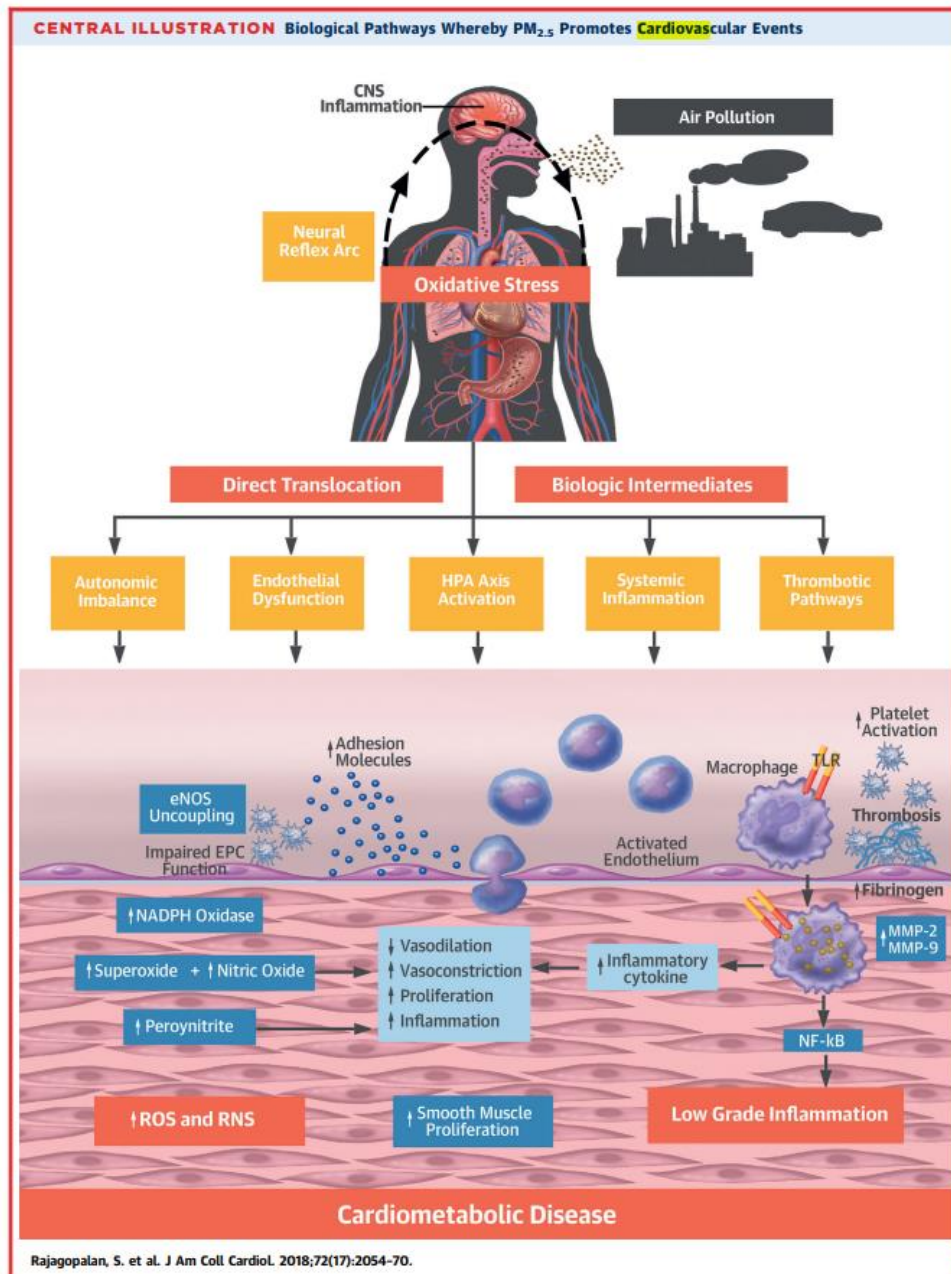


Figure 4 CENTRAL ILLUSTRATION Biological Pathways Whereby PM2.5 Promotes Cardiovascular Events (Rajagopalan, 2018)

Ethiopia's most important energy source for 95% of the population is biomass such as wood, manure, crop residues and charcoal. As a result, more than 50,000 people died in 2007



because of air pollution. Almost five percent of the country's diseases come from the use of solid materials for power generation (Habtamu Sanbata, 2014). 78.3 percent of the Ethiopian population settled in rural areas (The World Bank, 2018). These citizens using wood, dung, and such kind of source of energy, which can easily be found nearby for daily use (Habtamu Sanbata, 2014).

Greenhouse gases emissions and land resources degradation are caused by biomass energy source. Research shows 7,383.86 tons CO2 emissions come from biomass energy in Ethiopia (Table 2) (Addisu, 2020). Wood, charcoal and dung are traditional power generators in Ethiopia. The inhabitants of the capital of Ethiopia use traditional energy source for the family's energy needs like other regions of Ethiopia. According to a survey conducted on the average living conditions in the city, where most of the city's residents live, most of the city's residents use a power plant that can generate air pollution. Although energy consumption is related to income, the energy they use now is dangerous to health. Many people's health problem has a negative impact on the country's social, political and economic activity (Habtamu Sanbata, 2014).

Biomass Energy Source	CO2 Emissions per Tons
Dung	5,051.85
Wood	1,327.10
Charcoal	10,041.89

Table 2 CO2 Emissions per Tons from biomass energy source (Addisu, 2020)

As the WHO's climate and health country profile report, climate change is affecting Ethiopian health. Also urged the people of the country to be exposed to various climate change threats if proper action is not taken. Those challenges can be high temperature, river flood, diarrhoeal deaths and etc. these things are obstacles for the country's development. They affect livelihoods human health to name the significant (World Health Organization, 2015).

**1.4. Significance of the Study**

The findings of this study expected to be significant for the following reasons. Government and other parties involved in the Global warming, Climate change, environmental impact, greenhouse effect and etc. As a result, they may use the findings of the study as a result, they may use the findings of the study as additional a springboard for further studies. Academics, consultants, and government agencies may use the study as a stepping-stone for further study in the area at an advanced level. The result of the study may serve as an input for

planning and policy formulation. The findings may also be considered as important additions to the existing knowledge and literature in the area for the public at large.

### 1.5. The study area

The location of this research site is Addis Ababa, the capital city of Ethiopia. The headquarters of the African Union and the United Nations Economic commission for Africa (UNECA) is located in Addis Ababa and is an important city of the African continent. Addis Ababa is the 12<sup>th</sup> largest city in Africa (World population review, 2021) with estimated 5,2 million inhabitants (World population review, 2022)..

The meaning of the city's name is "New Flower", Empress Taytu Betul named it which is equivalent to Addis Ababa in Amharic in 1886 (B, 2005) (Addis Ababa means in English New Flower). Geographically, the city is located at latitude 9<sup>0</sup> 0 1' 48' 'North and longitude 38<sup>0</sup> 44' 24 " East (UN Environment in collaboration with Environmental Compliance Institute, 2018). The city covers an area of 540 km and is located at an altitude of 2355 meters above sea level under Entoto Mountain (UN Environment in collaboration with Environmental Compliance Institute, 2018). Sub-cities of the city of Addis Ababa are:

Addis Ketema, Akaky Kaliti, Arada, Bole, Gullele, Kirkos, Kolfe Keranio, Lideta, Nifas Silk-Lafto and Yeka. These 10 sub-cities are divided into 28 Wordas and 328 Kebeles (housing associations) (UN Environment in collaboration with Environmental Compliance Institute, 2018).

The two images below show where Addis Ababa is located on the map of Ethiopia and the subdivisions of the city.

Addis Ababa City Administration to facilitate a healthy living environment for migrants (for study or for work) from the countryside. The state divided the responsibilities among the three relevant agencies according to their level. The agencies in hierarchical; regions, sub-cities and woredas shall be working in accordance with the policy and implement the purpose of the city master plan.

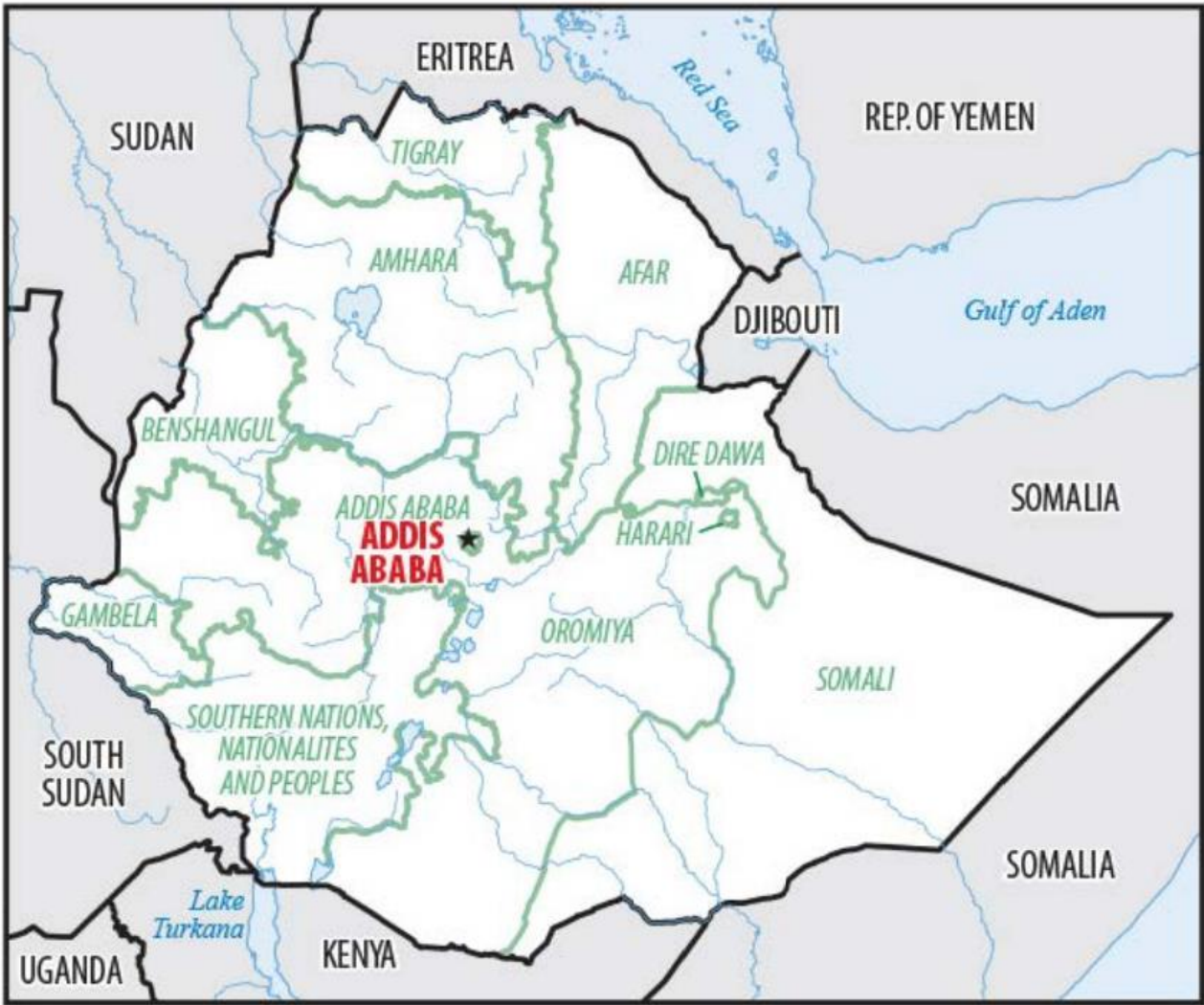


Figure 5 Administrative map of Ethiopia showing the position of Addis Ababa (World Bank Group, 2015) (UN Environment in collaboration with Environmental Compliance Institute, 2018).

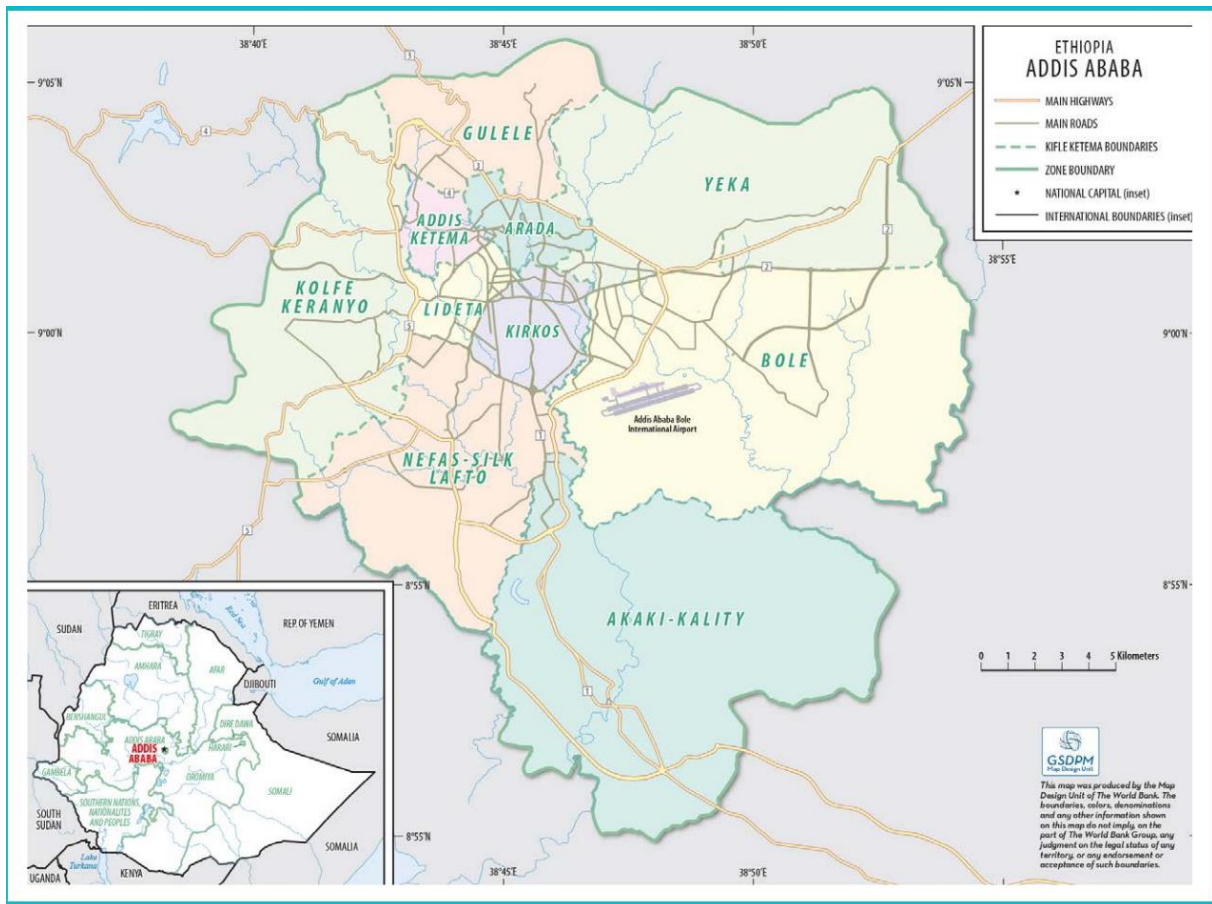


Figure 6 Map of Addis Ababa Metropolitan area showing the sub-cities (World Bank Group, 2015) (UN Environment in collaboration with Environmental Compliance Institute, 2018)

According to the 1995 Ethiopian Federal Constitution, Addis Ababa and Dire Dawa have the same autonomy as the regional governments. In addition, Addis Ababa is the capital city of the Federal Republic of Ethiopia. Although the city is the capital of the Federal Republic of Ethiopia and a self-governing state, the Federal Government can reconstruct the city's administration (UN Environment in collaboration with Environmental Compliance Institute, 2018)

## 1.6 Objectives

### 1.6.1 General Objective

The general objective of this study was to identify and interpret The Effect of existing climate adaptation strategies, including policies and technologies to mitigate harsh weather events in Addis Ababa.

