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CENTER FOR ENVIRONMENT AND DEVELOPMENT

A THESIS ON

FLOOD VULNERABILITY ASSESSMENT, ADAPTATION AND CHALLENGES. THE CASE OF AKAKI-KALITY SUB-CITY, ADDIS ABABA

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DECLARATION

I, the undersigned, thus confirm that this thesis is my original work and that all base resources utilized for the study have been properly recognized, following the guidance and advice of the research advisor. It is offered for the environmental and sustainability MA, which is half completed. This university, or any other connection, has not submitted a single degree along with this study.

Declared by

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Signature_____

Department_____

Date_____

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LIST OF ACRONYMS

CN - Communication Network

CRGE - Climate Resilient Green Economy

DFID - Department for International Development

ECA- Economics of Climate Adaptation

EFCCC - Environment, Forest and Climate Change Commission

EL - Education Level

ER - Evacuation Route

ES - Emergency Services

EW - Early Warning

FD - Flood Duration

FDRE - Federal Democratic Republic of Ethiopia

FF - Flood Frequency

FI - Flood Insurance

FPE - Feminist Political Ecology

FS - Family Size

FVI – Flood Vulnerability Index

GAD - Gender and Development

HHIN - Household Income

HPM - Houses with Poor Materials

INDC - Intended Nationally Determined Contribution

IPCC - Intergovernmental Panel on Climate Change

NAP - National Adaptation Programme

OP - Old People

P - Proximity to Water

PAS - People's Access to Sanitation

PFE - Past Flood Experience

PFM - Presence of Flood Protection Measures

SLF - Sustainable Livelihood Framework

UNCED - United Nations Conference on Environment and Development (UNCED)

UNDP - United Nations Development Programme

UNFCCC - United Nations Framework Convention on Climate Change

UNFPA - United Nations Population Fund

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ABSTRACT

Flooding is one of the most pervasive and destructive natural disasters, disproportionately affecting urban areas with inadequate infrastructure and vulnerable communities. Addis Ababa's Akaki-Kality sub-city, particularly Woreda 03, is highly prone to flooding due to its location near the Akaki River, making it a critical area for study. This research aims to assess the flood vulnerability of households in Woreda 03, with a focus on gender disparities, to provide actionable insights for equitable flood risk management. The study employs an indicator-based flood vulnerability index, drawing on socioeconomic data from 120 households. Factors such as early warning systems, flood frequency and duration, family size, proximity to water, elderly population, access to emergency services, household income, sanitation access, housing quality, education level, previous flood experience, evacuation routes, flood protection measures, flood insurance, and communication networks were analyzed. Descriptive statistics, regression, and t-tests were used to examine adaptive responses and the impact of socioeconomic factors on vulnerability. Findings reveal that female-headed households are more vulnerable to flood risks compared to male-headed households. This heightened vulnerability is attributed to social factors such as lower income, limited access to resources, and reduced adaptive capacity. The study also identifies significant differences in adaptive responses and socioeconomic determinants of vulnerability between the two groups. To address these challenges, the study recommends targeted interventions, including the implementation of gender-sensitive flood risk management strategies, improved early warning systems, and enhanced community-based flood protection measures. Policymakers are urged to prioritize the adaptive capacity of female-headed households through infrastructure development, better access to information, and inclusive urban planning to mitigate the negative effects of flooding on vulnerable groups.

Keywords: vulnerability indices, climate risk, gender, flood exposure, flood susceptibility, flood adaptive capacity, flood risk management, urban flood risk.

CHAPTER ONE: INTRODUCTION

1.1. Background of the study

Extreme climate change-induced events, including frequent and prolonged droughts or floods, greatly disrupt people's livelihoods, particularly in rural areas where reliance on the immediate environment is crucial. Although urban areas also suffer, research tends to emphasize rural settings because of this dependency. Poor land use practices have aggravated soil erosion and desertification problems on the continent (John et al., 2015), making the population more susceptible to extreme climate events like flooding. The Intergovernmental Panel on Climate Change (IPCC, 2015) study results estimates that by 2100, climate change is anticipated to raise the number of vulnerable individuals in both developed and developing countries.

According to the UNFCCC, developing countries are disproportionately impacted by the change in climate compared to developed nations. While the developed nations have advanced coping mechanisms, developing nations often rely on primitive methods, making them more susceptible to the destructive consequences of natural disasters like drought, extreme heat and floods (Huong et al., 2019). Ethiopia is particularly vulnerable to the change in climate because agriculture accounts for approximately half of the country's GDP (USAID, 2016). Ethiopia's average annual temperature increased by 1.65°C between 1955 and 2015, resulting in more frequent floods, droughts, and other extreme occurrences (Abebe, 2017; USAID, 2016).

Ethiopia is one of the African countries where the present level of severity and sequence of climate variation or change, as well as the resulting negative effects, make it unlikely that any social or economic sector in the region will remain uninfluenced by the impacts and shocks that are induced by climate variability (Emebet Bekele, 2013). Climate change has a substantial influence on Ethiopia because the bulk of the population relies on rain-fed crops for food and irrigation (Debebe & Argaw, 2022). Climate change has a detrimental effect on nearly every industry, but the agricultural sector, the preservation of biodiversity, water, the health sector, education, ecosystems, pastures, and energy are particularly vulnerable throughout Ethiopia. However, the level of vulnerability and susceptibility to catastrophes and shocks induced by climate variability varies by industry (Abate Feyissa, 2009).

Climate-related disasters, such as floods, greatly threaten the livelihoods and lives of individuals, creating food and water insecurity, increasing waterborne and vector-borne diseases, higher mortality and injury rates, and increased migration (Debebe & Argaw, 2022). Disasters, whether natural or man-made, have the capacity to interrupt daily life and cause financial losses, infrastructural damage, and fatalities. Bekele Tona et al. (2017) state that both customary and modern managing strategies for Ethiopia's climate variability and extreme events include altering planting and cropping techniques, cutting back on consumption, gathering wild foods, using inter-household loans and transfers, producing more petty commodities, migrating both temporarily and permanently in search of work, storing grain, selling assets like livestock and agricultural tools, receiving loans from lenders and vendors, implementing systems for early warning, and giving food assistance.

1.2. Statement of the problem

As urbanization accelerates, the proportion of impermeable land rises steadily, raising the possibility of floods brought on by rainfall, especially in metropolitan areas (Mustafa et al., 2018; Bayazit et al., 2020). Consequently, there has been a lot of focus on the prevention and control of urban disasters, and it is now urgent to find a solution to improve preparedness for extreme disaster events. Flooding is regarded as the most common, pervasive, and destructive natural disaster, wreaking havoc on the lives and properties of millions of people, in addition to infrastructures and the environment at large (Douben, 2006). Floods are becoming more common worldwide, subjecting a growing percentage of citizens to flood-related risks (Khan et al., 2011).

Approximately 2.2 billion people were impacted by floods worldwide between 1975 and 2001, accounting for 175,000 fatalities, according to Jonkman (2005). As per estimates from around the world, riverine floods would harm about 21 million people annually and cause roughly US$105 billion in economic damages annually by 2030, when they affect 54 million people (Lehmann 2015; UNISDR 2015). According to the EM-DAT (2020), because of flooding, over 31,000 people were killed, 6.34 million households were displaced. It directly affected 85 million individuals, and caused over 9.3 billion US dollars in property and governmental infrastructure damage between 1960 and 2020.

Studies reveal that despite numerous official initiatives to reduce their frequency, urban floods have continued to cause detrimental impacts on human beings (Ahadzie and Proverbs, 2011). Additionally, there is mounting evidence that suggests flooding in the upcoming future could be more complicated than it is presently (Alfieri et al. 2017). According to Owusu-Ansah (2016) and Amoako and Boamah (2015), Poor urban planning, which results in the expansion of slums, insufficient systems for managing waste, and increasing impermeability due to the depletion of wetlands and vegetation, is the primary cause for this persistence. Natural hazards, such as urban floods, have a greater impact on the urban poor, especially in developing nations (Balaban-Senol, 2009). Urban cities in developing nations such as Addis Ababa are characterized by population density and socio-economic disparities, present distinctive challenges in terms of climate resilience. By scrutinizing the vulnerability of urban residents across different gender groups to flooding, the investigation aimed to contribute crucial insights for the development of targeted adaptation and resilience mechanisms.

The disproportionate number of individuals in cities intensifies vulnerabilities when impoverishment intersects with declining municipal amenities and environmental degradation, along with its associated natural disturbances such as lower precipitation, higher temperatures, and the scarcity of food and water. While Addis Ababa is recognized as vulnerable to flooding, there is a scarcity of research exploring vulnerabilities specific to different gender groups within urban populations. Furthermore, existing literature often provides a generalized overview of flooding vulnerabilities without delving into the specific challenges faced by different genders.

As building adaptive capacity or resilience of communities is recognized as a shared objective for national and international policies and initiatives, some researchers question the customary normative representation of resilience at the community level, which fails to acknowledge inequalities resulting from variations in politics, socio-cultural factors as well as power dynamics, (Brown 2014). Furthermore, although there is growing evidence that gender affects disaster outcomes and responses, it is unclear if a household's capacity to recuperate from a disaster is impacted by the gender of the person in charge of the household. In other words, there is little study on how resilience results differ at the family level depending on whether the person in charge of the household is a male or a female. These analyses are primarily conducted in

countries with advanced economies, despite the fact that people in regions that are less developed are the most vulnerable to disasters like flooding (Bubeck et al. 2017).

According to Araujo, Quesada-Aguilar, and Aguilar (2007), women and children are up to 14 times more likely than men to die in severe weather and natural catastrophes. While a wealth of studies have been carried out on the intersection of gender and climate change in Africa, particularly on rural women in agriculture and natural resources (Agwu & Okhimamhe, 2009; Terry, 2009; Omari, 2010; Okali, 2011), there is a significant knowledge gap regarding women in urban areas. However, urban centers are home to a significant percentage of women who are currently vulnerable to floods, and other risks that global warming is expected to exacerbate (Satterthwaite et al., 2007). While we've made progress in understanding how disasters impact men and women in general, there's a critical gap in our knowledge in knowing the everyday factors that make a particular groups of men and women more susceptible or more resilient. This study prioritizes understanding the vulnerability as well as the adaptive capacity of women and girls in flood disaster risks since disasters harm more women than men. (Neumayer, Plumper, 2007). Furthermore, since the concerns and voices of women are frequently disregard during and after disasters (Khondker, 1996).

Women often lack access to resources and information that could assist them in adapting to floods. Gender disparities are merely a result of environmental challenges, but they also serve as a catalyst for environmental reform because gender is inextricably tied to how habitats are created. When gender is viewed as a mechanism, the complex interaction between gender, environment, and other pertinent components of cultural and social structures can be examined (Nightingale, 2006).

Not many researchers have focused on understanding and emphasizing the experiences and views of women when it comes to gender issues and flooding, especially in cities. This is a less explored area, highlighting the need for more studies to consider how women perceive and are affected by these challenges in urban environments. Overall, gender considerations in flood management has received little attention, despite the differences between the sexes in terms of resources, capacities, and responses. Gender disparities based on sociocultural dynamics are not taken into account in the extensive literature on the ongoing hazards that flooding poses to lives,

assets, and source of revenue (Owusu-Ansah, Dery & Amoako 2019; Campion & Venzke 2013; Douglas et al. 2008).

Consequently, little study has been done on the connections between gender, vulnerability to, and ability to withstand the effects of urban flooding caused by climate change. Therefore, the paper's aim was to contribute a more detailed knowledge of gender-related flood vulnerability and responses and attempted to fill the literature gap by providing a comprehensive analysis of the variables that increase women's vulnerability to floods in Addis Ababa. We explore ways women understand, experience, handle, and bounce back from disasters, particularly from flooding induced by climate variability. This study of female headed household disaster experiences was not conducted in isolation, but rather within the context of their social connections with men and in comparison, to male headed households. It also examined the coping strategies and adaptation measures that women are using to address these vulnerabilities.

1.3. Objectives

Based on the problem statement and given the knowledge gap, the primary goal of the study was to examine gender-based flood risk vulnerability and their responses to the impacts and challenges.

Specific Objectives:

- To assess the status of flooding risks vulnerability of urban residents of different gender groups.
- To analyze the adaptive responses of urban residents of different genders to flooding risks.
- To examine the different socio-economic factors that influences the differential vulnerabilities of population groups to climate risks.

1.4. Research Questions

1. How does vulnerability to flood risks vary among different gender groups in urban areas?
2. What are the existing adaptive responses taken by urban residents in the face of flood risks?

3. What socio-economic factors contribute to the differential vulnerability of various gender groups to flood risks?

1.5. Significance of the study

The outcomes of this research will contribute to the development of gender-responsive climate policies and programs that can enable the minimization of women's vulnerabilities to flood risk and enhance their capacity to adapt to climate change. These efforts will aid in decreasing the vulnerability of women and enhancing their ability to withstand the impacts of flood that is caused by climate change. The significance of this study lies in its potential to inform policies, empower communities, and contribute to both local and global initiatives aimed at building resilience against climate change. By specifically addressing the gender dimensions of vulnerability and focusing on the unique context of Akaki-Kality sub-city, this research provides a nuanced understanding of the risks posed by climate change and the corresponding responses. The practical implications of these findings extend to policymakers, urban planners, and community stakeholders, as they foster a more inclusive approach to climate resilience. Ultimately, this research not only adds to the existing academic knowledge but also aids in the development of effective and equitable strategies for mitigating the impacts of climate change on urban populations.

1.6. Scope of the Study

The conceptual scope of this study revolves around understanding the vulnerability of urban residents to flood risks with a specific focus on gender dimensions. It aims to explore how different socio-economic, demographic, and environmental factors contribute to the varying levels of flood vulnerability experienced by female-headed and male-headed households. The study examines key indicators such as flood frequency, flood duration, proximity to water bodies, access to emergency services and sanitation, housing quality, education levels, family composition, early warning systems, past flood experiences, evacuation routes, flood protection measures, flood insurance, communication networks, and land slope. By integrating these indicators, the study seeks to provide a comprehensive understanding of the disparities in flood vulnerability and to identify targeted interventions to mitigate these risks.

The geographical scope of this study is confined to urban areas within Addis Ababa, the capital city of Ethiopia. Addis Ababa, characterized by its diverse topography and varying levels of urbanization, provides a unique context for examining flood risks and vulnerabilities. The study specifically focuses on different urban neighborhoods to capture the heterogeneity in flood exposure and resilience. By analyzing data from various parts of the city, the research aims to highlight spatial variations in flood vulnerability and to draw attention to the areas that are most at risk.

The methodological scope of this study includes both quantitative and qualitative approaches to gather comprehensive data on flood vulnerability. The research utilizes a survey method to collect data from 120 household respondents, comprising an equal number of female-headed and male-headed households. The survey includes questions on various flood vulnerability indicators, some of which are normalized on a scale of 0 to 1. Additionally, secondary data sources such as government reports, academic publications are incorporated to supplement the primary data. Statistical analysis, including comparative analysis and regression models, is employed to identify significant differences and correlations between the variables.

