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Climate Change Adaptation Measures in Addis Ababa City Administration, Ethiopia

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Abstract

Climate *change has become a global challenge in ensuring sustainable development and has a significant impact on the lives of human beings, particularly in cities of developing countries. This study explored climate change adaptation measures in Addis Ababa City, Ethiopia. A household survey, focus group discussion, key informant interviews, and observations were used to acquire data about city adaptation measures. About 376 randomly selected households from two sub cities and four woredas were included in this study. Moreover, reports and published sources were used to acquire secondary data. Quantitative data were analyzed using descriptive statistics and Mann- Kendall test while qualitative data was analyzed in narration form. The results indicated that residents perceive an increase in mean annual temperature, extreme hot temperatures, and annual rainfall. The Mann-Kendall test on temperature and rainfall also supports the community's perception. The study results showed that the city has implemented various climate change adaptation measures such as tree planting, drainage system construction, construction of flood defenses/walls, terracing, and safeguarding drainage systems. While tree planting and drainage systems are the most widely used measures. The research results also confirmed that a lack of awareness, financial constraints, limited access to climate information, low support from responsible bodies, and limited decision-making power are barriers faced by the city residents to implementation measures. These barriers, along with the absence of formal housing for many residents, hinder their ability to actively participate in climate-sensitive response measures. This study recommends improving awareness, access to information and implementing adaptation measures in a planned and cooperative manner.*

Key words: Climate change, adaptation measures, flood, perceptions, Cities, Addis Ababa

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Introduction

Climate change is one of the most serious environmental issues facing humanity in the 21st century, and a serious natural threat worldwide (Kleina et al., 2018). According to Ajuang et al. (2016), there is increasing agreement among academics that human activities such pollution and deforestation are the main causes of climate change. Scientists agree that human activities like burning fossil fuels, industrial pollution, deforestation, and changes in land use are causing climate change, according to IPCC (2014) and Masson-Delmotte et al. (2018). Evidence suggests that the earth's climate is changing quickly due to an increase in greenhouse gas emissions (GHG), which have raised the average temperature and changed the amounts and distributions of rainfall (Kibue et al., 2015: Masson-Delmotte et al., 2021). Since the pre-industrial era, anthropogenic greenhouse gas emissions have grown, mostly due to population and economic expansion, and are currently at an all-time high.

Cities are currently generating significant amounts of greenhouse gases and being impacted by the effects of climate change (Nasiritousi and Grimm, 2022). Cities are experiencing climate hazards, such as intense precipitation that led to flood, and heat waves, which are projected to become more frequent and severe due to climate change (Kleina et al., 2018). Just as reducing greenhouse gas emissions are urgent, preparing for the inevitable impacts of climate change is also crucial (Neij et al., 2019). Cities must act now to prevent or reduce fatalities caused by weather related events, such as heat waves, and avoid economic losses resulting from climate related extremes in the future (Lorena, 2020; Lesnikowski et al., 2021). In the past, the focus of responses to climate change in urban areas has primarily been on reducing greenhouse gas emissions (Bulkeley (2010). However, recent research indicates that both mitigation and adaptation measures are crucial for cities (Fröhlich and Knieling, 2012; van der Heijden, 2019).

Adaptation is defined as adjustments in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects or impacts (Feng et al., 2017). Adaptation involves adjusting to the current or expected climate and climate hazards, aiming to mitigate negative impacts or exploit beneficial opportunities. According to (Araos, et al., 2016), planned adaptation is the result of a deliberate policy decision, based on awareness that conditions have changed or are about to change and that action is required to return to, maintain, or achieve a desired state.

The implementation of adaptation strategies by communities is hindered by the context-specific nature of climate change adaptation measures (Wako et al., 2017). One of the micro-level barriers to implementing these strategies is the community's perception of climate change, which influences the strategies they adopt to mitigate its impact on their livelihoods (Deressa et al., 2009). While these perceptions may vary, they can still be a useful part of the solution (Fagariba et al., 2018). However, community perceptions and adaptation practices to climate change vary across different geographical settings and ecological conditions (Abrha & Simhadri, 2015).

Adaptation to climate change is crucial, and it can be carried out autonomously or through policy-driven initiatives (Alam P, et al; 2017). Community based adaptation has been shown to reduce vulnerability and improve resilience to climate variability and change (Ana, 2017). Effective adaptation strategies should prioritize the well-being of local communities, but until recently, most efforts have been top-down, ignoring communities' experiences and efforts to cope with changing environments (Marshall MH, 2009). To make adaptation strategies effective, multiple stakeholders, including policymakers, extension agents, NGOs, researchers, and communities, must be involved. Moreover, the effectiveness of climate change adaptation is location specific and depends on local institutions and socioeconomic settings that mediate and translate the impact of external interventions (Gebreyes, 2018).

The community's perception of adaptation strategies plays a vital role in their implementation of climate change response measures. To build resilience, communities must leverage their local knowledge and adopt appropriate technologies while diversifying their livelihoods to cope with climate stress. The use of local knowledge and coping strategies in conjunction with government and local interventions through infrastructure provision can help communities respond to the change.

Climate change presents a significant risk to sustainable urban development, putting many

cities at risk (Díaz-Pont, 2020). Although there is considerable uncertainty regarding the extent and frequency of hazards and their effects, failure to implement effective adaptation measures will inevitably increase the vulnerability of urban areas to climate change impacts (Ebba and Christine, 2019). Despite being among the least responsible for causing climate change, African cities are expected to face some of the most severe consequences (Patience and Stephen, 2022). However, paradoxically, their response to implementing adaptation measures has been inadequate.

The successful implementation of climate change adaptation measures in Africa cities requires a holistic approach that considers a range of factors, including risk and vulnerability, political will and leadership, economic resources, technological innovation, public awareness and engagement, and institutional capacity (Herslund et al., 2015; Kareem et al., 2020; Patience and Stephen, 2022). Ethiopia is increasingly vulnerable to climate change, particularly in the form of floods, droughts, and extreme weather events. Several cities in Ethiopia are experiencing the direct effects of climate change, especially flood hazards.