### 1.6.2 Specific Objectives

Specifically, the study would look at to:

- Analyze both primary and secondary data of climate impact records in Addis Ababa.
- Identifying the major challenges and adaptation strategies of climate in Addis Ababa.
- Assessing the existing challenges of climate impacts
- Suggesting proposed plan of waste management and water recycling project as a means of mitigation strategies

### 1.7. Research Questions

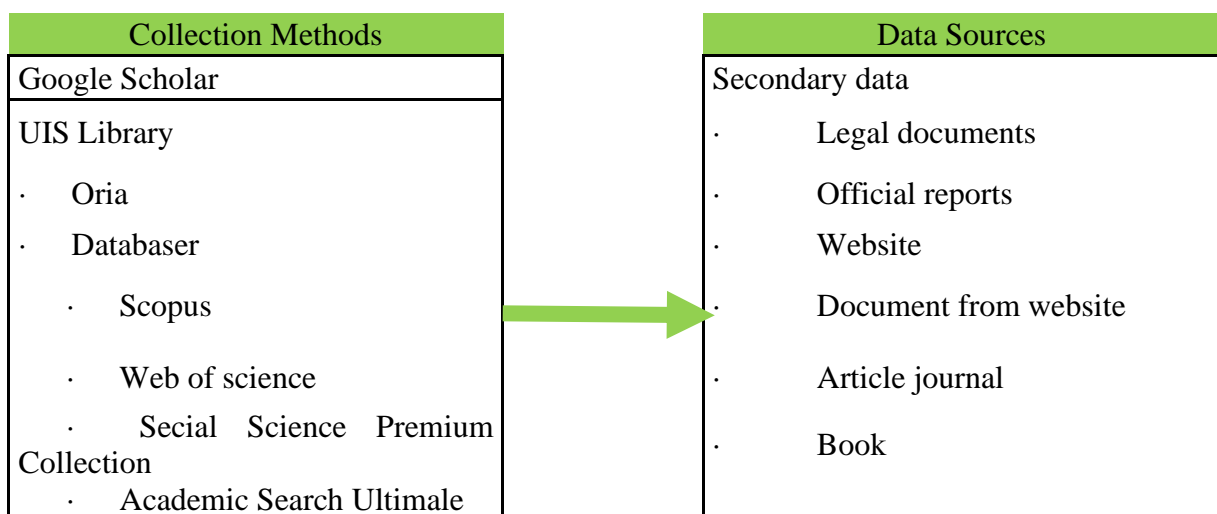
In order to meet my research objectives, the following research question were formulated:

- What are the impacts of climate change in Addis Ababa? Which type of natural disasters have occurred in Addis Ababa?
- What adaptation strategies are already in place and how can they disable that?
- What policies and agenda initiatives can be implemented in Ethiopia to limit the impacts of climate change?

### 1.8. Research Design

The study uses a systematic literature review. A systematic literature review is one of the research methodologies that can secondary data. To start the collection of information, which can be use in the review, first identified the type of information. This is to get the concerning associate data that can explain the topic of this research. The literatures that focus on climate adaptation, mitigation and weather event about Addis Ababa.

Data sources and collection methods



## 1.9 Data collection Methods

As to data collection method was concerned, a mixed approach was employed. First, the researcher tried to investigate the detail data both through semi structured and structured interview and document analysis. However due to physical distance of the study area, the latter method was found to be appropriate to apply.

Accordingly, a scientific data base which was studied by others was mainly used as a source of the data. In order to get the initial steps, the national climate change managements and practices were assessed and their mitigation strategies were also critically evaluated. Addis Ababa weather impact study has also entered into national context studies. The previous experiences geographically and content wise experiences were identified. Using the country's official document such as Addis Ababa resilience strategy, Addis Ababa city air quality management plan, climate change national adaptation programme of action (Napa) of Ethiopia. Addis Ababa environmental policy, Initial National Communication of Ethiopia to the United Nations Framework Convention on Climate Change (UNFCCC) on the climate issue, current developments and future plans of the city master plan was also critically observed and possible alternative plan was suggested. The national document-based analysis was narrated by the researcher in the perspective of solving problems, suggesting mitigation strategies and techniques.

## 1.10. The aim of the Study

In connection with the above discussion, it is necessary and crucial to examine and further explore environmental impact in terms of education and research in general and including a wide range of factors beyond climate change and ecological discipline.

The purpose of this thesis is, therefore, to analyze the objectives and practices relating adaptation and mitigation to climate change. An attempt was also made to show the potential threat of residents during heavy rain season. Furthermore, it aimed at identifying the things that lead to temperature rise and its consequences. It is interesting to note that the first literature and previous studies focused on national experiences and policy. Then, based on this examination of local practices in Addis Ababa city the study would clarify the current city's adaptation and the current strategies usage in order to address the challenges of climate change in the future effectively.

It would be great if this study covered many parts of the country. However, due to lack of vast data management problem and time constraints, it is delimited to focus only the harsh weather climate change in Addis Ababa.

### 1.11. Scope of the study

The impact of climate change in a big city is measured due to the extent of the damage. To study how to control this, it is important to see the effect. There are the variety factors for this, like population, traffic condition, industrial growth, construction, landscaping, land use and so on in the city. Here, the study investigates the suffering of Addis Ababa in urban temperatures and a related weather event as a measure of climate change.

It is common to use old and new research data to study climate change in a large city. However, the data could not be obtained such as the impact of different sectors, current weather conditions.

The study will assess in-depth of existing climate adaptation strategies, including policies and technologies to mitigate extreme weather events in Addis Ababa. There are 11 sub cities and more than 110 weredas in Addis Ababa where the data to be collected. But due to time and finance constraints the researcher limited to only selected cluster areas in the city.

The scope of this research will be delimited to its scope only to those meteorological and agricultural sectors which have the feedback of climate change and environmental adaptations. It takes the sample of the study only from those meteorological and agricultural sectors in Addis Ababa involving only in major sectors and extent to which stated success variables affect their adaptation.

## Chapter Two

### 2. REVIEW OF LITERATURE

#### 2.1 Introduction

This theoretical context section discusses applicable previous studies, literature and theories regarding the topic of the thesis. Initial, a general background and definitions of climate change and more specifically adaptation and mitigation are presented. The chapter discussed the challenge of weather event change, and lastly it looks at urban adaptation planning, the role planners and other main actors play within urban resilience.

The impact of climate change on the African continent is evident in all sectors. The most affected sectors are water, natural resources, agriculture, and health. The flood and drought events in Africa are the impact of climate change on water resources. The frequency change and the variability of rainfall, move away of water bodies, and other factors can disturb water resources. Then, the study of water sector is very important to eliminate the impact of weather events in the region (Jonathan I. Matondo, 2020).

Policies for controlling weather events are useful for eliminating the consequence of climate change. While national policy addresses weather event, regional willingness to implement the policy is essential. Climate change planning is that eliminate the cause and harms. Water is the first essential nutrient for human beings, and it can also cause loss of life. For example, drought and flood are lack of water, and they are also harmful natural catastrophe. Therefore, water resources management research is important at the national and regional levels. The research may provide an appropriate adaptation technique for appropriate region. (Akimasa Sumi, 2010)

It is important to know the annual rainfall of a country in order to determine a country's vulnerability for droughts and floods. Japan Meteorological Agency use the Automated Meteorological Data Acquisition System (AMeDAS) to prevented and mitigate the natural disasters. AMeDAS measure each weather elements, for example, precipitation amount, wind direction and humidity (Akimasa Sumi, 2010).

Ethiopia is one of the oldest settlements and civilizations countries in the world with its alphabet and calendar (Federal Democratic Republic of Ethiopia Ministry of Water Resources National Meteorological Services Agency, 2001). Ethiopia covers an area of 1.2 million square kilometers, and it is in the Horn of Africa (NATIONAL METEOROLOGICAL AGENCY Addis Ababa, 2007).



Ethiopia has experienced the challenge of climate change. According to the World Bank, in 2020, 78.3 percent of the Ethiopian population settled in rural areas (The World Bank, 2018). Like most developing countries, the people of Ethiopia's rural areas depend on agriculture for their livelihood. They cultivate their fields seasonally and traditionally. Therefore, they are the first vulnerable groups for the effects of climate change. In 1972/73, 1984, and 2002/03 in Ethiopia, many people have been displaced and lost their lives because of drought three times in different years (NATIONAL METEOROLOGICAL AGENCY Addis Ababa, 2007). Recently 2006, many people lost their lives, and many lost their homes and property in the 2006 floods (NATIONAL METEOROLOGICAL AGENCY Addis Ababa, 2007).

The country is at risk in many natural disasters such as droughts and flooding. The magnitude of the disaster varies from region to region, depending on the geographical and local climate. Ethiopia intends to minimize national greenhouse gas emissions to 145Mt CO<sub>2</sub>e (FEDERAL DEMOCRATIC REPUBLIC OF ETHIOPIA, 2016).

Climate change is having a major impact in Ethiopia. The country's lifestyle and level of consciousness have contributed to the worsening of the problem. As most of the country's population is dependent on agriculture, the country's economic potential depends on natural resources. When a farmer farms in a traditional way based on season, climate change makes the attack dangerous. Climate change is worse when the farmer runs the field in the traditional way and season. The effects of climate change have severely limited the farmer's ability to defend himself, both financially and intellectually.

Farmers are particularly vulnerable to fluctuations in rainfall, floods, and temperature fluctuations. In 2016, the country presented a plan to address this problem at the national level. The current epidemic and civil war are not only weakening the community but also killing it. Given the seriousness of the problem, if the government takes immediate action, it will be able to put an end to the health and social crisis in the community. Ethiopia's two most important national framework plans are the ones presented in 2016: Growth and Transformation Plan II (GTP II) and Climate Resilient Green Economy (CRGE) Strategy. The plans will contribute to the country's natural resource-based economy and seasonal agricultural development. The country's strategic plans will play a key role in the success of the country's 2025 growth plan. The plans not only move Ethiopia to the middle-income zone in time, but also show the country's commitment to reducing greenhouse gas emissions (The World Bank Group, 2021).

## 2.2 Drought

### 2.2.1 Drought in Horn of Africa

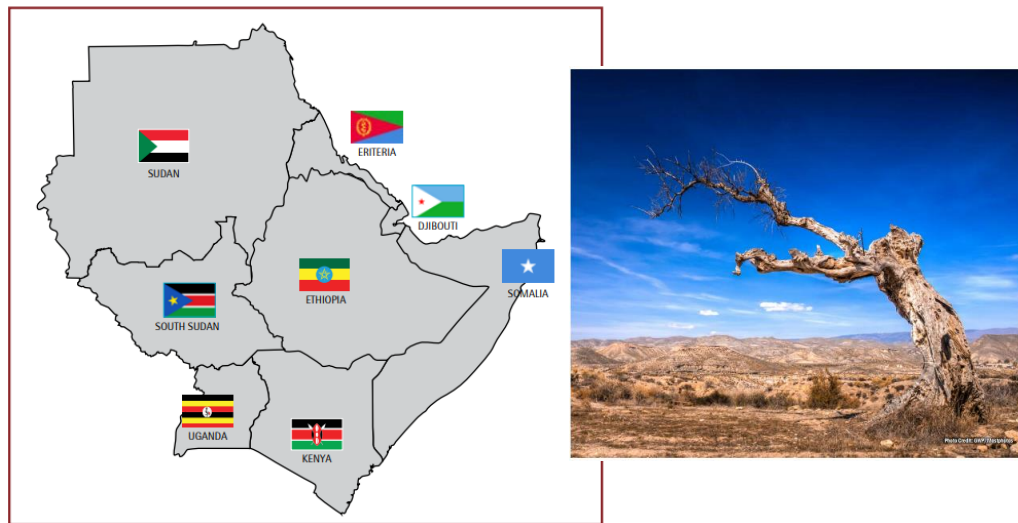


Figure 7 IDMP HOA project coverage and Challenges of climate change (*Global Water Partnership Eastern Africa (GWPEA), 2015*)

The study area is in Horn Africa, and they have many similarities due to climate change causes and consequences. The rate of population growth, energy sources and supply, and their major livelihoods are named come of the countries' similarity. It is therefore important to note the similar problem in the Horn of Africa to illustrate the scale and severity of the disaster.

The Horn of Africa's 70 percent are Arid and semi-Arid Lands (ASALs), then the annual rainfall in the region is less than 600mm. As the table below shows, countries in the region have one common major livelihood, which is agriculture. Agriculture is one of the most vulnerable sectors to drought as the water and forestry sectors. According to National Integrated Drought Information System (NDIS) the general definition of drought is the shortage of water (NIDIS, u.d.). In the post-season countries, water shortages create a lot of catastrophes and keep agricultural sector out of operation (Global Water Partnership Eastern Africa (GWPEA), 2015; Global Water Partnership Eastern Africa, 2015).

Parameters	Djibouti	Eritrea	Ethiopia	Kenya	Somalia	S. Sudan	Sudan	Uganda
Size of the country (km <sup>2</sup> )	23,200	121,320	1,119,683	581,309	637,660	644,330	1,879,360	241,550
Population (Million) <sup>2</sup>	0.873	6.333	94.101	44.354	10.496	11.296	37.964	37.579
Life expectancy at Birth (years) <sup>3</sup>	61.3	61	59.3	61.08	54.69	54.64	61.86	58.65
Gross Domestic Product (GDP) per capita (US\$) <sup>3</sup>	1,468.3	450	389.3	1,245.5	145.0	1,044.99	1,753.3	571.8
Total renewable water resources per capita (actual) (m <sup>3</sup> /yr.) (2013) <sup>3</sup>	475	1163	1,627	792	572	1,445	920	1913
Major livelihoods	Agriculture, livestock	Agriculture, livestock	Agriculture	Agriculture, Livestock, Entrepreneurship	Livestock, Agriculture	Agriculture	Agriculture, Livestock	Agriculture, Livestock, Fishing
Major economies	Port banking railway	Agriculture fisheries mining	Agriculture Services mining	Agriculture Tourism industries	Livestock services (informal)	Agriculture petroleum	Petroleum, mining agro-industries	Agriculture, fisheries tourism

Table 3 Socio-economic profile of the countries of the HOA (*Global Water Partnership Eastern Africa, 2015*)

Horn of Africa is a vulnerable area for climate change. A non-governmental organization (NGOs) such as the ICPAC works to help the community that is affected by climate change. The disaster affected human health, water resources, risk management, agriculture and food security then NGOs are contributing to making the crisis not be worse. Appropriate water supply to the victims is often provided by ICPAC (IGAD, 2022).