The primary unit of analysis in this study is the household, with a specific distinction between female-headed and male-headed households. The analysis focuses on understanding the vulnerability levels of these households to flood risks by examining various socio-economic, demographic, and environmental indicators. By comparing the two types of households, the study aims to highlight the gender disparities in flood vulnerability and to provide evidence-based recommendations for policy and intervention strategies aimed at reducing these disparities. The household-level analysis allows for a detailed examination of the factors contributing to flood vulnerability and the identification of targeted measures to enhance resilience.

1.7. Limitations of the Study

This study acknowledges the limitations that may impact the research findings. Due to resource constraints, the study was focused on a single Woreda, which means that the outcomes may not be applicable directly to other urban areas with diverse socio-economic and environmental contexts. This focus allowed for an in-depth analysis of a specific area but suggests that further research could explore additional regions for a more nuanced understanding.

Furthermore, the dynamic nature of the variability of climate presents ongoing challenges. The evolving and unpredictable characteristics of climate change make it complex to accurately assess current vulnerabilities and predict future impacts. These challenges highlight the significance of constant monitoring and adaptive approaches to effectively address the shifting risks associated with urban flooding. Despite these limitations, the aim of this study was to provide valuable comprehensions into gender specific vulnerabilities as well as adaptive responses of urban residents, serving as a fundamental step for further studies and contributing to the development of targeted strategies for lowering vulnerability and enhancing adaptive capacity.

1.8. Organization of the Thesis

The structure of this research unfolds in the following manner: The first chapter establishes the scene by giving a comprehensive synopsis that includes the study's background, the city's contextual backdrop, a precise formulation of the research problems, defined research objectives, an examination of the study's importance, and a description of its boundaries. After that, a more in-depth analysis of the literature is presented, including conceptual definitions of vulnerability, adaptation, gender, and climate change. To provide a strong basis for the study that follows, theoretical frameworks and the conceptual framework are also examined.

The approach, method, and design—as well as important elements like the selected demographic, sampling techniques, size of sample calculation, sampling technique, and the scope—are all carefully described in the third chapter of the study on research design and methodology. The methodological framework includes talks on data type, measurement scale, and selected data analysis approach in addition to detailed descriptions of sampling procedures and data gathering gear. The outcomes of the questionnaires and key informant interviews are summarized in the following chapter, which is devoted to data analysis and presentation.

Lastly, a chapter devoted to summarizing important findings and responding to the main research question rounds off the study. In addition, this final section provides insightful suggestions for future developments and upgrades based on the study's results, establishing a link between the present discoveries and upcoming research projects.

CHAPTER 2: REVIEW OF LITERATURE

2.1. Conceptual Review

Climate risk refers to the potential for negative consequences affecting human or environmental systems resulting from the impacts of climate change (IPCC, 2012). These negative consequences may include physical harm, financial losses, and social disruptions, such as the repercussions on human lives, source of revenue, health, and well-being, as well as social, cultural, and economic assets. Impacts are the repercussions of climate change for human and natural systems (IPCC, 2012).

According to Meyer et al. (2009), disaster damage is a common way to quantify the effect of hazards on urban systems. It is defined as the total loss of system components in the process of responding to a disaster (UNFCCC, 2012). Disaster damage includes the direct destruction brought about by a physical or structural impact (such as the loss of properties, buildings, or infrastructure) and the indirect damage brought about by a decrease in production, medical costs, lost income from unemployment, or effects on the well-being of people (such as casualties or health issues) (Cochrane, 2004). The capacity of the system to withstand the hazard is mostly reflected in the direct damage, while its capacity to recuperate and return to a stable state is demonstrated by the indirect damage.

Climate change has already increased the frequency and severity of catastrophic weather conditions. Climate threats are complex, and scientific forecasts are highly uncertain (Obersteiner et al., 2001). According to Obersteiner et al. (2001), strong tools to address climate risk include technologies that reduce the risks and vulnerability associated with climate risk, reliable scientific methods that identify, assess, and model risk and risk-mitigation strategies, and effective institutions that guide human activities in response to climate challenges. Climate threats are a major concern to both human and ecological systems. Understanding and managing these risks is critical for building a resilient future.

The IPCC (2014) defines adaptive capacity as the ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner, including through ensuring the preservation, restoration or improvement of its essential basic structures and functions. The adaptive capacity of a system depends on its ability

to adapt to changing conditions, withstand shocks and stressors, and maintain or enhance its functionality over time. In this context, enhancing adaptive capacity for women, particularly in urban areas, involves ensuring that women have equal access to financial resources, education, healthcare, and technology; providing women with timely and accurate information about flood risks and emergency procedures; and building strong community and local establishments for disaster risk management.

To develop a resilient future, we must first understand what vulnerability means in terms of climate change. The IPCC (2012) defines vulnerability as a system's susceptibility to and inability to cope with the negative consequences of climate change, such as climate variability and extremes. This is dependent on the system's sensitivity, exposure, and adaptive capacity. According to IPCC (2007), a system's adaptive capacity shows its potential and capability to lessen the prospective effects of climate variability through current opportunities or by making initiatives to cope with the repercussions.

The term "susceptibility" refers to how much a system is affected favorably or adversely by climate-related stimuli, whereas "exposure" refers to how much a system is exposed to large climate extremes or important climate-related events. The IPCC's approach to exposure considers both spatial and temporal elements, as well as vulnerability at various scales. Social norms and expectations impact women and men's social roles, behaviors, expressions, and identities. Gender, as a societal model, influences climate risks and responses. For this study, we employ Moser's (1993) definition of gender as "the social aspect of culture, religion, and classes that condition the way masculine and feminine roles and status are constructed and defined in each society." It refers to the social disparities and interactions between the genders that are learnt, vary by culture and society, and change over time. Relations between gender are dynamic and change in accordance with diverse ideological and socioeconomic factors. Gender inequality has far-reaching social, political, economic, and cultural consequences for those dealing with climate change.

2.2. Theoretical Framework

The rapid expansion of urban areas and the emergence of cities as hubs of socioeconomic development have prompted a high concentration of individuals, revenue generation,

development assets, and vital infrastructure, and numerous risks within small geographic areas (UNDP, 2021). Consequently, development deficits and heightened vulnerabilities have led to an increasing manifestation of systemic risks characterized by more frequent occurrences, amplified magnitudes, and rising economic losses and impacts (UNDP, 2021). In Ethiopia, gendered inequalities within the household and community put women and girls at a disproportionate risk, making them extremely exposed to the negative effects of climate change. Unfortunately, climate change intervention measures frequently overlook gender factors. Addressing how disparities between genders create and exacerbate vulnerability is crucial for effectively addressing climate change (UN Women, 2016).

Constructs and concepts about the social roles and responsibilities of women, in addition to their perceptions, experiences, and surviving mechanisms during flood disasters, served as the initial framework for the analysis (Norris et al., 2002; Tong et al., 2011). Hence, this paper examines the statement of the problem through the lenses of Ecofeminism, Feminist Political Ecology, and the Sustainable Livelihoods Framework to address and analyze the unequal distribution of environmental hazards and liabilities according to gender, power relations, and access to resources, particularly focusing on urban flooding risk.

2.2.1. Feminist Political Ecology

Feminist political ecology (FPE) emerged in the the second half of1990s as a branch of political ecology. Within political ecology, FPE provides an agenda for including a feminist perception (Rocheleau et al., 1996). FPE is an analytical framework that investigates power dynamics that lead to unequal management of resources at every level, from local to global (Castree & Braun, 2001). Sundberg (2017) defines FPE as a branch of political ecology that incorporates feminist theory, objectives, and processes, emphasizing the role of gender in relation to class and race, as well as other relevant dimensions of political-ecological operation, in determining access to, control over, and knowledge of natural resources and influencing environmental relations.

The value of this form of analysis is from its ability to expose specific consequences and reactions, providing the required information for legislative actions which encourage justice and empowerment among vulnerable populations (Elmhirst, 2018). The idea that women belong to a single autonomous group is rejected by feminist political ecology, which instead focuses on the

different contexts and power play in which gender interacts with ethnicity, national identity, and class to influence how individuals perceive and are interested in their surrounding (Schroeder, 1997). This method provides a framework for analysis designed at helping understand and recognize local experiences within the worldwide dynamics of economic and environmental transformation.

Overall, FPE provides a framework for rethinking the relationships amongst our surroundings and community. It expands beyond a narrow emphasis on individuals and ecology to investigate the gender related consequences of climate change (Arora-Jonsson, 2011). This model places a strong emphasis on women's roles and responsibilities in the home and community, as well as their gendered rights to assets, resources, space, and decision-making. According to Enarson et al. (2006), the vulnerability of women to disasters is not only influenced by poverty but also by their gender-specific roles as caregivers and mothers. Their capacity to seek out security during disaster is frequently impeded by their caregiving responsibilities for the elderly and the toddlers, who both need assistance and supervision (Babugura, 2010).

Through the perspective of FPE, we investigate the goals of achieving a more comprehensive and nuanced understanding of gendered urban flood vulnerability. FPE goes beyond simply recognizing gender inequities to critically examine how power dynamics, social structures, and cultural norms influence our susceptibility to as well as reaction to environmental concerns (Sundberg, 2017). By addressing these characteristics, FPE sheds light on how women and other oppressed groups face an unjust proportion of the weight of environmental challenges, showing the interdependence of environmental challenges with broader social justice concerns. This viewpoint emphasizes the relevance of gender and social equality in establishing effective and inclusive measures to address urban flood vulnerability and resilience.

2.2.2. Ecofeminism

During the 80s, the debate over the roles of women in development changed toward a more socialist viewpoint, and the Gender and Development (GAD) theory recognized women's reproductive and biological roles. It also questioned the existing power systems that perpetuated inequality (Sturgeon, 1997). As a result, ecofeminism emerged as a significant concept in the late 1980s and early 90s to explain the association between the oppression of women and the degradation of the environment, which was generally attributed to male supremacy (Manion,

2002; Tong, 2009). One of ecofeminism's core points is that women are the main victims of the deterioration of the environment (Arora-Jonsson, 2011). Researchers such as Mies et al. (1993) and Manion (2002) contend that environmentally destructive concerns, such as climate change, have a bigger negative impact on women than males, owing to women's greater engagement in home management.

Ecofeminism, just like Feminist Political Ecology, advocates for acknowledging the interconnection of all living beings and encourages environmental stewardship based on mutual respect and care (Mellor, 1997). Women and vulnerable populations frequently endure a uneven share of environmental impacts, from natural hazards like flooding, resource extraction to pollution. Ecofeminism highlights these unequal responsibilities and promotes environmental solutions that prioritize social justice and gender equality.

When looking at ecofeminism through the lens of urban flood vulnerability, it is especially pertinent. Urban floods disproportionately harm women, particularly in low-income regions with high informal settlement rate, because of their involvement in household management and childcare (Callaghan et al., 2007). The variability of climate has increased the rate and intensity of urban flooding, exacerbating existing vulnerabilities. Women frequently face larger barriers to getting emergency services, securing housing, and rebuilding following disasters. Furthermore, a lack of gender-sensitive policies and infrastructure worsens the impact on women's health, safety, and economic security. Which is why it is imperative that the ecofeminist principles are integrated into urban planning and management of disasters in order to reduce these discrepancies.

2.2.3. Sustainable Livelihood Framework

Agenda 21 widened the notion of sustainable livelihoods during the 1992 United Nations Conference on Environment and Development (UNCED). It called for the establishment of sustainable livelihoods as a general goal for poverty alleviation. It emphasized that sustainable livelihoods can operate as a uniting factor, allowing strategies to address both poverty eradication as well as sustainable resource management. A livelihood is considered sustainable when people can deal with and recuperate from disasters and disruptions while preserving or

enhancing their capabilities and assets without jeopardizing the source of their natural resources (S. Kariki, 2021).

A livelihood should create opportunities for future generations while also offering net benefits to others on a local and global scale (Chambers & Conway, 1992). A sustainable livelihood approach is defined as a collection of numerous methods used by an individual to effectively accomplish their financial goals depending on their capacities and resources (Gani et al., 2021). Individuals' livelihoods and the overall accessibility of resources are greatly impacted by substantial trends, as well as unforeseen events and seasonal variations above their control or influence (DFID, 1999).

The Sustainable Livelihoods Framework identifies the fundamental elements influencing people's livelihoods and the common links between them. This framework can be used to plan new development projects as well as to assess how existing activities contribute to livelihood sustainability. It is meant to be a multipurpose instrument for preparation and management, providing a methodical approach for grasping livelihoods and identifying the multiple factors that influence them (DFID, 1999).

Analyzing gendered urban flood vulnerability using the Sustainable Livelihoods Framework offers an extensive basis for investigating the complex relationships between people, their environment, and their overall quality of life. As aforementioned, urban floods disproportionately impact women, particularly in low-income regions, because of their involvement in household management and childcare which is usually an unpaid work that limits women from having access to resources as well as emergency services.

The Sustainable Livelihoods Framework takes into account issues such as resource accessibility, vulnerability to shocks, and adaptive capacity, providing a broader view than a restricted focus on environmental or economic elements. Furthermore, addressing gendered urban flood vulnerability necessitates an integrated approach that acknowledges the mutual dependence of environmental, economic, and social problems.

2.3. Climate Policy and Gender in Ethiopia

The paper examines a variety of national policies and legal documents, emphasizing their importance in comprehending the historical nexus of climate change and gender. Ethiopia's government has implemented a number of significant policies to alleviate and adapt to climate change. Ethiopia's Environmental Policy of 1997 is a cornerstone document for the country's long-term development, encapsulating key concepts for responsible resource use. The policy is to improve the wellbeing and quality of life of all Ethiopians while also promoting long-term social and economic growth via judicious management and usage of natural, cultural assets, man-made as well as the environment as a whole (FDRE 1997).

The government of Ethiopia has also showed its commitment to increasing women's participation in environmental issues through a variety of initiatives. In response to the problems faced by climate change, the Ethiopian government developed a National Adaptation Plan. The primary goal of this plan is to identify and push for projects that address the urgent need to adapt to the negative effects of climate change.

In 2009, the Environment, Forest and Climate Change Commission (EFCCC) In 2009, carried out specific analysis of gender to inform adaptation decision-making, recognizing the importance of incorporating gender perspectives for developing an efficient and long-term adaptation program (Zewdu M, 2020). Additionally, Ethiopian authorities devised a approach known as the Climate Resilient Green Economy (CRGE) in 2011, with the goal of reducing emissions of greenhouse gases and unsustainable use of natural resources, as well as achieving middle-income status by 2025 in line with green economy growth. The strategy plan for the Climate Resilient Green Economy presents the way to ensure Ethiopia attains middle-income status by 2030 while maintaining the greenhouse emissions which are responsible for climate change and the increase in the frequency of natural catastrophes like flooding to a minimum.