Addis Ababa is one of the African cities that are already being affected by the impacts of climate change. The city is highly susceptible to the impacts of climate change that induced extreme rainfall, leading to floods (Mengistu and Assefa, 2021). Floods have significantly increased in the city because of poor drainage systems, fast rate of urbanisation, loss of green spaces, and the change of climate (Birhanu et al., 2016).

Between 2013 and 2018, the city witnessed a total of eighty-nine flood-related incidents, with a notable increase in floods between 2017-2018 (AAEPGDC, 2020). These floods have resulted in loss of life and damage to property and infrastructure within Addis Ababa (Jalayer et al., 2014). Additionally, the frequency of heavy rainfall events is projected to increase in the future, exacerbating the city's flooding situation (Worku, 2017).

Climate change induced droughts have become a significant concern in Addis Ababa, affecting the quantity of water and the well-being of its inhabitants (Worku, 2017; Arisiso, 2017). In recent years, the city has experienced unprecedented droughts due to a decline in seasonal rainfall, river flows, inflow into reservoirs, falling groundwater tables, and increased temperatures that cause more evapotranspiration from the reservoirs (Arsiso et al., 2018; AAEPGDC, 2020). Additionally, rising temperatures have led to overheating and the Urban Heat Island Effect, which can have adverse effects on the health of the city's residents, including heat stress, impacts on water supply and infrastructures (AAEPGDC, 2021; Worku et al., 2021). The growth and development of cities are the main causes of climate change and its effects. The unprecedented rate of urbanization and rapid population growth, expansion of built-up areas, reduced green space coverage are the main significant man-made influences on the climate (Arsiso et al., 2018). The disregard for climate sensitive concerns in urban design exacerbates the effects of climate change (Worku, 2017).

Therefore, Addis Ababa city authorities are increasingly facing the challenge of formulating and implementing adaptation strategies in their activities (Worku, 2017). As climate change adaptation is still a relatively new activity in the city and the response of climate change action is very limited. Besides the local level or city dwellers poor perception of climate change and its impact are the other main constraints to practicing adaptation response to climate variability as well as reducing the attitude towards participating adaptation response to changing climate condition.

Various researchers shown in the above have been conducted studies related to, climate change scenarios, impacts, and the vulnerabilities of the urban systems in Addis Ababa, but thus far, there has been no attempt made to know the challenges to practicing climate change adaptation by the authorities and local communities of Addis Ababa city. As a result, information on challenges to the employment of adaptation measures in the city is not clearly available in the way that policy makers and stakeholders take them into consideration.

Therefore, this implies that further research is needed to Addis Ababa city to assess the details of city residents' perception, climate change trends, climate change adaptation strategies and its challenges which were left unfocused by the researchers. Hence, this study examined a detailed assessment of the practice, strategy, and policy of climate change adaptation action, and it attempted to give answers to the following major research questions.

1. How do city residents perceive and respond to the impact of climate change in Addis Ababa?
2. What are the trends in temperature and rainfall in Addis Ababa over time?
3. What climate change adaptation practices are currently implemented in Addis Ababa?
4. What are the major barriers to implementing climate change adaptation measures in the city?

Materials and Methods

The Background Description of Study Area

Addis Ababa is situated in the central part of Ethiopia, occupying a geographical position of 9°1′48″N latitude and 38°44′24″E longitude. The city spans an area of 540 square kilometers (AABFED, 2013). Its elevation varies from 2,100 meters in the southern part, specifically Akaki, to over 3,000 meters above sea level in the northern part, particularly in Entoto Mountain.

Administratively, the city is structured into three levels of government. The highest tier is the city administration, followed by the sub-city level, which is accountable to the city administration. The lowest administrative hierarchy is the woreda level, with each sub-city consisting of 10 to 13 woredas. Currently, there are a total of 121 woredas across 11 sub-cities in Addis Ababa.

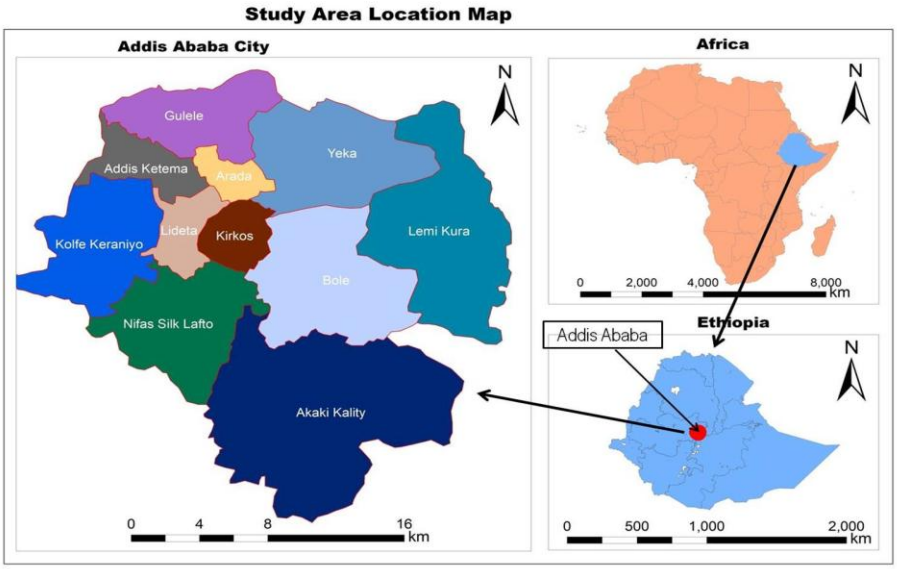

Figure 1: Map of Study Area

In 2011, the population of the city was recorded as 3,061,404, with 1,395,378 males and 1,666,026 females. The estimated number of households was 783,439 (CSA, 2012). Addis Ababa accounted for 32.27% of the country's total urban population. With a current population growth rate of 3.8%, it is projected that the city's population will reach 9.8 million by 2037. Additionally, Addis Ababa has been experiencing an annual urban land expansion rate of 3.2% (WB, 2015).

To this study, two sub-cities were selected: Akaki Kaliti from the periphery and Addis Ketema sub-city from the inner-city center. Specifically, two woredas were chosen from each sub-city, namely Woreda 1 and 8 from Akaki and Woreda 4 and 9 from Addis Ketema sub city. These woredas were selected due to their susceptibility to flood hazards.