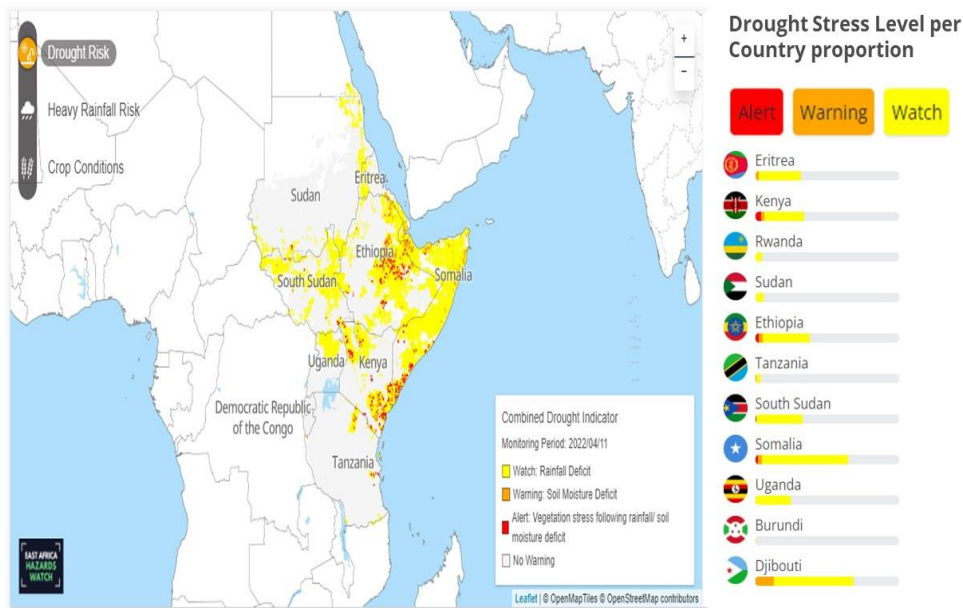


Figure 8  
Drought  
Stress

Level per Country proportion (ICPAC, 2022)

East African countries, Ethiopia, Kenya and Somalia have been hit by the worst drought in 40 years. This is because of the lack of rain in the country for four consecutive seasons. Humanitarian agencies have been called in for emergency assistance. The United Nations and its humanitarian partners discussed ways to address the situation and future support with hydrometry community experts (World Meteorological Organization, 2022).

The drought in the Horn of Africa this year is severe. The worker in the humanitarian organization said that it is very difficult to save lives in the region. In three Horn of Africa countries, Somalia, Ethiopia and Kenya, people are struggling too much to survive, especially children. Children did not get enough food. The number of children suffering to get malnutrition are round about 5.5 million, 1.6 million of them in the worst condition (OCHA, 2022) (UNICEF Eastern and Southern Africa Regional Office, 2022).

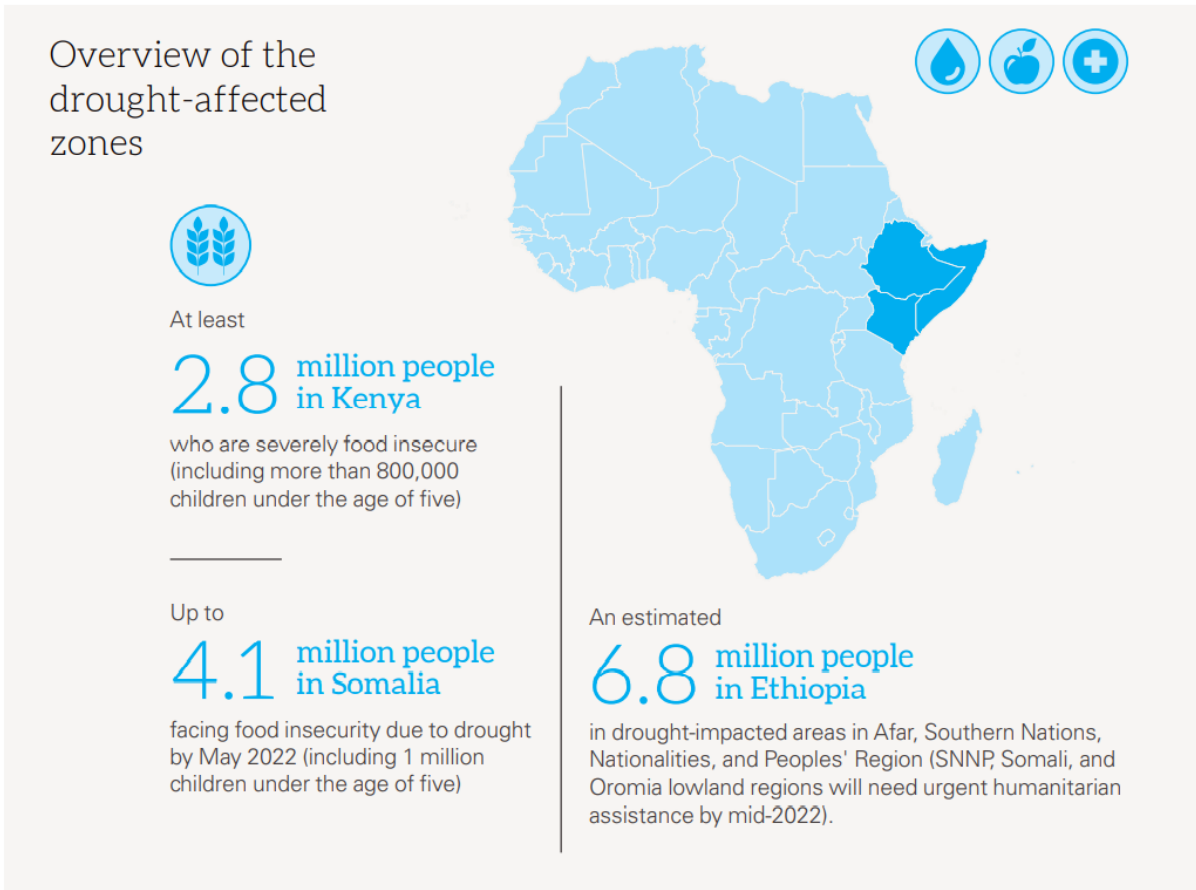


Figure 9 Overview of the drought-affected zones with number (UNICEF Eastern and Southern Africa Regional Office, 2022)

The community affected by the drought will do everything possible to keep the children or their families alive. In order to earn money for the family, he gave his daughter in marriage before she is old enough. The other family, children are forced to work in way that does not fit their age. Children who lost their parents due to the drought have no guardians and their lives are in danger (UNICEF Eastern and Southern Africa Regional Office, 2022).

The World Food Programme (WFP) announced that to give emergency response the organization need 437 million US Dollars for the next six months as soon as possible. The notification from WFP shows the hunger of people in the Horn of Africa will be increasing the end of this year. Currently 14 million people are in hanger, this number will be 29 million on the end of this year. Because of the war in Ukraine rising the prices of food and fuel in region. The Horn of Africa has been hit by a series of four drafts, and rising food and fuel prices could cost many lives. It is in this context that the international community urgently needs help (Snowdon, 2022).

In 2022 UNICEF's Intersectoral Response Strategy is to give life-saving assistance to drought-affected children and their families in four countries. Those are Ethiopia, Somalia,

Eritrea and Kenya. Since water is the most important thing, UNICEF, in collaboration with Health and Education programmers, prioritizes the provision of clean drinking water to families who have water problem, health centers, and schools. Water supply is essential to protect the community from health problems caused by poor hygiene, such as cholera and skin diseases. According to the culture of the community, the supply of water to the family is due to the role of women. Recognizing this, UNICEF facilitated the installation of water lines in the middle of Bole to reduce sexual harassment. Conflict over political differences has exacerbated the problem in drought-stricken countries. In war-torn countries, there are the potential to provide life-saving assistance to those affected by drought is limited. Crisis in Kenya, Somalia after New Presidential Election, there has been significant tension in the delivery of aid. The civil war in Ethiopia has led to an increase in the number of Internally Displaced People (IDPs) (UNICEF Eastern and Southern Africa Regional Office, 2022).



Figure 10 Michael Dunford, WFP's regional director for East Africa, inspects drought damage in Adadle, in Ethiopia's Somali region (Snowdon, 2022)

2.2.2.1 Drought in Somalia

Drought in Somalia is highly risk of human lives. The struggle is live or death for the community and they are trying to save their families as much as possible. Food prices have

increased by 36 percent in the Somali region. Drought in the region in 2016-17 was easily stopped by the international community. According to WFP warning, every second is harmful, and the international community have to give attention seriously to save lives (Snowdon, 2022).

This year's drought in Somalia is worse than the drought that the community has experienced so far. Decades of conflict in the country, combined with climate change, have endangered communities. According to OCHA, 4.5 million Somalis are directly affected by the drought and about 700,000 have been displaced. In February, 1.6 million people received life-saving assistance from the United Nations, but it is not enough (UNITED Nations, 2022).

Like many other countries in the Horn of Africa, children are the first victims of the drought in Somalia. 1.4 million children under the age of five are malnourished, and about 300,000 of them will not survive without proper nutrition. The United Nations estimates that by 2022, \$ 5.5 billion will be needed to save the lives of 5.5 million Somalis, but only 4 percent has been raised. This shows that the



UN does not have the capacity to cooperate with humanitarian organizations to carry out its life-saving work (UNITED Nations, 2022).

Figure 11 A mother and her five children inside their makeshift shelter at a camp for Internally Displaced Persons (IDPs) in Luuq, Somalia on 21 March 2022 (UNITED Nations, 2022)

2.2.2.2 Drought in Ethiopia

Rainfall in one area is much lower than normal, and drought occurs in the area. This event is one of the most dangerous in the world because it kills so many people. Various researchers have suggested that this is due to global warming and predict that the damage will worsen in the future. Drought in various parts of Ethiopia occurs when the region's rainfall

decreases from 30 percent to 50 percent. Ethiopia has experienced a series of droughts, but this is the first time this has happened again and again every year. Various researchers have suggested that global warming is the cause of climate change, and that if it continues to do so, it could be a major threat. It is important to know the geographical location, natural resources, and climate of a country at risk of drought (Mera, 2018).

Drought in northern Ethiopia, along with war, has led to the loss of many lives. Pastoralists and farmers in the area have also been forced to reach out to help. In the Amhara region, the farmer did not get enough rain last year (2020) and not produced as much produce as he needed. This year (2021), some territories were at war during the sowing season, so production was not possible. As a result, children and adults in the region are suffering from severe hunger. (Food and Agriculture Organization of the United Nation, 2021).



Figure 12 Northern Ethiopia (OCHA, 2022)

Eighty percent of the population in these three northern regions of Ethiopia (Amhara, Afar, Tigray) depend on agriculture and livestock. As a result, climate change impact can easily harmful them. The Afar region is a naturally arid region, with a slight reduction in rainfall, which is detrimental to the region. The latest IPS figures show that 4.4 million people in



northern Ethiopia are suffering from hunger. According to the latest IPS data, 4.4 million people in northern Ethiopia are suffering from hunger and 4.2 million people have been displaced. It added that many animals in the region are dying of skin diseases, nasopharynx and foot disease (Food and Agriculture Organization of the United Nation, 2021).

## 2.3 Flood

### 2.3.1 Flood in Horn of Africa

Flooding is one of the most dangerous and recurring challenges. For example, the 2004 tsunami killed many people. Floods in the United States in 2005, floods in the United Kingdom in 2007, and flooding in Europe in 2010 are indicative of the frequency of floods. The worst flooding in 30 years was registered in 2006. It has killed more than 200,000 people and infected millions of people with various diseases. If climate experts and city planners work together to develop emergency plans for flooding risk management, the damage can be reduced (Lamond, 2011).

After extensive research on flood risk, it is widely believed that the most effective way to prevent floods is the society and professionals learning from the accident and rehabilitates the area future, focusing on disaster prevention has been the focus of more recent attention. There are four steps involved in coordinating disaster prevention:

- Emergency responder or respondent
- Reconstruction of the victims area
- Investigate the accident strictly
- Reduce the risk of flood damage by learning from the disaster (Lamond, 2011)

These four steps will help prevent flooding from getting worse and keep it at its current level. Rehabilitation of communities in the aftermath of floods can be done as much as possible, along with providing flood awareness to the community. Provide an in-depth analysis of how the disaster has occurred and how it can be managed to prevent further disasters by providing an in-depth analysis of the public's perceptions for the future. The result will be great because the community is willing to participate in the event. The local community should consider all options, both professional and non-professional, for post-disaster action. The community needs to work together with scientists, policy makers and climate pests for the future to be successful (Lamond, 2011).

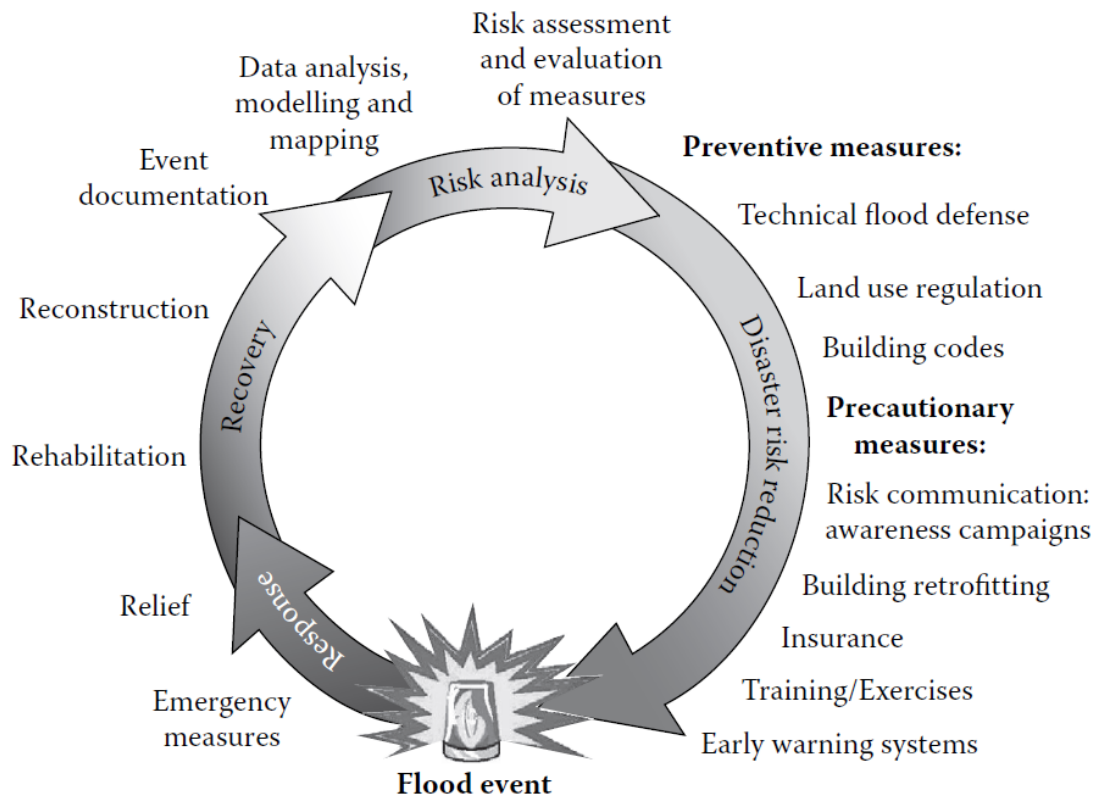


Figure 13 Flood risk management cycle (Lamond, 2011)

Ethiopia, Kenya and Somalia are the country’s most at risk of flooding in the Horn of Africa. The number of affected people in this year (2006) is increasing rapidly, it is difficult to estimate. Because the relief action is ongoing. Flood damaged road, water resources, houses, agricultural land not least loss of human live and animal death (United Nations System Standing Committee on Nutrition, 2006).