Under Ethiopia's climate policy, the gender analysis for Ethiopia's National adaption Plan (EFCC, 2019) provides thorough suggestions for adaption choices and gender-specific strategic priorities. The policy promotes gender sensitivity and the collecting of gender-disaggregated data across all levels. However, gender is only addressed in one of the eighteen primary adaptation alternatives, namely social protection and livelihoods. The analysis and recommendations in Integrating Gender Recommendations in Ethiopia's National Adaptation Plan (NAP) Process (EFCCC, 2019)

consist of specific recommendations for gender-specific alternatives to adaptation and strategic priorities, such as addressing social norms, encouraging the involvement of women, and ensuring similar opportunities for livelihood.

Another environmental strategy that takes gender into account is the Intended Nationally Determined Contribution (INDC) (Ministry of Environment and Forest, 2015). The INDC report includes a general declaration that emphasizes the goal of including initiatives to strengthen women's and children's rights within Ethiopia's response to climate change. However, this strategy lacks precise objectives and detailed strategies to achieve those goals.

2.4. Review of Empirical Studies

Urban flooding risk assessment focuses on the unique challenges and vulnerabilities that cities experience as a result of floods. These hazards are related with metropolitan regions' distinct traits and dynamics, such as high population density, inadequate infrastructure, and concentrated economic activity (Economics of Climate Adaptation, 2009). Informal settlements in poorly ventilated and congested regions is increasing in urban cities like Addis Ababa, particularly among the economically active labor force working in non-permanent, low-skill employment such as daily manual labor or comparable trades (Mcdowell et al., 2021). As a result of insufficient drainage systems and inadequate infrastructure, these locations are frequently prone to flooding.

Urbanization and deforestation have altered land use and cover patterns, increasing flood risks in Addis Ababa. The city is especially vulnerable to urban flooding, particularly in sub-cities like Akaki-Kaliti, which are located on the Akaki River and experience frequent floods due to heavy rainfall and insufficient drainage systems (McDowell et al., 2021). Disasters not only cause acute humanitarian issues, but they also have long-term ramifications for city development (Asprone & Manfredi, 2015). Extreme weather occurrences such as flooding pose issues for urban dwellers, particularly the poor. As a result, people frequently face difficult decisions about their site of living (Dickson et al., 2012). This selection requires evaluating trade-offs between closeness to economic prospects, tenure security, service provision, disaster protection, and cost.

2.4.1. Vulnerability of Gender to Flood Risks

Gendered vulnerability to flood hazards emphasizes how gender differences interact with political, socioeconomic, and cultural concerns, resulting in variances in how people experience and adjust to the effects of flooding when faced with extreme conditions and catastrophic events, women may be more vulnerable to harm and fatalities than men (Alston, 2013; Kukarenko, 2011; Nellemann et al., 2011). Several studies have emphasized the gender associations of catastrophes caused by climate change in terms of readiness and effects (Enarson and Morrow, 1998), the sharing of responsibilities within a family (Ikeda, 1995; Enarson, 2001), raising children (Peek and Fothergill, 2008), and emergency response and recovery in other words community rebuilding after hazards (Bradshaw, 2002; Enarson et al., 2006).

Several researchers, notably Fordham (1999), Bradshaw (2002), and Pincha (2010), have looked into the complex relationship between gender, hazards, age, and family structure. Their research generated a variety of results, stressing the need for more investigation in this field. By continuing to examine these relationships, we can obtain a better knowledge of gender concerns in catastrophes and devise more tailored solutions.

Scholars in the field of gender and disaster argue that there needs to be a more nuanced understanding of men's and women's experiences during and post disasters. These broad generalizations tend to portray men and women as having the same experiences and capacities. They can lead to overlooking the specific needs of vulnerable groups (MacGregor, 2010; Arora-Jonsson, 2011). Furthermore, generalizations can limit the potential contribution of both men and women in disaster preparedness, response, and recovery efforts. This perspective acknowledges that gender plays an important role in affecting how individuals are impacted by and respond to climate-related difficulties, particularly in metropolitan areas.

Wright and Chandani (2014), for example, hypothesized that women are more likely than men to lose their source of income in the case of catastrophic weather conditions brought on by climate change because of their conventional roles, societal norms, and power structures. In many cultures, women are often anticipated to run households and care for kids and family members who are elderly. This limits the mobility of women in caregiving responsibilities, making them less likely of escaping or evacuating in time in the event of a flood and putting them at a higher risk (David & Enarson, 2012; UNPFA, 2009). Women in the later stages of pregnancy, for

example, may be especially susceptible in extreme weather or during a natural catastrophe due to their particular physical requirements and limited mobility. Women's higher vulnerabilities, on the other hand, are frequently associated with socially manufactured disparities in gender norms and duties (Nellemann et al., 2011).

Ruminta and Handoko (2016) argue that the assessment of vulnerability is based on the idea that vulnerability is directly proportional to exposure and susceptibility, but inversely related to adaptive capacity. Several factors impede certain women's adaptation efforts, including limited access to formal education, impoverishment, discrimination in food dispersion, food insecurity, restricted access to capitals, exclusion from policy-making institutions, and social marginalization (Anbesu Bikila, 2013). Therefore, promoting adaptation among women entails modifying their exposure, reducing the system's susceptibility to flood impacts, and raising their adaptive capacity.

Climate change will have a substantial impact on the entire hydrological cycle in cities like Addis Ababa, worsening existing difficulties such as land use and demographic shifts (Brody et al., 2008; IPCC, 2007). Females are particularly vulnerable to climate change because of their higher representation among the economically poor, their dominant role in crop cultivation, their unequal responsibility for food security in their households, their disproportionate burden in both fuel and water collection, and their dependency on scarce natural resources for their way of life (UN, 2009; Terry, 2009). Thus, it is critical to guarantee that gender concepts, methods, inclusion, and equity are included throughout all phases and components of project and program funding for development. Following climate-related disasters, women and children may experience economic and security issues that push them to seek improved living circumstances, shelter, and safe housing, leaving them exposed to gender-based violence and exploitation.

Mitchell et al., (2007) states that given that vulnerability and climate change are socially constructed, contested, and gendered ideas, it is critical to investigate and question the underlying discourses that influence gender and climate politics. That is imperative because women's political and economic marginalization as a result of gender disparities can be see that they have resulted in a reduced ability to influence policy processes when compared to men. Furthermore, there is a need to consistently emphasize the importance of the knowledge of women and their abilities through their job. It is critical to make greater efforts to take a people-

centered approach to climate discussions and ensure that women are given their proper place in the arena of sustainable development.

2.4.2. Urban Flooding Risk Adaptation Measures and Challenges

Climate change poses enormous dangers to global metropolitan areas, including the risk of urban flooding. Enhancing resilience is critical; nevertheless, there is a significant lack of an inclusive collection of effective climate adaptation methods (Rezvani et al., 2023). The importance of tackling climate change adaptation measures has grown in academic and policy circles over the last few decades (Lafond et al. 2014). Flood vulnerability risk assessment and adaptation strategies are critical tools in this process because they improve physical infrastructure, reinforce social systems, maximize water resources, and guide policy (Rezvani et al., 2023).

According to Espada et al. (2015) and Kuwae and Crooks (2021), flood risk adaptation strategies can be divided into 5 categories: restoration and protection of ecosystems, physical infrastructure, policy and planning, and water management. These methods include a variety of physical infrastructure upgrades, such as enhanced water drainage systems, flood protection barriers, and retention basins to prevent flooding. Furthermore, strategic urban planning with climate change concerns is an important component of these approaches (Economics of Climate Adaptation, 2009). Despite their differences, these methods all aim to improve adaptability to flooding in both natural and human-made systems. Overall, effective adaptation methods allows villages and cities to prepare for natural hazards, disasters and unforeseen events induced by climate change-related extreme weather conditions (Büyüközkan et al., 2022).

Thus, urban resilience extends beyond simply enduring climate change induced shocks; it also incorporates the capacity of cities to adapt and transform. Urban flooding risk adaptation measures are designed to address the varying vulnerabilities and capacities of individuals, both genders, in urban cities like Addis Ababa. Climate change adaptation and disaster risk reduction are closely related since both involve actions aimed at addressing long-standing climate change and disaster risk concerns. Which is why it is critical to address both of these phenomena in depth (Banwell et al., 2018).

According to Busayo and Kalumba (2020), adding gender-responsive techniques into disaster risk reduction and management is another adaptation strategy that can improve a city's resilience. This includes improving early warning systems to address various gender demands, pushing for gender-inclusive evacuation and emergency response protocols, and providing equal access to disaster relief resources for all genders. However, Martine et al., (2013) argue that implementing these strategies presents several substantial problems. The increasing concentration of population in developing towns and cities poses both a significant challenge and a promising opportunity for future global adaptation efforts, potentially impeding the effective integration of gender-responsive strategies into urban flood resilience efforts.

Similarly, Banwell et al. (2018) and Seidler et al. (2018) argue that insufficient financial resources and budgetary constraints may impede the implementation of urban flood risk adaptation measures, limiting the development of inclusive infrastructures public assets, and other services that address diverse needs and vulnerabilities. Addressing these issues requires a collaborative effort to integrate gender perspectives into urban climate resilience agendas, strengthen institutional capacity and stakeholder collaboration, improve the gathering and analysis of data, and promote gender-transformative strategies and policies that adhere to equity and inclusivity in urban development and mitigation and adaptation planning.

2.5. Conceptual Framework

In accordance with the frameworks and works of literature discussed in the preceding parts, the conceptual framework for this thesis was developed. These various theoretical and analytical reviews provided valuable insights into the thesis's major themes. As aforementioned, vulnerability is a function of exposure, susceptibility and adaptive capacity. In this study, the conceptual framework was developed that breaks down the numerous variables into three major categories: exposure, susceptibility, and adaptive capacity. These components have either a positive or negative association with flood vulnerability, and they all contribute to the Socio-Economic Flood vulnerability Index, which offers an overall measure of the community's flood risk. By organizing the framework in this manner, the study captures a broad perspective of flood vulnerability, taking into account both the chance of exposure to floods and the households' ability to deal with and recover from such disasters.

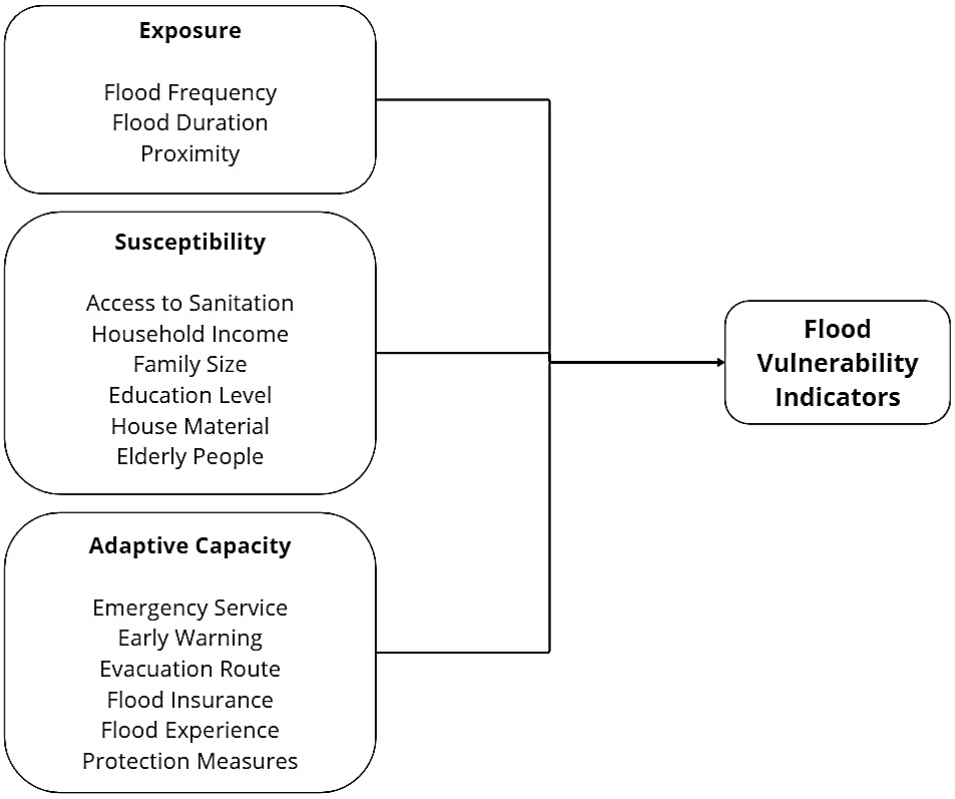

Figure 1. Conceptual Framework of the Study
Source: Adopted and modified from Erena, S.H., Worku, H. (2019)

2.6. Research Hypothesis

The central focus of this research is to explore the gendered dimensions of flood vulnerability among urban residents in Addis Ababa. Given the socio-economic dynamics and the urban climate risks observed, the study posits the following hypothesis:

- H1: Female-headed households are more vulnerable to flood risks compared to male-headed households in urban areas of Addis Ababa.

This hypothesis is grounded in the recognition that female-headed households often face disproportionate challenges due to socio-economic factors, limited access to resources, and differing adaptive capacities. The investigation will utilize a mixed-methods approach, combining quantitative data from household surveys with qualitative insights from interviews and focus group discussions, to examine and validate this hypothesis. The aim is to understand the underlying causes of heightened vulnerability among female-headed households and to provide evidence-based recommendations for targeted interventions.

CHAPTER 3: RESEARCH METHODOLOGY

3.1. Description of the study area

Addis Ababa, the country's major economic, political, cultural, and historical center, is both the largest city and a state. It is the federal government's capital and a chartered city. With a population of 4 million, Addis Abeba is Ethiopia's largest metropolis, accounting for 30% of the country's population living in cities. Furthermore, it is one of Africa's fastest growing cities, with a population that roughly doubles every decade. The population of the city was 1,412,575 in 1984, and it had grown to 2,112,737 by 1994. The population is expected to continue to grow, surpassing twelve million people by 2024 (UN Habitat, 2008). The city is split into eleven sub-cities, which are the second administrative units after the city government.