Research Methods

To comprehensively grasp the driving forces behind urban climate change and the corresponding actions taken for adaptation, it is essential to integrate multiple disciplines. Therefore, this research employed a combination of quantitative and qualitative research approaches, depending on the specific research questions being addressed. Moreover, the research used a concurrent triangulation strategy to collect and analyze qualitative and quantitative data concurrently or simultaneously, because both quantitative and qualitative data are important for this research.

The population of the research includes government organizations, private sectors, the residents, and civil society organizations that are involved in the overall urban development process in Addis Ababa city. The quantitative data collected from two sub cities (Akakai kaliti and Addis Ketema) residents that are more affected by climate hazards. Regarding the sampling technique, both probability and non-probability sampling techniques were used. From a probability sampling technique, a multistage technique was used to choose the desired sample. To get a representative sample size of residents, a proportional sampling method was applied. Finally, the respondents were selected by applying simple random samples.

Under the non-probability sampling technique, a purposive sampling technique was applied by

government officials, key informants from the residents, business firms, and from civil society organization heads to get in-depth information about the research in many directions. Representative sample size was determined employing the formula developed by Cochran (1963). The sample size of the residents is 376 households.

Sources and Method of Data Collections

In this study, both primary and secondary data sources were used to collect quantitative and qualitative data. Primary data related to climate change adaptation actions were collected from respondents from the public, private, civil society organization, communities, and other key informants. Secondary data was collected from different sources, such as books, journal articles, internet, strategies, plans, and official documents and reports, which are related to climate change adaptation.

To achieve the objectives of this research, the data was collected by using multiple data collection tools, such as survey, key informant interview, observation, and review of different materials. The following data collection tools were applied to this research. The first is, survey.

The primary data was collected from city residents by using questionnaires. Both open-ended and close-ended questions were employed to gather primary data. To get important qualitative data, opportunities were also given to the respondents by preparing open-ended questions through which the respondents can express their own opinions and experiences under each section. The second data collection tool is interview. To support and substantiate data collection by questionnaires, interview was conducted with selected officials and key informants. Semi-structured interviews were prepared for each leader and key informant. Based on the administrative position, information, and knowledge capacity, the researcher did take a total of thirty-two individuals who have a deeper and better understanding about the current climate change issue in the city.

Field observation is also another data collection instrument. During the field observation, the existing physical infrastructures, flood affected sites, green areas, terracing activities, flood protected walls and others were observed. Document Review is also important source of information A comprehensive examination was conducted, encompassing relevant books, research journal articles, policies, strategies, rules, regulations, proclamations, reports, minutes, and other literature pertaining to climate change and urban issues. This systematic review aimed to gather a thorough understanding of the research matter.

Method of Data Analysis

The data analysis was undertaken both qualitatively and quantitatively, based on interpretation and discussion. The data collected by questioners was analyzed quantitatively. Moreover, the data from the interview, both from open-ended items of the questionnaire, observation, and different secondary sources, was analyzed qualitatively. To strengthen the quality of data collection instruments, questionnaires were developed and provided to five individuals who have research experience and knowledge related to climate change adaptation. After that, discussions were held with individuals about the overall issues of the questionnaires. Based on the comments and suggestions of the individuals, modification was made on items of the questionnaires. The questionnaires included both closed and open-ended items. They were initially prepared in English and then translated into Amharic to avoid language barriers and capture the attention of respondents. Subsequently, data was collected using both Amharic and

English languages.

Furthermore, a pilot study was conducted with a selected sample of respondents to assess the validity and reliability of the research instruments. The reliability of the items was evaluated using Cronbach's Alpha, considering the findings from the pilot study. Moreover, the triangulation approach was used for both data sources & analysis methods. The outputs of analysis are presented using different ways of data presentation tools: table, chart, graph, and narration. SPSS 26.0, EXCEL, and other software were used to analyze the data. In general, the following data analysis methods were used.

To analyse the existing climate change adaptation measures and residents' perception of climate change, descriptive statistics and thematic analysis methods were used as specific objectives. The Mann-Kendall test was utilized to analyse the trends in temperature and rainfall in the city. Descriptive statistics was chosen to determine the factors that hinder climate change adaptation strategies.

The primary climate change adaptation actions at the community level comprise the following: constructing flood defenses/walls, constructing drainage systems, safeguarding drainage systems from blockage, planting trees or greening and air conditioning at the home. These are dependent variables.

Different literatures reviewed to the purpose of identifying independent variables that influence the practice of adaptation response actions to changing climate condition. Based on the reviewed literature the researcher used the following ten explanatory variables as a factor affects city resident's implementation of adaptation action to the impact of climate in Addis Ababa City. Age, Gender of household head, education, household size, climate information, Climate change perception, off –farm Income, on- farm income, living years and access to formal housing.

Results and Discussion

Temperature and Rainfall Data Trend Analysis in Addis Ababa City

Temperature Data trend Analysis in Addis Ababa City

The Addis Ababa City has experienced annual temperature variations ranging from 15.5°C to 18.01°C between 1993 and 2023 (Figure 2). The temperature exhibits an increasing trend overall, but there are fluctuations observed. For instance, in 1993, the annual temperature was 16.08°C, followed by 16.38°C in 1994, 16.64°C in 1995, 16.32°C in 1996, 16.97°C in 1997, and 16.99°C in 1998. In 2002, there was a significant increase to 17.23°C. Constantly, the analysis showed that the annual temperature has increased year after year in Addis Ababa City for the period of 2002–2023 (Figure 2). This result is consistent with the findings of NMSA (2007), which reported that temperature in the country has increased by approximately 0.37°C per decade.

The trend analysis also revealed that the annual temperature in Addis Ababa City reached its highest point in 2015 and 2019, with a recorded temperature of 18.01°C (Figure 2). Conversely, the lowest temperature was observed in 2017, measuring 15.9°C. Starting from 2018, the annual temperature exhibited an increasing trend within the city. In 2018, it was 17.32°C, followed by 18.01°C in 2019, 17.72°C in 2020, 17.5°C in 2021, 17.51°C in 2022, and 17.54°C in 2023.

This trend analysis clearly demonstrates the consistent increase in annual temperatures in Addis Ababa City. Moreover, the perceptions of the city's residents align with these findings, as indicated in the subsequent results of the respondents' perceptions.