	Affected population	Displaced population
Kenya	700,000, including 100,000 refugees (OCHA, 29/11/06)	
Ethiopia	362,000 (GoE, 23/11/06)	122,500 (GoE, 23/11/06)
Somalia	Worst-case scenario 902,000 (FSAU, 30/11/06)	340,000 (FSAU, 30/11/06)

Table 4 Estimates of affected population, Kenya, Ethiopia and Somalia floods, November 2006 (United Nations System Standing Committee on Nutrition, 2006)

Due to heavy rains in the Horn of Africa in early November 2006, rivers in Ethiopia, Somalia, and Kenya increased. While the drought-stricken area received good rain, extreme

levels of flood danger were announced in many parts of the countries. As a result, many people have been forced to leave the area (NASA, November 17, 2006).

During the November 2006 floods, 723,000 people in Kenya were affected. The floods were the result of heavy rains, it has caused landslides in the country. The area had to be exposed to diseases such as cholera caused by a lack of clean water, this can take the lives of many people. The Tana River Delta is one of the worst affected areas in the country (NASA, November 27, 2006).

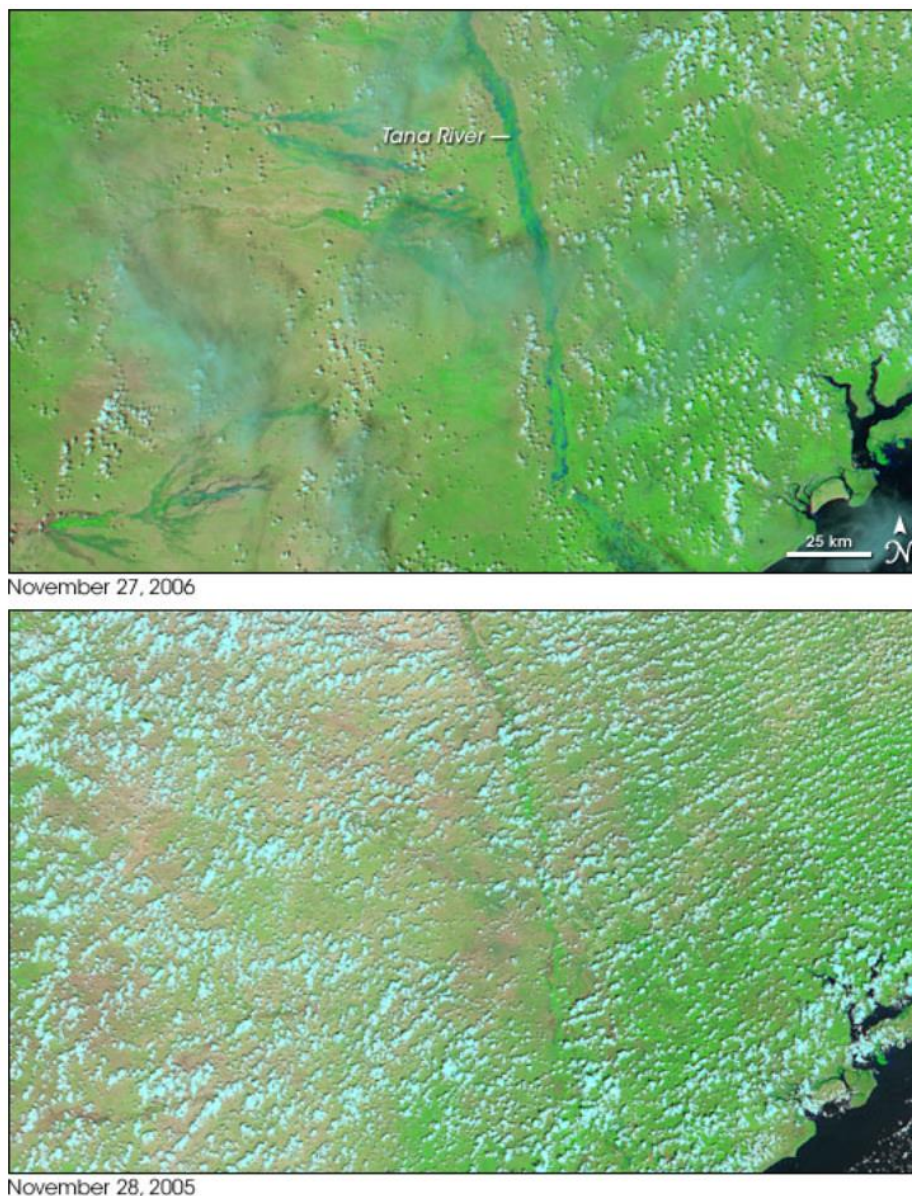


Figure 14 The river during the flooding on November 27, 2006 (top), compared to November 28, 2005 (NASA, November 27, 2006)

In Dadaab, northeastern Kenya, Somali refugees were flooded in 2006 after heavy rains. More than 12,000 people lived at the site, and aid workers were unable to provide adequate assistance due to flooding (UNHCR, 2006). This shows that the area has not been designed for human habitation by the region's master plan. Kenyans living in a local hut at the time were also exposed for flooding (UNHCR, 2006).



Figure 15 A UNHCR vehicle navigates through flood waters on the road between Dadaab (UNHCR, 2006)



Figure 16 Shelters at the Ifo camp under water after the heavy rains in north-east Kenya (UNHCR, 2006)

#### 2.3.1.1 Flood in Ethiopia

Flood is the most dangerous natural hazards all over the world. The influence, the nature and regularity of incidence/rate of flood is varies worldwide. It is reported flood affected highly Africa and Asia to compare with the other parts of the world. The year between 2000-2016 reported 621 flood hazards and 12176 people died. In the same years happened 102 drought and no deaths recorded. In the same years listed 27 flood hazards in Ethiopia and reported 1534 deaths, in the other hand seven drought was registered in Ethiopia and there was not death, directly or indirectly was listed. It is reported that round about 2.2 million people in Ethiopia have been affected by the flood hazard since the 1980s, there was over 47 flood hazards registered. Flood event is the major hazard in many regions in Ethiopia, every year 250000 people.

Extreme levels of flood danger were announced in several countries. When a natural or man-made drainage systems are not withstood for the amount of water that comes from rain, it will be flooded. Rainfall varies from region to region due to climate change. Seasonal rains in

Ethiopia During June to September, the country will experience heavy rains. According to the DPPC, vulnerable areas for flood hazard have been identified:

- East of Lake Tana where River Ribb and Gumara enter the Lake, in Gondar region.
- Wabe Shebelle River from Imi to Mustahil, Hararghe region.
- Baron River from the town of Gambela to the border town of Jakao, Illubabor region.
- Awash River around Assayita, Wollo region.
- Around Tewfik in the Teji Depression, Shewa region (Assefa, 2018).

Regions	Causes of flooding	Flood Risk			Duration
		Number of affected people	Number of affected livestock	Property damaged in Birr	
Tigray	Flash flooding	112	15	13835	1987
Afar	River flooding	445700	-	-	1985/87
Oromia	River flooding	63359	359	9882811	1985-87
	Flash flooding				
SNNP	Flash flooding	252513	79781	4708683	1981/86/87
	River flooding				
Gambela	River flooding	224828	-	-	1985/87
Fourteen	Flash flooding	10572	29	16400718	1986/87
Grand Total		1162647	82877	32510792	

Table 5 Summary of Causes of Flooding, Flood Risk, and duration by Region (DPPC, Flood Risk Areas in Ethiopia, 1996) (Assefa, 2018)

In 2021, floods hit the Ethiopian nation hard, in several parts of the country registering deaths and many people displaced. In the period 26 April to 10 May in Ethiopian three Region round about

70000 displaced. Due to heavy rain and wind in several part of the Afar Region, there have been flood and then around 27400 people displaced, in Somalia Region 7 people died and around 11,200 displace and 9 7 people died in Dire Dawa. Extreme levels of flash floods danger kill 7 people in the capital city of Ethiopia in the same year (FloodList, 2021).



Figure 17 Flash Floods in Addis Ababa, Ethiopia, 17 August 2021. Photo via Mayor of Addis Ababa / Twitter (FloodList, 2021)



Figure 18 Floods in Mogadishu, Somalia, May 2021. Photo: Somali Red Crescent (FloodList, 2021)

## 2.4. Country Natural Resources

Natural resources are the backbone of a country's economy. When this resource is damaged by natural or man-made disasters, it will cause huge economic losses to the country. Ethiopia's natural resources are being severely exploited by natural and man-made disasters. For example, deforestation is classified as an artificial disaster, the main reason for this is that the society of the country is mainly subsidized by wood and charcoal. Natural disasters can be cited as one of the country's major erosion problems. This natural disaster is one of the most devastating to the country. Since most Ethiopians live in rural areas, and they are dependent on the soil for their livelihood losing topsoil is harmful (Authority, E. P., & ABABA, A, 1997).

Erosion has made it difficult for farmers to carry out their daily activities. Whenever the land loses its fertility, it does not produce as much as it needs. The farmer uses dug for householding (cooking), so it is difficult to get enough cattle manure to be used as fertilizer. Due to the 1990 erosion, the country lost 59 million Birr (Ethiopian money)(Authority, E. P., & ABABA, A, 1997).

Due to the high migration rate in the cities, the settlement situation did not upgrade for the resent situation modern. The lack of housing in the capital, Addis Ababa, indicates that the problem is serious. The problem with toilets in Addis Ababa is that the residents are exposed to the disease(Authority, E. P., & ABABA, A, 1997).

Climate change is having a major impact on Ethiopia. The country's lifestyle and level of consciousness have contributed to the worsening of the problem. As most of the country's population is dependent on agriculture, the country's economic potential depends on natural resources. When a farmer farms in a traditional and seasonal based way, climate change makes the attack dangerous. Climate change is worse when the farmer runs the field in the traditional way and season. The effects of climate change have severely limited the farmer's ability to defend himself, both financially and intellectually. Farmers are particularly vulnerable to fluctuations in rainfall, floods, and temperature fluctuations. In 2016, the country presented a plan to address this problem at the national level (The World Bank Group, 2021).

The current epidemic and civil war are not only weakening the community but also killing it. Given the seriousness of the problem, if the government takes immediate action, it will be able to put an end to the health and social crisis in the community. Ethiopia's two most important national framework plans are the ones presented in 2016: Growth and Transformation



Plan II (GTP II) and Climate Resilient Green Economy (CRGE) Strategy. The plans will contribute to the country's natural resource-based economy and seasonal agricultural development. The country's strategic plans will play a key role in the success of the country's 2025 growth plan. The plans not only move Ethiopia to the middle-income zone in time, but also show the country's commitment to reducing greenhouse gas emissions (The World Bank Group, 2021).

## 2.5. Ethiopia's environmental policy

Ethiopia's environmental policy was enacted in 1997. The policy contains a strategy to use the natural resources wisely and conserve the needs of the current generation for the benefit of the next generation. As is well known, Natural resources are often reusable/renewable, instructions on how to do so are provided (Authority, E. P., & ABABA, A, 1997).

The policy has key objectives and provides a consistent and lasting solution for all part of the country. It was designed to improve the living conditions of the community, the natural resources of the region contribute to the building of economic potential, the preservation of culture and heritage. In addition, funding to curb air pollution from developed countries to make power plants more renewable will be used to improve the country's climate. This underscores the importance of creating a community that benefits from technology that respects the local culture and identity (Authority, E. P., & ABABA, A, 1997).

Many important principles are set out in the policy to achieve the goal. The clarity of principles ensures to implement the correct policy plan on time. By emphasizing the principles of human right to live in a healthy and peaceful society, it is clear that environmental health is not only the responsibility of the government but also the responsibility of every resident. When it comes to natural resources, there are two types of natural resources: renewable and non-renewable natural resources. The importance of both is well known, and non-renewable natural resources require great care. Awareness of the use and conservation of natural resources in the community is scarce and requires professional support (Authority, E. P., & ABABA, A, 1997).

## 2.6. Ethiopian sectoral environmental policies

### 2.6.1. Agriculture

Facilitate the agricultural technology to help the farmer to face the situation without leaving the area. It is a method of demonstrating how the farmer can prepare fertilizers on his own, as the technology preserves the natural content of the soil. It is stated that the experts will provide proper training to the farmers regarding to livestock (Authority, E. P., & ABABA, A, 1997).

### 2.6.2. Deforestation

To stop deforestation, it is important to teach the community to change energy consumption the use of building materials and wood products. Deforestation can be stopped by educating the community to change their habit of power generation, construction materials and wood products. Demonstrate appropriate professional information to the society on the use of renewable energy sources such as solar energy (Authority, E. P., & ABABA, A, 1997).

Although water is harmful to the environment such flooding due to too much and drought far too little., it is also good then it will be supply for benefits human health. The country's water resources should use all type of technology as long as it is good for human health. For the region that has water shortage it is useful using recycling water technic (Authority, E. P., & ABABA, A, 1997).

Ethiopia has hydraulic power plant. Biodiesel will replace fossil fuel consumption until it gives a full supply of hydraulic electricity. It is important to use other renewable energy sources to ensure that the country's energy supply is properly managed (Authority, E. P., & ABABA, A, 1997).

Environmental information system gives a clear overview about healthy environment living area. It protects the society's phycological health by low. All people who live in the community have right to get all environmental information (Authority, E. P., & ABABA, A, 1997).

To develop environmental technology, more research work should be conducted. Developing traditional environmental system gives comfort and intellectual for the society. It will be understandable, because the society knows about the traditional system so how to develop this is not new. Research work will be fundable, then any research project support (Authority, E. P., & ABABA, A, 1997).

### 2.7. Climate Adaptation in Ethiopia

The impacts of climate change are very high in Ethiopia, top of that, climate variability makes the problem worse. Majority of the country's population livelihood options limited the country's adaptation capacity. The challenge of climate change can be addressed by making good climate change adaptation policies. In order to reach the affected community, the country's financial capacity have to be used for developing the major sectors like, agricultural and manufacturing (Federal Democratic Republic of Ethiopia, 2019).

Ethiopia has repeatedly hosted and is hosting climate change attacks. To mention the main sectors of the victim: agriculture, water, infrastructure forestry and public health. The study from world bank group “climate risk country profile” shows drought and water scarcity are in risk conditions for the future. The nations both in rural and urban area face heavy rain, erosion and flooding. Food security, livestock and farmers are in risk in terms of less rain and drought for a long term for the upcoming years (The World Bank Group, 2021).