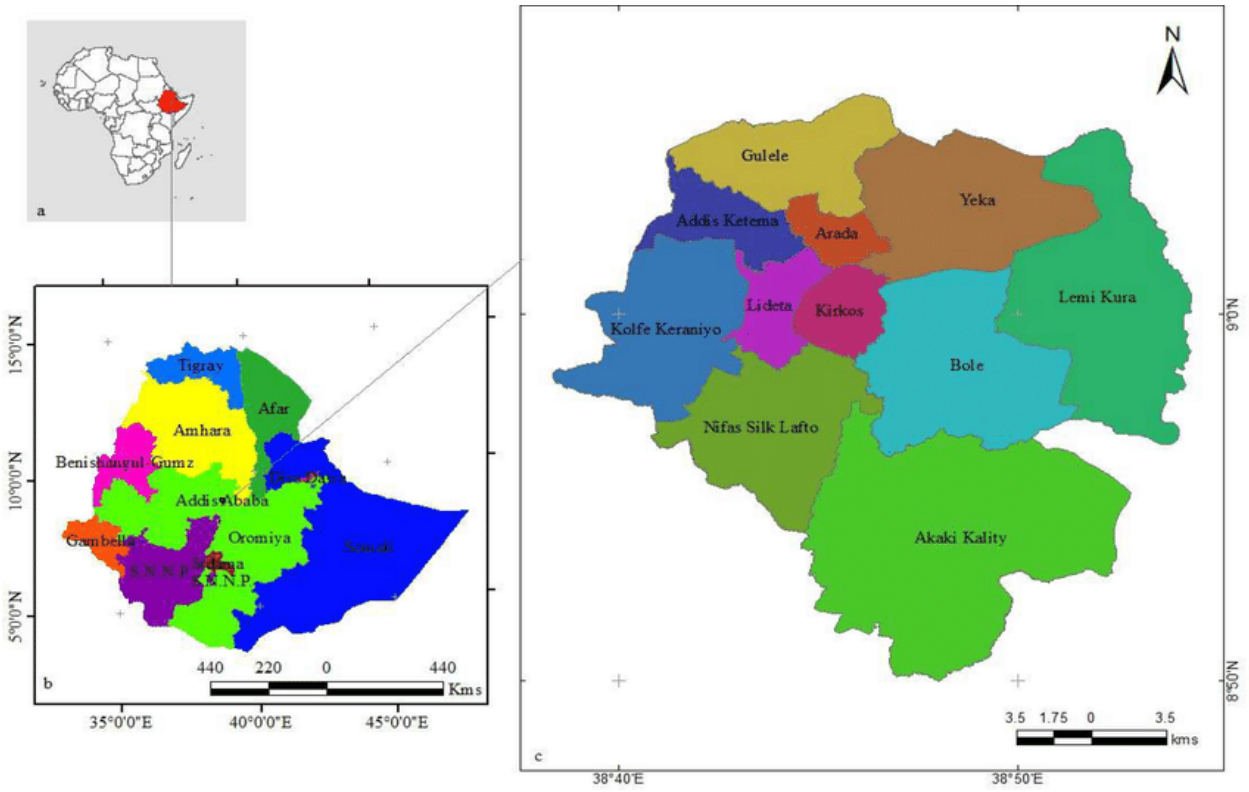

Figure 2 Study area
Source: (Ayele et al., 2022)

This study focused on the Akaki-Kality sub-city, the second largest of the eleven sub-cities. The data is taken from Woreda 03 in the Akaki-Kality sub-city, which is particularly prone to

flooding due to its geographical location. The sub-city borders the Nifas Silk-Lafto and Bole sub-cities, as well as the Oromia region. Akaki-Kality is a vast sub-city in southern Addis Ababa, Ethiopia. According to the central statistics agency's 2007 census, the sub-city has a total population of 181,270, with an estimated population of 255,348 by 2022. Akaki-Kality has a dense and diversified population, including a large proportion of young people and female-headed households. The male population is estimated to be 123,823, while the female population is forecast to be 131,525. Akaki-Kaliti, one of Addis Ababa's largest sub-cities, spans 118.08 km² and has diverse landscapes, including urban and rural areas. It is also an important industrial zone for the city, housing various manufacturers.

Table 1 Population of Akaki-Kality Sub-city and Woreda 03

Akaki-Kality Sub-city	Population	Woreda 03	Population
Male	123,823	Male	15,580
Female	131,525	Female	16,883
Total	255,348	Total	32,463

(Source: Author)

Additionally, a substantial proportion of families in Akaki-Kaliti are headed by single women. Given this context, Akaki-Kaliti presents a complex and dynamic environment for studying climate risk vulnerability and adaptive capacity. The interplay between industrial activities, diverse livelihoods, gender dynamics, and environmental challenges makes it an intriguing research site.

Akaki-Kaliti demonstrates significant disparities in income. The presence of a substantial group of factory workers is overshadowed by their often meager wages, resulting in poverty and limited access to resources. Moreover, the concentration of industries significantly influences the environmental and socioeconomic conditions of the sub-city. A considerable portion of the population relies on informal employment, such as day labor, street vending, and small-scale

agriculture, rendering them more susceptible to climate-related shocks and disruptions (Central Statistical Agency, 2012). Additionally, the proximity of the sub-city to the Akaki River exposes it to flood risks, particularly during the rainy season. Akaki-Kality presents a multifaceted and dynamic landscape that is ripe for examining vulnerability and adaptive capacity to climate risks. The interplay between industrial activities, diverse livelihoods, gender dynamics, and environmental challenges renders it an engrossing site for this study.

3.2. Research Design

3.2.1. Research approach

Research approaches refer to the techniques of inquiry that provide particular recommendations for the procedures inside a research design. Creswell (2003) classified scientific research methodologies into three categories: quantitative, qualitative, and hybrid or mixed research. Qualitative research seeks to understand diverse elements of social and human behavior using particular methodologies such as interviews, observations, and focus groups. Quantitative research, on the other hand, is the systematic and scientific study of quantitative qualities and occurrences, as well as their relationships. Meanwhile, the mixed research approach entails collecting and analyzing both quantitative (numerical) and qualitative (descriptive) primary data in a single study (Creswell, 2003). According to Creswell (2003), the mixed-methods approach is a relatively new method that uses various types of data to help researchers generate an effective design from complex data.

Consequently, this study used a mixed-approach that includes both quantitative and qualitative research methods, with an emphasis on a descriptive and explanatory research design, to comprehensively explore and describe the vulnerability to climate risks, adoption responses, and adaptive capacity among urban residents of varying ages and genders.

3.2.2. Data: Types and Sources

The collection of quantitative data for this study will primarily rely on structured surveys designed to obtain information on vulnerability to climate risks and adoption responses. These surveys will serve as the main instrument for collecting quantitative data. The sources of this quantitative data will include local government offices and residents of Woreda 03 of Akaki-

Kaliti sub-city, with a deliberate effort to capture diverse perspectives. The surveys were be administered to randomly selected households within the sub-city, ensuring a representative sample that reflects the diverse demographics of the urban population. Utilizing the indicator approach of vulnerability quantification, the socioeconomic data gathered from the household survey of the 120 chosen respondents was examined.

In order to acquire an in-depth understanding of the experiences and perspectives of the respondents, this research will prioritize the collection of qualitative data through in-depth interviews conducted with residents of Akaki-Kality sub-city. The selection of participants will be purposeful, ensuring diversity and representation of various perspectives on vulnerability to climate risks, gender roles, and strategies for adaptive capacity. This focus on rich and personal narratives will enable us to explore nuances and complexities that might be overlooked by purely quantitative methods.

3.3. Sampling Size and Techniques:

Cochran's Formula (1977) for finite populations is used in this study to get the right sample size. Two essential components are used in Cochran's (1977) equation. The first is the level of risk—also known as the error or margin of error—that the researcher is willing to take on for the study, and the second is the alpha level, or the amount of acceptable risk that the researcher is willing to accept in the event that the true margin of error is greater than the acceptable margin of error. The sample size for this investigation was established with a 5% error margin and a 95% confidence level. The Akaki-Kaliti sub-city's Woreda 03 homes make up the study's target population. A total of 2,244 homes under Woreda 03 consist of 1431 households headed by men and 813 households headed by women. Consequently, utilizing the data and settings listed below,

(Cochran, 1977) Formula

$$n = n_0 \ / (1 + n_0 \ / N)$$

$$\text{Where } n_0 = Z^2 p(1-p)/ e^2$$

Parameters

- *n*: sample size that is required
- *N*: the size of the finite population.
- *Z*: Z-score Z= 1.96
- *p*: population proportion
- *e*: error of margin

Table 2 Household Distribution in Woreda 03

Woreda 03	Households
Female	813
Male	1431
Total	2244

(Source: Author)

no= no= 3.84*0/5(1-0.5)/ 0.09^2

$\text{no} = \frac{3.84*0.5(1-0.5)}{0.09}$=118.564

$$\text{n} = \frac{118.564}{1+\frac{118.564}{2244}} = 114$$

Non-response bias can significantly impact the validity of research findings. In this study on vulnerability assessments, we initially aimed to collect data from 114 households. However, despite our best efforts, some respondents declined to participate. To mitigate this bias, we expanded our recruitment efforts and successfully gathered data from 120 households. This adjustment allowed us to enhance the representativeness of our sample. This approach ensured the attainment of a representative sample that accurately mirrors the diversity within different strata of the population.

3.4. Data Collection Instruments

In the pursuit of comprehensive data collection for this study, diverse techniques have been strategically employed to capture the nuanced aspects of flood risk vulnerability assessment.

Document analysis: One of the main techniques applied in this research is document analysis that involves the examination and interpretation of various types of documents, texts, or records to gather valuable information related to the research objectives. It is one of the main techniques used in this study because it allows to leverage pre-existing materials to complement other data collection methods, providing a historical, contextual, or supplementary perspective to the study.

Household Survey: To identify the indicators, a meticulously designed household survey was conducted. This survey is carefully crafted to elicit information on flood risk vulnerability assessment and adoption responses. To ensure a representative sample, the survey was systematically administered to 120 randomly selected households by using stratified random sampling. This method allowed us to gather quantitative data that reflects the diverse demographic composition of the urban population.

Key informant Interviews: To supplement the quantitative findings with qualitative insights, key informant interviews were incorporated into the methodology. In this study 5 key informant interviews were conducted with the local experts, community leaders, and the administrators of the Woreda who possessed invaluable knowledge about the region. Through these interviews we were able to capture nuanced perspectives that may not have been fully captured through surveys alone. These interviews provided a qualitative depth to our understanding of the community's experiences and responses to flood risk.

Furthermore, a direct observation was undertaken to gain firsthand insight into the communities' current adaptation techniques and the actions performed by governmental entities to lessen the vulnerability to flood risk.

3.5. Data Analysis and Processing

As aforementioned, by utilizing the indicator approach of vulnerability quantification, the socioeconomic data gathered from the household survey of the 120 chosen respondents was

examined. It has been determined that the indicator-based flood vulnerability assessment is the best suitable method for assessing groups of people at all levels (UNISDR 2008; Salami et al. 2017). This approach uses a systematic combination of context-specific indicators to quantify vulnerability. However, the actual factors that impact flood susceptibility are hazard-dependent, site-specific, and localized. Consequently, there are relatively few indicators that are commonly used. The main goal of this study is to identify the reasons that made a certain population more susceptible to flooding and the ways in which these variables affect that susceptibility, with the aim of practically assessing the vulnerability of a particular study region. As a result, the indicators were chosen after considering the existing literature, the setting of the study, data accessibility, and firsthand observation.

As a result, the composite vulnerability evaluation consisted of 16 indicators for what information were available and the ones that best matched the local risk conditions. In order to make all of the indicators' values fall between 0 and 1, normalization was used. Ultimately, the normalized score index was created. There are two possible functional relationships between indicators and vulnerability. While some people have unfavorable relationships that lower vulnerability, others have great relationships that raise vulnerability. Vulnerability is positively impacted by exposure and susceptibility and negatively impacted by adaptive capacity.

The following is the formula for normalization:

$$Y = \frac{X - Min\ (X)}{Max(X) - Min(X)}$$

Where Y is the normalized value of the indicator

And X is the value of the indicator

Following normalization, these indicators' scores fell between 0 and 1. The greatest value corresponds to a value that is closer to 1, and the minimum value corresponds to a value that is closer to 0. The functional link between vulnerability and the flood vulnerability indicators is displayed in the following table. To measure the variables under investigation, a combination of yes/no questions and continuous scale questions was employed. This methodological approach

facilitated the collection of both categorical and continuous data, thus enabling a comprehensive analysis of the study's subject matter.

Table 3 Flood Vulnerability indicators of Woreda 03 of Akaki-Kality Sub-city and their functional relationship

No	Indicators	Abbv.	Factors	Unit	Relation with vulnerability
1	Flood Frequency	FF	Exposure	Year	The vulnerability increases with the frequency of flooding (+)
2	Flood Duration	FD	Exposure	Days	The vulnerability increases with the length of the flood (+)
3	Proximity to Water	PW	Exposure	m	The vulnerability increases with the proximity of the homes to the river (+)
4	Emergency Services	ES	Adaptive capacity	%	The less vulnerable a region is, the more people who receive help during a flood(-)
5	Household Income	HHIN	Susceptibility	ETB	The degree of vulnerability increases with decreasing household income (+)
6	People Access to Sanitation	PAS	Susceptibility	%	The greater the vulnerability, the lower the percentage of persons with access to sanitation (+)
7	Poor Quality House	HPM	Susceptibility	#	The vulnerability increases with the number of homes made of subpar materials (+)
8	Education Level	EL	Susceptibility	%	vulnerability increases with the percentage of older people. (+)
9	Elderly People 65+	OP	Susceptibility	%	The vulnerability decreases as education level rises (-)
10	Family Size	FS	Susceptibility	%	The vulnerability increases with the percentage of family size (+)
11	Early Warning	EW	Adaptive capacity	%	The lower the vulnerability, the more effectively the warning system functions. (-)
12	Past Flood Experience	PFE	Adaptive capacity	%	The greater the susceptibility, the lower the percentage of previous flooding experience. (+)

13	Evacuation Route	ER	Adaptive capacity	%	The vulnerability decreases as the percentage of evacuation routes increases (-)
14	Presence of Flood Protection Measures	PFPM	Adaptive capacity	%	Lower vulnerability corresponds with increased flood prevention measures (-)
15	Flood Insurance	FI	Adaptive capacity	#	The vulnerability decreases as the number of insured households rises (-)
16	Communication Network	CN	Adaptive capacity	#	The vulnerability decreases as more people have access to information (-)

Source: Adopted and modified from Erena, S.H., Worku, H. (2019)

When creating the vulnerability index, the weights of the chosen variables were ascertained through the application of principal component analysis. Additionally, the relationships between the chosen indicators and locations were examined using the T-test. Simple descriptive statistics (tables and figures) were used to assess and present the data on flood risk adaptation techniques as well as the different factors impacting the adaptation strategies chosen by households. In order to support the concepts discovered numerically and to cross-check results, the qualitative data gathered via the use of key informant interviews was examined qualitatively. This helped to strengthen the validity and dependability of the conclusions. Additionally, secondary data from the Woreda and the CSA was used and examined.

3.5.1. Constructing the Indices of Vulnerability of Woreda 03

Numerous writers concur that exposure, susceptibility, and adaptive capacity all contribute to vulnerability. (IPCC 2001; Cardona 2013). As a result, the typical formula for calculating FVI requires that the indicators be divided into three categories: exposure, susceptibility, and adaptive ability. According to the paradigm, vulnerability would result from exposure to climate change and unpredictability depending on how sensitive the lives and livelihoods of the populations are. Furthermore, the vulnerability to the effects of climate change will be much higher when the adaptive capacity to endure the negative consequences of exposure and sensitivity becomes very low. The FVI, according to Wannasai et al. (2013) and Villagrán de León (2006), is calculated using the following formula:

$$FVI = \frac{Exposure * Susceptibility}{Adaptive\ Capcity}$$

If adaptive capacity is expressed as 1/lack of adaptive capacity, then this equation can be modified. Balica (2007) states that the following equation can be used to measure vulnerability in urban sectors

$$FVI = Exposure \times Susceptibility \times Lack\ of\ Adaptive\ Capacity$$

using the same three factors:

$$FVI = Exposure + Susceptibility - Adaptive\ Capacity$$

The data in this study were structured using an equation created by Balica (2007) to facilitate the computation of FVI. Utilizing the summing relationship among all vulnerability indicators is made easier by this equation. Consequently, the FVI equation applied in this study is based on the formula created by Balica (2007). Using the indicator approach, the community's vulnerability level was determined. This approach uses a systematic combination of context-specific indicators to quantify vulnerability. Then, using PCA, on the variables in accordance with Deressa et al.'s (2008) research, the vulnerability indices were determined.