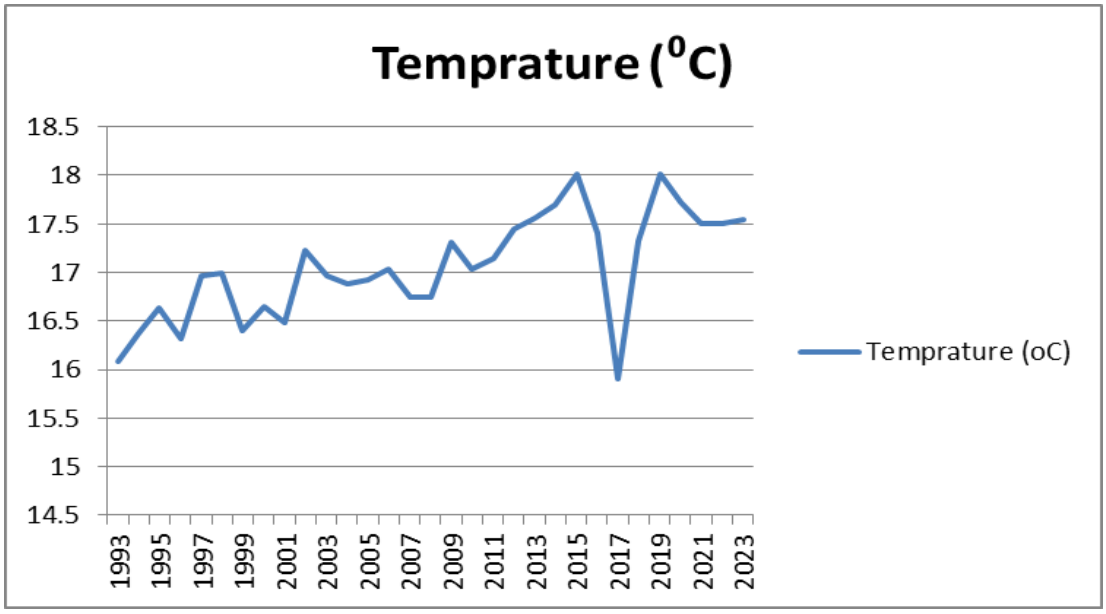

Figure 2. Annual Temperatures (^{O} C), Trend of Addis Ababa City

Source: Calculated Using Data from the National Meteorological Institute, 2024

Annual Rainfall Trend in Addis Ababa City

The annual total rainfall in Addis Ababa City has ranged from a minimum of 622mm in 2022 to a maximum of 1625.2mm in 2020 (Figure 3). Regarding rainfall, it cannot be concluded whether there is an increasing or decreasing trend as it exhibits high variation from year to year. For example, in 1993, the city experienced rainfall of 1207.8mm, followed by 816.8mm in 1994, 1009.7mm in 1995, 1552.5mm in 1996, 877. 1 mm in 1997, 1379. 8 mm in 1998, 946.7mm in 1999, and 902.1mm in 2000. As depicted in Figure 3, the data shows that rainfall fluctuated every year in Addis Ababa City.

The volume of total annual rainfall in the city has shown an increase in certain years, specifically in 1993, 1996, 1998, 2001, 2006, 2007, 2018, 2020, and 2023 (Figure 3). Conversely, the amount of total annual rainfall decreased in the years 1994, 1997, 2002, 2014, 2015, and 2022. The distribution of annual rainfall of the city in the last 31 years has been considered by fluctuations, with significant increases in some years and significant decreases in others.

The trend analysis of rainfall clearly indicates that there is no consistent increase in annual rainfall in the city, which contradicts the perceptions of the city's residents. As mentioned in the following parts of the results of the respondents' perceptions, the residents believed that rainfall was showing an increasing trend. However, during the interviews, key informants mentioned that the community's perception might be influenced by the repeated occurrence of flood hazards in the city. They assured that this perception is related to infrastructure issues, such as the presence of a poor drainage system in the city.

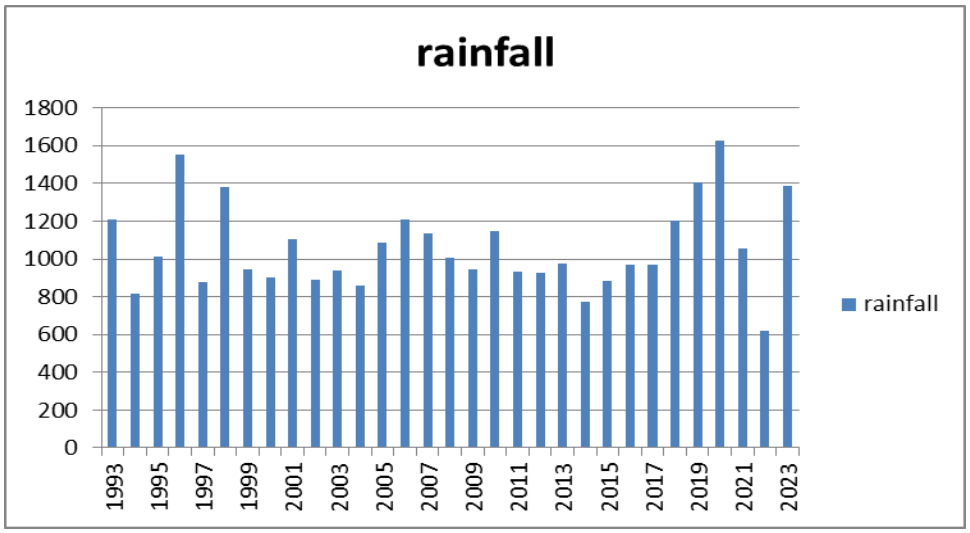

Figure 3. Annual Rainfall Trend of Addis Ababa City

Source: Calculated using data from the National Meteorological Institute, 2024

3.2 Addis Ababa City Dweller's Perception to Climate Change

Questionnaires were distributed in two sub-cities and four woreda in Addis Ababa to collect the general perceptions of city dwellers regarding climate change. Indicative variables of climate, such as temperature, rainfall, and floods, were used. Understanding residents' views on climate change and their perceptions of climate change indicators are crucial. Therefore, discussing residents' perceptions of climate change in the study area is appropriate and necessary for implementing climate change adaptation measures. To triangulate the perspectives on climate change among the city communities, various parameters such as annual temperature, annual maximum temperature, annual minimum temperature, and annual rainfall were derived from long-term meteorological data. These parameters were utilized to complement and validate the viewpoints of the city communities.