Natural Hazard 1900-2010	Subtype	Events count	Total Deaths	Total Affected	Total Damage (‘000 USD)
Drought	Drought	16	402,367	77,141,879	1,492.600
Earthquake	Ground Movement	2	24	585	320
Epidemic	Bacterial Disease	16	10,999	134,551	0
	Viral Disease	6	156	4,819	0
	Parasitic Disease	1	157	25,000	0
Flood	Flash Flood	9	863	1,129,358	9,400
	Riverine Flood	32	1,105	1,809,978	8,900
Insect Infestation	Locust	4	0	0	0
Landslide	Landslide	5	93	215	36
Mass Movement (dry)	Landslide	1	13	0	0
Volcanic Activity	Ash Fall	3	69	11,000	0
Wildfire	Forest Fire	1	0	5	0

Table 6 Natural disasters in Ethiopia 1900-2020

As shown in the National plan of Ethiopia, greenhouse gases (GHG) emissions will be reduced by 2030. The country target by the year 2030, the emission to 145 Mt CO<sub>2</sub>e or lower. The country’s climate resilient Green Economy strategy is the key to achieve weather event adaptation and mitigation. The national plane of Ethiopia is reducing 64% of ‘business-as usual’ (BAU) emission by 2030 (The Federal Democratic Republic of Ethiopia, 2015).

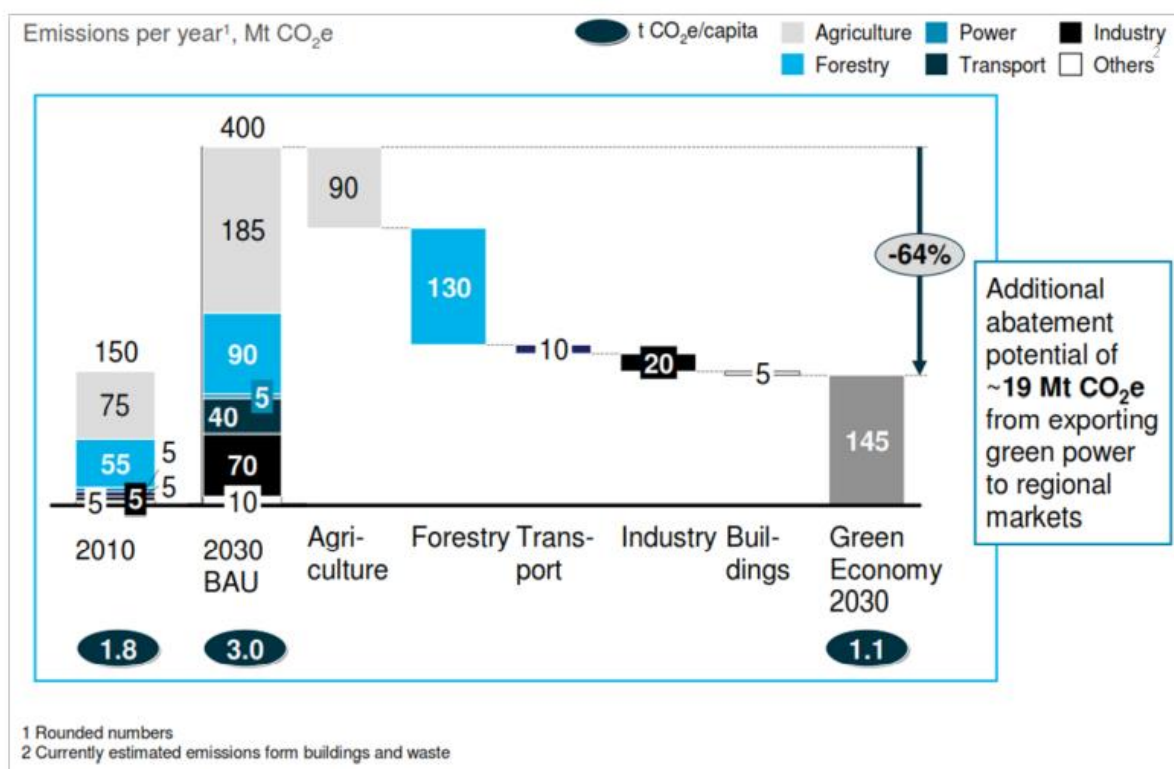


Figure 19 Emission per year Mt CO<sub>2</sub>e (*The Federal Democratic Republic of Ethiopia, 2015*)

It registers the country's greenhouse gases emissions in 2010 were 150 Mt CO<sub>2</sub>e. The emissions sources were all sectors (*The Federal Democratic Republic of Ethiopia, 2015*).

Sectors	Gases	Mt CO <sub>2</sub> e	In % from total
Livestock	Methane and nitrous	65	42
Crop cultivation	Nitrous Oxide	12	9
Deforestation and Forest Degradation		55	37
Electric Power		5	3
Transport		5	3
Industry		4	3
Building		5	3

Table 7 National GHG emissions in 2010 by sectors (*The Federal Democratic Republic of Ethiopia, 2015*)

## Chapter Three

### 3. RESEARCH METHODOLOGY

#### 3.1 Introductions

This section describes the study design, population and model size determination, information collection methods, sampling design, research tools, and method of data analysis. Research methodology is a process that used to analyze the data with the purpose of generating the required information. The purpose of this section is to state out the background of the study methodology. This section describes how the research was carried out in terms of research design, data collection methods, sampling design, operational definitions of constructs, measurement scales, and methods of data analysis will be included in this study.

As to data collection method was concerned, a mixed approach was employed. First, the researcher tried to investigate the detail data both through semi structured and structured interview and document analysis. However due to physical distance of the study area, the latter method was found to be appropriate to apply.

Accordingly, a scientific data base which was studied by others was mainly used as a source of the data. In order to get the initial steps, the national climate change managements and practices were assessed and their mitigation strategies were also critically evaluated. Addis Ababa weather impact study has also entered into national context studies. The previous experiences geographically and content wise experiences were identified. Using the country's official document such as: Addis Ababa resilience strategy, Addis Ababa city air quality management plan, climate change national adaptation program of action (Napa) of Ethiopia, Addis Ababa environmental policy, Initial National Communication of Ethiopia to the United Nations Framework Convention on Climate Change (UNFCCC) on the climate issue, current developments and future plans of the city master plan was also critically observed and possible alternative plan was suggested. The national document-based analysis was narrated by the researcher in the perspective of solving problems, suggesting mitigation strategies and techniques.

#### 3.2. Research Approach

As mentioned in the introduction part section one, the objective of the study is to examine In-Depth Study of Existing Climate Adaptation Strategies; Including Policies Technologies to Mitigate Extreme Weather Events (A Case Study in Addis Ababa City) assess the culture of existing climate adaptation in Addis Ababa city administration; especially, based

on the evidence of Ethiopian Meteorology and Agricultural evidences. The research design for this study is explanatory in nature. This is because the study attempts to explain the connection among the occurrence of climate change and the attempt of adaptations and data will be obtained through quantitative means.

### 3.3. Population and Sample

The researcher used for the study is Addis Ababa city administration, in Ethiopia. The total population of the study area is 4.2 million as world 2022 and could not be gathered the data via primary sources like interview and questionnaire, rather the researcher uses the secondary data sources. Secondary data sources such as annual reports, strategy manual, published and unpublished resources books, articles journals and websites are used.

### 3.4. Data Collection Procedure

To facilitate approaching to the climate change and adaptation for collecting data first of all the addresses and websites of the secondary data will be known and obtained to create a conducive to environment for conducting study. Those annual reports, strategy manuals, published and unpublished resources books, articles journals and websites based the fact that with climate change and adaptations are selected based on the criteria on population and sample size.

### 3.5. Ethical Considerations

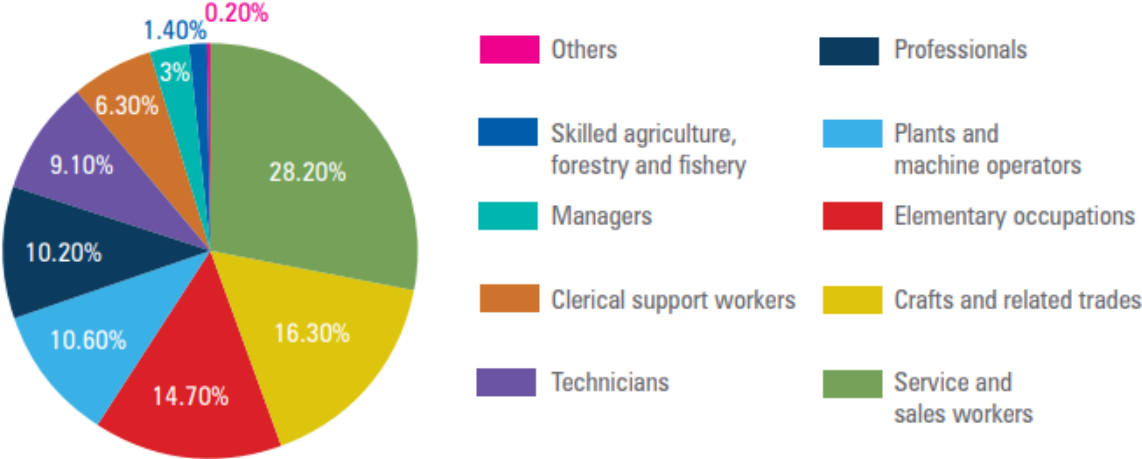
To reach the respondents and acquire primary data, the researcher had to provide formal letter to the office of each case study, but because of the shortage of time and the distance of the location the researcher focused only on secondary data sources. So, the researcher used both published and unpublished written about existing climate change and adaptation strategies, including policies technologies to mitigate extreme weather events to gather adequate information. Every research as a profession has its own ethics. Respecting all these common and basic ethics the researcher will give more attention for those insightful issues that concern about the research data to be secured. The concerned issues will be the city's code of ethics that need to be taken in to account without significantly compromising the findings of the study. Respecting the validity of the data obtained in fine way the researcher will analyze the interpretations.

# Chapter Four

## 4. Discussion

### 4.1. Introduction

Ethiopia is one of the fastest economically growing countries in the world. However, the country is one of the least developed countries in the world and one of the poorest countries in the world. The country's economy depends on rainfall or traditional farmers. The capital, Addis Ababa, has the largest economy in the country and a quarter of its gross domestic product. Most of the city's residents are employed in the private or public sectors. Seventy-five percent of the city's workforce is service providers. The number of urban dwellers engaged in the private sector is not insignificant. Despite this, the unemployment rate, and the number of informal employments of the urban poor are high (AACPPPO, 2017).



Source: CSA, 2015

Figure 20 ADDIS ABABA’S EMPLOYMENT BY MAJOR OCCUPATIONAL GROUP (AACPPPO, 2017)

Addis Ababa, one of the fastest-growing cities in Africa, is home to 25 percent of Ethiopians. The city’s economy is growing at an annual rate of 14% and is projected to be one of the middle-income and carbon-neutral cities by 2025. To illustrate the strategic role of the city in Ethiopia, it is worth mentioning that almost 50 percent of the city’s GDP is donated by the city (World Bank Group, 2015).

The rising unemployment rate in the city is one of the major factors obstacles to the development of the city. In other Ethiopian cities, one in ten households has an unemployed family member, and in Addis Ababa, one in four households has an unemployed family

member. The contrast between the rich and the poor in the city clearly shows the seriousness of the problem (World Health Organization, 2015).

The city government is stressed to provide a full range of basic services. The city provides clean water for 40 percent of the city's population and less than 30 percent of its populations get sewerage service. In general lack of the basic services to contrast with the income of the city, it is unbalanced. These factors clearly show the weakness of the city's government capacity. The reason given for this is migration from rural towns to the city (World Health Organization, 2015).

Cities have many challenges. These can be natural or artificial. Efforts to solve problems, build the capacity of cities, take them to the next level, and make them effective if the right efforts are made. While this success is gradual, the attention of professionals and the community will determine whether the results will be short-term or long-term. Cities in developing countries have more challenges, such a low economic status, and low public awareness of climate change (World Health Organization, 2015).

Addis Ababa is expected to face many challenges in its development. The city's financial constraints and low incomes, combined with climate change, make the effort tedious and tedious. An integrated professional organization provides a temporary solution to the problem. To find a lasting solution, it is useful to combine the knowledge of local experts with climate change experience with the experience of foreign experts. To make Addis Ababa a climate-resilient city, the city's administration needs strong leadership. The municipality can address the shortcomings of existing plans and establish a strong disaster prevention institute to reduce and even stop natural or man-made disasters by addressing climate change-related problems such as floods and droughts (World Bank Group, 2015).

#### 4.2. City's masterplan

When Menelik II and Empress Taytu founded Addis Ababa, Emperor Menelik II's ancestral history, its location in the heart of the country, its favorable climate, and its geographical strategy, and its hot springs in the city attracted their attention. Although modern settlements did not follow the road, it was a master plan which was called Taytu Master Plan. In 1990, the City Council established a city administration that followed the day-to-day running of the city. During the reign of Emperor Menelik II, Addis Ababa underwent a modest settlement until the 1960s (UN- Habitat 2017, 2017).