By identifying the linear combination of the variables with the greatest variance—typically the first principle component—PCA overcomes the indeterminacy. Next, it finds a second linear combination of the variables that is orthogonal to the first and has the greatest remaining variance, and so on. The process solves the equations in a technical sense $((R-\lambda I))\ vn=0$ for λn and V_n, where the correlation matrix between the scaled variables (a's) is denoted by R. and for each variable, V_n is the vector of coefficients on the n^{th} component. The distinctive roots of R, λn (sometimes referred to as eigenvalues), and the corresponding eigenvectors, $V_{n,}$ are obtained by solving the equation. Another limitation put in place to accomplish problem determinacy is scaling the V_ns to the point where the sum of their squares equals the total variance, which yields the final estimates.

3.5.2. Description of model variables

Scale and environment have a significant impact on vulnerability (Alebachew, 2011). Consequently, care must be taken to prevent reading vulnerability indications too strictly. As a result, the vulnerability analysis conducted for this study was predicated on many indications that were discovered by looking through the literature and the study's environment. The study's conceptual framework, which comprises the subsequent indicators under adaptive ability, exposure, and susceptibility, was then used to group the variables.

Adaptive capacity

A town or region's ability to adapt is mostly determined by its infrastructure, institutions, technology, knowledge and skills, and equity, as stated by IPCC (2001). Adaptive capacity was measured through indicators representing the community's infrastructure, institutional readiness and technology. Therefore, communication networks, flood insurance, protection from flooding measures, access to emergency services, evacuation routes, and early warning systems were used to represent adaptive capacity for this analysis. Stated differently, the greater the proportion of individuals able to utilize emergency services and early warning systems, the less susceptible they are. Additionally, the greater the number of people with flood-related experience, flood safety gear, and a communication network, the less vulnerable they are.

Susceptibility

According to Cardona (2013), Balica (2007), and Veenstra (2013), susceptibility is the capacity of a system to be damaged by a dangerous event, such as floods, as a result of fragility, relative social or economic shortcomings, or unfavorable circumstances. It has to do with both the system's features and more general non-climatic variables (including land use, livelihood, infrastructure, and governmental policy). Susceptibility was quantified based on the physical, social, and economic attributes that make individuals or households prone to flood damage. Here, homes made of subpar materials, the proportion of elderly residents, the number of illiterates, the size of the family, and the lack of access to sanitary facilities all serve as symbols of susceptibility. It is believed that homes with stronger construction materials, more educated

residents, and smaller families will be less vulnerable to extreme weather events like flooding than those with the opposite characteristics.

Exposure

Exposure was determined by the likelihood and extent to which households could be directly affected by flood events. Variables existent at the potential flood site are represented by exposure. Flood frequency, flood length, and household closeness to the water are the study's measures of exposure. In addition, a level of assessment was conducted on household perceptions regarding flooding and climate change in order to characterize the behavior of climate variables. They all reported changes in rainfall and temperature, as well as an increase in the frequency and length of flooding in recent years, which led to a similar conclusion. However, because there isn't much of a distance between the research regions, it's thought that their weather patterns are similar, meaning that the amount of exposure is assumed to be very similar.

To acquire the indicators free of units and scales for this study, the UNDP's Human Development Index (HDI) normalization approach was used (UNDP 2006). In order to make all of the indicators' values fall between 0 and 1, normalization was used. Vulnerability is positively influenced by exposure and susceptibility and negatively influenced by adaptive capacity. The villages with the highest value are represented by the number 1, and the villages with the lowest value are represented by the number 0. In this scenario, greater vulnerability is correlated with higher indicator levels, and vice versa.

3.6. Ethical consideration

The safety and well-being of all human participants were prioritized in conducting this research. A high level of self-discipline and professionalism was maintained, ensuring that ethical considerations remained at the forefront of the research process. To minimize any potential risks to respondents, the study was carefully designed to expose participants to no more than minimal danger. The invitation to participate in the study explicitly stated that participation was voluntary, and participants were informed that they could withdraw at any time without negative consequences.

Confidentiality was a key consideration throughout the research process. Measures were taken to protect the information provided by respondents, ensuring that their data remained confidential and secure. In line with the guidelines provided by Fink (2009), all information was handled with the utmost care and discretion. To adhere to ethical standards, the principles outlined by the American Psychological Association (2002) were followed:

1. **Honestly Address Intellectual Property**: All intellectual property was correctly attributed, and the contributions of others were acknowledged appropriately.

2. **Awareness of Multiple Responsibilities**: Responsibilities to the participants, the research community, and society at large were consciously upheld.

3. **Informed Consent**: Informed consent regulations were adhered to, providing participants with all necessary information about the study, including its purpose, procedures, risks, and benefits, enabling them to make informed decisions about their participation.

4. **Respect for Privacy and Confidentiality**: Participants' privacy was respected by clearly communicating the boundaries of confidentiality. Federal and state laws related to data protection were observed, and robust security measures were implemented to safeguard the data.

5. **Data Sharing Considerations**: The implications of data sharing were considered before the commencement of the research, ensuring that any shared data would protect the privacy and confidentiality of participants.

Recognizing that research ethics are crucial for maintaining the integrity and credibility of the study, efforts were made to respect both the participants and the research settings during the data collection process. By upholding these ethical standards, the study was conducted in a manner that was both rigorous and respectful of the individuals who contributed to it.

3.7. Data Reliability and Validity

To ensure the reliability of the data in this study, rigorous methodological techniques and robust data-gathering procedures were employed. A well-defined research design was implemented, utilizing standardized instruments and uniform data collection techniques to enhance reliability.

Specifically, the standardized instrument developed by Balica SF (2007) in *"Development and application of flood vulnerability indices for various spatial scales (Master thesis, Unesco-IHE)"* was utilized. This recognized and tested measurement instrument minimizes measurement errors and enhances the repeatability of the research.

Extensive training was undertaken to reduce potential biases in data collection and to ensure consistency in survey administration and interview methods. This training-maintained uniformity in the data collection process, thereby increasing the reliability of the findings. By adhering to these rigorous procedures and employing a standardized instrument, the dependability of the data is significantly improved, ensuring that the research results are both credible and replicable.

Validity: Ensuring the legitimacy of the data is critical to ensuring the correctness and validity of the research results. To address this, the study combines content, construct, and criterion-related validity. Content validity is maintained by doing a thorough literature study and consulting with experts during the construction of research instruments, ensuring that the measures capture the intended constructs. Furthermore, criterion-related validity is assessed through comparisons to already validated measures and external criteria. Throughout the data collecting process, attempts will be made to create rapport with participants, creating an environment conducive to honest and accurate responses. Overall, the combination of these tactics ensures that the data acquired is both accurate and valid, which strengthens the integrity and credibility of the research findings.

CHAPTER 4: RESULTS

4.1. The socio demographic traits of the participants

The baseline socioeconomic information of the study area is provided in this subsection, which is where the primary findings should be interpreted. The respondents' total socio demographic profile offers a thorough understanding of the research population.

Table 4 Socio demographic profile of the respondents

Variables	Differential categorization	Frequency	Percentage
Household head's sex	Male-headed	60	50
	Female-headed	60	50
	Total	120	100
Age	15 -30	32	26.67
	31 -65	79	65.83
	Above 65	9	7.5
	Total	120	100
Marital status	Married	100	83.33
	Divorced	16	13.34
	Widowed	4	3.33
	Total	120	100
Educational status	Illiterate	8	6.67
	Able to read and write	59	49.17
	Primary education	37	30.83
	Secondary education	16	13.33
	Total	120	100

(Source: Author)

This study analyzes essential demographic variables based on a sample of 120 respondents. The dataset comprises an equal number of male-headed (50%) and female-headed (50%) households. Notably, the majority of respondents fall within the 31-65 years age range (65.83%), while the

15-30 years group constitutes 26.67%. A smaller proportion—7.5%—belongs to the above 65 years category. Since the main goal of this paper is to see the differences between the two genders, here is a gender specific demographic data of the participants.

Table 5 Gender Specified Profile of the Household Heads

Demographic Variables	Variable Classification	Female	Male
Household head sex	Female-headed	60	-
	Male-headed	-	60
	Total	120	120
Age group	15 - 30	16	14
	31 - 65	39	42
	Above 65	5	4
	Total	60	60
Marital status	Married	47	53
	Divorced	9	7
	Widowed	4	0
	Total	60	60
The status of Education	Uneducated	8	0
	Capable of writing and reading	32	27
	Primary education	16	21
	Secondary education	4	12
	Total	60	60

(Source: Author)

Regarding marital status, approximately 83.33% of respondents are married, with 13.34% reporting divorce and 3.33% being widowed. In terms of educational attainment, the majority are illiterate, with 49.17% capable of reading and writing, 30.83% having attained primary education, and 13.33% completing secondary education. A small segment (6.67%) remains illiterate.

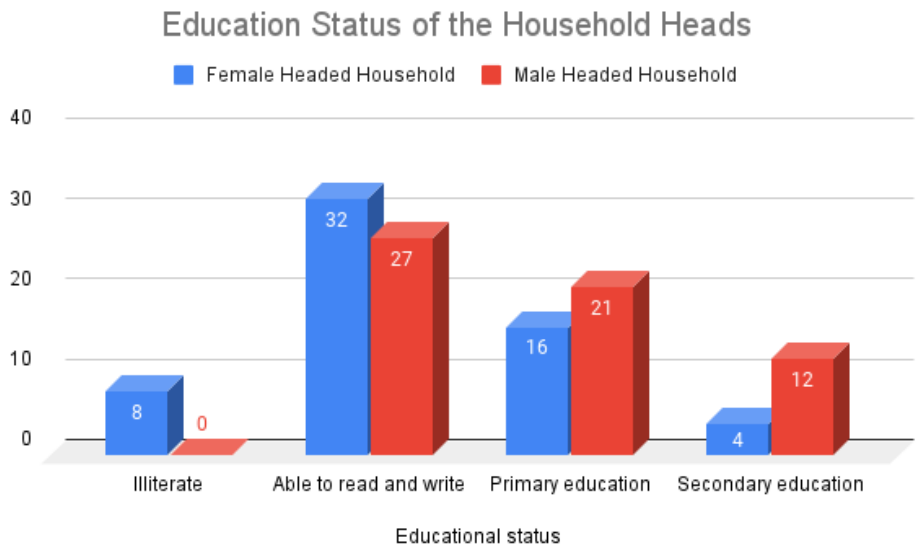

Figure 3 Education Status of the Household Heads

(Source: Author)

4.2. The Perceptions of Urban Residents in Woreda 03

Residents in Woreda 03 have provided their perspectives on temperature and rainfall fluctuations over the last two decades, providing insight into the community's experiences with climate variability and its consequences. Of the 120 responders, 94 household heads (78.3%) reported a change in temperature. Among the 94 respondents who reported a temperature change, an overwhelming majority of 93 people (98.9%), including 48 men (51.6%) and 45 women (48.4%), feel temperatures are rising. Only one male respondent (1.1%) stood out as an exception, indicating that temperatures are dropping.

Table 6 Perception of Change in Temperature

Gender	Noticed Changes	Not noticed changes
Female	45	15
Male	49	11
Total	94	26

(Source: Author)

When it comes to rainfall variations, 75 respondents (62.5%)—38 females (50.7%) and 37 males (49.3%)—have seen changes in rainfall patterns, while the remaining 45 respondents (37.5%)—22 females (48.9%) and 23 males (51.1%)—haven't noticed anything. The majority of those who perceived changes said that rainfall is increasing, with 31 females (82.0%) and 33 males (89.2%) sharing this viewpoint. In contrast, seven females (18.0%) and four males (10.8%) stated that rainfall was decreasing.

Table 7 Perception of Change in Rainfall

Gender	Noticed Changes	Not noticed changes
Female	38	22
Male	37	23
Total	75	45

(Source: Author)

Flooding has also caused great concern among the residents of Woreda 03, Akaki-Kality Sub-city. Out of 120 respondents, the majority, 78 (65.0%), comprised of 37 females (47.4%) and 41 males (52.6%), had previously experienced flooding, whereas 23 females (65.7%) and 19 males (34.3%) had not. Over the recent decade, 38 females (50.0%) and 36 males (46.2%) reported an increase in flooding, while 22 females (28.2%) and 24 males (30.8%) did not report such a trend.

Table 8 Past Flood Experience

Gender	Experienced Flooding (Yes)	Not Experienced Flooding (No)
Female	37	23
Male	41	19
Total	78	42

(Source: Author)

Access to information networks is another essential aspect in determining community adaptive capacity. A significant majority of 92 respondents (76.7%) stated that they had access to information channels, with 48 females (52.2%) and 44 males (47.8%) falling into this category.

However, 28 respondents (23.3%)—12 females (42.9%) and 16 men (57.1%)—reported a lack of access to information networks, indicating a gap in information transmission that could impact emergency preparedness and response.

Table 9 Access to Information

Gender	Access to Information	No access to Information
Female	48	12
Male	50	10
Total	92	22

(Source: Author)

During floods, emergency services play an important role. According to 73 respondents (60.8%), the government provide critical services such as rescue and evacuation, temporary shelter, basic supplies, and medical help. Key informant interviews suggested that authorities maintain excellent communication and alert systems, distributing critical information about hazards, evacuation orders, and safety precautions. These services are critical for addressing emergencies and protecting residents. Additionally, the government has been working in relocating those who live too close to the river and taking steps to reduce flooding damage. During data collection, we saw coordinated efforts between the community and the government to reconstruct dwellings made of low-quality materials and fortify them before the following rainy season.

When asked about the vulnerability to floods, 44 respondents (37.0%) selected poor households as the most vulnerable, while 40 respondents (33.3%) said women were the most vulnerable. Others pointed out that youngsters and the elderly are especially vulnerable to flood damage. The majority of respondents, 97 in total (80.8%)—50 females (51.5%) and 47 males (48.5%)—felt that flooding had negatively impacted their livelihoods, whereas 23 respondents (19.2%)—10 females (43.5%) and 13 males (56.5%)—did not perceive such an impact. These findings give an overview of the community's perceptions and experiences with temperature and rainfall variations, flooding, and the effectiveness of adaptive measures and government interventions in Woreda 03.