Perception of Addis Ababa City Residents About Temperature Changes

The survey results regarding the perception of long-term changes in annual temperature within the study area are presented in Table 1. When asked about the nature of temperature over the past 30 years in the study area, approximately 75.5% of respondents strongly agreed that the annual temperature had increased. Additionally, 19.7% of respondents agreed with this statement, while 2.4% remained neutral. Only 1.3% of respondents disagreed, and 1.1% strongly disagreed with the statement. As depicted in the table, most respondents (78.7%) strongly disagreed with the notion that the annual temperature had not changed in the city. Conversely, only 3.5% of respondents agreed with this statement.

Furthermore, as shown from the results about 82.4%, 14.1%, 1.6%, 0.5% and 1.3% of respondents strongly disagreed with the concept of annual temperature was decreased in Addis Ababa City (Table 1). Based on the findings, it can be inferred that most respondents held the view that the annual temperature had been increasing in Addis Ababa City over the past 30 years.

Table 1. Perception of Respondents about Climate Change (Temperature)

	Frequency	Percent	Valid Percent	Cumulative Percent
Change in temperature increased				
strongly disagree	4	1.1	1.1	1.1
Disagree	5	1.3	1.3	2.4
Neutral	9	2.4	2.4	4.8
Agree	74	19.7	19.7	24.5
Strongly agree	284	75.5	75.5	100.0
Total	376	100.0	100.0	
No change of temperature				
strongly disagree	296	78.7	78.7	78.7
Disagree	67	17.8	17.8	96.5
Neutral	10	2.7	2.7	99.2
Agree	3	.8	.8	100.0
Total	376	100.0	100.0	
Temperature decreased				
strongly disagree	310	82.4	83.6	83.6
Disagree	53	14.1	14.3	97.8
Neutral	11	2.9	1.6	99.5
Agree	2	.5	.5	100.0
Total	376	98.7	100.0	

Source: Own Survey Result, 2024

Perception of Addis Ababa City Residents about Extreme Hot Temperature

Regarding extreme temperatures, among the total participants who were involved in this study, approximately 62.2% strongly agreed that the number of very warm days in a year increased from year to year. Whereas 31.1%, 3.5%. 1.9% and 1.3% agreed, neutral, disagreed and strongly disagreed respectively with the issues stated. As the result shows that majority of the respondents (93%) assured that in Addis Ababa City hot temperature increase for the last 30 years (Figure 4).

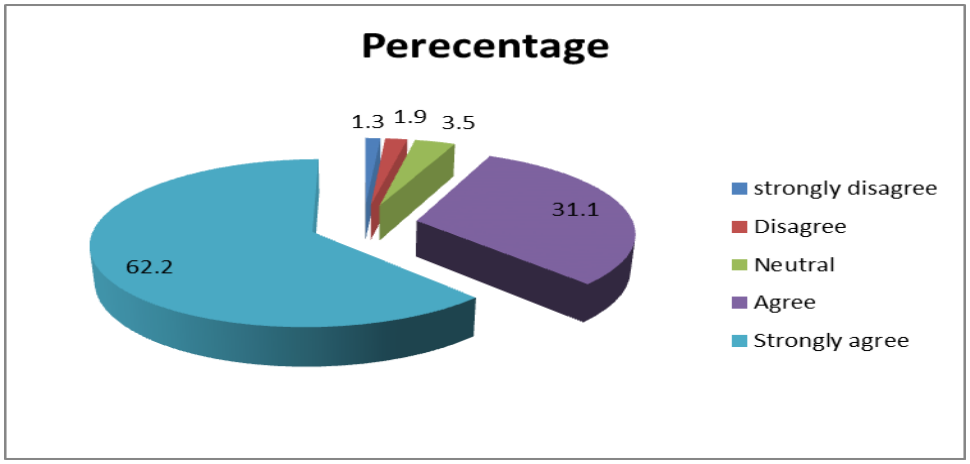

Figure 4 Response About Increment of Number of Hot Days. Source: Filed Survey Result, 2024

Perception of Addis Ababa City Residents about Rainfall Changes

Over 90% of the respondents agreed that the annual rainfall in Addis Ababa City is increasing, while an insignificant percentage disagreed with the observed increment in the city. The survey results further revealed that 64.6% strongly disagreed, 29.3% disagreed, 2.1% remained neutral, 2.1% agreed, and 1.9% strongly agreed with the statement that the annual rainfall had not changed in the city. Additionally, concerning a decrease in annual rainfall, 63.3% strongly disagreed, 28.2% disagreed, 2.7% were neutral, 3.7% agreed, and 2.2% strongly agreed with the notion (Table 2). These results indicate that the majority, or over 90%, of the city dwellers responded that the trend of rainfall is showing an increase.

Table 2. Perception of Respondents about Rainfall Trend

Rain Fall has Increased		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	strongly disagree	7	1.9	1.9	1.9
	Disagree	12	3.2	3.2	5.1
	Neutral	13	3.5	3.5	8.5
	Agree	93	24.7	24.7	33.2
	Strongly agree	251	66.8	66.8	100.0
	Total	376	100.0	100.0	
No change in rain fall					
strongly disagree		243	64.6	64.6	64.6
Disagree		110	29.3	29.3	93.9
Neutral		8	2.1	2.1	96.0
Agree		8	2.1	2.1	98.1
Strongly agree		7	1.9	1.9	100.0
Total		376	100.0	100.0	
The amount of rainfall has decreased					
strongly disagree		238	63.3	63.5	63.5
Disagree		106	28.2	28.3	91.7
Neutral		10	2.7	2.7	94.4
Agree		14	3.7	3.7	98.1
Strongly agree		8	2.2	1.9	100.0
Total		376	100.0		

Source: Filed survey result, 2024

Perception of Addis Ababa City Residents about Flood Events

Addis Ababa City residents were questioned on the view of flood occurrence in City. From the total participant involved in this research, around 19.7% and 75.5% strongly agreed and agreed that the flood event is increasing from time to time in the past (Figure 5).