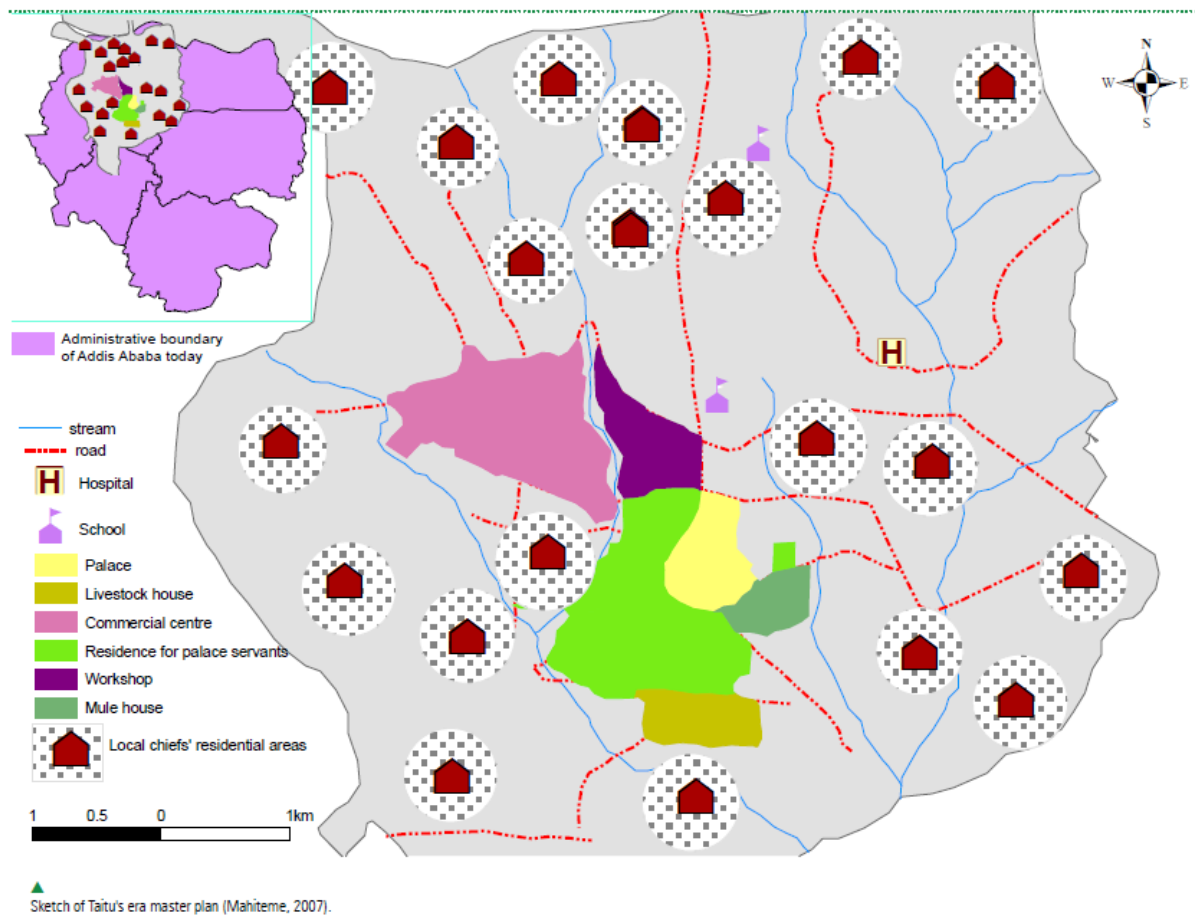


Figure 21 Sketch of Taitu's era master plan (UN- Habitat 2017, 2017)

During the Italian occupation of Ethiopia, the master plan was studied twice. The first was rejected, and the second was implemented. It focused on the construction of roads in the city and the isolation of Italian troops along with the Indigenous peoples. The master plan focuses on modernizing the city, including waste management and transportation. After the Adwa victory, the need to modernize the city continued, and the city's master plan proposal was presented at three foreign concerts. The study did not take into account the geographical location of the city and could not be implemented. These and other factors contribute to the city's air pollution and unhealthy lifestyle. The current sewerage system in the city shows that there is no proper sewerage system (UN- Habitat 2017, 2017).

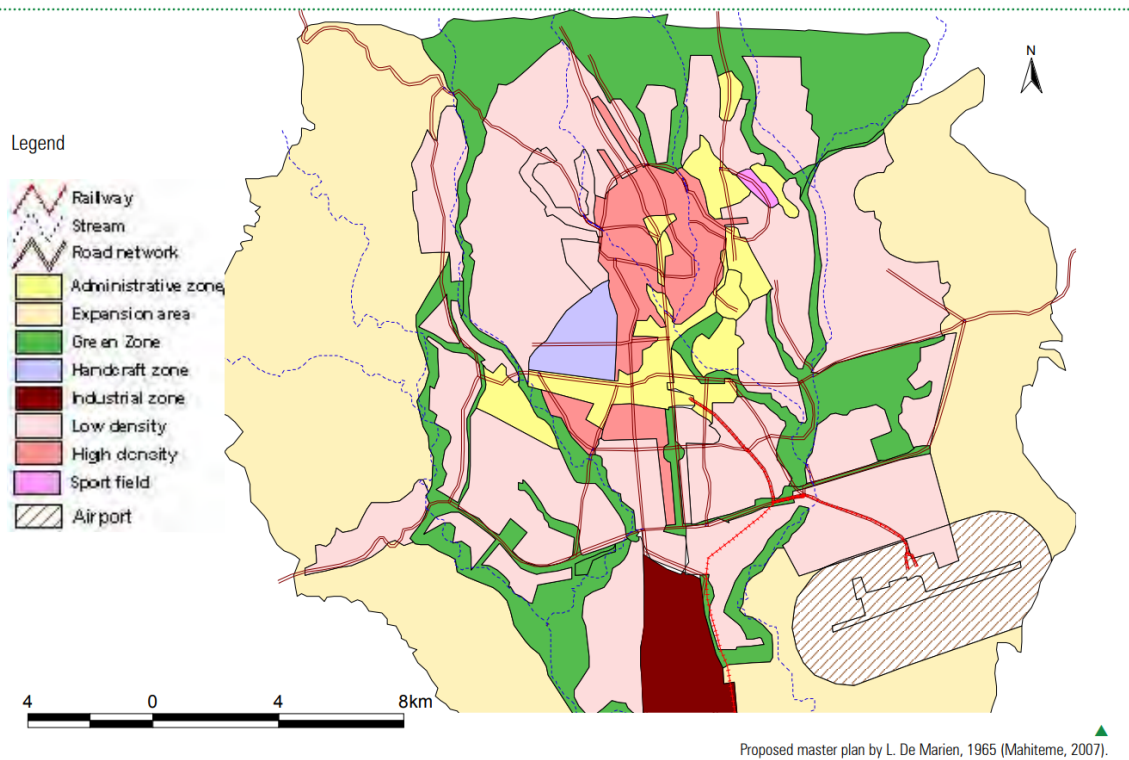


Figure 22 Master plan proposed in 1965 (*UN- Habitat 2017, 2017*)



Figure 23 Common toilets (*UN- Habitat 2017, 2017*)

### 4.3. Climate resilience in Addis Ababa

The study, which focuses on keeping the city's climate healthy, shows the seriousness of the problem. He says he has decided to work with foreign charities on climate change mitigation plans. The city's source of greenhouse gases emissions are sort and the Addis Ababa administration starting mitigation. The minimality of Addis Ababa has a policy to eliminate the GHGs emissions. To mention some; The cars which will be imported have to be not more than three years old, all waste from the industry have to be managed to not affect climate and the building material it must meet the requirements of sustainable construction materials (Addis Ababa City Administration).

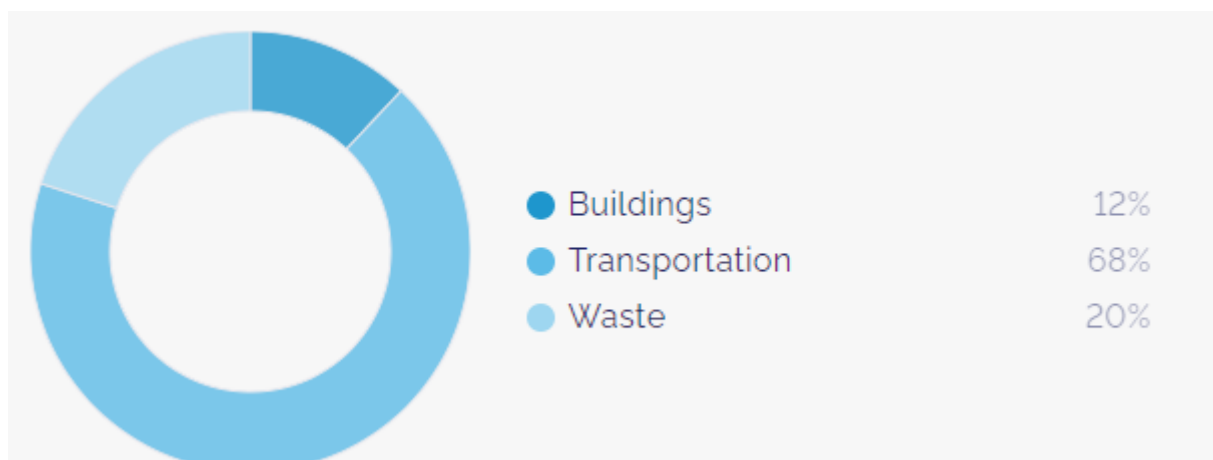


Figure 24 Emissions Inventory in Addis Ababa (*GLOBAL COVENANT of MAYORS for CLIMATE & ENERGY, 2022*)

Efforts have been made to address the city's housing problem since 2005, but so far only 24 percent have been covered. Although it is said that the low-income citizens should have benefited from this opportunity, it is difficult to say that this figure is for them. It is designed to be built with the customer in mind by designing and building materials that consider the capabilities and culture of the customers. The materials used for the construction were imported then the constructions cannot go as planned due to the shortage of construction materials and rising prices. Citizens who have been evacuated from the city center on the pretext of living in unhealthy housing are being subjected to daily traffic congestion and harassment as their workplaces are not included in the plan. The relocation of these people will increase the number of transport users, which is not a goal to avoid the impact of climate change (Addis Ababa City Administration, 2020).

Challenges	Opportunity
<b>Unemployment and poverty</b>	
<ul style="list-style-type: none"> <li>- 65% of women in Addis Ababa are job seekers</li> <li>- 90% of the job in Addis Ababa are concentrated in sectors with low productivity</li> <li>- 23.5% of Addis Ababa's population live under the poverty limit</li> </ul>	<ul style="list-style-type: none"> <li>- Every month the elderly, including homeless people get 215 Birr</li> <li>- Deploying young people through education and financial support to help build the city's capacity</li> <li>- Educating the unemployed on the micro and small supply</li> </ul>
<b>Lack of safe and affordable housing</b>	
<ul style="list-style-type: none"> <li>- Estimated homeless people in Addis Ababa 10000-20000</li> <li>- Lack of affordable and healthy house</li> <li>- Poor quality housing and overcrowding</li> </ul>	<ul style="list-style-type: none"> <li>- Affordable vertical housing (condominiums) options is in second phase</li> </ul>
<b>Inadequate public transport systems</b>	
<ul style="list-style-type: none"> <li>- Inadequate public transportation</li> </ul>	<ul style="list-style-type: none"> <li>- Plan to introduce its first Bus Rapid Transit (BRT)</li> <li>- Strategic Comprehensive Transport Development Plan (2020-2030)</li> <li>- Non-Motorized Transport (NMT) strategy</li> </ul>
<b>Lack of human-centric and inclusive planning</b>	
<ul style="list-style-type: none"> <li>- Eighty-six percent of the 114-kilometer highways are safe and do not have adequate pedestrian services</li> <li>- 88% of traffic deaths involve pedestrians</li> <li>- Between 2009 and 2015, 23,154 households were affected by the Addis Ababa City Renewal Program.</li> </ul>	<ul style="list-style-type: none"> <li>- The Safe Intersection Program</li> <li>- Menged Le Sew, Addis Ababa's monthly car-free event</li> </ul>
<b>Water scarcity</b>	
<ul style="list-style-type: none"> <li>- Percentage of the water produced and distributed lost in the system due to aging and poorly maintained infrastructure</li> </ul>	<ul style="list-style-type: none"> <li>- Gerbi dam project</li> <li>- Decentralized wastewater treatment program</li> <li>- Second Urban Water Supply and Sanitation Project (SUWSSP)</li> <li>- Emergency water delivery during COVID-19</li> </ul>
<b>Environmental pollution and degradation</b>	
<ul style="list-style-type: none"> <li>- 40% of flooding and landslides is attributed to loss of green spaces in Addis Ababa</li> <li>- 90% of industries discharge their waste directly into nearby rivers</li> <li>- 17years The average age of vehicles on the city's roads</li> <li>- 50% of the vehicles generate nearly 90% of hydrocarbon and carbon monoxide emissions</li> </ul>	<ul style="list-style-type: none"> <li>- Air quality management system development</li> <li>- Addis Ababa Drainage Master Plan</li> <li>- Urban Agriculture Initiative</li> </ul>

Table 8 Addis Ababa's climate change challenges and opportunities (*Addis Ababa City Administration, 2020*)

#### 4.4. Climate change adaptation, mitigation, and city's master plan

Climate change adaptation should be incorporated into urban development planning (UDP) and landscape design (LD) to minimize the risk of climate change, which is a major impediment to sustainable development. To reduce the risk of climate change, which is a major impediment to sustainable development, it is important to include climate change adaptation in urban development planning and landscape design. The findings of various researchers show that Addis Ababa is vulnerable to climate change. A study conducted in 2013 to identify flood-prone areas in the city and to study residential areas, and a study of urban warming in 2014, highlighted the severity of the disaster. There is no evidence to suggest that adaptation to climate change is included in UDP and LD, based on studies showing that cities are at risk due to climate change. Climate adaptation has been suggested by academics and experts to be included in the 2017 City Master Plan, but has not been implemented; As a result, the problem is getting worse. Scientists believe that disaster risk can be mitigated by strengthening the city's UDP and LD, which includes adaptation to climate change to reduce the risk of climate change, such as floods (Worku, 2017).

Climate change is a new phenomenon in our world and no definitive solution has yet been found. Environmentalists are still aware of the presence of greenhouse gases and their potential sources of climate change. The damage caused by climate change is not insignificant. As a result, important concepts such as adaptation and mitigation are being emphasized. Since the defense-based investment so far has been costly and only a temporary solution can be found; It is important to create an environment in which these concepts can be incorporated into CDP and LD (Worku, 2017).

#### 4.4. Flood in Addis Ababa

The effects of climate change (CC) affect cities via two principal mechanisms: long-term and moderate extreme weather events. Rainfall variation, global warming and general all negative atmospheric changes are the result of extreme weather events. Finger 25 shows how and in what case the city of Addis Ababa is affected by climate change (Worku, 2017).

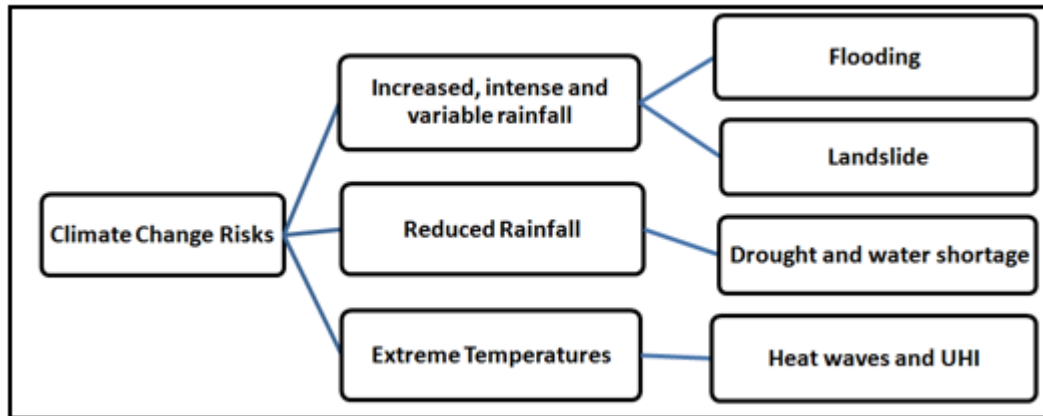


Figure 25 Climate change impacts and risks of Addis Ababa (Worku, 2017)

According to world bank group report, Addis Ababa is dealing with main shocks and stresses. Flooding, Urban fire and Earthquakes are listed under shocks. In other hand unprecedented urban growth, water scarcity and unemployment are listed under stresses (World Bank Group, 2015).

Rivers are overflowing due to poor drainage and heavy rainfall. As a result, Addis Ababa is at risk of flooding. Because of heavy rainfall frequency registered and poor drainage system the city is in flood risk for the future will be increasing. According to a study conducted in Addis Ababa following the rainy season from 1950 up to 2002, approximately 18 mm per decade increased. Rainfall is expected in East Africa, according to an IPCC report (World Bank Group, 2015, Birhanu, 2016, Conway, 2004).