4.3. Flood Vulnerability Index (FVI) Computation

The Flood Vulnerability Index (FVI) for the study area was calculated by looking at both social and economic factors. We used 16 different indicators to understand how exposed and susceptible the community is to flooding. For this, the flood vulnerability ranking by Balica (2007) was used to determine the vulnerability level of the community. The functional relationships between vulnerability indicators were established using previous results from other studies, theoretical assumptions, and responses from the participants.

Table 10 Ranking of Flood vulnerability (Balica 2007)

Index value	Description
< 0.01	Extremely minimal vulnerability to flooding
0.01–0.25	Minimal vulnerability to flooding
0.25–0.50	Moderate Vulnerability to flooding
0.50–0.75	Elevated vulnerability to flooding
0.75–1	Extremely vulnerable to flooding

(Source: Author)

In this study on flood risk vulnerability assessment, the community of Woreda 03 was found to have an elevated vulnerability to flooding, with an overall index value of 0.73. However, when analyzing the data by gender, distinct differences in vulnerability levels emerged. Male-headed households exhibited an elevated vulnerability to flooding, which was reflected by the value of 0.59. In contrast, female-headed households displayed an extreme vulnerability to flooding, with an index value of 0.866.

Table 11 Raw Datasets of 16 Flood Vulnerability Indicators of Woreda 03

No	Indicators	Abv.	Factors	Unit	Value	Male HH	Female HH
1	Flood Frequency	FF	Exposure	Year	2.32/year	2.32/year	2.32/year
2	Flood Duration	FD	Exposure	Days	4	4	4
3	Proximity to Water	PW	Exposure	m	<2000	<2000	<2000
4	Household Income	HHIN	Susceptibility	ETB	8,450	7,500	4,700
5	People Access to Sanitation	PAS	Susceptibility	%	62.5	41.67	20.83
6	House with Poor Material	HPM	Susceptibility	#	69	30	39
7	Education Level (illiteracy)	EL	Susceptibility	%	6.67	0	6.67
8	Old People 65+	OP	Susceptibility	%	7.5	3.33	4.17
9	Family Size	FS	Susceptibility	%	3	3	3
10	Early Warning	EW	Adaptive capacity	%	34.17	22.5	11.67
11	Emergency Services	ES	Adaptive capacity	%	60.83	34.167	26.67
12	Past Flood Experience	PFE	Adaptive capacity	%	65	34.16	30.83
13	Evacuation Route	ER	Adaptive capacity	%	45	27.5	17.5
14	Presence of Flood Protection Measures	PFPM	Adaptive capacity	%	60.83	34.167	26.67
15	Flood Insurance	FI	Adaptive capacity	#	7	7	0
16	Communication Network	CN	Adaptive capacity	%	81.6	41.67	40

(Source: Author)

4.4. Adaptive Responses to Flooding Risk

In this study, we proceeded to look at how they respond to high level of flooding risk and the household heads in Woreda 03 reported various adaptive responses to manage flooding risks. The responses, along with the number of respondents who chose each adaptation strategy, are

detailed below, highlighting both gender-specific preferences and common practices across the community:

Table 12 Adaptive Responses to Flooding Risk

Types of Activities	Female Respondents	Male Respondents
Flood proofing of houses and buildings	2	4
Harvesting rainwater during the rainy season	8	2
Planting trees around the home	5	3
Covering the ground in marketplaces with plastic sheets	12	16
Constructing river dykes	0	0
During the flood season, wear rubber boots, raincoats, and umbrellas	31	42
Keeping up and clearing the current drainage channels	24	33
Putting sandbags in front of houses or businesses	23	14
Making traditional urban flooding passages around the house or business	0	2

(Source: Author)

To understand this table better;

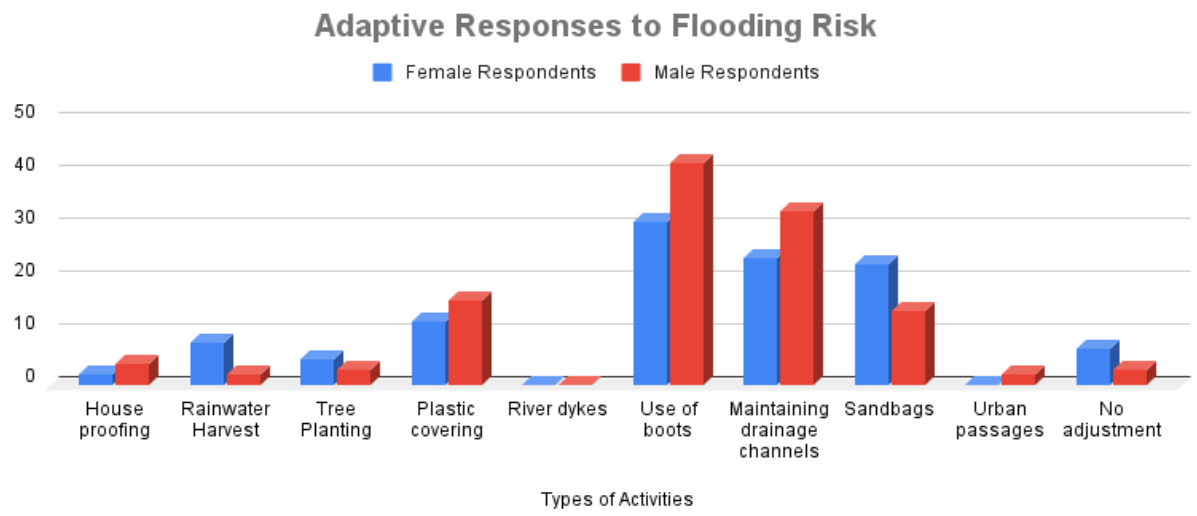

Figure 4 Adaptive Responses to Flooding Risk

The most common adaptive response among both female (31 respondents) and male (42 respondents) household heads were the use of rubber boots, raincoats, and umbrellas during the flooding season. This indicates a widespread reliance on personal protective measures to cope with flooding. A significant number of respondents, 24 females and 33 males, reported maintaining and cleaning existing drainage channels. This reflects a communal effort to improve local infrastructure and prevent waterlogging. Most of the respondents worked in the market place and covering the ground with plastic sheets at marketplaces was reported by 12 female and 16 male respondents. This practice helps to protect goods and maintain market operations during flooding.

However, among the respondents, there were 10 people—7 women and 3 men—who said they made no adjustments to adapt to flooding risks. The reasons they provided shed light on the various barriers they face. For the women, 3 of them cited a lack of awareness about how to effectively respond to and prepare for flooding. Four women mentioned a shortage of labor, indicating that they either did not have enough help or the physical capacity to implement necessary measures.

On the other hand, the men had slightly different reasons. One man pointed to a lack of awareness, similar to some of the women. However, the other 2 men highlighted financial constraints, stating that a lack of money prevented them from making any adjustments to protect against flooding.

4.5. Socio-economic factors: using T-test and Regression Analysis

One of the most destructive types of natural disasters are floods, causing immense damage to lives and property worldwide. Vulnerability to floods varies across different groups, influenced by a variety of causes including socio-economic status, access to resources, and gender roles within societies. For disaster risk reduction and management to be effective, it is imperative to comprehend these variations. To analyze the socio-economic variables that contribute to the differential vulnerability of various gender groups to flooding risks a T-test and Regression analysis was conducted using the values of the indicators. By conducting the T-test analysis we were able to understand the vulnerability difference between the two genders. Furthermore, by conducting the regression analysis, we explore the influence of various socio-economic factors on flood vulnerability on both the genders.

T-test Analysis

The basic assumption before conducting the t-test analysis in this study was that there may be statistically significant differences between male-headed and female-headed households regarding flood vulnerability indicators. The data used in the study were evaluated to ensure they approximated a normal distribution. This was achieved by applying appropriate statistical tests, such as the Shapiro-Wilk test using Python. The adherence to normality ensures that the assumptions underlying the t-test are valid.

The study design ensured that the observations between the two groups (male-headed and female-headed households) were independent. The data points in one group did not influence or depend on the data points in the other group. This independence was maintained by collecting data separately for each group and ensuring there was no overlap or interaction that could bias the results.

Before performing the t-test, Levene's test for equality of variances was conducted to verify that the variances of the two groups were approximately equal. The test results confirmed that the assumption of homogeneity of variance was satisfied, allowing the independent t-test to be appropriately applied.

The dependent variables used in the t-test analysis, such as household income, access to sanitation, and educational levels, were measured on an interval or ratio scale. These scales provide continuous data, meeting the t-test requirement for the dependent variable to be measured on an appropriate scale.

When looking at the results, the value that is indicated by T-statistic demonstrates the disparity between the means of households headed by women and those headed by men for each indicator as shown in Annex 4. A higher absolute value indicates a larger disparity between the two genders. The P-value indicates the probability of observing the results while assuming the null hypothesis is true.

Table 13 T-test Values

Indicator	T-Statistic	P-Value
FF	-1.545687	0.124858
FD	-0.515445	0.607207
FS	-1.79061	0.07592
HHIN	-6.101949	1.37E-08
ES	-1.689122	0.093837
PAS	-5.178627	9.31E-07
HPM	1.667365	0.098094
EL	3.012793	0.003168
OP	0.343855	0.731567
EW	-2.548679	0.012097
PFE	-0.761013	0.448167
ER	-2.228996	0.027708
FPM	-1.689122	0.093837
FI	-2.791497	0.006121

Source: Author

In this study, a p-value below 0.05 suggests there is a statistically significant disparity between the two groups. Accordingly, Household Income (HI), Access to Sanitation (AS), Education Level (EL), Early Warning (EW), Evacuation Route (ER) and Flooding Insurance (FI) have p-values below 0.05 which indicates significant differences between the households. On the other hand, other indicators such as Emergency Service, Houses with poor materials, old people and previous flooding experience had p-values higher than 0.05 showing that there is no statistically significant distinction among families headed by men and those headed by women.

Regression Analysis

Similar to the T-test, the data used in the analysis came from 120 households in Woreda 03 of Akaki-Kality sub-city using indicators such as flood frequency, duration, proximity to water, and socio-economic factors like household income, education level, and access to services. The data is divided into two groups: female and male-headed households.

The basic assumption before conducting the regression analysis in this study was that there are significant relationships between flood vulnerability (the dependent variable) and various socio-economic, demographic, and environmental factors (the independent variables). In essence, the foundational assumption was that flood vulnerability could be explained and quantified through a systematic relationship with the selected independent variables, and that these relationships would provide insights into the underlying factors contributing to the disparities in flood risk among households.

The relationship between the dependent variable (e.g., flood vulnerability) and the independent variables (e.g., household income, education level, access to sanitation, and early warning systems) was tested for linearity. Scatter plots and residual plots were used to confirm that the relationships were approximately linear, satisfying this condition. The study design ensured that observations were independent, meaning the data collected for one household did not influence data collected for another. Since the data were cross-sectional (not time-series), there were no issues of autocorrelation, and the assumption of independence was upheld.

Residual plots were examined to confirm that the variance of the residuals was constant across all levels of the independent variables. The analysis showed no significant patterns or heteroscedasticity, fulfilling the homoscedasticity requirement. The residuals were tested for

normality using visual inspection (histograms and Q-Q plots) and statistical tests. The results indicated that the residuals were approximately normally distributed, meeting this condition for regression analysis. The dependent variable, flood vulnerability, was measured on an interval scale, while the independent variables were a mix of interval, ratio, and categorical scales.

The following equation was used to conduct the regression analysis:

$$Y=\beta_0+\beta_1X_1+\beta_2X_2+\beta_3X_3+\ldots+\beta nXn+\epsilon$$

Where:

- **Y**: The dependent variable, is flood vulnerability.
- **β0:** The intercept, representing the expected value of Y when all independent variables are zero.
- **β1,β2,β3,…,βn**: The regression coefficients for the independent variables X1,X2,X3,…, Xn. Each coefficient represents the expected change in Y for a one-unit change in the corresponding X, holding all other variables constant.
- **X1,X2,X3,…, Xn**: The independent variables, such as household income, education level, access to sanitation, early warning systems, family size, housing quality, etc.
- **€\epsilon**: The error term, accounting for the variability in Y that cannot be explained by the independent variables.

The multiple linear regression analysis revealed interesting insights into the factors influencing flood vulnerability: For female-headed households, household income, access to sanitation, education level, were found to be a significant factor, with greater access associated with higher vulnerability. Furthermore, effective early warning systems were significantly associated with reduced vulnerability for both groups, although the effect was stronger for females.

Other factors such as Family Size, Emergency Services, and Past Flood Experience were not significant predictors of vulnerability for either group. The findings suggest that gender is a major factor in shaping vulnerability to floods. Families led by women, particularly, are relatively vulnerable in the context of sanitation access, household income and education level. The significant impact of early alerting mechanisms (early warning) highlights the importance of

investing in these systems to reduce vulnerability across gender groups. This is particularly critical in the face of increasing impacts of climate change, which are likely to exacerbate flood risks.

4.6. Discussion

4.6.1. Status of Flood Risk Vulnerability of Woreda 03

Using the Balica (2007) ranking, the degree of vulnerability of the Woreda 03 residents to flooding was assessed. The results showed that the community showed elevated vulnerability to flooding with an aggregated overall index value of 0.73. However, when analyzing the data by gender, distinct differences in vulnerability levels emerged. Male-headed households exhibited a high vulnerability to flooding, which was reflected by the value of 0.59. In contrast, female-headed households displayed a very high vulnerability to flooding, with an index value of 0.866. These results underscore the heightened flood risk faced by families led by women compared to their male counterparts, highlighting the necessity of focused interventions to address gendered vulnerabilities within the community.

During the key informant interviews with the community leaders, we were able to gather that the majority of the households led by women were active in the informal sector which could be explained by the women's educational attainment in this field that was shown through the data that was collected in the community. Less than 1% of the 60 women in the Woreda who participated in the survey had a degree from college, which helps to explain why the majority of the participants were working in the informal economy. The dropout rate after primary school was significantly high for both genders however it is witnessed more with women. According to FAO (2011), women who lack a formal education or training are compelled to work in informal sectors with low wage and earn lower incomes, which may limit their ability to diversify their sources of income or strengthen their resistance to climate-related impacts like droughts and floods.

Based on the gathered information, the majority of survey participants (65%) assessed their living circumstances and their housing conditions as subpar. Women's daily lives in this Woreda were extremely challenging and affected by a number of variables, such as disparities in gender in their homes, poverty, illiteracy, and domestic violence. The majority of the women were the

only ones responsible for taking care of the home, raising the family, and providing food. They were also resourceful individuals who took up odd jobs to supplement the revenue in their households.

Laws, the effects of globalization, in addition to hyper-urbanization all contribute to the disparity in gender that women experience (Enarson and Morrow, 1998). These factors significantly contribute to limiting women's access to the productive and financial resources needed to deal with and recover from floods and other extreme weather disasters. Land, for instance, is a valuable asset for female-headed households that are dependent on agriculture; but, in numerous parts of the world, customary or traditional decrees frequently limit the land and property rights of women (Schroeder, 1997; World Bank, 2007). According to studies carried out in Bangladesh, other reasons that can exacerbate women's vulnerability to climate catastrophes such as floods are social marginalization, poverty, and a lack of life-saving abilities like swimming (Rowshan, 1992; Alim, 2009).