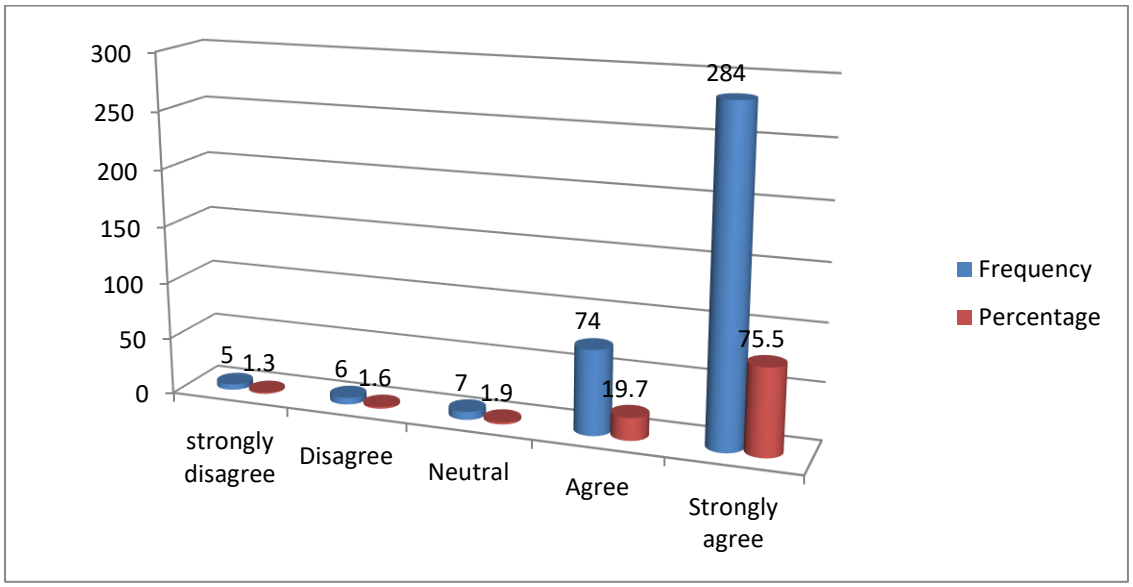

Figure 5. Respondents Response about Flood Increment

Source: Survey Result, 2024

In recent times, the city has been witnessing a surge in the occurrence of frequent flood events, primarily attributed to climate change. Additionally, the expansion of informal settlements within the city has further exacerbated the risks associated with flooding (AAFDRC, 2024). The lack of proper planning and unsustainable storm water management strategies in urban areas only serve to intensify the impact and frequency of flood incidents in the city. The following are some sites identified as flood prone areas by the Addis Ababa City Fire and Disaster Risk Management Commission (AAFDRMC).

Figure 6. Flood Prone Areas in the city. Source: AAFDRC, 2024

During each rainy season, Addis Ababa experiences destructive floods because of the effect of heavy rainfall, leading to the loss of human lives and harming their properties. Site visits have

revealed that individuals residing in areas highly prone to flooding are particularly vulnerable from an environmental standpoint. This vulnerability arises due to housing structures that may not adhere to current planning and building regulations, as well as their proximity to water bodies and environmentally hazardous locations.

Practice of Climate Change Adaptation Measures in Addis Ababa City

Several studies (Larsen, 2015; Pasquini, 2019; Barreira et al., 2023) have highlighted the implementation of various adaptation measures to mitigate climate change hazards in urban areas. These measures include the construction of flood defenses/walls, the establishment of efficient drainage systems, ensuring the protection of drainage systems from blockages, terracing, tree planting or greening initiatives, and the use of home air conditioning. These adaptation measures have been employed to address the challenges posed by climate change in urban environments.

Residents living in Addis Ababa City are likely to implement different adaptation options against the impacts of climate change. In (Figure 7 shows that planting trees (59.7%) were the most widely used adaptation measures followed by constructing drainage systems (11.6%). In contrast, using air conditioning at home (3.9%) was the least-practiced adaptation response measures by Addis Ababa City residents specifically in two sub cities. Majority of city dwellers engaged in planting trees. This observation can be attributed to the country's focus on promoting a green legacy. This finding is consistent with Larsen's (2015) research, which indicates that greening initiatives are currently one of the most widely adopted adaptation measures in urban areas worldwide.

During the field observation, it was observed that significant efforts have been made in implementing tracing practices to mitigate flooding. However, during the preparation phase, there was no consideration given to terracing as an option in the adaptation measures. Respondents took the initiative to choose and emphasize terracing as a crucial measure. The residents strongly asserted that tracing techniques improve soil erosion prevention by allowing water to seep into the ground. Additionally, interviews conducted with woreda experts revealed that, instead of solely relying on the construction of defense walls, terracing and tree planting are currently recognized as the primary climate adaptation action in the city.