	MAM	JJAS	ONDJF	Annual
1898-1950				
R <sup>2</sup>	0.00	0.00	0.02	0.00
Trend (mm/decade)	+4	-4	-7	-7
Mean (mm)	238	894	87	1220
SD	109	153	67	236
CV (%)	50	17	77	19
1951-2002				
R <sup>2</sup>	0.00	0.04	0.01	0.03
Trend (mm/decade)	+3	+18	-4	+17
Mean (mm)	231	831	111	1171
SD	93	135	64	165
CV (%)	40	16	58	14
1898-2002				
R <sup>2</sup>	0.00	0.02	0.01	0.01
Trend (mm/decade)	0	-7	+2	-6
Mean (mm)	234	862	99	11196
SD	106	147	67	204
CV (%)	45	17	67	17

Table 9 Seasonal and annual rainfall statistics (*Conway, 2004*)

	MAS		MAM		ONDIF		Annual	
	T <sub>max</sub>	T <sub>min</sub>	T <sub>max</sub>	T <sub>min</sub>	T <sub>max</sub>	T <sub>min</sub>	T <sub>max</sub>	T <sub>min</sub>
Mean (°C)	21.2	10.8	24.4	11.4	23.1	8.5	22.8	10.0
SD (°C)	0.7	0.8	1.1	1.0	1.0	1.2	0.8	1.0
CV	3.4	7.6	4.5	8.6	4.4	13.6	3.3	9.6
R <sup>2</sup>	0.23	0.51	0.02	0.37	0.05	0.46	0.10	0.50
Trend (°C/decade)	0.2	0.4	0.1	0.4	0.2	0.5	0.2	0.4

Table 10 Seasonal and annual temperature statistics for 1951–2002 (*Conway, 2004*)

Rain fluctuations are one of the major factors that make Addis Ababa vulnerable to floods. In addition, surface water flooding with the three rivers and tributaries flooding are among the reasons why Addis Ababa is prone to floods. Due to the high altitude of the city,

various parts of the city are prone to flooding. Drainage lines are also not up to standard, and the main roads are flooded with floodwaters during heavy rains. As the population grows and human necessities increase, the city becomes increasingly vulnerable to floods. The land a risk of landslides due to repeated excavations for construction (Worku, 2017).

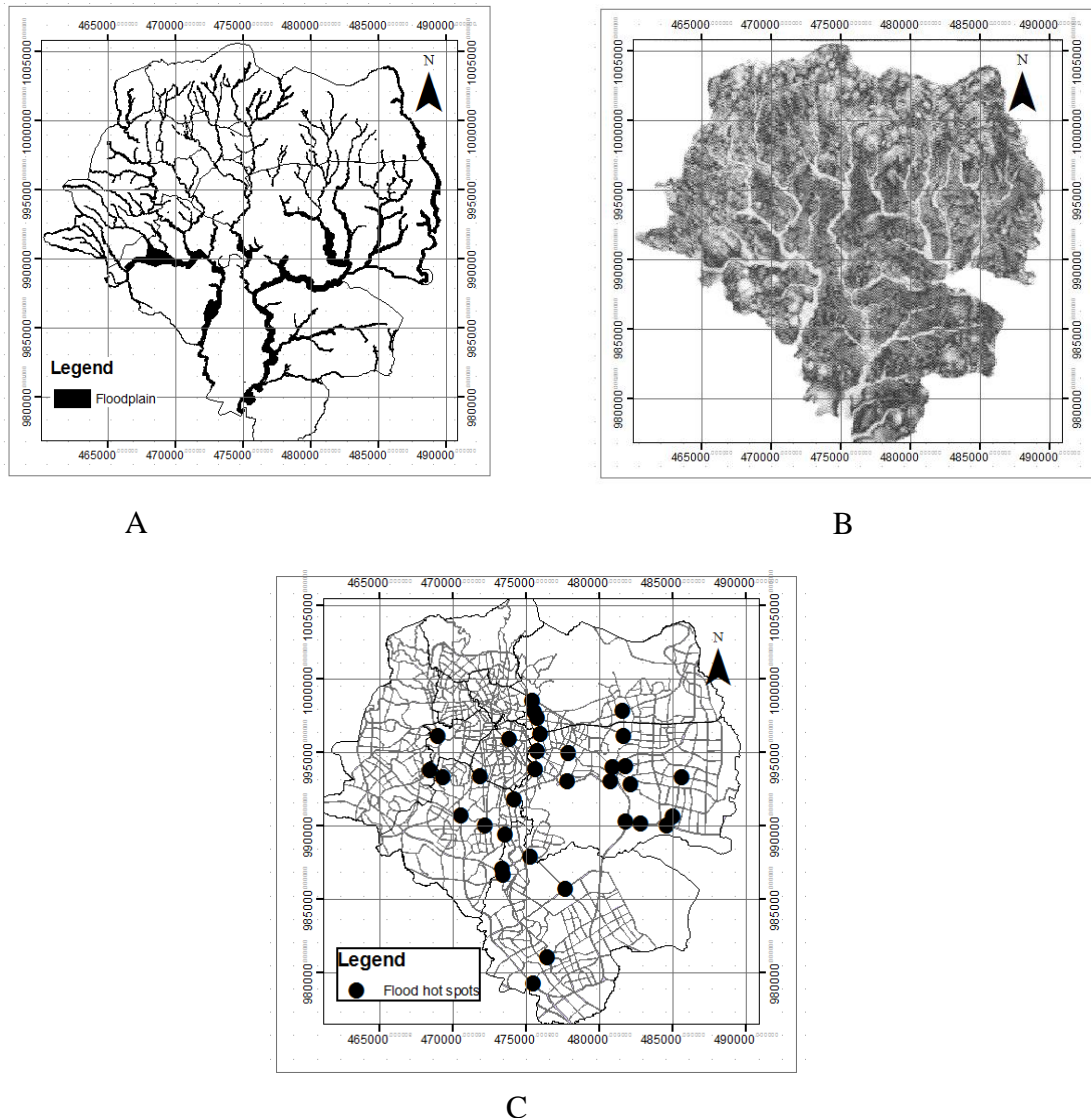


Figure 26 Areas of Addis Ababa at flood risk: a) areas of fluvial flood risk based on wetness index (from De Risi et al., 2013), b) delineation based on aerial photographs and field mapping, and c) hot-spots of street flooding areas as a result of improper drainage network design (modified from AACRA, 2013) (Worku, 2017)

The impact of the flood in Addis Ababa is many, to mention some of them; humans and animals' loss of life, health impacts in terms of air pollution, different diseases, landscape damage, and property and infrastructure damage (Worku, 2017).





c)



d)



e)



f)



g)



h)



Figure 27 Flood impacts in Addis Ababa: a) Collapsed stream banks and land loss; b) damage to transport infrastructure (bridge); c-f) flooded streets in the middle of the city causing disruption of the transport system; g) damaged roads as a result of flooding I leading to increased maintenance and replacement requirements; h) flood markers showing overtopped bridge by flood (*Worku, 2017*)

#### 4.5. Drought in Addis Ababa

Due to the lack of rain, the water crisis in Addis Ababa is severe. Drought can be described in various ways in Addis Ababa, but the main problem is the water crisis in the city. Consecutive years of drought, it has affected the city's reservoir, water-related businesses, and the city's green development and biodiversity (Worku, 2017).

The impact of the flood in Addis Ababa is many, to mention some of them; humans and animals' loss of life, health impacts in terms of air pollution, different diseases, landscape damage, and property and infrastructure damage. Drought directly affects the city of Addis Ababa in the water sector and vegetation. Indirectly, the city's food security has been affected because the city is dependent on other Ethiopian regions when it comes to food (Worku, 2017).

#### 4.6. Mitigation and adaptation in Addis Ababa

##### 4.6.1. Mitigation

The municipality of Addis Ababa built many parks to upgrade the city's air quality. The municipality is using the city's open area that was just a garbage dump for green spaces. Additionally, the city's municipality built a car-free area that can be used for walking, an activity center, and public space. The logic is to meet the city's target to be carbon neutral by 2025 (Addis Ababa City Administration, 2020).

##### 4.6.2. Adaptation

The city's administration working together with the government of the country to solve urban problems such as sanitation and drinking water since 2005 by finding the challenge and then solving it. In this way, much of the city's problems are being addressed to some extent. Protecting the nation from climate change is no easy task, but the city's administration working hard to transfer the city of Addis Ababa to be a smart and thriving city. The city's vision is "By 2030, Addis Ababa will flourish into a safe, livable, and prosperous city" (Addis Ababa City Administration, 2020).

##### 4.6.3 Ten-minute city

The concept of ten minutes city is to address the requirement of a sustainable city. The idea is to have access to daily services within a short distance. It gives an opportunity to have more time with the family is one of the most important for all and also it reduces the economic pressure on the community (Kesarovski, 2022).

There are 10 sub-cities in Addis Ababa and Addis Ketema is a very congested area in terms of population (The City of Addis Ababa's website, u.d.). Most of the people living in the area have no proper job; their income depends on the market center Merkato. From Addis

Ketema to Mercato is 2.7 km, and people can walk within 30 min Figure 28. From Left to Mercato is 10.6 km and it takes over two hours by walk Figure 29. They have no fast job, or they have no monthly salary.

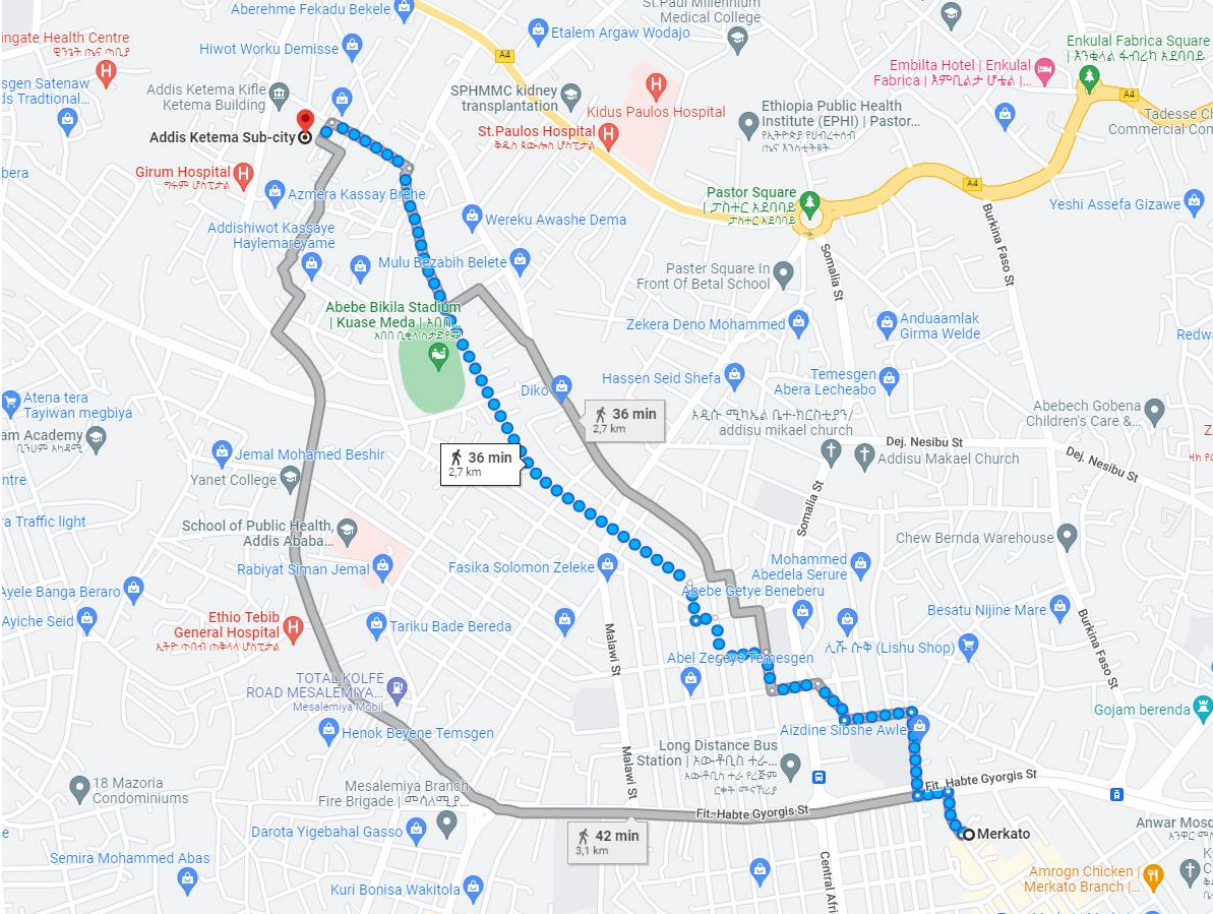


Figure 28 Google map from Addid Ketema to Merkato

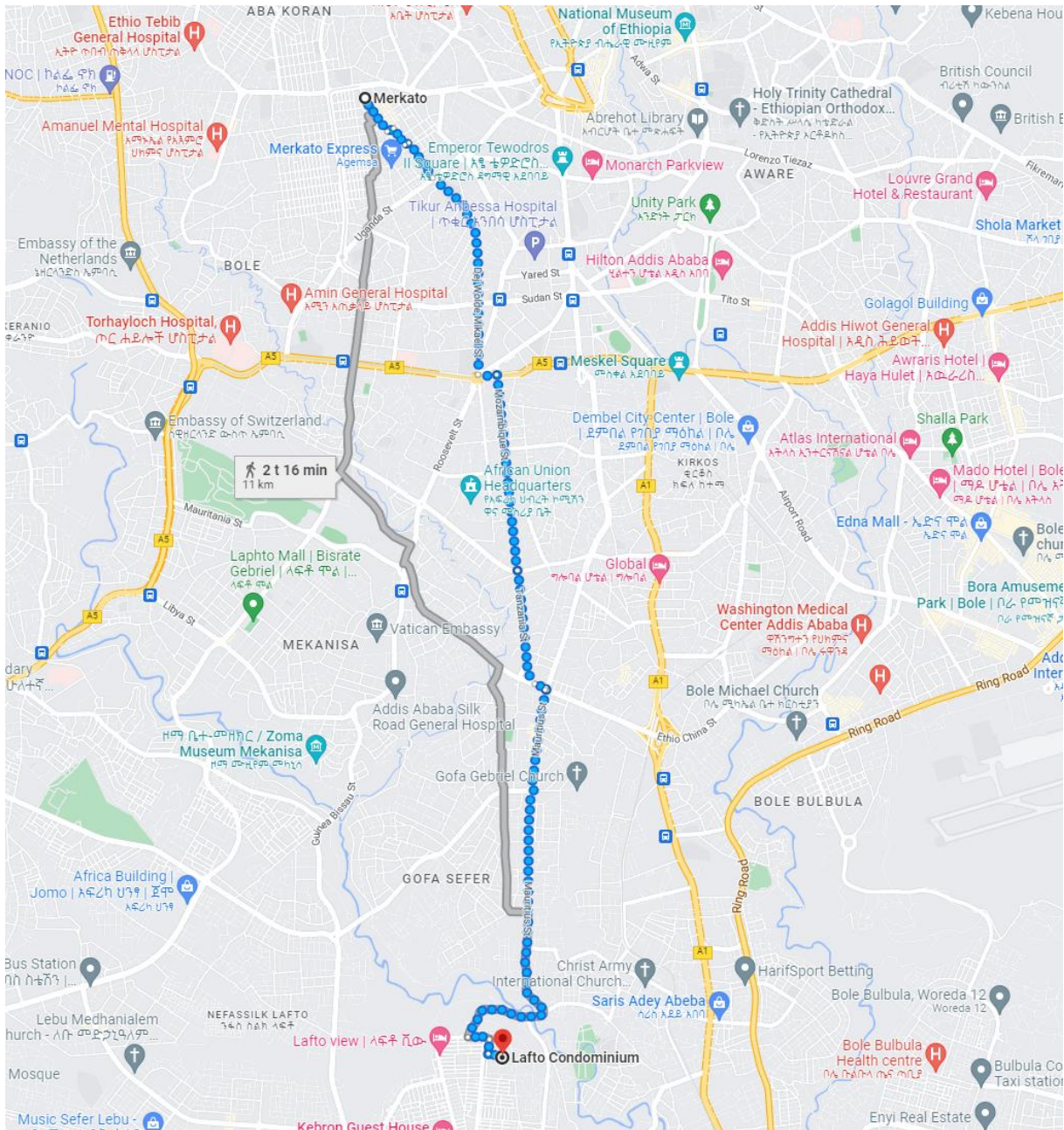


Figure 29 Google map from Addis Ketema to Lafto

There are a lot of things that a community can lose when they move from a usual place to another. It loses its social connection; the other is that the city planners do not take culture into account when it comes to landscape design in the new area. As a result, cooking traditional food in the new place is impossible. To give a better house with a good sanitation service, it is better to improve the local zoning plan (see the proposal).