This study discovered a significant gap in how natural catastrophes, notably flooding, affect households that are led by men and women. Families that are led by women are often more vulnerable because of their limited mobility and more difficult recovery processes from disruptive events such as floods. This greater vulnerability could largely be attributed to their conventional gendered duties, which include responsibilities as mothers, caretakers, and managers of disturbances. These roles, which are firmly embedded in pre-existing socio-cultural practices and power systems, increase the difficulties women experience during and after disasters. The limits imposed by these roles limit women's ability to leave quickly, utilize relief supplies efficiently, and rebuild their lives after a disaster (Enarson, 2006).

Nevertheless, interviews with key informants from the Woreda administration indicate a positive development. The government acknowledges that this area is prone to flooding. This recognition has led to tangible initiatives targeted at increasing the community's resilience. These measures involve moving households currently living in high-risk areas near the river. Furthermore, the government is launching rehabilitation programs to replace homes damaged by earlier floods. These preventive efforts reflect a commitment to reducing future flood risks and enhancing the community's long-term well-being.

4.6.2. Gender Adaptive Responses to Flooding

Enhancing the ability to adapt is among the main objectives of sustainable urban development. But for now, we're still in the investigation phase. While some cities and researchers have intentionally suggested a range of actions to improve adaptive capacity (Doyle et al., 2017; Pfefferbaum et al., 2018), the majority of the studies have a tendency to develop guidelines and regulations from a macroscopic perspective without examining the suitability and efficacy of the enhancement approaches.

This study revealed the diverse ways the people in the Woreda cope with flooding. The findings indicate an integrated approach that included individual preparedness, joint infrastructure maintenance, and market protection strategies. Individual protection measures such as the widespread usage of rubber boots, raincoats, and umbrellas by both male and female home heads demonstrated a high emphasis on personal preparation. This implied that people are aware of the risks involved with flooding and are taking proactive steps to reduce personal harm. Many respondents reported actively maintaining and cleaning existing drainage systems. This demonstrated a community-driven initiative to address the underlying cause of flooding and that is poor drainage. Residents who work together to ensure good drainage can potentially minimize the severity of flooding and safeguard their homes and businesses. The majority of participants who work in the marketplace reported covering the ground with plastic sheets during floods. This inventiveness demonstrated a viable strategy to preserving livelihoods. By protecting their goods from flooding, market vendors can reduce losses and assure the continuing operation of markets, which are critical to the community's economic well-being.

While the study found a variety of adaptive responses, it is troubling that some women, in particular, reported taking no precautions to prepare for floods. The reasons they mentioned suggest significant barriers that impede their ability to adapt. From the women who reported to taking no precautions, some women acknowledged a lack of knowledge and comprehension about the proper flood preparedness and response measures. In a similar case, women's knowledge and information about disasters was restricted due to their focus on caring for their homes, which hindered them from engaging with others outside of their homes and watching television (De Silva and Jayathilaka 2014). When it comes to adaption, women in Pakistan also had trouble getting to relief distribution facilities and were therefore mostly excluded from

receiving aid due to lack of information (Ariyabandu, 2003). In another case, men in Indonesia were better at coping than women because they spent more time socializing in community centers and getting knowledge about hazards (Paradise 2005).

Other women claimed a labor shortage as a cause for not implementing flood mitigation measures. This could be due to a lack of male assistance in the household, limited access to hired help due to financial constraints, or this shortage of labor could be because of physical impairments or old age that prevent them from performing duties independently. Despite the difficulties mentioned above, women can make a major contribution when it comes to the efforts of disaster relief, improving adaptive capacity, caregiving, rehabilitation, and renovation (Aladuwaka and Momsen 2010). Women, for example, have been found to be more likely to follow evacuation instructions because of gendered roles, which can help decrease the effects of catastrophes on their households (Enarson 2006; Bateman & Edwards 2002). Women were more conscious of the necessity to get ready for and evacuate amid Hurricane Andrew, according to Morrow and Enarson (1996). According to Aladuwaka and Momsen (2010), because they oversee the home environment, they are the first to recognize changes and take appropriate action. Even when taken out of the context of the value of their domestic job, these women made a noteworthy contribution to the welfare of the family, even though many of them earn less than their husbands. In order to improve the financial stability of the household, many of them put in more hours than men do.

While only one man, indicated a lack of awareness regarding flood preparedness, others found financial barriers to be the most significant. They stated that restricted finances stopped them from implementing necessary steps. This emphasizes the economic aspects of flood adaption. Flood-proofing homes or businesses can be costly, such as raising structures, installing flood barriers, and purchasing waterproof materials. For people living in poverty, these fees may be too expensive, leaving them exposed to water damage.

Similar to the surveys, in the key informant interviews we were able to gather that even if citizens recognize the benefits of flood adaption techniques, funding may be limited. Without the opportunity to obtain loans or grants, they may be unable to afford critical materials or hire workers. Furthermore, flooding can interrupt livelihoods of the people and money generating,

resulting in a vicious cycle. According to the collected data, 81% of the respondents believe that their livelihoods are being significantly affected by the impacts of flooding. Thus, individuals who do not earn enough money may be unable to invest in flood preparedness, leaving them even more susceptible in the future.

According to a case study in three areas at significant danger in England, Harvey, Petts, & Chilvers (2011), discovered that the responses to floods varied according to the gender, indicating that men and women have distinct adaptive capacities and responses to the consequences of natural disasters. Furthermore, the study shown above indicated that the resilience to calamity of a household could be influenced by political and sociocultural attributes that are determined by the gender of the head of the family. This emphasizes how crucial gender-sensitive assessments are to households' capacity to anticipate, get ready for, react to, and ease the aftermath of hazards (Sohrabizadeh, Tourani, & Khankeh 2014).

4.6.3. The Factors Resulting in Differential Vulnerability of Gender Groups to Flood Risks

To understand how social and economic factors influence how men and women experience flood risks, we analyzed data using statistical tests. A t-test helped us observe if there's a noteworthy difference in vulnerability between households led by men compared to those led by women. Additionally, t-test analysis allowed us to explore how various social and economic factors affect flood vulnerability for both genders.

The current study found substantial differences (p-value < 0.05) in vulnerability to flooding across multiple parameters. These include household income, access to sanitation, education level, early warning systems, evacuation routes, and flood insurance (see Annex 4 for further information). The T-statistic number represents the size of the difference in each factor's average score between the two groups. Higher absolute T-statistic values indicate greater differences.

Household income is an important factor. The T-statistic showed a noteworthy difference in the monthly income between the two household groups. Families led by men generate greater income than families led by women. And, as previously said, this may have an influence on a household's ability to invest in flood preparation (e.g., sandbags) or recover financially after a

flood, making households, specifically female-headed households with lower incomes, more vulnerable to flooding.

Access to basic sanitation facilities (toilets, drainage) was also a key indicator. A considerable difference in T-statistics indicates that female-headed households were at a disadvantage in terms of hygiene and sanitation following a flood. Similar to the results of this paper, another case study found that a lack of sanitation and privacy contributed to the gendered problem during the flooding. During the flooding, women and men were forced to sleep outside, however, women had limited access to water for cleanliness and personal feminine hygiene items. Ladies were restricted to relieving themselves after nightfall in order to avoid being noticed by the others, while men may do it anywhere. Women who take on this kind of difficulty run the risk of developing health issues such UTIs (Sultana, 2010), sexual assault, and harassment (Krishnakumar, 2003). These issues can negatively affect women's sense of privacy and safety (Davis, 2006).

The study also identified education level as an important indicator that distinguishes between male and female-headed families. The outcomes revealed that female-headed households had a higher illiteracy rate than male-headed households. This may further limit the household's access to information regarding flood hazards, preparedness measures, and early warning systems.

Similarly, the study shows a. higher absolute T-statistic values in access to early warning systems and evacuation routes. Early flood warnings are critical for evacuating quickly and limiting damage. However, illiteracy might make it difficult to interpret these warnings, whether they are sent via text message, printed alerts, or community announcements. Hence, this disparity between the two groups could be directly related to the illiteracy rate in female-headed families, as it limits their ability to comprehend and effectively employ these resources. In basic terms, the study identifies a circle of vulnerability. Illiteracy in female-headed families makes it difficult to obtain information about flood hazards, limiting their preparation and capacity to respond effectively to early warnings. It is worth noting that other criteria, such as availability to emergency services, housing quality, the presence of elderly people, and previous flood experience, did not differ statistically significantly (p-value > 0.05) between the two household

types. This implied that these indicators are equally accessible or similar in both male- and female-headed households in Woreda 03.

Regression analysis investigates how changes in one aspect (for example, the household income) may affect another (for example, flood risk vulnerability). The investigation was done separately for female and male-headed families to find unique characteristics influencing vulnerability in each household group. The investigation was based on data from 120 households in Woreda 03 of the Akaki-Kality sub-city. Accordingly, low household income was identified as a significant factor in female-headed families. As aforementioned this is because it could limit their ability to invest in flood mitigation measures (such as sandbags and flood proofing their houses) or recover financially after a flood. Furthermore, higher illiteracy rates among female-headed households were connected to increased flood susceptibility. This is expected to limit access to information on flood risks, preparatory measures, and early warning systems.

The regression analysis revealed interesting insights into the factors influencing flood vulnerability: For female-headed households, household income, Access to Sanitation, Education Level, were found to be a significant factor, with greater access associated with higher vulnerability. Furthermore, early warnings were strongly associated with decreased vulnerability in both male and female-headed households. This stresses the need of having reliable and easily accessible early warning systems in flood-prone locations. Early warnings enable residents to take prompt action, such as moving to safer areas or securing their things, reducing potential damage and loss of life.

According to the study, early warning systems may have a greater favorable impact on female-headed families. This could be due to their higher vulnerability in other areas (poor resources, less mobility). Effective early warnings may be even more important in compensating for these vulnerabilities and enabling them to respond successfully to a flood risk.

The regression study found that some characteristics, such as family size, access to emergency services, and prior flood experience, were not significant predictors of vulnerability for male or female-headed households. This implies that these elements may not be as widely influential in this particular setting. However, the study stresses that gender emerged as a significant predictor of flood susceptibility. Despite the difficulties experienced by female-headed households, the

study reports a positive finding: effective early warning systems were strongly associated with lower vulnerability for both genders. The study acknowledges the growing risk of flooding caused by climate change. Investing in strong early warning systems and addressing the particular risks of female-headed families are critical steps toward increasing flood resilience in the face of a changing climate.

CHAPTER 5: CONCLUSION AND RECOMMENDATION

5.1. Conclusion

The study took a mixed-method approach, incorporating both quantitative and qualitative research methods. The study used an indicator-based method to evaluate vulnerability to flooding using socioeconomic data from 120 families. The data were gathered from 120 families, resulting in a strong dataset for analysis. early warning systems, Flood frequency, flood duration, family size, proximity to water, elderly population, emergency services access, household income, sanitation access, housing quality, education level previous flood experience, evacuation routes, flood protection measures, flood insurance, and communication networks were among the indicators considered. The above indicators were critical in determining the various aspects of vulnerability.

The weights of these factors were determined using Principal Component Analysis (PCA), Principal Component Analysis (PCA) was used to calculate the weights of the specified indicators. PCA is a statistical technique that converts the original indicators into a series of uncorrelated components. These components are then weighted based on the variability they explain in the dataset. This strategy aids in reducing dimensionality and identifying the most important aspects that contribute to vulnerability. Which was subsequently applied to create the Flood Vulnerability Index. The data was analyzed using descriptive statistics and PCA to determine adaptive capacity and sensitivity characteristics, as well as qualitative data from key informant interviews to increase validity and reliability.

The study included 120 individuals, equally divided between male and female-headed families. According to the demographic profile, the majority of participants were 31-65 years old. This age group often includes people who are economically active, have considerable family responsibilities, and have wide-ranging local knowledge and experience. And it proved similar in this study, since most family heads in that age range were the sole breadwinners in their households.

The majority of participants were married, with implications for household dynamics and resource allocation. Furthermore, participants generally possessed basic reading skills, allowing them to understand basic material and engage in written communication. This literacy level is

critical for comprehending early warning messages and disaster preparedness material. However, the results suggest that both male and female household heads have a high dropout rate, but it is particularly severe among female respondents. It is worth noting that a small number of women (13.3%) did not know how to read and write, which enhanced their vulnerability.

Residents have seen considerable changes in temperature and rainfall patterns over the last two decades, with the majority reporting an increase in both temperature and rainfall. Flooding was prevalent, affecting a substantial portion of the town, particularly in the past decade. Access to early warning and information networks was discovered to be crucial in mitigating flood risks, however, in this study, the results show that there is gaps in distribution and preparedness.

The risk to floods differed significantly across male and female-headed families. The Flood vulnerability Index, which is a composite measure built from multiple factors, showed that female-headed households had a greater risk score. An FVI of 0.866 for female-headed families, compared to 0.59 for male-headed households, indicates the increased risk and obstacles experienced by women in handling flood impacts. Rubber boots, raincoats, and umbrellas were the most common adaptive responses to floods. These strategies, while somewhat helpful, focus on short-term, immediate requirements rather than long-term adaptation and resilience.

In addition to individual protective measures, community-level adaptive strategies were identified, particularly in marketplaces. Maintaining and cleaning drainage ditches, as well as covering the ground with plastic sheets, were both effective adaptive strategies in marketplaces. Maintaining and cleaning drainage ditches ensures appropriate water flow and lowers the chance of stagnant water, which can increase flooding and pose health risks. It is critical that drainage ditches are not blocked with debris, especially during the rainy season when the Akaki river poses a high risk of flooding. And, by covering the ground with plastic sheets, the community attempted to keep water from leaking inside stalls and businesses, safeguarding products and minimizing damage.

However, despite the implementation of numerous adaptive measures, several respondents, particularly women, encountered considerable hurdles that impeded effective adaptation. Many respondents, particularly women, faced challenges such as knowledge gaps, labor shortages, and limited financial resources, which hampered successful adaptation. Many women were unaware

of appropriate flood adaption measures and early warning systems. Female-headed families frequently have fewer able-bodied adults available to perform labor-intensive adaptation activities like cleaning drainage ditches or building flood barriers. Financial constraints posed a big hurdle for many women. Personal protection equipment and other adaptive measures can be prohibitively costly particularly for low-income households.

T-tests and regression analyses were performed to investigate how socioeconomic factors influence flood vulnerability. T-tests were used to compare the mean values of several socioeconomic characteristics in male-headed and female-headed households. This helped to uncover statistically significant variations in these factors between the two groups. Multiple regression analyses were used to investigate the association between flood vulnerability and other factors. This strategy allows us to analyze the relative impact of several socioeconomic parameters in predicting flood vulnerability.