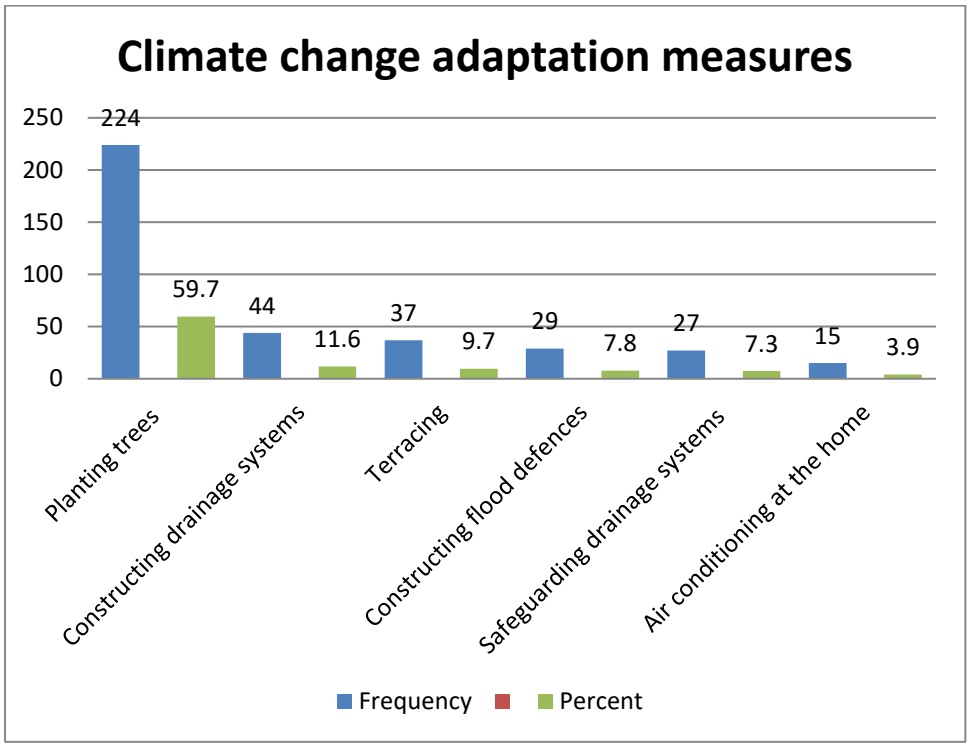

Figure 7. Adaptation Measures Implemented by Residents.

Source: Survey result, 2024

Planting Trees in Addis Ababa City

Climate change poses significant challenges to urban areas, including increased temperatures, extreme weather events, and water scarcity. In response to these challenges, cities are adopting various adaptation measures to enhance their resilience. One such measure is the planting of trees and greening initiatives, which have gained recognition for their multiple benefits in mitigating climate change impacts. Study conducted by (Gomez-Baggethun et al., 2013). Planting trees and greening is the major measures for climate change adaptation through temperature regulation and storm water management. Planting tree is also important for carbon sequestration, air quality improvement and biodiversity conservation (Escobedo et al., 2018; Nowak et al., 2018).

In Addis Ababa City, following government's green legacy initiative the citizens actively participate in tree planting activities, development of parks, and beautification of streets and public areas. Efforts are being made to protect and restore watersheds in and around Addis Ababa. Reforestation projects are being carried out to increase vegetation cover, prevent soil erosion, and improve water resource management.

Figure 8 A. Plant Seedling Site in Akaki Sub City and B, Addis Ketema Sub City

Source: Photo taken during field observation, 2024

In a recent study by Mekonnen et al. (2024), it was discovered that climate change has a detrimental impact on the residents of Addis Ababa city. One of the identified adaptation measures to mitigate the adverse effects of climate change is tree planting. In the City, around 59% of residents have been implementing planting tree as climate change adaptation measure. Based on the survey results, it was found that most residents employed this strategy. The interviews further revealed that most residents were not adequately informed about climate change adaptation measures, particularly the practice of planting trees. However, due to the implementation of the city administration's green legacy initiative, residents have become more engaged in tree planting activities.

Constructing Drainage Systems

Climate change brings about increased precipitation, leading to a higher risk of flooding and water related challenges in urban areas. Constructing effective drainage systems is crucial for climate change adaptation, as they help manage storm water and reduce the impacts of extreme weather events. Drainage system construction enables them to withstand and adapt to changing climate conditions (ASCE, 2017). In Addis Ababa City, some practices are being implemented to construct drainage systems for climate change adaptation measures. These practices aim to manage storm water effectively and mitigate the risks of flooding and water-related challenges.

Figure 9 Inner Road Drainage Constructions by Community Participation in Akakai Sub City

Source: Filed Photo taken, 2024

Constructing Flood Defenses/Walls

With the increasing risks of flooding due to climate change, constructing flood defenses and walls is crucial for climate change adaptation in urban areas. These structures serve to protect cities from rising sea levels, storm surges, and heavy rainfall events (UNDRR, 2018). In Addis Ababa City, there are practices being implemented to construct flood defenses/walls for climate change adaptation. These practices aim to protect the city from flood risks, particularly during heavy rainfall events.

Akaki sub city is prone to recurrent flood hazards due to its geographical location, as multiple water bodies converge in this area. To mitigate the impact of floods, the sub-city has undertaken the construction of flood walls at various locations. The accompanying photograph was captured during a field observation conducted in the study area.

Figure 10 Flood Walls Found in Akaka Sub City.

Source: Photo Taken from Field, 2024

Like Akaki sub-city, Addis Ketema sub-city is also susceptible to flood hazards due to outdated infrastructures, particularly the drainage system, which is in dire need of renovation. Being an inner sub-city, the area faces challenges in managing excessive rainfall and preventing flooding. The accompanying photo depicts the ongoing construction of flood barriers in Addis Ketema sub-city, aimed at mitigating the impact of flooding events.

Figure 11 Flood Walls Found in Addis Ketema Sub City.

Source: Photo taken from field, 2024

Terracing

Terracing in urban areas for climate change adaptation action typically refers to the process of identifying and mapping vulnerable areas, assessing climate risks, and tracking the progress of

adaptation measures. Climate change adaptation actions require specific local knowledge like terracing (Jorgelina and Regina, 2013; Carter, 2018). Adaptation actions are linked more to flood-related work (Jorgelina and Regina, 2013.) Addis Ababa city specifically Akakai sub city is particularly vulnerable to flood hazards, and as a result, has actively involved the community in terracing activities. The accompanying figure illustrates the current implementation of terracing works in various Woredas within the sub-city.

Figure 12 Terracing Works in Akaki Sub City.

Source: Photo Taken from Field, 2024

Like Akaki sub-city, Addis Ketema sub-city is also actively involved in terracing works across different Woredas within the sub-city. These terracing activities are carried out with the active participation of the community.

Figure 13 Terracing Works in Addis Ketema Sub City.

Source: Photo taken from field, 2024

Safeguarding Drainage Systems from Blockage

Safeguarding drainage systems from blockage is crucial to ensure their proper functioning and prevent flooding in urban areas. It involves a combination of preventive measures, regular maintenance, and community engagement to minimize the risk of blockages and ensure the proper functioning of the drainage infrastructure. According to the Addis Ababa City Fire and Disaster Risk Commission (AAFDRRC) report of 2024, the major challenge concerning the drainage system is its aging infrastructures and frequent blockages caused by various materials. Interviews with officials and my personal observations have confirmed that the drainage systems are obstructed by solid waste, including plastic bottles.