The water problem in the city is not only in the city but also in the country. Many technologies can be used to approach the city's water shortage by looking at staff from other cities. Take the Norwegian city Mandal as an example. Mandal is a small city in Norway. The

city's water is of the highest quality cities in Norway. This is due to the fact that space to irrigate the water and wastewater for recirculating, by wastewater treatment solving the water problem in the area.

#### 4.6.4 Suggested proposal of Waste management and water cycling

The following picture gives a brief view of what a sub city called ‘Addis ketema’ looks like. As it has been shown in the figure, waste storage from toilet only, car fee road, road for car and waste storage from shower and dish are installed and proposed for the sub-city to utilize it.

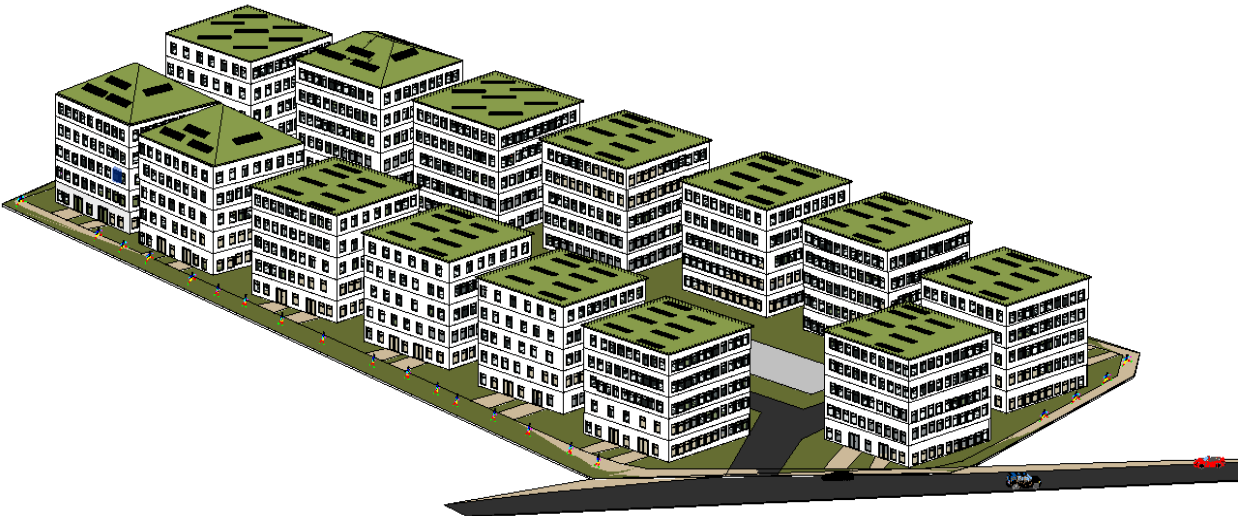
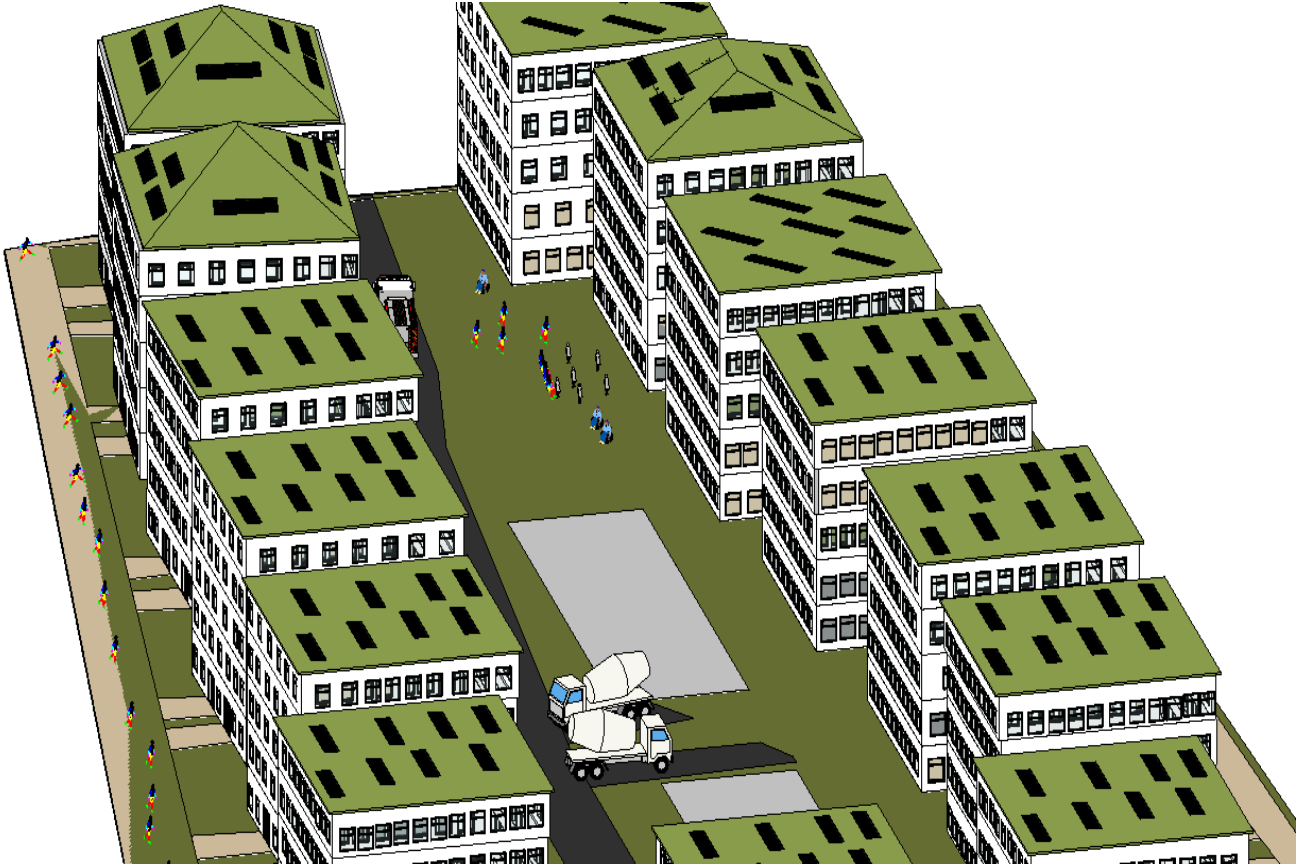
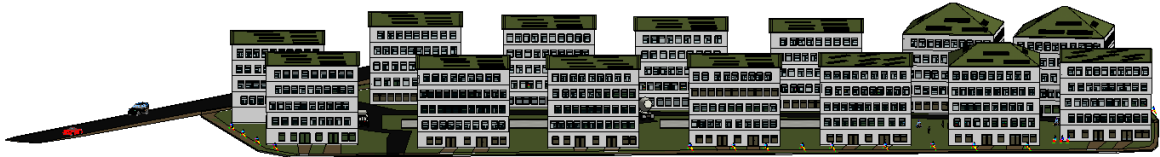


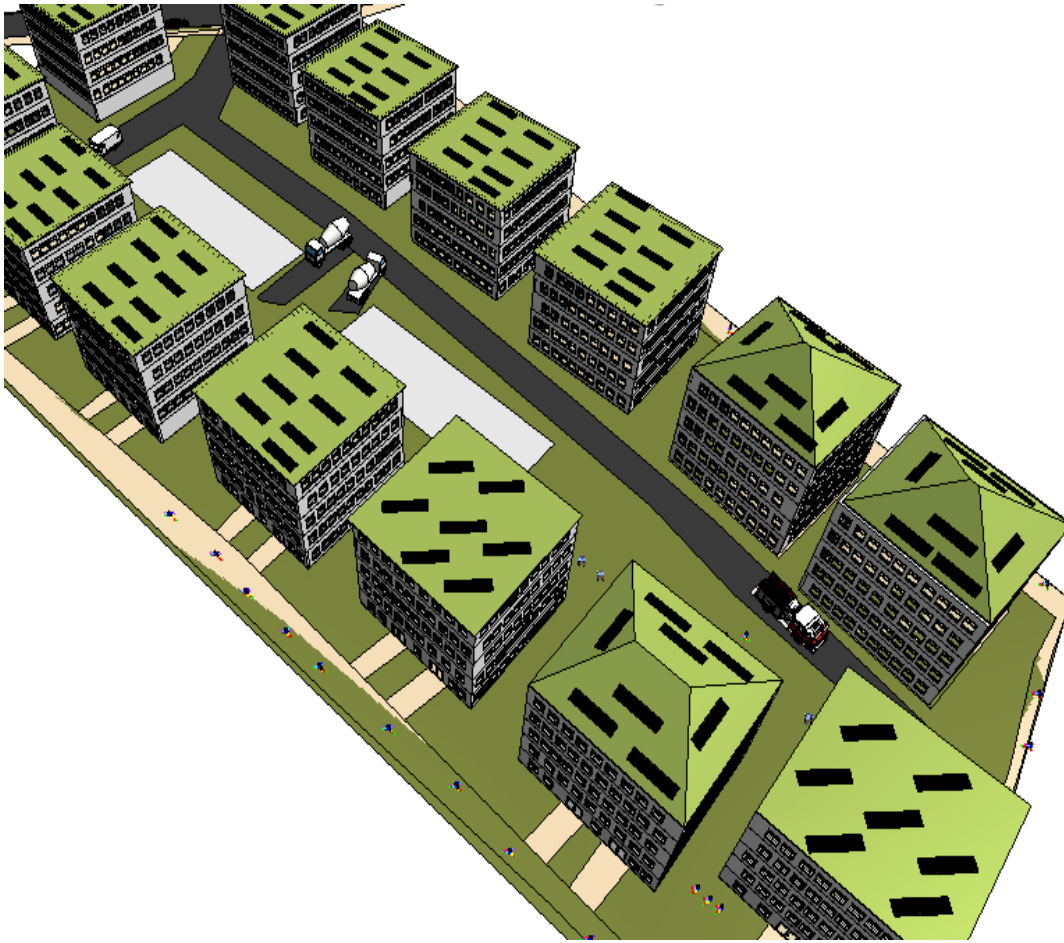
Figure 30 A partial view of proposed project to be implemented in Addis ketema sub-city Revit design by the researcher

Things that focused	Existing	New
Area	3838m <sup>2</sup>	3838m <sup>2</sup>
Householder	120	120
Green area	One percent	Twenty percent
Electrical supply / availability	Not always	Always

Table 11 To compare the current situation with the new design / proposal

4.6.4. Revit models





## Chapter Five

### 5. Summary, Conclusion and Recommendation

#### 5.1. Summary

The challenges that may come in the future will have an impact on the future of the city of Addis Ababa's urban development. It is difficult to predict the magnitude of the impact. How the municipality works with risk management of climate change as of today will be a platform for speculation about what may happen in the future. Climate change is affecting many parts of the city of Addis Ababa for example flood map Figure 27 shows the risk area is spreading to almost the entire city is at risk. The administration of Addis Ababa and the city municipality's planners themselves have to be aware of the risk of future flooding, temperature rising, and drought and then work on the city's climate adaptation guidelines that have been analyzed by international and national climate organizations. Looking at the Addis Ababa Municipality's Urban Development Section's relationship with climate change, it is possible to say what the solution will be in the future. International, national and local links at various levels will play an important role in better planning and disaster prevention based on the values set for the coming years concerning floods, droughts, and global warming.

Climate change must be specified in the municipality's regulations. Adjustment measures will have an impact on the severity and severity of the accident. But as long as the municipality has its plan for the disaster matrix, the impact can be reduced. This solution must be informed and notified of the dangers associated with new dangers.

#### 5.2. Conclusion

This study sheds light on gaining more knowledge on climate adaptation in the future of urban development/plans in connection with floods, global warming, and drought.

The study generally has dealt with climate change impact at a global, national and local level.

- It also explored some newly affected areas in Addis Ababa.
- Based on the indicators, three natural disasters were prioritized and the long-term planning was taken into account in the city's urban development plan.
- Climate change and its theoretical contact were discussed in this paper.
- Alternative solution was also put forward so as to move the city one step forward via suggesting one model proposal in Addis ketema sub-city.



### 5.3. Recommendation

Looking at the Addis Ababa Municipality's Urban Development Section's relationship with climate change, and based on the problems and challenges identified in this study, the following anticipated solutions were recommended:

- International, national and local links at various levels should play an important role in better planning and disaster prevention based on the values set for the coming years concerning floods, droughts, and global warming. And this can be achieved if only city administration officials and its experts could work hand in hand.
- Resettlements should be planned to solve the social bonds of the communities in the way that they can resettle in similar areas to maintain their civic organizations, cultural values, norms and traditions via building apartments in their localities than moving them to other sub-cities. Further suggestion was given via providing a model alternative project in Addis ketema sub-city.
- The residents should be aware on how to manage their dry wastes that usually fill the ditch and lead to over flooding. Here, it needs to develop a policy in the city's master plan that that inhibits residents from dumping the wastes ignorantly.
- Decreasing the number of old vehicle which simply move in the town transporting only a driver due to its gas emission is very high.
- Developing and fostering the green project in the town which has already been started by the Prime Minister Dr. Abiy Ahmed through developing Addis Ababa river sides to recreational areas and afforestation in the country. This gives an opportunity of removing the amount CO<sub>2</sub> and releases O<sub>2</sub>.
- Addis Ababa city administration should seriously follow the standard of buildings and their drainage system including road side drainages.

## Referanser

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