Household income, access to sanitation, and education level were all strong predictors of vulnerability in female-headed households. Household income was found to be a substantial predictor of flood susceptibility, especially among female-headed families. Lower incomes were connected to higher vulnerability. This is because lower-income households frequently have fewer means to invest in flood prevention, recovery, and adaptation techniques. Similarly, the regression analysis revealed that economic gaps have a considerable impact on households' ability to cope with and recover from floods. Access to sufficient sanitary services was another important indicator of flood vulnerability. Households with poor sanitation are more likely to suffer health problems during and after floods, increasing their overall vulnerability. Female-headed households frequently experience higher difficulty in maintaining sanitation due to economic and structural constraints, rendering them more vulnerable during floods.

The study discovered that efficient early warning systems were related with lower flood vulnerability in both male and female-headed households. These devices give important information that allows for timely evacuation and preparedness, minimizing the impact of flooding. Investing in effective early warning systems benefits the entire community by increasing adaptive capacity and allowing residents to take preemptive measures to safeguard themselves and their property.

Overall, this paper emphasized the necessity of gender-sensitive approaches to flood risk management. The findings underline the importance of focused interventions to address the special vulnerabilities of female-headed households, as well as the crucial role of early warning systems in mitigating flood risks. Improving community adaptable capacity through improved infrastructure, better information transmission, and inclusive adaptive methods is critical for mitigating the negative effects of flooding on vulnerable people.

5.2. Recommendation

In light of the results of the Woreda 03 flood vulnerability assessment, various recommendations can be listed to reduce the impacts of flooding, with a focus on decreasing gender inequities. In order to keep an already vulnerable social group from becoming even more impoverished, social and gendered concerns must be addressed. One such paradigm that can address the vulnerability of women in both every day and emergency circumstances is a human rights-based approach that prioritizes rights and empowerment (Sen, 1981; Tschakert and Machado, 2012).

This strategy works well because it tackles fundamental human rights issues head-on. The majority of the benefits will be distributed to low-income women, who are disproportionately represented in marginalized groups. Additionally, gender equality guarantees equal treatment and does away with discrimination. It is not an afterthought. Furthermore, when faced with obstacles like climate change, governments are required by human rights to actively ensure that people's fundamental requirements such as shelter and health care are met. As part of this responsibility, institutions and society must be helped to adapt in ways that address unequal vulnerability along social, economic, and gender lines. Additionally, it implies that discussing women's issues must take into account the power dynamics between men and women as well as larger societal and process of development.

Therefore, putting a human rights-based strategy into practice calls for specific strategies and measures aimed at empowering women. Scholars have suggested important areas for intervention. Heyzer (1992) highlights that social development programs including housing, healthcare, and education, as well as fair pay and access to a variety of occupations, can provide women with economic prospects. In order to promote gender equality in financial affairs, Wieringa (1994) advocates for addressing structural inequities such as discriminatory laws,

fostering better social interactions through the prevention of violence against women, and even reforming economic institutions.

To do this, targeted vulnerability reduction programs should be developed to meet the specific needs of female-headed households. These programs should prioritize raising literacy rates, increasing access to sanitation facilities, and improving economic opportunities for women. By addressing these critical areas, female-headed families' vulnerability to flooding can be greatly reduced. Improving early warning systems is also critical to ensuring that vulnerable groups, such as women and children, receive timely and effective flood-related information. Strengthening these systems can assist communities in better preparing for floods and reducing their impact. Furthermore, investing in infrastructure projects like strengthening drainage systems and building flood barriers can help protect both male and female-headed households from the negative consequences of flooding.

Community engagement is critical to disaster risk reduction measures. Promoting community engagement, particularly among women, who are frequently at the forefront of dealing with flood consequences, can result in the sharing of information and best practices within the community. This can help communities take proactive steps to lessen their vulnerability to flooding and improve their adaptive capability.

Finally, campaigning for gender-responsive policies is crucial. There is a need for measures that address women's special needs and vulnerabilities in flood prone areas. These policies should ensure that women have access to resources and decision-making processes linked to flood risk management. By implementing these recommendations, Woreda can lessen the impact of flooding and strengthen the adaptive capacity of its residents, especially vulnerable groups like female-headed households.

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Annex 1: Normalized values of the indicators

	Female Household		Male Household	
Indicators	mean	std	mean	std
FF	0.254167	0.274216	0.3375	0.314969
FD	0.389	0.218195	0.411167	0.251707
FS	0.45	0.255449	0.5375	0.279319
HHIN	0.379167	0.212804	0.625167	0.228544
ES	0.533333	0.503098	0.683333	0.469102
PAS	0.416667	0.497167	0.833333	0.375823
HPM	0.65	0.480995	0.5	0.504219
EL	0.133333	0.342803	0	0
OP	0.083333	0.278718	0.066667	0.251549
EW	0.233333	0.426522	0.45	0.501692
PFE	0.616667	0.490301	0.683333	0.469102
ER	0.35	0.480995	0.55	0.501692
FPM	0.533333	0.503098	0.683333	0.469102
FI	0	0	0.116667	0.323732
CN	0.8	0.403376	0.833333	0.375823

Annex 2: Principal Component Analysis of the Indicators

Indicators	Eigenvalue	Proportion of Variance	Cumulative Proportion
FF	7.305136	0.482951	0.482951
FD	1.663797	0.109995	0.592946
FS	1.455786	0.096244	0.68919
HHIN	1.316839	0.087058	0.776247
ES	0.879476	0.058143	0.834391
PAS	0.694656	0.045924	0.880315
HPM	0.538434	0.035596	0.915911
EL	0.295631	0.019545	0.935456
OP	0.285786	0.018894	0.95435
EW	0.229294	0.015159	0.969508
PFE	0.181626	0.012008	0.981516
ER	0.120304	0.007953	0.989469
FPM	0.087223	0.005766	0.995236
FI	0.072063	0.004764	1
CN	1.48E-33	9.78E-35	1

Annex 3: The access of the respondents to the social institutions

	Social Institutions		
Institution	Male Members	Female Members	Total Members
Iddir	4	25	29
Equb	20	12	32
Religious Groups	36	23	59
Total	60	60	120

	Access to Early Warning System		
Gender	Access to EWS	No access to EWS	Total
Female	14	46	60
Male	27	33	60
Total	41	79	120

	Emergency Services		
Gender	Yes	No	Total
Female	32	28	60
Male	41	19	60
Total	73	47	120

	Access to Market		
Gender	Yes	No	Total
Female	55	5	60
Male	57	3	60
Total	112	8	120

	Insurance		
Gender	Yes	No	Total
Female	0	60	60
Male	7	53	60
Total	7	113	120

	Industries		
Gender	Yes	No	Total
Female	49	11	60
Male	46	14	60
Total	95	25	120

	Distance from Industry		
Gender	2- 4km	4km and above	Total
Female	25	24	49
Male	29	17	46
Total	54	41	95

	Access to Sanitary Products		
Gender	Yes	No	Total
Female	25	35	60
Male	50	10	60
Total	75	45	120

	Distance to water source		
Gender	2- 4km	4km and above	Total
Female	47	13	60
Male	48	12	60
Total	95	25	120

	State of Roads during Rainy season		
Gender	They are okay	They are not okay	Total
Female	28	32	60
Male	21	39	60
Total	49	71	120

	Flooding affecting livelihood		
Gender	Yes	No	Total
Female	50	10	60
Male	47	13	60
Total	97	23	120

	Access to Evacuation route		
Gender	Yes	No	Total
Female	21	39	60
Male	33	27	60
Total	54	66	120

Annex 5: Regression Analysis values

Female-headed Household Model Results Vs Male-headed Household Model Results

Female-headed Household Model Results			Male-headed Household Model Results		
Variable	Coefficient	Std_Err	Variable	Coefficient	Std_Err
const	-0.2502	1.417	const	-3.2448	3.478
FF	0.4751	1.064	FF	0.4379	1.901
FD	0.7482	1.046	FD	-1.8106	1.751
FS	0.6644	2.283	FS	3.9604	3.533
HHIN	-1.5966	1.052	HHIN	0.9097	1.51
ES	-0.3485	0.435	ES	0.6545	0.556
PAS	2.7312	0.906	PAS	-0.7645	1.327
HPM	1.1528	1.08	HPM	3.1237	2.083
EL	1.23	1.057	EL	6.04E-16	3.96E-16
OP	0.0042	1.022	OP	1.497	2.122
EW	-1.9747	0.843	EW	-3.2293	1.629
PFE	-0.6781	1.15	PFE	0.6545	0.556
ER	-0.4779	0.961	ER	0.7305	1.893
FPM	-0.3485	0.435	FPM	0.6545	0.556
FI	0	0	FI	-0.2241	1.762

Annex 6: Household survey

HOUSEHOLD SURVEY TO BE COMPLETED BY THE HOUSEHOLD HEADS

Survey Title: Socioeconomic Flood Vulnerability Assessment in Akaki-Kaliti Sub-city

This Sabrin Nureddin Abdu, a graduate student at Addis Ababa University, is doing this study to gather fundamental information/data about flooding vulnerability in order to assess the difficulties of neighboring communities and plan for long-term adaptation and development initiatives.

The purpose of this questionnaire is to collect primary data on socioeconomic, vulnerability, and existing adaptation strategy information needed to analyze the vulnerability and adaptation strategy of urban people in the Woreda 03 Akaki-kaliti sub-city. Therefore, you are cordially invited to submit your free and correct reaction regarding the success of this study.

Finally, we appreciate your participation in this important survey. Your replies will help us better understand the flooding vulnerability of the Akaki-Kaliti sub-city. You should be confident that the data/information you provide us is just for this study and the benefit of the target community. Please answer the following questions truthfully and to the best of your knowledge.

Section 1: Demographic Information: Socioeconomic Characteristics:

1. Household head Sex : 1. Male 2. Female

2. Age: 1. <15 (child headed family) 2. 15-30 3. 31-65 4. >65

3. Marital Status

1. Single 2. Married 3.Separated 4. Divorced 5. Widowed

4. Educational Status

1. Illiterate 2. Capable of reading and writing 3. Primary school 4. Secondary school and above

5. Size of family

No.	Age	Sex (in number)		
		Male	Female	Total
1	<14 years			
2	15-65 years			
3	>65 years			

Section 2: Wealth, economic activities, and household income

1. In what type of house do you live? 1. Corrugated 2. Non corrugated 3. Others (Specify)?

2. Would you say your house is built with good materials? 1. Yes 2. No

3. How is the slop of your house? 1. On a plane land 2. On a hill 3. (Other specify)

4. Would you tell your household source of cash income and its amount in Birr

Major area	Source and amount of cash		
	Types of activities	Yes	No
Farm activity	Selling of crop production		
	Selling of livestock and their products		
	Selling of fruits, roots and vegetables		
Off farm activity	Labor wage Engaging in fetching water		
	Labor wage Engaging in industrial activities		
	Selling of fuel woods Selling of grasses		
	Selling of timbers and wooden trees		
Nonfarm activity	Mat, basket, and spinning		
	Bamboo work		
	Weaving Tannery		
	Blacksmithing		
	Tela and Areki		
	Cooking egg, kolo and kita		
	Food aid		
	Food-for-work		
	Grain and livestock		
	Consumer goods (salt, soap, kerosene etc.)		
	Remittance		
	Others(specify)		
Total/ year			

3. How do you see the trend of income level in your household for the last 10 years?

1. Increasing 2. Decreasing 3. No change 4. I don't know

Section 3: Flooding

1. Have you noticed any changes in temperature over the last 20 years? 1. Yes 2. No
2. If your answer to the above question is yes, what do you say about the trend of temperature over the last 20 years? Increasing 2. Decreasing 3. No change 4. I don't know
3. Have you noticed any changes in rainfall over the last 20 years? 1. Yes 2. No
4. If your answer to the above question is yes, what do you say about the trend of rainfall over the last 20 years? 1. Increasing 2. Decreasing 3. No change 4. I don't know
5. Have you ever experienced flooding in the past? 1. Yes 2. No

6. Do you live around an area where flooding happens quite often? 1. Yes 2. No
7. Have you noticed an increase of flooding over the last decade? 1. Yes 2. No
8. How often does flooding occur in your area? 1. Once/year 2. Twice/year 3. More than twice/year 4. Other (specify)_____
9. How long does a flooding last?
10. How close is your village to the river? 1. 1-4 km 2. 4 and above kms

4: Infrastructure and Institution

1. Do you have access to information (communication network)? 1. Yes 2. No
2. If your answer to question number 1 is yes, identify your source?

   1. Radio 2. TV 3. Journal/ newspaper 4. Internet 5. Neighbors 6. Others (specify)? _____
3. Are you a member of social institutions in your village? 1. Iddir 2.Equb 3.Religious groups 4. Others
4. Do you have access to the early warning system? 1. Yes 2. No
5. Are there evacuation routes? 1. Yes 2. No
6. Are there any emergency services given during times of crisis? 1. Yes 2. No
7. If your answer was yes to the previous question, what are they? _____
8. Do you have market access nearby? 1. Yes 2. No
9. Do you have insurance? 1. Yes 2. No
10. If yes, specify. _____-
11. Are there industries in your village? 1. Yes 2. No
12. If yes, how many? 1. 2 2. 2-5 3. 5-10 4. Other(specify)
13. If your answer is yes, how far is it from your home? 1. 1-4 km 2. 4 and above km
14. Do you have access to sanitation and sanitary products? 1. Yes 2. No
15. What is the distance to water source from your home? 1. 1-4 km 2. 4 and above kms
16. Are the roads ok to use in rainy seasons? 1. Yes 2. No

Section 5: Adaptation strategies and the factors influencing it

1. Do you think your livelihood is being affected by climate change impacts such as flooding? 1. Yes 2. No
2. If yes, what adjustments have you made to protect your livelihood?

Adaptation Strategies to Flooding		
Types of activities	Yes	No
Flood proofing of houses and buildings		
Through harvesting rainwater during rainy season		
Through planting trees around home		
Covering ground with plastic sheets at market places		
Through river dykes		
Using rubber boots, rain coats and umbrella during flooding season		
Maintaining and cleaning existing drainage channels		
Putting sand bags in front of house or business		
Making traditional urban flooding passage around the house (business)		
Other (Specify)		
No adjustments		

3. If you are not making adjustments towards adapting to the climate change impacts such as flooding what are the reasons?

   1. Lack of awareness 2. Lack of money 3. Shortage of labour 4. Other (specify)

4. When your source of income is not sufficient to fulfill your needs, which of the following coping mechanisms have you used to overcome the problem?

No	Coping mechanism	In the last year (2015 E.C)	
		Yes	No
1	Selling livestock		
2	Selling other household property		
3	Daily labor		
4	Borrowing money or grain		
5	Selling fuel wood/ charcoal		
6	Reducing consumption		
8	Migration to other area		
9	Others (specify)		

5. Who do you think are the most affected when flooding takes place in your locality?

   1. Women and children 2. Elderly people 3. Poor households 4. Others (specify)

Thank you for completing the survey! Your input is valuable in understanding and addressing flooding vulnerability in Akaki-Kaliti sub-city.