Figure 14 Solid Waste Blocked, Drainage System in Addis Ababa City

Source: Jemberie and Melesse, 2023

Air Conditioning at Home

Air conditioning at home in cities is an important aspect of climate change adaptation, particularly in areas where rising temperatures and heat waves are becoming more frequent and intense. Research shows that household air conditioning is one of the "most effective adaptation strategies to reduce heat related mortality and morbidity. Air conditioning is an important cooling device for responding to high temperatures and to maintain thermal comfort at home (Randazzo et al., 2023). However, in the case of Addis Ababa city, the use of air conditioning is very minimal among the community. This practice is primarily observed in large hotels located within the city.

It was established during most of the key informant discussions that they are fully aware of the effects and changes brought about by climate change, especially the heavy rains and rising temperatures. These elements have an impact on people's life and mean of subsistence. Even while people profess to be well-informed on climate change, issues have been identified, including a lack of understanding about how to address its challenges. Many adaptation solutions are clearly not being well-managed and implemented in an organised manner, based on the opinions expressed by city dwellers and field observations.

Barriers Faced by City Residents to Implementing Adaptation Measures

The primary challenge faced by residents in coping with climate change adaptation issues was a lack of awareness regarding climate change response measures. In addition to this, financial constraints, lack of access to climate information, low support from responsible body and limited decision-making power and lack of access to formal housing are the barriers of climate change response actions (Fig.15). The community of two sub cities identified that lack of awareness about climate change response measure (32.7 (%), lack of access to land or formal housing (25.3%) and lack of access to climate information (22.6%) as the major barriers to implementing adaptation measures, respectively. This might be attributed to the low awareness and understanding of the trends, impacts, and response measures of climate change in the city. The dissemination of climate information through different media channels is also limited in the city.

Furthermore, the low response measures to climate hazards are related to the lack of formal housing. Most of the respondents are renters and frequently move from one place to another every month or year. Due to the absence of permanent residential areas, they face challenges in participating in climate sensitive response measures.

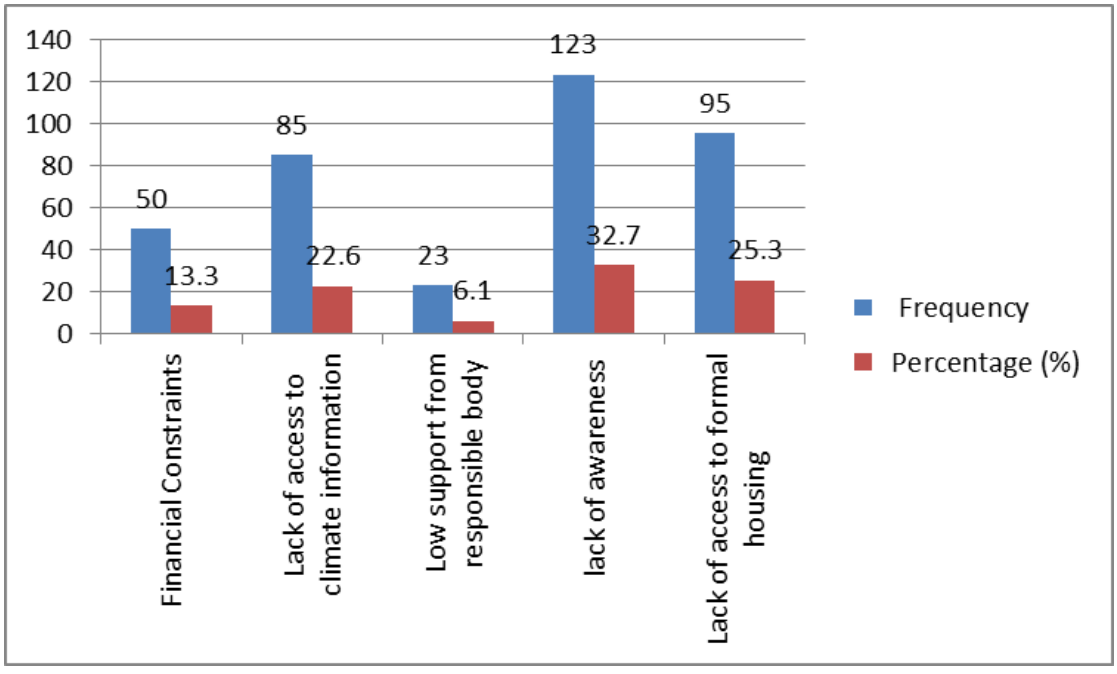

Figure 15 Barriers Faced by City Residents Source: Survey Result, 2024.

Conclusion

This study explored how residents of Addis Ababa perceive climate change and how they respond to its impacts. Most respondents acknowledged a rise in average temperatures, more frequent extreme heat, and an increase in rainfall over the past 30 years. Many also noted a growing number of flood events in the city. These perceptions are consistent with the challenges Addis Ababa faces, particularly in relation to climate change and the city's limited capacity to respond effectively. However, while temperature trends support the residents'

observations, rainfall data tells a different story, showing irregular patterns rather than a steady increase. This mismatch may be due to the visible effects of frequent flooding, which are more closely tied to poor infrastructure than to rainfall amounts alone.

In terms of adaptation, the city has made efforts to respond to climate challenges, with key strategies including tree planting, building drainage systems, constructing flood barriers, terracing, and maintaining drainage infrastructure. Tree planting emerged as the most common adaptation activity among residents, boosted by the government's Green Legacy Initiative. Yet, these efforts are often undermined by aging infrastructure and recurring blockages in drainage systems. Despite a relatively high level of climate impact among residents, the overall implementation of adaptation strategies remains weak and disorganized, pointing to a need for stronger coordination and long-term planning.

The study also highlights several barriers that hinder residents from effectively adapting to climate change. These include limited awareness, financial challenges, lack of access to climate information, weak institutional support, and restricted decision-making power. A significant obstacle is housing instability many residents live in rental housing and are frequently forced to relocate, making it difficult to commit to local adaptation measures. To improve climate resilience in Addis Ababa, it is essential to address these systemic barriers, provide stable housing, increase financial and informational support, and integrate climate considerations across all sectors of city planning and governance.

Data Availability Statement

The original data supporting the conclusion of this article will be made available by the authors, without undue reservation.

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Conflict of Interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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